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ENERGY SECTOR USERS' GUIDEBOOK

IPCC Inventory Software, version 2.94

Compiled by:

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This Guidebook is prepared by IPCC TFI TSU.
It has not been a subject to the formal IPCC review process
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Abbreviations

2006 IPCC Guidelines	2006 IPCC Guidelines for National Greenhouse Gas Inventories
2019 Refinement	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
AD	activity data
C	carbon
CC	carbon content
CV	calorific value
ECT	emission control technology
EF	emission factor
GCV	gross calorific value
Gg	gigagram
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
IPCC TFI-TSU (or TSU)	Technical Support Unit of the IPCC Task Force on National Greenhouse Gas Inventories
IPPU	Industrial Processes and Product Use
kPa	kilopascal
l	litre
LTO	landing / take-off
m^3	cubic meters
NCV	net calorific value
NGHGI	national GHG inventory
TFI	IPCC Task Force on National Greenhous Gas Inventories
TJ	terajoule
Wetlands Supplement	2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands

Introduction

Goal

The guidebook for the IPCC Inventory Software (*Software*) is produced by the Technical Support Unit (TSU) of the IPCC Task Force on National Greenhous Gas Inventories (TFI) to support inventory compilers in the use of the *Software* for the preparation of national greenhouse gas (GHG) inventories through the description of the complete procedure from activity data (AD) organization and input, to emission factor (EF) selection and input, to GHG estimation and reporting.

Software users must be familiar with the *2006 IPCC Guidelines* methods and read the *Software*'s manual (downloadable from the "Help" menu) before going through this guidebook. This guidebook does not replace guidance provided in the *2006 IPCC Guidelines*.

Scope

The guidebook covers all methodological tiers and approaches provided in the *2006 IPCC Guidelines* and the *Wetlands Supplement*[1] to estimate anthropogenic GHG emissions and removals from each inventory category as well as to deal with cross-cutting elements. Elements of the *2019 Refinement*[2] are introduced in limited cases, where needed to enable interoperability between the *Software* and the UNFCCC electronic reporting tool for CRT.

Structure

Inventory preparation for each category, and each associated GHG, is described in this guidebook. Each section provides practical information to help the user enter information and estimate GHG emissions and removals for one or more categories from the *2006 IPCC Guidelines*[3]. Multiple categories (e.g. electricity generation and non-ferrous metals) are grouped together when the underlying instructions are the same for entering information in the *Software*. Table 1 below provides the definitions of various categories, as well as a hyperlink to the relevant section of the guidebook where further information may be found.

Each section is then presented with a parallel structure. General information on the category and gas(es) covered is provided, along with the relevant equations from the *2006 IPCC Guidelines* used to estimate GHG emission and removals in the *Software*. The section then introduces the worksheet(s) contained in the *Software* that are to be used to enter relevant activity data, emission factors and other parameters with a "User's work Flowchart" to help illustrate the user's series of steps to enter this information. Data may be entered either within a single nation-wide aggregate (i.e. "country name" subdivision or "unspecified") or within a national disaggregation such as administrative units (e.g. provinces, regions, states) or production units (e.g. companies, facilities, or any other aggregation according to which the user collects AD). Finally, the guidebook elaborates on the relevant activity data and emission factor input, and highlights how results are presented.

Finally, a word on selection of Tiers.

Tiers

The *Software* provides functionalities -calculation worksheets and data managers- to prepare estimates according to any of the methodological tiers for which IPCC provides equations. Thus, in this Guidebook the following definitions are used to indicate the methodological tier of the relevant equations, and the correspondence with tiers in an NGHGI:

IPCC Tier 1 refers to the IPCC Tier 1 equations and default EFs/parameters.

Furthermore, recognizing that the *2006 IPCC Guidelines* allow reporting estimates produced with a Tier 3 user-specific[4] methodology, Tier 1 equations can be used to enter AD and Implied Emission Factor(s), as calculated by dividing the Tier-3 estimated GHG emission with the underlying AD required by the IPCC Tier 1 equation(s), to reproduce the estimated Tier 3 emissions.

IPCC Tier 2 refers:

- ✓ either to the IPCC Tier 2 equations, with IPCC default values or user-specific EFs/parameters, different from IPCC Tier 1 equations in the level of stratification and/or in the variables/parameters;
- ✓ or, when a Tier 2 Equation is not provided, to the IPCC Tier 1 equation and user-specific EFs/parameters (e.g. category 1.A.3.d water-borne navigation).

IPCC Tier 3 is the IPCC methodology different in the level of stratification and/or in the variables/parameters, from the IPCC Tier 1 and Tier 2 methodologies.

Tips

[1] Elements derived from the *Wetlands Supplement* are clearly distinguishable because of the liliac colour used to mark those.

[2] Elements derived from the *2019 Refinement* are clearly distinguishable because of magenta colour used to mark those.

[3] In few instances, denoted by magenta colour, from the 2019 Refinement.

[4] User-specific methodologies need anyhow to be accordant with IPCC *good practice* to satisfy the Transparency, Completeness, Consistency, Accuracy and thus Comparability reporting principles.

Stratification[5] of variables[6] used to calculate GHG emissions according to IPCC methodologies is a key element to promote accuracy and precision of estimates. Thus, the *Software* allows an unlimited input of elements for each of the variables and allows any combination of those.

Stratification is actually implemented in a two-way, by subdividing the entire category, in segments (subdivisions) and applying a single methodological tier, or subdividing the category in segments and applying different methodological tiers to different segments. Which means that within a category, those segments for which data are available -e.g. a specific technology for which EFs are known- are singled out[7] while all remaining are reported within a single aggregation[8], as e.g. *unspecified*[9].

However, the *Software* allows to enter each combination of variables, e.g. subdivision/fuel/vehicle type/ECT, only once. A way to further disaggregate such a combination across time series is through using the subdivision name with a time-prefix. For instance, where the carbon content of a fuel or the emission rate of a technology changes across time, in both cases the addition of a prefix that indicates the fuel or the technology before and after a certain date where the change in the carbon content or in the emission rate occurred, allows the user to implement such technological evolution within the current structure of stratification of the variables (e.g. *pre-year Y* and *post-year Y fuel X* or *Technology Z*).

Often worksheets have sub-layers that the user shall access to enter data. To do so, click on the element ⊞ on the left-hand side of worksheet. Once clicked the element ⊞ changes to ⊟.

Interoperability with the UNFCCC electronic reporting tool for the Common Reporting Tables (CRT)

The *Software* has been upgraded for the energy sector to be interoperable with the United Nations Framework Convention on Climate Change (UNFCCC) electronic reporting tool for the Common Reporting Tables (CRT) under the Enhanced Transparency Framework of the Paris Agreement.[10] In practice, that means that users of the *Software* can estimate GHG emissions and CO_2 removals for categories and gases that are required to be reported pursuant to the UNFCCC CRT. Once data are entered into the *Software*, users wishing to use these data to facilitate reporting to the UNFCCC must generate a file in the *Software* (in JSON format) that may then subsequently, through a separate UNFCCC platform, be uploaded and further processed through the UNFCCC electronic reporting tool for CRT.

A separate Guidebook, titled IPCC Inventory Software: UNFCCC Interoperability- CRT Export Quick Start Guide, has been developed to assist users in generating the JSON file for upload to the UNFCCC electronic reporting tool for CRT. Annex I illustrates the mapping of activity data and GHG estimates for categories/gases from the *Software* to the corresponding UNFCCC CRT category/ies.

[5] The larger the number of strata, the more accurate and precise the estimates are.

[6] Stratification is the act of sorting data into distinct groups or layers.

[7] By applying a higher tier method

[8] By applying a lower tier method

[9] This does not apply to variables required by IPCC Tier 1 method.

[10] As requested by Parties in decision 5/CMA.3, paragraphs 19 and 20.

1 Energy Sector

The Energy sector covers all GHG emissions arising from combustion of fuels or as fugitive releases from those. Emissions from the non-energy uses of fuels are generally not included here, but reported under the Industrial Processes and Product Use (IPPU) sector. Where carbonates such as limestone or dolomite are consumed for environmental pollution control (e.g. for flue gas desulphurisation) these emissions are reported in the category of the energy sector where the carbonates are consumed. However, these emissions are calculated in the IPPU sector of the *Software* (see the IPPU Guidebook for further information).

As CO_2 emissions from fuel combustion dominate GHG emissions in many countries, an independent check is required through the "Reference Approach". It is *good practice* to apply both, a sectoral approach and the reference approach, to estimate a total CO_2 emission from fuel combustion and to compare the results of these two independent estimates. Significant differences indicate possible problems with the AD, calorific values, carbon contents, excluded carbon calculation, etc.

The Reference Approach is a top-down approach and in that respect is relatively independent from the bottom-up approach as described in the Tier 1, Tier 2, and Tier 3 methods. It consists of a methodology for producing a first-order estimate of national GHG emission based on a C mass balance of fuels supplied for energy use [see section on **Reference Approach**].

Where not indicated, all references from the *2006 IPCC Guidelines* and its *2019 Refinement* come from Volume 2 [Energy sector]

Table 1. all categories included in the Energy sector of the 2006 IPCC Guidelines, as refined by the 2019 Refinement for those categories relevant for the interoperability with the UNFCCC ETF reporting tool

Categories	Definitions	Guidebook
1.A - Fuel Combustion Activities	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus.	
1.A.1 - Energy Industries	Comprises emissions from fuels combusted by the fuel extraction or energy-producing industries	
1.A.1.a - Main Activity Electricity and Heat Production	Sum of emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (formerly known as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership. Emissions from own on-site use of fuel should be included. Emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) should be assigned to the sector (e.g. 1.A.2/1.A.4) where they were generated and not under 1.A.1.a. Autoproducers may be in public or private ownership.	
1.A.1.a.i - Electricity Generation	Comprises emissions from all fuel use for electricity generation from main activity producers except those from combined heat and power plants.	1.A - Stationary Combustion Source Categories
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single CHP facility.	1.A - Stationary Combustion Source Categories
1.A.1.a.iii - Heat Plants	Production of heat from main activity producers for sale by pipe network.	1.A - Stationary Combustion Source Categories
1.A.1.b - Petroleum Refining	All combustion activities supporting the refining of petroleum products including on-site combustion for the generation of electricity and heat for own use. Does not include evaporative emissions occurring at the refinery; which should be reported separately under 1.B.2.a.	1.A - Stationary Combustion Source Categories
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	Combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries	
1.A.1.c.i - Manufacture of Solid Fuels	Emissions arising from fuel combustion for the production of coke, brown coal briquettes and patent fuel.	1.A - Stationary Combustion Source Categories
1.A.1.c.ii - Other Energy Industries	Combustion emissions arising from the energy-producing industries own (on-site) energy use not mentioned above or for which separate data are not available. This includes the emissions from own-energy use for the production of charcoal, bagasse, saw dust, cotton stalks and carbonizing of biofuels as well as fuel used for coal mining, oil and gas extraction and the processing and upgrading of natural gas. This category also includes emissions from pre-combustion processing for CO_2 capture and storage. Combustion emissions from pipeline transport should be reported under 1.A.3.e.	1.A - Stationary Combustion Source Categories
1.A.2 - Manufacturing Industries and Construction	Emissions from combustion of fuels in industry. Also includes combustion for the generation of electricity and heat for own use in these industries. Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under 1.A.1.c and not within manufacturing industry. Emissions from the industry sector should be specified by sub-categories that correspond to the International Standard Industrial Classification of all Economic Activities (ISIC). Energy used for transport by industry should not be reported here but under Transport (1.A.3). Emissions arising from off-road and other mobile machinery in industry should, if possible, be broken out as a separate subcategory. For each country, the emissions from the largest fuel-consuming industrial categories ISIC should be reported, as well as those from significant emitters of pollutants. A suggested list of categories is outlined below.	

Categories	Definitions	Guidebook
1.A.2.a - Iron and Steel	ISIC Group 271[11] and Class 2731	1.A - Stationary Combustion Source Categories
1.A.2.b - Non-Ferrous Metals	ISIC Group 272 and Class 2732	1.A - Stationary Combustion Source Categories
1.A.2.c - Chemicals	ISIC Division 24	1.A - Stationary Combustion Source Categories
1.A.2.d - Pulp, Paper and Print	ISIC Divisions 21 and 22	1.A - Stationary Combustion Source Categories
1.A.2.e - Food Processing, Beverages and Tobacco	ISIC Divisions 15 and 16	1.A - Stationary Combustion Source Categories
1.A.2.f - Non-Metallic Minerals	Includes products such as glass, ceramic, cement, etc.; ISIC Division 26.	1.A - Stationary Combustion Source Categories
1.A.2.g - Transport Equipment	ISIC Divisions 34 and 35	1.A - Stationary Combustion Source Categories
1.A.2.h - Machinery	Includes fabricated metal products, machinery and equipment other than transport equipment; ISIC Divisions 28, 29, 30, 31 and 32.	1.A - Stationary Combustion Source Categories
1.A.2.i - Mining (excluding fuels) and Quarrying	ISIC Divisions 13 and 14	1.A - Stationary Combustion Source Categories
1.A.2.j - Wood and wood products	ISIC Division 20	1.A - Stationary Combustion Source Categories
1.A.2.k - Construction	ISIC Division 45	1.A - Stationary Combustion Source Categories
1.A.2.l - Textile and Leather	ISIC Divisions 17, 18 and 19	1.A - Stationary Combustion Source Categories
1.A.2.m - Non-specified Industry	Any manufacturing industry/construction not included in previous categories, or for which separate data are not available. Includes ISIC Divisions 25, 33, 36 and 37.	1.A - Stationary Combustion Source Categories
1.A.3 - Transport	Emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector, specified by sub-categories below. Emissions from fuel sold to any air or marine vessel engaged in international transport (1.A.3.a,i and 1.A.3.d.i) should as far as possible be excluded from the totals and subtotals in this category and should be reported separately.	
1.A.3.a - Civil Aviation	Emissions from international and domestic civil aviation, including take-offs and landings. Comprises civil commercial use of airplanes, including scheduled and charter traffic for passengers and freight, air taxiing, and general aviation. The international/domestic split should be determined based on departure and landing locations for each flight stage and not by the nationality of the airline. Exclude use of fuel at airports for ground transport which is reported under 1.A.3.e Other Transportation. Also exclude fuel for stationary combustion at airports; report this information under the appropriate stationary combustion category.	
1.A.3.a.i - International Aviation (International Bunkers)	Emissions from flights that depart in one country and arrive in a different country. Include take-offs and landings for these flight stages. Emissions from international military aviation can be included as a separate subcategory of international aviation provided that the same definitional distinction is applied, and data are available to support the definition.	1.A.3.a - Civil Aviation

[11] The ISIC references to "Division", "Group" and "Class" are based on the International Standard Industrial Classification of All Economic Activities (ISIC), Revision 3.1, which was the latest available publication at the time of development of the 2006 IPCC Guidelines.

Categories	Definitions	Guidebook
1.A.3.a.ii - Domestic Aviation	Emissions from civil domestic passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.), including take-offs and landings for these flight stages. Note that this may include journeys of considerable length between two airports in a country (e.g. San Francisco to Honolulu). Exclude military, which should be reported under 1.A.5.b.	1.A.3.a - Civil Aviation
1.A.3.b - Road Transportation	All combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads.	1.A.3.b - Road Transportation
1.A.3.b.i - Cars	Emissions from automobiles so designated in the vehicle registering country primarily for transport of persons and normally having a capacity of 12 persons or fewer.	1.A.3.b - Road Transportation
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	Emissions from passenger car vehicles with 3-way catalysts.	1.A.3.b - Road Transportation
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	Emissions from passenger car vehicles without 3-way catalysts.	1.A.3.b - Road Transportation
1.A.3.b.ii - Light-duty trucks	Emissions from vehicles so designated in the vehicle registering country primarily for transportation of light-weight cargo or which are equipped with special features such as four-wheel drive for off-road operation. The gross vehicle weight normally ranges up to 3500-3900 kg or less.	1.A.3.b - Road Transportation
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	Emissions from light duty trucks with 3-way catalysts.	1.A.3.b - Road Transportation
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	Emissions from light duty trucks without 3-way catalysts.	1.A.3.b - Road Transportation
1.A.3.b.iii - Heavy-duty trucks and buses	Emissions from any vehicles so designated in the vehicle registering country. Normally the gross vehicle weight ranges from 3500-3900 kg or more for heavy duty trucks and the buses are rated to carry more than 12 persons.	1.A.3.b - Road Transportation
1.A.3.b.iv - Motorcycles	Emissions from any motor vehicle designed to travel with not more than three wheels in contact with the ground and weighing less than 680 kg.	1.A.3.b - Road Transportation
1.A.3.b.v - Evaporative emissions from vehicles	Evaporative emissions from vehicles (e.g. hot soak, running losses) are included here. Emissions from loading fuel into vehicles are excluded.	1.A.3.b.v - Evaporative emissions from vehicles
1.A.3.b.vi - Urea-based catalysts	CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions).	1.A.3.b.vi - Urea-based catalysts
1.A.3.c - Railways	Emissions from railway transport for both freight and passenger traffic routes.	1.A.3.c - Railways
1.A.3.d - Water-borne Navigation	Emissions from fuels used to propel water-borne vessels, including hovercraft and hydrofoils, but excluding fishing vessels. 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.	

Categories	Definitions	Guidebook
1.A.3.d.i - International water-borne navigation (International bunkers)	Emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters. Includes emissions from journeys that depart in one country and arrive in a different country. Exclude consumption by fishing vessels (see Other Sectors - Fishing). Emissions from international military water-borne navigation can be included as a separate sub-category of international water-borne navigation provided that the same definitional distinction is applied, and data are available to support the definition.	1.A.3.d - Water-borne Navigation
1.A.3.d.ii - Domestic Water-borne Navigation	Emissions from fuels used by vessels of all flags that depart and arrive in the same country (exclude fishing, which should be reported under 1.A.4.c.iii, and military, which should be reported under 1.A.5.b). Note that this may include journeys of considerable length between two ports in a country (e.g. San Francisco to Honolulu).	1.A.3.d - Water-borne Navigation
1.A.3.e - Other Transportation	Combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c Agriculture/Forestry/Fishing/Fish Farms or 1.A.2. Manufacturing Industries and Construction. Military transport should be reported under 1.A.5 (see 1.A.5 Non-specified).	
1.A.3.e.i - Pipeline Transport	Combustion related emissions from the operation of pump stations and maintenance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry and other commodities via pipelines. Distribution of natural or manufactured gas, water or steam from the distributor to final users is excluded and should be reported in 1.A.1.c.ii or 1.A.4.a.	1.A.3.e.i - Pipeline transport
1.A.3.e.ii - Off-road	Combustion emissions from Other Transportation, excluding Pipeline Transport.	1.A.3.e.ii - Off-road transportation
1.A.4 - Other Sectors	Emissions from combustion activities as described below, including combustion for the generation of electricity and heat for own use in these sectors.	
1.A.4.a - Commercial/Institutional	Emissions from fuel combustion in commercial and institutional buildings; all activities included in ISIC Divisions 41, 50, 51, 52, 55, 63-67, 70-75, 80, 85, 90-93 and 99.	1.A - Stationary Combustion Source Categories
1.A.4.b - Residential	All emissions from fuel combustion in households.	1.A - Stationary Combustion Source Categories
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	Emissions from fuel combustion in agriculture, forestry, fishing and fishing industries such as fish farms. Activities included in ISIC Divisions 01, 02 and 05. Highway agricultural transportation is excluded.	
1.A.4.c.i - Stationary	Emissions from fuels combusted in pumps, grain drying, horticultural greenhouses and other agriculture, forestry or stationary combustion in the fishing industry.	1.A - Stationary Combustion Source Categories
1.A.4.c.ii - Off-road Vehicles and Other Machinery	Emissions from fuels combusted in traction vehicles on farm land and in forests.	1.A.3.e.ii - Off-road transportation
1.A.4.c.iii – Fishing (mobile combustion)	Emissions from fuels combusted for inland, coastal and deep-sea fishing. Fishing should cover vessels of all flags that have refuelled in the country (include international fishing).	1.A.3.d - Water-borne Navigation
1.A.5 - Non-Specified	All remaining emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations.	

Categories	Definitions	Guidebook
1.A.5.a - Stationary	Emissions from fuel combustion in stationary sources that are not specified elsewhere.	1.A - Stationary Combustion Source Categories
1.A.5.b - Mobile	Emissions from vehicles and other machinery, marine and aviation (not included in 1.A.4.c.ii or elsewhere).	
1.A.5.b.i - Mobile *(aviation component)*	All remaining aviation emissions from fuel combustion that are not specified elsewhere. Include 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.	1.A.3.a - Civil Aviation
1.A.5.b.ii - Mobile *(water-borne component)*	All remaining water-borne emissions from fuel combustion that are not specified elsewhere. Include 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.	1.A.3.d - Water-borne Navigation
1.A.5.b.iii - Mobile *(other)*	All remaining emissions from mobile sources not included elsewhere.	1.A.3.b - Road Transportation 1.A.3.e.ii - Off-road transportation
1.A.5.c - Multilateral Operations	Emissions from fuels used in multilateral operations pursuant to the Charter of the United Nations. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries.	1.A.3.a.i - Civil Aviation 1.A.3.d - Water-borne Navigation
1.B - Fugitive emissions from fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.	
1.B.1 - Solid Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of solid fuel to the point of final use.	
1.B.1.a - Coal mining and handling	Includes all fugitive emissions from coal.	
1.B.1.a.i - Underground mines	Includes all emissions arising from mining, post-mining, abandoned mines and flaring of drained methane.	
1.B.1.a.i.1 - Mining	Includes all seam gas emissions vented to atmosphere from coal mine ventilation air and degasification systems.	1.B.1.a.i - Underground Mines
1.B.1.a.i.2 - Post-mining seam gas emissions	Includes methane and CO_2 emitted after coal has been mined, brought to the surface and subsequently processed, stored and transported.	1.B.1.a.i - Underground Mines
1.B.1.a.i.3 - Abandoned underground mines	Includes methane emissions from abandoned underground mines.	1.B.1.a.i.3 - Abandoned Underground Mines
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO_2	Methane drained and flared, or ventilation gas converted to CO_2 by an oxidation process should be included here. Methane used for energy production should be included in Volume 2, Energy, Chapter 2 'Stationary Combustion'.	1.B.1.a.i.4 - Flaring or Conversion of drained CH_4 to CO_2
1.B.1.a.ii - Surface mines	Includes all seam gas emissions arising from surface coal mining	
1.B.1.a.ii.1 - Mining	Includes methane and CO_2 emitted during mining from breakage of coal and associated strata and leakage from the pit floor and highwall	1.B.1.a.ii - Surface Mines
1.B.1.a.ii.2 - Post-mining seam gas emissions	Includes methane and CO_2 emitted after coal has been mined, subsequently processed, stored and transported.	1.B.1.a.ii - Surface Mines

Categories	Definitions	Guidebook
1.B.1.a.ii.3- Abandoned surface mines	Includes methane emissions from abandoned surface mines.	1.B.1.a.ii.3 - Abandoned Surface Mines
1.B.1.b - Uncontrolled combustion and burning coal dumps	Includes emissions of CO_2 from uncontrolled combustion due to coal exploitation activities.	1.B.1.b - Uncontrolled combustion and burning coal dumps
1.B.1.c - Fuel transformation	Fugitive emissions arising during the manufacture of secondary and tertiary products from fuels.	1.B.1.c - Fuel Transformation
1.B.1.c.i – Charcoal and biochar production	Fugitive emissions arising during the production of charcoal and biochar.	1.B.1.c.i - Charcoal and Biochar production
1.B.1.c.ii – Coke production	Fugitive emissions arising during the production of coke.	1.B.1.c.ii - Coke production
1.B.1.c.iv – Gasification transformation	Fugitive emissions from the transformation of biomass, coal or natural gas into syngas, composed by H_2, CO, CO_2 and CH_4, and, then, into a liquid hydrocarbons fuels.	1.B.1.c.iv - Gasification transformation
1.B.2 - Oil and Natural Gas	Comprises fugitive emissions from all oil and natural gas activities. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases.	
1.B.2.a - Oil	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, transmission, upgrading, and refining of crude oil and distribution of crude oil products.	
1.B.2.a.i - Venting	Emissions from venting of associated gas and waste gas/vapour streams at oil facilities.	1.B.2.a.i - Oil, Venting
1.B.2.a.ii - Flaring	Emissions from flaring of natural gas and waste gas/vapour streams at oil facilities.	1.B.2.a.ii - Oil, Flaring
1.B.2.a.iii - All Other	Fugitive emissions at oil facilities from equipment leaks, storage losses, pipeline breaks, well blowouts, land farms, gas migration to the surface around the outside of wellhead casing, surface casing vent bows, biogenic gas formation from tailings ponds and any other gas or vapour releases not specifically accounted for as venting or flaring.	
1.B.2.a.iii.1 - Exploration	Fugitive emissions (excluding venting and flaring) from oil well drilling, drill stem testing, and well completions.	1.B.2.a - Oil, Fugitives
1.B.2.a.iii.2 - Production and Upgrading	Fugitive emissions from oil production (excluding venting and flaring) occur at the oil wellhead or at the oil sands or shale oil mine through to the start of the oil transmission system. This includes fugitive emissions related to well servicing, oil sands or shale oil mining, transport of untreated production (i.e., well effluent, emulsion, oil shale and oilsands) to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems and produced water disposal systems. Fugitive emissions from upgraders are grouped with those from production rather than those from refining since the upgraders are often integrated with extraction facilities and their relative emission contributions are difficult to establish. However, upgraders may also be integrated with refineries, cogeneration plants or other industrial facilities and their relative emission contributions can be difficult to establish in these cases.	1.B.2.a - Oil, Fugitives

Categories	Definitions	Guidebook
1.B.2.a.iii.3 - Transport	Fugitive emissions (excluding venting and flaring) related to the transport of marketable crude oil (including conventional, heavy and synthetic crude oil and bitumen) to upgraders and refineries. The transportation systems may comprise pipelines, marine tankers, tank trucks and rail cars. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.	1.B.2.a - Oil, Fugitives
1.B.2.a.iii.4 - Refining	Fugitive emissions (excluding venting and flaring) at petroleum refineries. Refineries process crude oils, natural gas liquids and synthetic crude oils to produce final refined products (e.g., primarily fuels and lubricants). Where refineries are integrated with other facilities (for example, upgraders or co-generation plants) their relative emission contributions can be difficult to establish.	1.B.2.a - Oil, Fugitives
1.B.2.a.iii.5 - Distribution of oil products	This comprises fugitive emissions (excluding venting and flaring) from the transport and distribution of refined products, including those at bulk terminals and retail facilities. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.	1.B.2.a - Oil, Fugitives
1.B.2.a.iii.6 - Other	Fugitive emissions from oil systems (excluding venting and flaring) not otherwise accounted for in the above categories. This includes fugitive emissions from spills and other accidental releases, waste oil treatment facilities and oilfield waste disposal facilities.	1.B.2.a - Oil, Fugitives
1.B.2.b - Natural Gas	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, processing, transmission, storage and distribution of natural gas (including both associated and non-associated gas).	
1.B.2.b.i - Venting	Emissions from venting of natural gas and waste gas/vapour streams at gas facilities.	1.B.2.b.i - Natural Gas, Venting
1.B.2.b.ii - Flaring	Emissions from flaring of natural gas and waste gas/vapour streams at gas facilities.	1.B.2.b.ii - Natural Gas, Flaring
1.B.2.b.iii - All Other	Fugitive emissions at natural gas facilities from equipment leaks, storage losses, pipeline breaks, well blowouts, gas migration to the surface around the outside of wellhead casing, surface casing vent bows and any other gas or vapour releases not specifically accounted for as venting or flaring.	
1.B.2.b.iii.1 - Exploration	Fugitive emissions (excluding venting and flaring) from gas well drilling, drill stem testing and well completions.	1.B.2.b - Natural Gas, Fugitives
1.B.2.b.iii.2 - Production	Fugitive emissions (excluding venting and flaring) from the gas wellhead through to the inlet of gas processing plants, or, where processing is not required, to the tie-in points on gas transmission systems. This includes fugitive emissions related to well servicing, gas gathering, processing and associated waste water and acid gas disposal activities.	1.B.2.b - Natural Gas, Fugitives
1.B.2.b.iii.3 - Processing	Fugitive emissions (excluding venting and flaring) from gas processing facilities.	1.B.2.b - Natural Gas, Fugitives
1.B.2.b.iii.4 - Transmission and Storage	Fugitive emissions from systems used to transport processed natural gas to market (i.e., to industrial consumers and natural gas distribution systems). Fugitive emissions from natural gas storage systems should also be included in this category. Emissions from natural gas liquids extraction plants on gas transmission systems should be reported as part of natural gas processing (Sector 1.B.2.b.iii.3). Fugitive emissions related to the transmission of natural gas liquids should be reported under Category 1.B.2.a.iii.3.	1.B.2.b - Natural Gas, Fugitives

Categories	Definitions	Guidebook
1.B.2.b.iii.5 - Distribution	Fugitive emissions (excluding venting and flaring) from the distribution of natural gas to end users.	1.B.2.b - Natural Gas, Fugitives
1.B.2.b.iii.6 - Other	Fugitive emissions from natural gas systems (excluding venting and flaring) not otherwise accounted for in the above categories. This may include emissions from well blowouts and pipeline ruptures or dig-ins.	1.B.2.b - Natural Gas, Fugitives
1.B.3 - Other emissions from Energy Production	Emissions from geothermal energy production and other energy production not included in 1.B.1 or 1.B.2.	1.B.3 - Other Emissions from Energy Production
1.C. Carbon dioxide Transport and Storage	CO_2 capture and storage (CCS) involves the capture of CO_2, its transport to a storage location and its long-term isolation from the atmosphere. Emissions associated with CO_2 transport, injection and storage are covered under category 1.C. Emissions (and reductions) associated with CO_2 capture should be reported under the IPCC sector in which capture takes place (e.g. Stationary Combustion or Industrial Activities).	
1.C.1. – Transport of CO_2	Fugitive emissions from the systems used to transport captured CO_2 from the source to the injection site. These emissions may comprise fugitive losses due to equipment leaks, venting and releases due to pipeline ruptures or other accidental releases (e.g. temporary storage).	
1.C.1.a. Pipelines	Fugitive emissions from the pipeline system used to transport CO_2 to the injection site.	1.C - Carbon Dioxide Transport and Storage
1.C.1.b. Ships	Fugitive emissions from the ships used to transport CO_2 to the injection site.	1.C - Carbon Dioxide Transport and Storage
1.C.1.c Other (please specify)	Fugitive emissions from other systems used to transport CO_2 to the injection site and temporary storage.	1.C - Carbon Dioxide Transport and Storage
1.C.2. Injection and Storage	Fugitive emissions from activities and equipment at the injection site and those from the end containment once the CO_2 is placed in storage.	
1.C.2.a Injection	Fugitive emissions from activities and equipment at the injection site.	1.C - Carbon Dioxide Transport and Storage
1.C.2.b Storage	Fugitive emissions from the end containment once the CO_2 is placed in storage.	1.C - Carbon Dioxide Transport and Storage
1.C.3. Other	Any other emissions from CCS not reported elsewhere.	1.C - Carbon Dioxide Transport and Storage
Reference Approach	The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustion of mainly fossil fuels. The Reference Approach is a straightforward method that can be applied on the basis of relatively easily available energy supply statistics.	Reference Approach

Note: The category tree in the *Software* reflects the categories included in the *2006 IPCC Guidelines*, as refined by the *2019 Refinement* for those categories relevant for interoperability with the UNFCCC electronic reporting tool for CRT, plus those added by the *Wetlands Supplement*. Categories from the *2019 Refinement* are shown in this Guidebook, and in the *Software,* in a magenta colour.

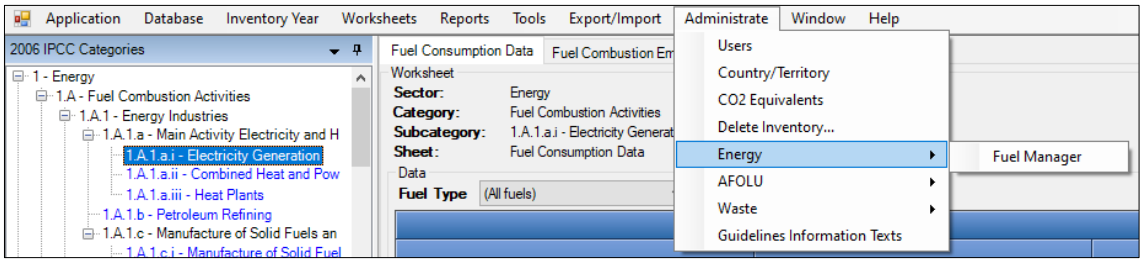
I.1 Fuel Manager

Before entering data in the Energy sector worksheets to estimate emissions from 1.A. (Fuel Combustion Activities), the Fuel Manager shall be populated with all relevant data that will be used by the *Software* to estimate GHG emissions.

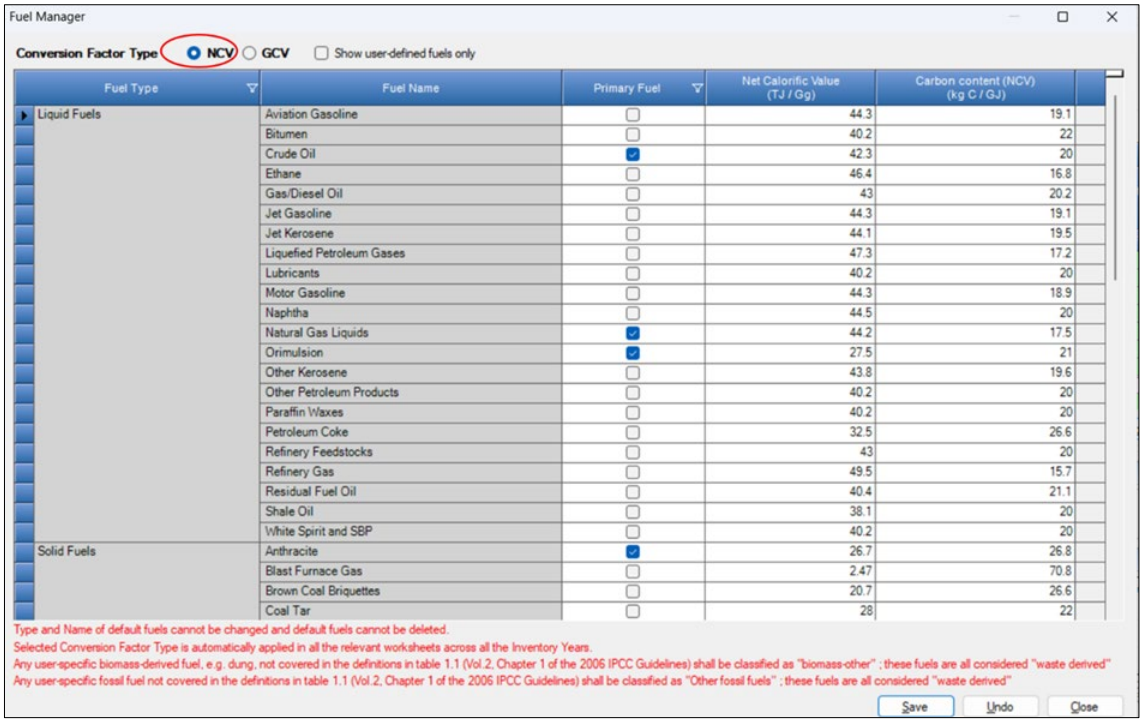
The Fuel Manager contains data on *carbon content* and *calorific value* for each fuel used in the NGHGI. All IPCC default fuels are listed in it; in addition, the user can enter its own user-specific fuels together with relevant data required by the Fuel Manager.

Fuel manager setting is the first step to prepare GHG estimates in 1.A, and it is done as follows:

1. On the **Administrate** tab, click **Energy** and then **Fuel Manager**.



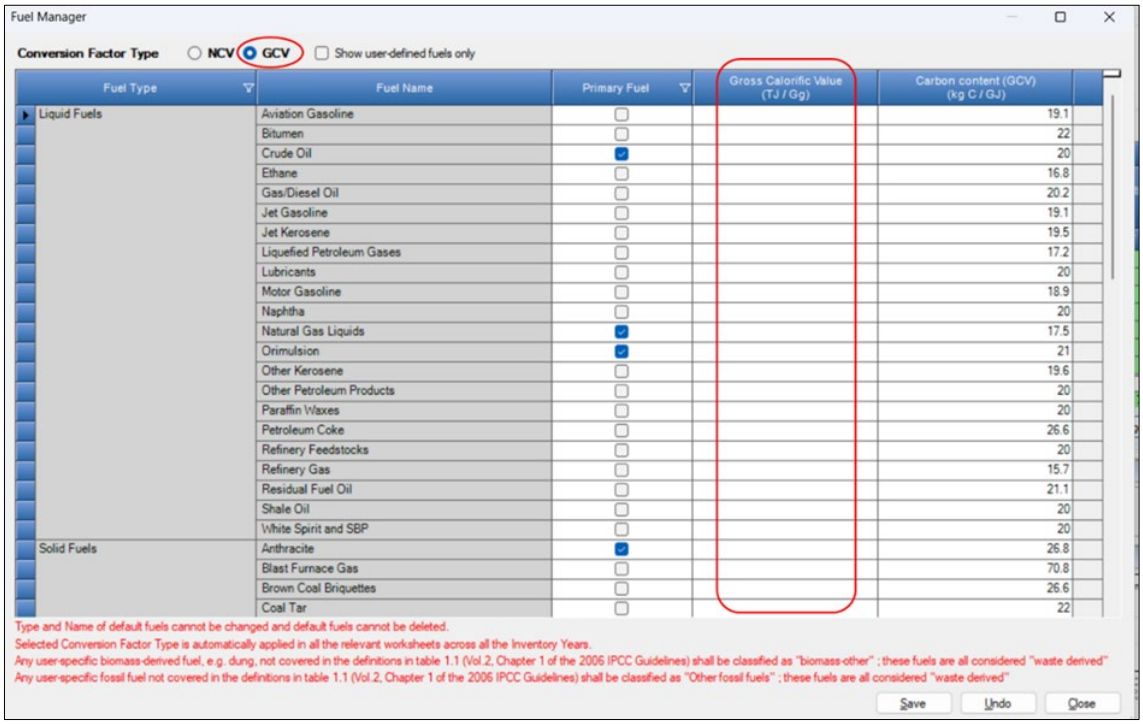
2. On the window's top border, select either *NCV* (Net Calorific Value) or *GCV* (Gross Calorific Value) as the **Conversion Factor Type**. Note that:
   - ✓ For each IPCC default fuel, when *NCV* is selected, the **Calorific Value** and the **Carbon Content** are prefilled with IPCC default values, which anyhow can be replaced with user-specific values.
   - ✓ For *GCV* no IPCC default values are available, and so those need to be entered by the user.



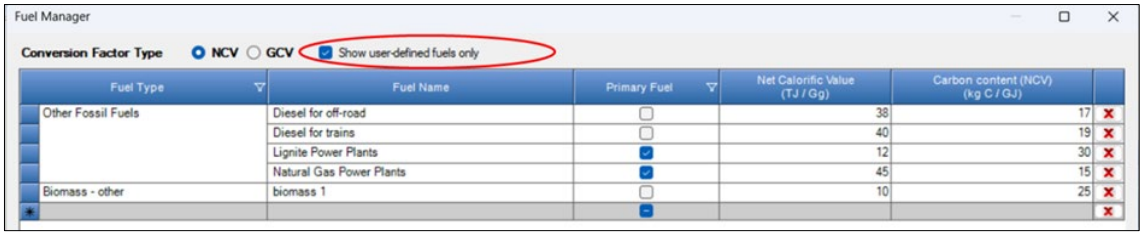
Fuel Type	Fuel Name	Primary Fuel	Net Calorific Value (TJ / Gg)	Carbon content (NCV) (kg C / GJ)
Liquid Fuels	Aviation Gasoline	☐	44.3	19.1
	Bitumen	☐	40.2	22
	Crude Oil	☑	42.3	20
	Ethane	☐	46.4	16.8
	Gas/Diesel Oil	☐	43	20.2
	Jet Gasoline	☐	44.3	19.1
	Jet Kerosene	☐	44.1	19.5
	Liquefied Petroleum Gases	☐	47.3	17.2
	Lubricants	☐	40.2	20
	Motor Gasoline	☐	44.3	18.9
	Naphtha	☐	44.5	20
	Natural Gas Liquids	☑	44.2	17.5
	Orimulsion	☑	27.5	21
	Other Kerosene	☐	43.8	19.6
	Other Petroleum Products	☐	40.2	20
	Paraffin Waxes	☐	40.2	20
	Petroleum Coke	☐	32.5	26.6
	Refinery Feedstocks	☐	43	20
	Refinery Gas	☐	49.5	15.7
	Residual Fuel Oil	☐	40.4	21.1
	Shale Oil	☐	38.1	20
	White Spirit and SBP	☐	40.2	20
Solid Fuels	Anthracite	☑	26.7	26.8
	Blast Furnace Gas	☐	2.47	70.8
	Brown Coal Briquettes	☐	20.7	26.6
	Coal Tar	☐	28	22

3. For each new (user-specific) fuel entry the following steps apply:
   1. Click on the asterisk in the bottom-most row to add the user-specific fuel.
   2. Select **fuel type** from the drop-down menu.
   3. Enter specific **fuel name**.
   4. Indicate (checkbox) if it is a **primary fuel**[12] or not.
   5. Enter its **calorific value** in **TJ/Gg**, (either *NCV* or *GCV* according to the selection made for the entire Fuel Manager).
   6. Enter **carbon content** in **kg C/GJ**.

[12] Primary fuels are fuels found in nature such as coal, crude oil, and natural gas, while secondary fuels or fuel products are derived from primary fuels, such as gasoline and lubricants. A complete list of fuels is provided in Section 1.4.1.1 of the *2006 IPCC Guidelines*.



To single out the user-defined fuels only, the corresponding box on the window's top border shall be marked.

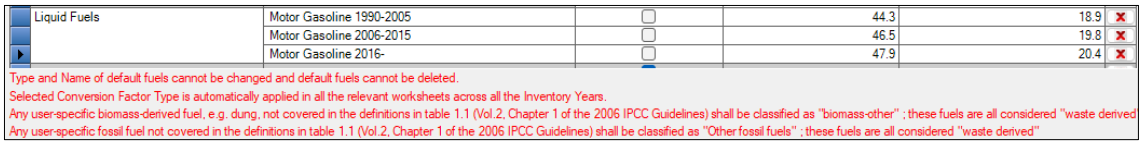


Note: If the name of values assigned to a user-defined fuel added to the *Fuel Manager* are subsequently changed, such change is propagated by the *Software* to each calculation worksheet where that fuel is used.

TIP: where a fuel has a different *Carbon Content*, and thus *Calorific Value*, across the Inventory time series, the way to proceed is to split the fossil fuel in a number of fuels according to the number of different pairs of data -i.e. *Carbon Content* & *Calorific Value*- the fuel has across the time series. For instance, assuming that *Motor Gasoline* had the following values of CC and CV

Years	Carbon Content	Calorific Value
1990- 2005	18.9	44.3
2006-2015	19.8	46.5
2016-	20.4	47.9

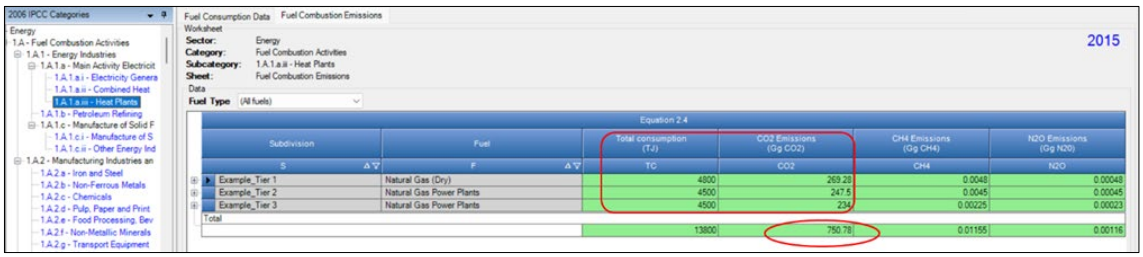
Accordingly, user will enter three *Motor Gasoline* types of fuel in the *Fuel Manager*:



I.2 Use of multiple tiers for reporting

The *2006 IPCC Guidelines* provide methodological guidance to estimate anthropogenic GHG emissions and removals according to three methodological tier levels: Tier 1, Tier 2, Tier 3. Where Tier 1 is the common default methodological approach that the IPCC Guidelines provide to all inventory compilers, higher tiers are based on user-specific and multivariable-dependent rates of GHG emissions and CO_2 removals, and likely requires data with a higher spatial and temporal resolution. Tier 2 may apply a different methodological approach, or the Tier 1 methodology approach with user-specific values for parameters and EFs, and may further disaggregate the population of activity data to apply condition-specific values of parameters and EFs[13]. Tier 3 is generally[14] a user-specific methodology that maintain consistency with IPCC *good practice*, although it is designed to better cope with the user-specific statistical population for which GHG emissions/removals are estimated or it is based on the direct monitoring of the source of GHG emissions.

Given that the *Software* can calculate GHG emissions and removals for each source/sink category using any of the methodological tiers provided in the *2006 IPCC Guidelines* and its *Wetlands Supplement*, the user may apply a single methodological tier to the entire category or may use instead a combination of different tiers according to the significance of subcategories and data availability.



Figures show an example of applying three[15] different tiers, and reporting the total

In doing so the user shall transparently describe in any accompanying inventory report the original methodology and the way it has derived the implied EF.

While, as described above, the user may use a combination of tiers within a single source category, it may also wish to apply multiple tiers to the same activity as a means of quality control through comparative analysis (e.g. Tier 1 *vs* Tier 2 or Tier 2 *vs* Tier 3). Although this is a legitimate use of the *Software*, those comparative analysis shall be done in a separate database not used for reporting the GHG inventory, so avoiding to double count GHG emissions from a source.

Where a user-specific Tier 3 method, which cannot be calculated by the *Software*, is used to prepare estimates of GHG emissions that need to be included in the NGHGI for completeness, the user can use the relevant calculation worksheet(s) to report it as it follows:

1. enter in the *Software* the AD required by the IPCC default methodology.
2. back-calculate CO_2 and/or CH_4 and/or N_2O IEFs[16], as the total emissions of the relevant GHG calculated through the user-specific Tier 3 method divided by the AD required at bullet 1 above, and enter those in the *Software*.
3. the *Software* then reproduces the user-specific Tier 3 GHG estimates.

A dedicated subdivision could be entered, e.g. specifically titled as "Tier 3" with any other identifying information, as appropriate.

[13] For example, the Tier 2 approach for estimating CO_2 emissions from civil aviation separately considers CO_2 emissions from landings and take-offs and the cruise phase, whereas the Tier 1 approach estimates CO_2 emissions based on fuel consumption and default EFs.

[14] In some cases, IPCC also provides a Tier 3 methodology, as for instance for CH_4 and N_2O emissions from Road transportation.

[15] In this example, Tier 1 – default factors, Tier 2 – user-specific NCVs, Tier 3 – technology specific factors

[16] Implied Emission Factors

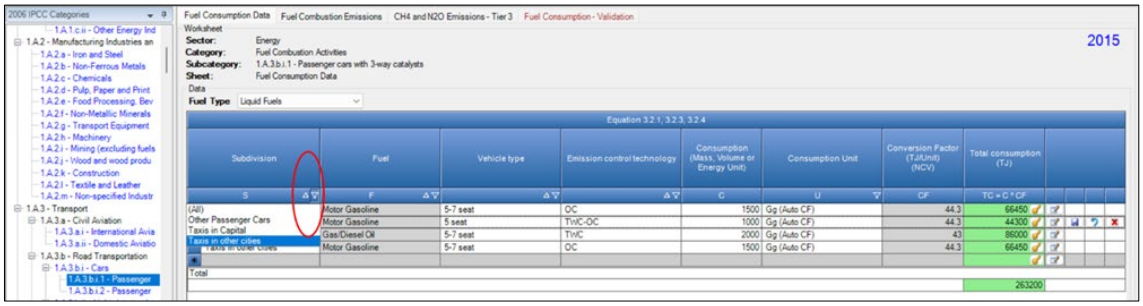
I.3 Reporting of Subdivisions

GHG inventories can be calculated at multiple levels of aggregation (e.g. facility, corporate, regional, national) to meet various domestic and international needs. Thus, *Subdivisions* can be entered for all source categories in the Energy sector.

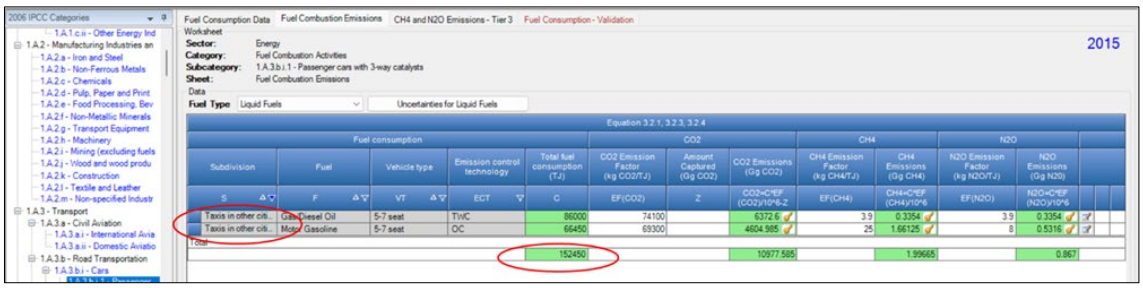
Where the user is interested in calculating GHG estimates at a single level of aggregation, e.g. national, in Column |S| either *unspecified* is to be selected from the dropdown menu or the single univocal name/code is to be entered e.g. the *country name*. Where the user is interested in calculating GHG estimates for multiple subdivisions, the univocal name/code for each subdivision will be entered in Column |S|, users have full flexibility to name those subdivisions based on user-specific circumstances. Nevertheless, care shall be taken to ensure that subdivisions do not overlap so causing a double counting of some emissions.

Every calculation worksheet[17] includes filters to enable the user to view data entry, by subdivision.

Example: **subdivisions and applying filter**



Example: **viewing filtered results**

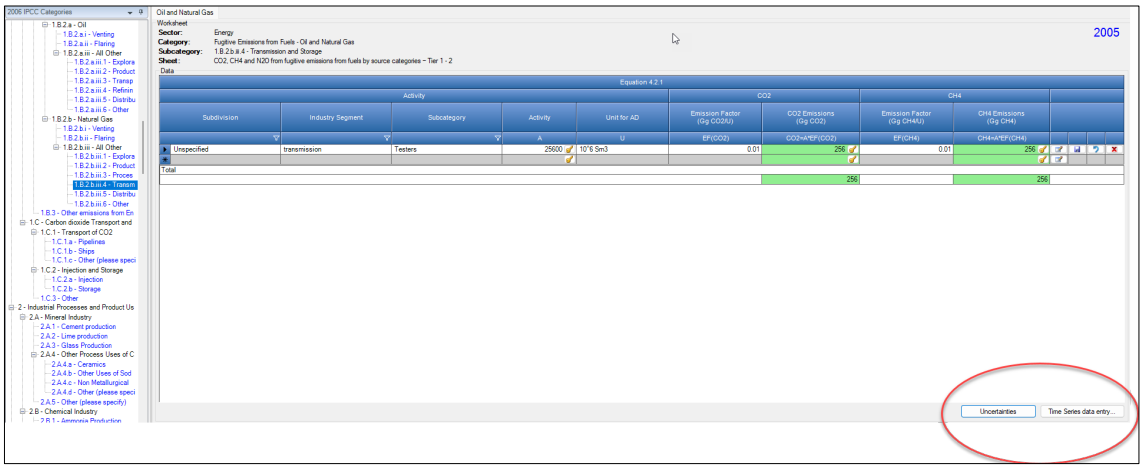


[17] Those can also be referred as TABs of the Software

I.4 "Uncertainty" and "Time Series data entry"

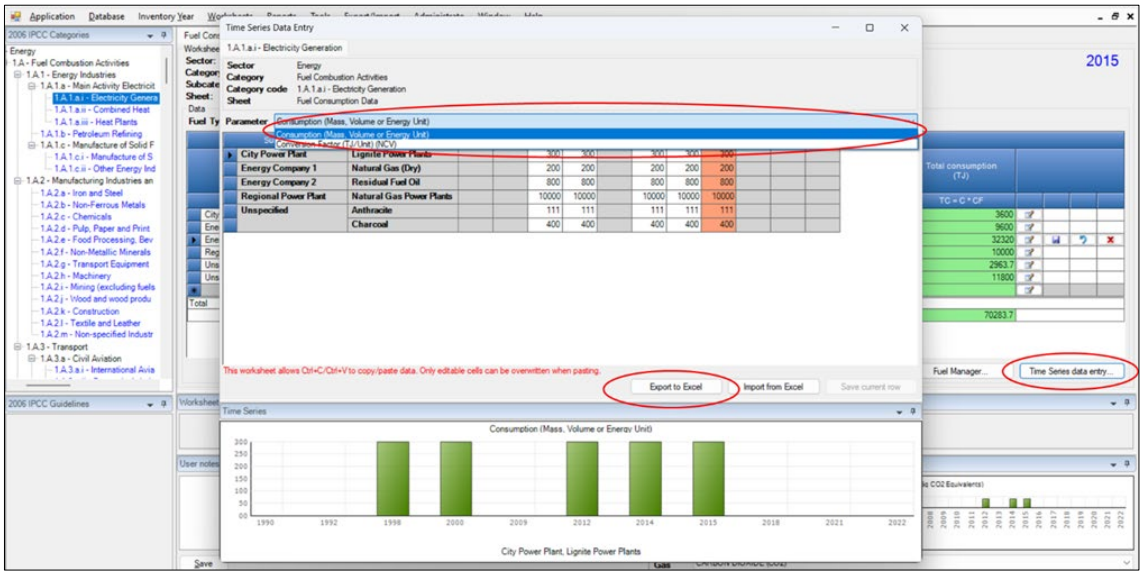
To enter data on *Uncertainties* or to enter *Time Series data*, calculation worksheets have dedicated tabs that can be accessed through buttons placed either at the lower right-hand side or next to the *Fuel type* button. Users are prompted to learn about how to use these functionalities in the *User Manual* of the *Software* (accessible at *Help* tab).

Example: **tabs for uncertainties and time series data entry**



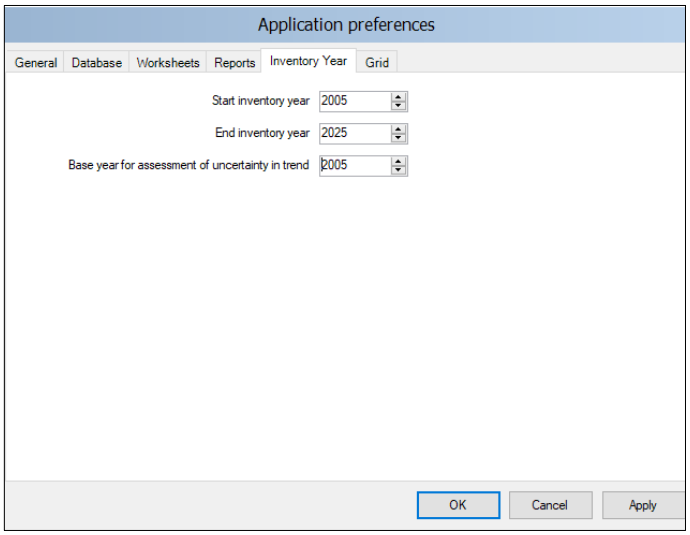
Time series data entry:

In each worksheet, there is a button "Time Series data entry" as shown in the screenshot below.



To use this functionality then users:

1. Select in TAB **Application**, sub-TAB **Inventory Year**, the time-period of the inventory:



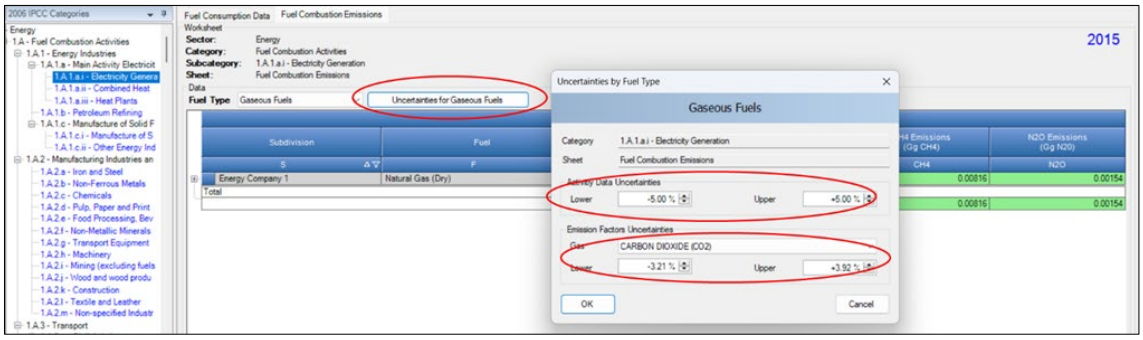
and click on button *Apply* to save it.

2. press the button *Export to Excel*, name the file and export it.
3. open exported file and for the entire time series, or for any fraction of it, enters data or make changes to data already present.
4. once data are compiled, the file is imported back into the *Software* by clicking the button *Import from Excel.*

Uncertainty:

For 1.A categories, IPCC default uncertainty data for AD and EFs are automatically filled in the *Software*. Further, information on the underlying sources of uncertainty, and the default uncertainty values is available in the *2006 IPCC Guidelines* in the section titled *Uncertainty Assessment* of each source category.

Further, once the user selects a *Fuel type* [this does not apply to the option *All Fuels*] from the dropdown menu, the button *Uncertainties for selected fuels* appears. Clicking the button, a pop-up window opens where users can enter lower and upper ranges of uncertainties for both AD and EF.



Please note that the Uncertainty Analysis has not yet been enhanced in this *Software* version, so this section is going to be revised in the next future.

1.A Stationary Combustion Source Categories (1.A.1, 1.A.2, 1.A.4 and 1.A.5)

Information

In general, emissions of each GHG from stationary combustion sources are calculated by multiplying fuel consumption (AD) by the corresponding EF.

NGHGI Stationary Combustion source categories are shown in **Table 1**.

GHGs

Stationary combustion source categories emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 Equations 2.1 and 2.2
- ✓ Tier 2: IPCC Tier 1 equations, although with user-specific EFs
- ✓ Tier 3: Equations 2.3, 2.4 and 2.5

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains for each subdivision the amount of fuel consumed, in the source category, for each fuel.

  *Note that in worksheet **Fuel Combustion Emissions** where data on technology types are available, fuel consumption data are apportioned to the various technology-types, considering the penetration rate of each technology type.*
- ✓ **Fuel Combustion Emissions**: contains for each subdivision, the relevant CO_2, CH_4 and N_2O EFs for each fuel, the penetration rate of specific technologies (if known), the CO_2 captured, if any, and calculates associated GHG emissions.

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

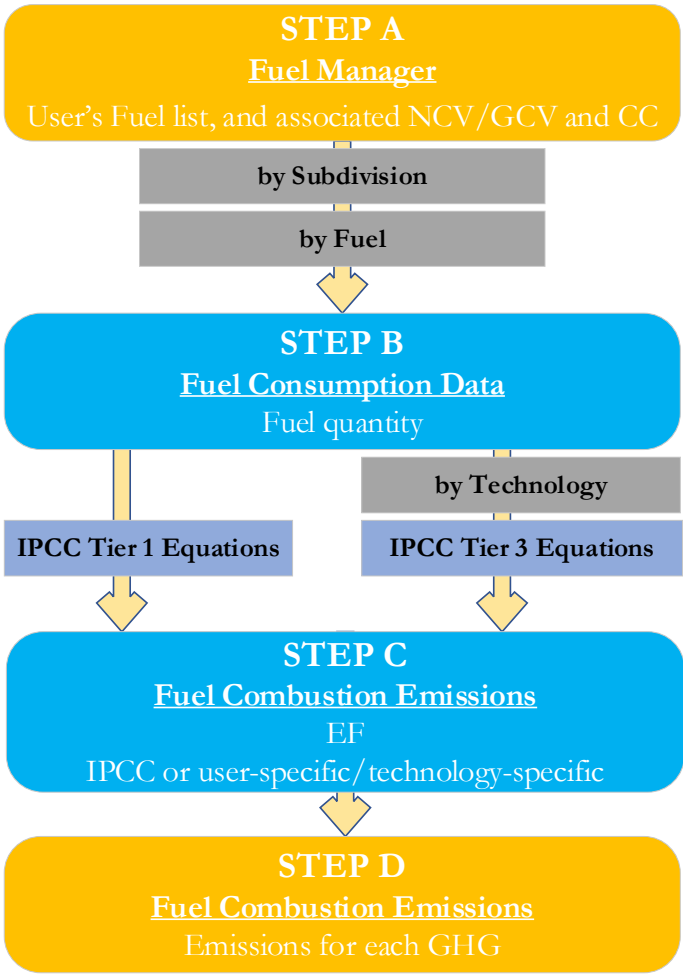
Data compilation of each of 1.A.1, 1.A.2, 1.A.4, and 1.A.5 categories is operated independently, following for each category the entire set of instructions below.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 2.1 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[18] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:

Stationary combustion - flowchart



Thus, for the relevant source-category:

Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

Step B, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel.

Step C, worksheet **Fuel Combustion Emissions**, users collect and enter in each row associated EFs for each GHG. Where technology-specific EFs are available, fuel consumption data are apportioned to the various technology-types, considering the penetration rate of each technology type.

Step D, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[18] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and use energy statistics data. Further information on the choice of AD for stationary combustion can be found in Section 2.3.3.

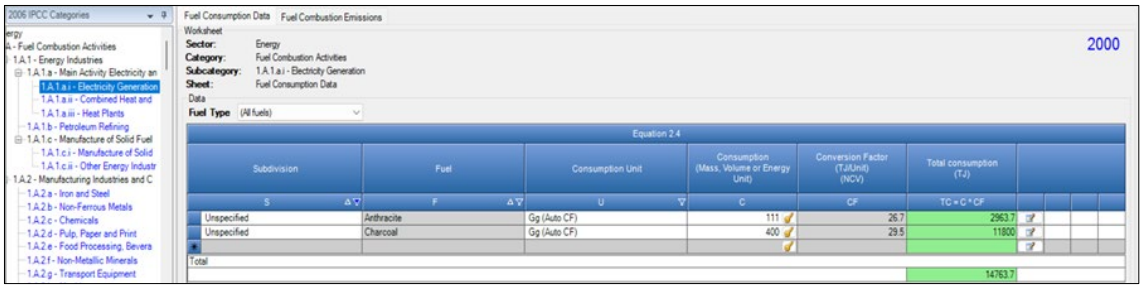
Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the **Fuel Consumption Data** worksheet, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter a user-defined conversion factor (TJ/unit).

Thus, for the relevant source-category:

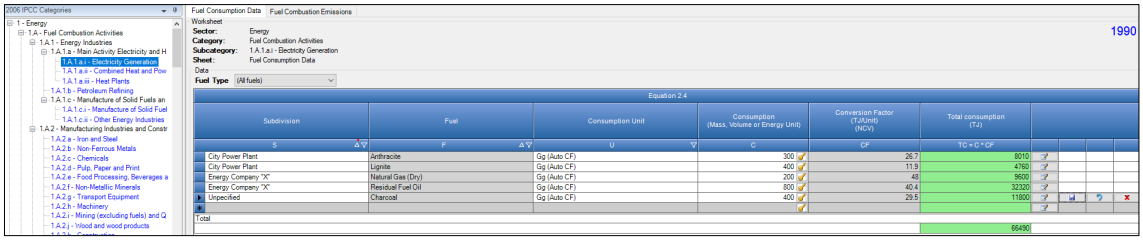
As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the worksheet **Fuel Consumption Data** either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Then, for each subdivision in Column |S| data are entered in worksheet **Fuel Consumption Data** row by row as follows:

1. Column |F|: select each fuel used from the drop-down menu (one row for each fuel).

   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager.

   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.

2. Column |U|: enter unit of fuel consumption data (e.g. Gg, TJ, m^3). To enter a user-specific unit (e.g. m^3) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-specific unit.

3. Column |C|: enter amount of fuel consumed.

4. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ).

   Note that where Gg of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as the conversion factor; while if the consumption unit is TJ the Software compiles the conversion factor cell with the value 1. Where other units are applied (e.g. m^3) the user shall enter the relevant conversion factor here.

Emission factor input

IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel C content, where the fuel C content is expressed in C units of mass per unit of energy (IPCC default values in Table 1.3 are in kg C/GJ).

IPCC default values for EFs are provided in Tables 2.2, 2.3, 2.4, 2.4, in kg/TJ.

The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel combinations entered in worksheet **Fuel Consumption Data**. Then:

i. For each row, users click the symbol "⊞" on the left of the row to open a drop-down table where EF values are to be compiled.

Note that the drop-down table can be filled: either with a single row of data, this is the case for IPCC default method; or with several rows, one row for each technology type, this is the case for IPCC Tier 3 method.

Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.

ii. Compile each row as follows:

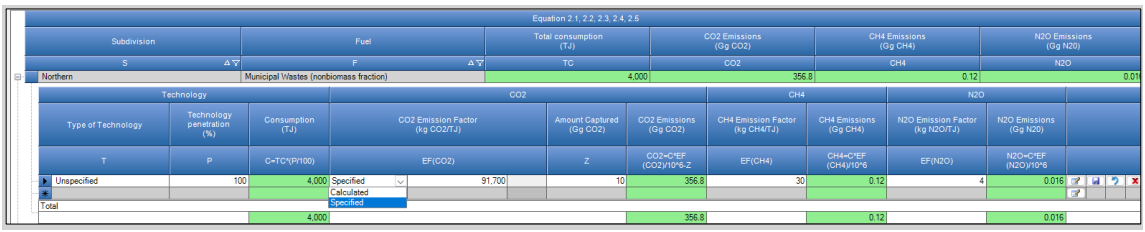
1. Column |T|: enter technology type. Where the IPCC default method[19] is applied, the notation "unspecified" is selected.
2. Column |P|: enter technology penetration rate (%) associated with each technology type. The technology penetration rate[20] apportions the total fuel consumed in the subdivision among technology types. Where the IPCC default method is applied[21], the value *100* is automatically entered by the *Software*.

Note that for each fuel in each subdivision, summing up technology penetration rates of technologies reported shall always result in 100%.

Example: **unspecified technology type**

Example: **technology types (Tier 3)**

3. Column |EF(CO_2)|: users select



[19] This is the case for Tier 1 and Tier 2.

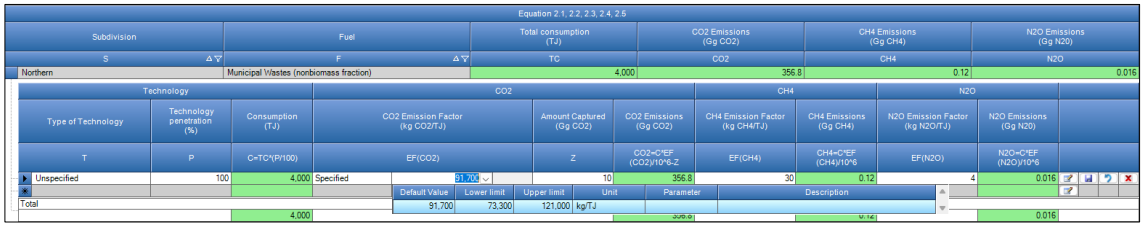
[20] Where the penetration rate is calculated based on the specific technology share of the total energy produced with the specific fuel and its per unit of energy fuel consumption.

[21] This is the case for Tier 1 and Tier 2.

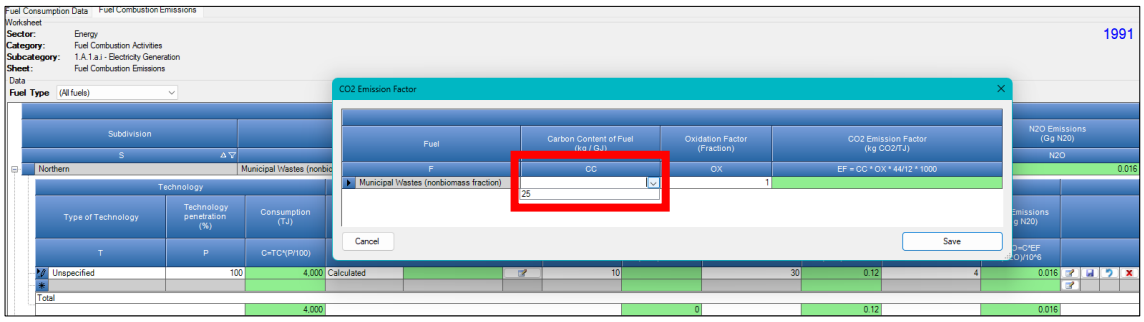
✓ either *Specified*, if users wishes to:

a. either enter a technology-type-specific value, in kg of CO_2 per TJ
Note that to enhance Transparency, instead of directly specifying a measured CO_2 EF here, it is suggested to derive from the measured CO_2 EF the oxidation factor and report the derived CO_2 EF under the "Calculated" option below. This is done by dividing the measured CO_2 EF by the product of the Carbon Content multiplied by 44/12.

b. or select from the dropdown menu the value calculated by the *Software* based on the *Carbon Content* value, contained in the **Fuel Manager**, (which is either the IPCC default value of the value entered instead by the user), multiplied by 44/12



✓ otherwise *Calculated*, which allows to calculate the EF's value on the basis of the *Carbon Content* and an *Oxidation Factor*. To calculate it, users shall click on the symbol  to open a pop-up window where:



a. for the *Carbon Content* value

➢ either select from the dropdown menu the value of *Carbon Content* for the relevant fuel that is contained in the **Fuel Manager**, (which is either the IPCC default value of the value entered instead by the user)

➢ or enter a user-specific value for the relevant fuel type in the relevant year.

b. for the *Oxidation Factor* value

➢ either keep the IPCC default value of 1,
Note that the value of 1 means that the entire Carbon Content is oxidised to CO_2. This means assuming that the entire carbon content that is otherwise emitted as other chemical carbon species is eventually oxidised to CO_2 in the atmosphere. Accordingly indirect CO_2 emissions from those chemical carbon species are not estimated in the NGHGI to avoid to double count those emissions.

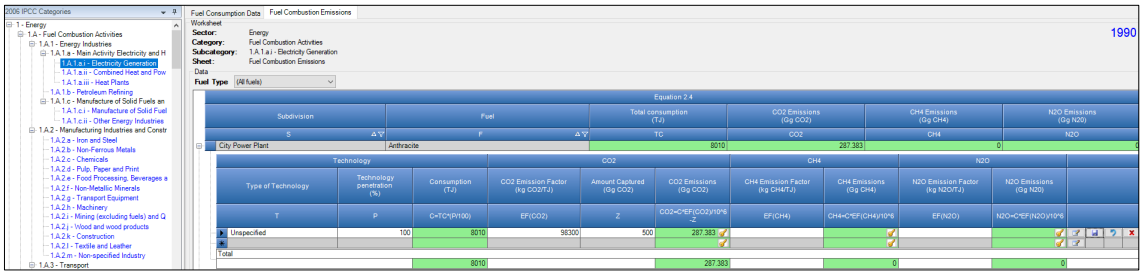
➢ or enter a technology-type-specific value for the relevant fuel.

Then, the *Software* calculates the EF value as the *Carbon Content* multiplied by the *Oxidation Factor* and by 44/12, in kg of CO_2 per TJ.

4. Column |EF(CH_4)|: select from the drop-down menu the IPCC default value for the given fuel or enter the technology-type-specific value, in kg of CH_4 per TJ.
5. Column |EF(N_2O)|: select from the drop-down menu the IPCC default value for the given fuel or enter the technology-type-specific value, in kg of N_2O per TJ.

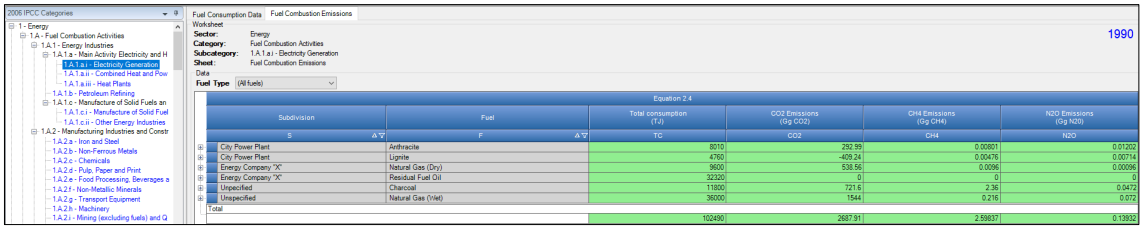
Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 produced across the process from that fuel used by that technology in that subdivision that has been captured instead of emitted into the atmosphere is to be entered in Gg CO_2 in Column |Z| of worksheet **Fuel Combustion Emissions**.



Note that Column |Z is accessed in worksheet ***Fuel Combustion Emissions*** *by clicking the symbol "⊞" on the left of the row (a drop-down table opens and Column |Z| becomes visible:*

Then, for each GHG, emissions from each source are calculated by the *Software*, in mass unit (Gg). Total emissions from each source of stationary combustion is the sum of all emissions from combustion of all fuels listed in all subdivisions reported in worksheet **Fuel Combustion Emissions**.



1.A.3 - Mobile Combustion Source Categories

Information

In general, emissions of each GHG from mobile sources is calculated by multiplying fuel consumption (AD) by the corresponding EF.

NGHGI Mobile Combustion source categories are shown in **Table 1**.

The following sections group sources according to the methodological approaches applied in the *Software*, and corresponding worksheets:

- ✓ **1.A.3.a Civil Aviation** - counts for domestic and international air transport emissions.
- ✓ **1.A.3.b 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 gaseous and liquid fuels.
- ✓ **1.A.3.c Railways** – includes diesel railway locomotives only; while for electric locomotives, emissions associated with electricity production are covered under Stationary Combustion.
- ✓ **1.A.3.d Water-borne Navigation** - counts for domestic and international water-borne navigation emissions.
- ✓ **1.A.3.e.i Pipeline transport** – counts combustion related emissions from the operation of pump stations and maintenance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry, and other commodities. Distribution of natural or manufactured gas, water, or steam from the distributor to final users shall instead be reported under 1.A.1.c.ii or 1.A.4.a.
- ✓ **1.A.3.e.ii Off-road transportation** – includes combustion emissions from all remaining transport activities excluding Pipeline Transport. Military transport shall instead be reported under 1.A.5.

GHGs

Mobile combustion source categories in aviation emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 3.6.1
2. Tier 2: IPCC Tier 2 Equations 3.6.2, 3.6.3, 3.6.4 and 3.6.5
3. Tier 3: Emissions are estimated based on actual flight traffic data.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation. In such a case, it is suggested to report estimates as two subdivisions i.e. *Tier 3-Commercial Scheduled Aviation* and *Tier 3- Other Jet-Fuelled Activities*, recognizing that the *2006 IPCC Guidelines* refer to these two subdivisions at the Tier 3 level (see section 3.6.1.1.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets **Fuel Consumption Data** and **Fuel Combustion Emissions** for Tier 1, and worksheets **LTO Fuel consumption and LTO emissions** and **Cruise and total emissions** are to be used for Tier 2. In particular:

- ✓ **Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains, for each subdivision, the amount of fuel consumed, in the source category, for each fuel.
- ✓ **Fuel Combustion Emissions**: for each subdivision, contains the relevant CO_2, CH_4 and N_2O EFs for each fuel and calculates associated GHG emissions.
- ✓ **LTO Fuel consumption and LTO emissions – Tier 2**: contains for each subdivision the amount of fuel consumed and estimates associated GHGs emitted during LTO[22] cycles according to each aircraft type and its number of LTOs.
- ✓ **Cruise and total emissions – Tier 2**: contains for each subdivision the amount of fuel consumed and calculates associated GHGs emitted during the cruise mode from all aircrafts entered in worksheet **LTO Fuel consumption and LTO emissions – Tier 2**. This worksheet also sums up total fuel consumption and associated GHG emissions in aviation (either domestic or international).

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

In the upper part of worksheets **LTO Fuel consumption and LTO emissions – Tier 2** and **Cruise and total emissions – Tier 2**, users select the GHG for which to enter data.

Data compilation for each of the 1.A.3.a subcategories is operated independently, following for each subcategory the entire set of instructions below.

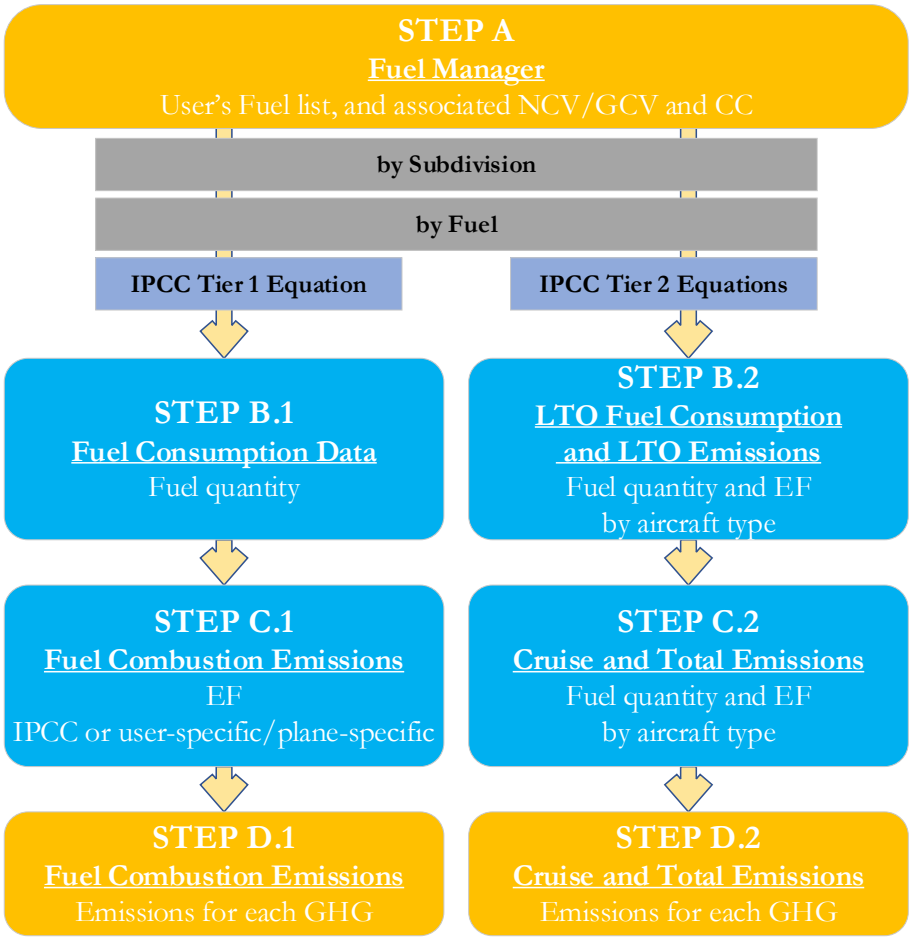
[22] Landing/Take-Off

User's work Flowchart

Consistent with the key category analysis and the decision trees in figures 3.6.1 and 3.6.2, of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[23] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category (domestic and international), the users apply steps described in the following flowchart:

Mobile combustion - Aviation - flowchart



Thus, for the relevant source-category:

Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

When Tier 1 Equation is applied:

Step B.1, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel.

Step C.1, worksheet **Fuel Combustion Emissions**, users collect and enter in each row associated EFs for each GHG.

Step D.1, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

When Tier 2 Equations are applied:

Step B.2, in worksheet **LTO Fuel consumption and LTO Emissions – Tier 2**, users collect and enter data on the amount consumed of each fuel for each aircraft type and associated number of LTOs. Further the *Software* calculates fuel consumption (to be used in step C.2) and associated emissions for LTO cycles in mass units (Gg). In addition, for each GHG, LTO emissions are calculated.

Step C.2, **Cruise and Total Emissions – Tier 2** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel combinations entered in the **LTO Fuel consumption and LTO Emissions – Tier 2** worksheet**.** Users collect and enter total amount of fuel consumed for each subdivision/fuel combination, as well as for the

[23] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

cruise phase associated EFs for each GHG. In addition, the *Software* estimates fuel consumption. in TJ, for cruise mode, as well as associated GHG emissions, in Gg, for each subdivision/fuel combination.

Step D.2, worksheet **Cruise and Total Emissions – Tier 2**, for each fuel and GHG the *Software* calculates total emissions[24] in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[24] LTO plus Cruise

Activity data input

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and use energy statistics data. Section 3.5.1.3 describes how to disaggregate AD between domestic aviation (described as journeys that arrive and depart in the same country) and international aviation (journeys departing from one country and arriving in another), since emissions from domestic and international aviation are reported separately.

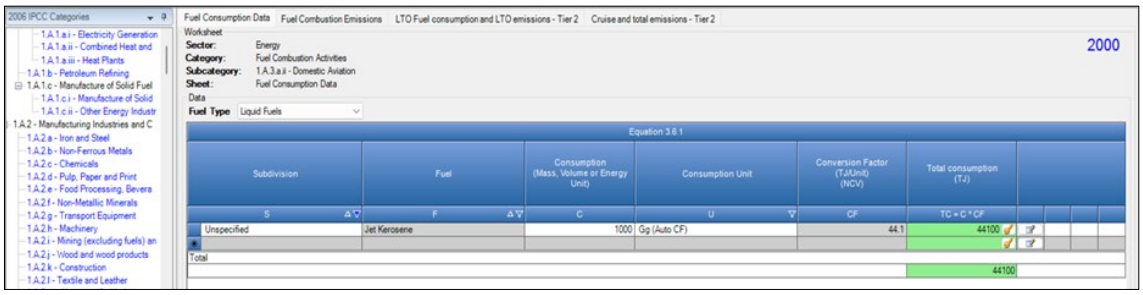
Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the calculation worksheets, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter a user-defined conversion factor (TJ/unit).

Thus, for the relevant source-category:

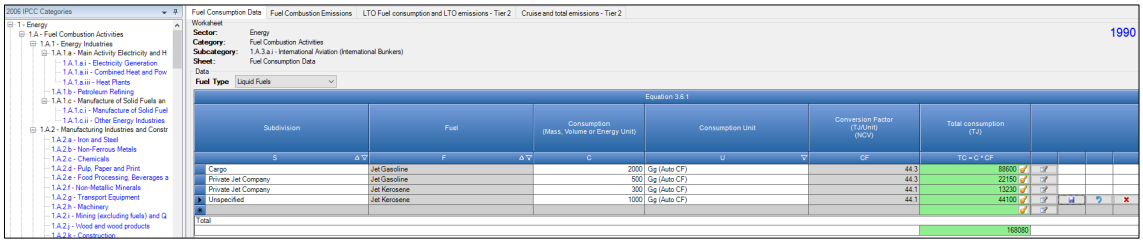
As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



When Tier 1 Equation is applied:

For each subdivision in Column |S| data are entered in worksheet **Fuel Consumption Data** row by row as follows:

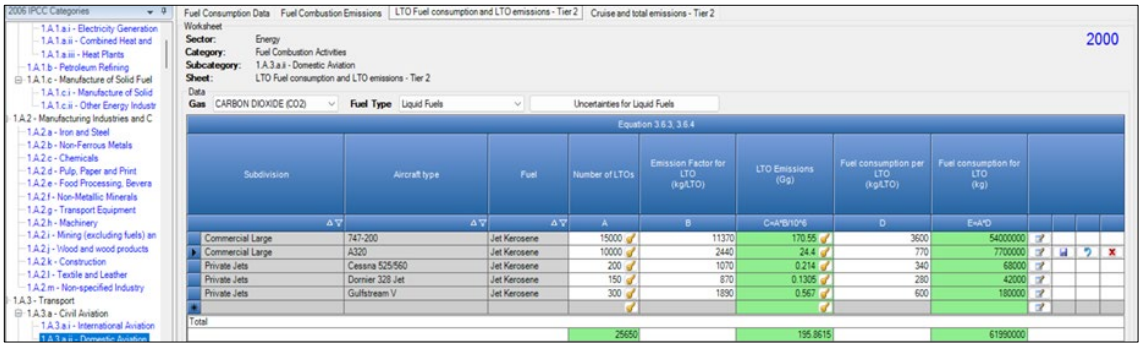
1. Column |F|: select each fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager.
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
2. Column |U|: enter unit of fuel consumption data (e.g. Gg, TJ, m^3). To enter a user-specific unit (e.g. m^3) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-specific unit.
3. Column |C|: enter amount of fuel consumed.
4. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ).
   Note that where Gg of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as the conversion factor; while if the consumption unit is TJ the Software compiles the conversion factor cell with the value 1. Where other units are applied (e.g. m^3) the user shall enter the relevant conversion factor here.

When Tier 2 Equations are applied:

For each subdivision in Column |S| data are entered in worksheets **LTO Fuel consumption** and **LTO Fuel consumption and LTO Emissions – Tier 2** row by row as follows:

1. Column |AT|: select the aircraft type in operation from the drop-down menu or enter user-specific aircraft type(s).
2. Column |F|: select from the drop-down menu the fuel used by the corresponding aircraft type.
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager.
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
3. Column |A|: enter number of LTO cycles for the corresponding combination of aircraft type/fuel.
4. Column |D|: enter specific fuel consumption for the LTO cycle in kg/LTO.
   Note that for each default aircraft type default values from table 3.6.9 of the 2006 IPCC Guidelines are automatically compiled by the Software, although the user can overwrite those with user-specific values.

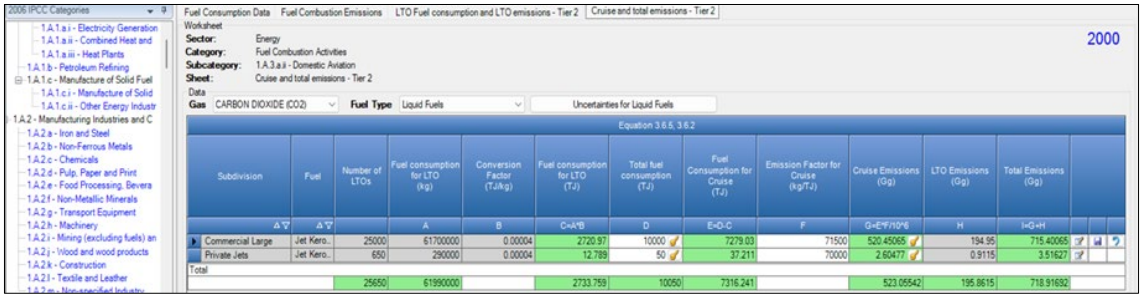
Example: **LTO consumption**



Data on subdivision, fuel, number of LTOs and LTO fuel consumption compiled in the **LTO Fuel consumption and LTO Emissions – Tier 2** worksheet is automatically compiled by the *Software* in the worksheet **Cruise and total emissions – Tier 2**. In addition, for each row of data, users enter total fuel consumption in Column |D|, and the *Software* calculates fuel consumption for cruise mode in Column |E| as the difference between total fuel consumption and LTO fuel consumption.

Note that for all aircrafts under the subdivision, AD for cruise mode is entered in one row, without dividing by each aircraft type.

Example: **cruise mode consumption**



Emission factor input

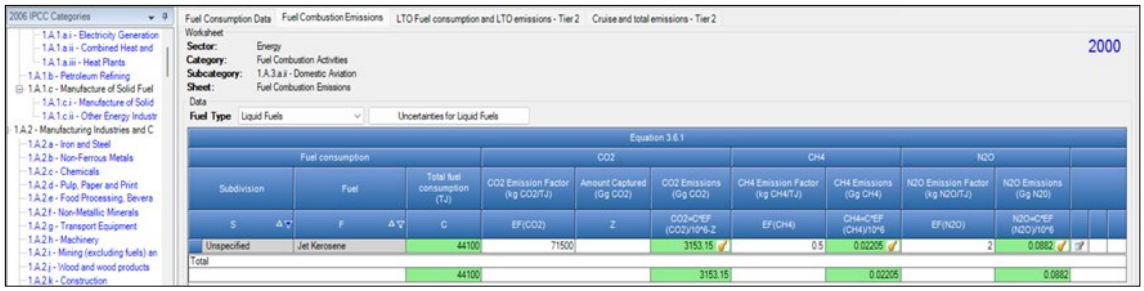
IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel carbon content, where the fuel C content is expressed in C units of mass per unit of energy (IPCC default values for CO_2 in Table 1.3 are in kg/GJ).

IPCC default EFs are provided in tables 3.6.4 and 3.6.5, in kg/TJ.

When Tier 1 Equation is applied:

The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel combinations entered in worksheet **Fuel Consumption Data**. Then, for each row:

Example: **single subdivision (unspecified)**



1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value or, for user-specific fuels the value calculated by the *Software* as the CC multiplied by 44/12; otherwise enter a user-specific value, in kg of CO_2 per TJ.
2. Column |EF(CH_4)|: select from the drop-down menu the IPCC default value for the given fuel or enter it, in kg of CH_4 per TJ.
3. Column |EF(N_2O)|: select from the drop-down menu the IPCC default value for the given fuel or enter it, in kg of N_2O per TJ

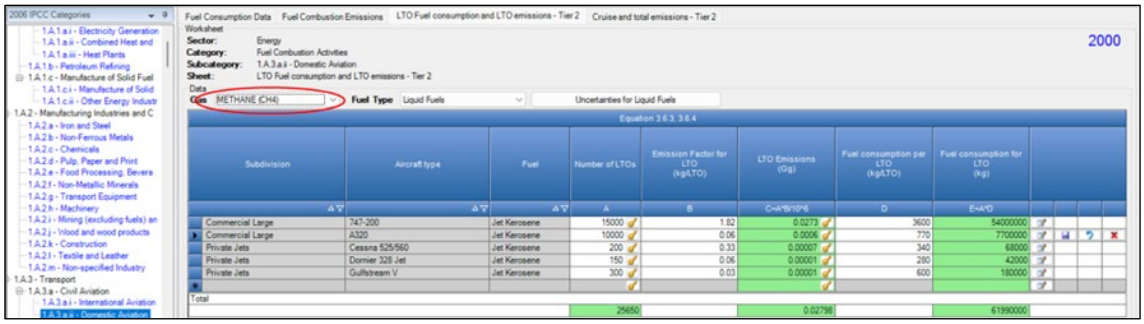
When Tier 2 Equations are applied:

First, in worksheet **LTO Fuel consumption and LTO emissions – Tier 2**, for each GHG for each row:

1. Column |B| enter EF for LTO cycle, in kg/LTO.

   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous oxide (N_2O)" in the "Gas" bar at the top, to enter the relevant EF to estimate emissions data for each GHG one by one.

Example: **LTO emissions - methane**

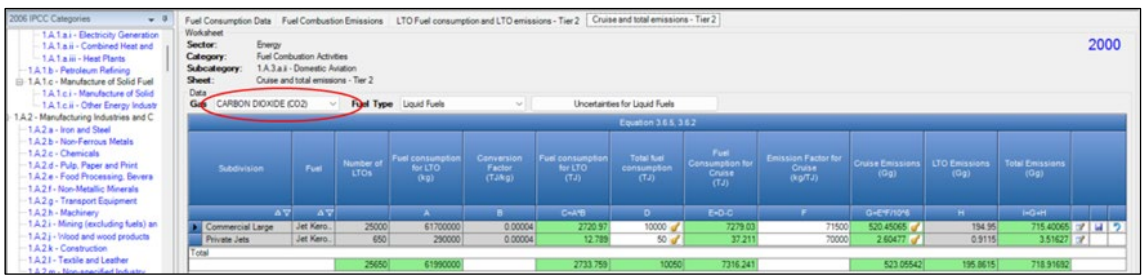


Second, in worksheet **Cruise and total emissions – Tier 2**, for each GHG for each row:

1. Column |F| enter EF for cruise mode, in kg/TJ. For all aircrafts within a subdivision, the EF for cruise mode should be entered in one row, without dividing by each aircraft type.

   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: **cruise and total emissions - CO_2**



Results

Then, for Tier 1, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data in worksheet **Fuel Combustion Emissions**.

While, for Tier 2, for each GHG, emissions from each source category are calculated by the *Software*, in mass unit (Gg), for each row of data in worksheets:

i. **LTO Fuel consumption and LTO emissions – Tier 2**: LTO emissions are calculated in Column |C| and then reported by the *Software* in Column |H| of worksheet **Cruise and total emissions – Tier 2.**

ii. **Cruise and total emissions – Tier 2**: Cruise emissions are calculated in Column |G|. Column |I| calculates total emissions: LTO *plus* cruise mode.

Thus, for each GHG, total emission from domestic or international aviation is the sum of all emissions from combustion of all fuels by all aircraft types listed in all subdivisions reported in worksheets **Fuel Combustion Emissions** and **Cruise and total emissions – Tier 2**.

GHGs

Mobile combustion source categories in road transport emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

1. Tier 1 (CO_2): IPCC Tier 1 Equation 3.2.1
2. Tier 1 (CH_4, N_2O): IPCC Tier 1 Equation 3.2.3
3. Tier 2 (CO_2): IPCC Tier 1 equation, although with user-specific EFs
4. Tier 2 (CH_4, N_2O): IPCC Tier 2 Equation 3.2.4
5. Tier 3 (CH_4, N_2O): IPCC Tier 3 Equation 3.2.5
6. Tier 3 (CO_2): no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets **Fuel Consumption Data** and **Fuel Combustion Emissions**, or for CH_4 and N_2O at Tier 2 or Tier 3 using worksheet **CH_4 and N_2O Emissions – Tier 3**. Further, the additional **Fuel Consumption – Validation** worksheet is provided to verify fuel consumption data. In particular:

- ✓ Fuel Manager: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains for each subdivision/fuel/vehicle type/emission control (ECT) technology the amount of fuel consumed, in the source category, for each fuel.
- ✓ **Fuel Combustion Emissions**: contains for each subdivision/fuel/vehicle type/ECT the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.
- ✓ **CH_4 and N_2O emissions – Tier 3**: contains for each subdivision/fuel/vehicle type/ECT/operating conditions the distance travelled and associated GHG EF as well as the emissions on cold start of the vehicle and calculates associated GHG emissions.
- ✓ **Fuel Consumption – Validation**: estimates fuel use from the distance travelled data based on the types of fuel, road (e.g. urban highway or rural road) and, if known, vehicle type (e.g. car, bus) (Equation 3.2.6).

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

In the upper part of worksheet **CH_4 and N_2O emissions – Tier 3**, users select the greenhouse *Gas* for which to enter data.

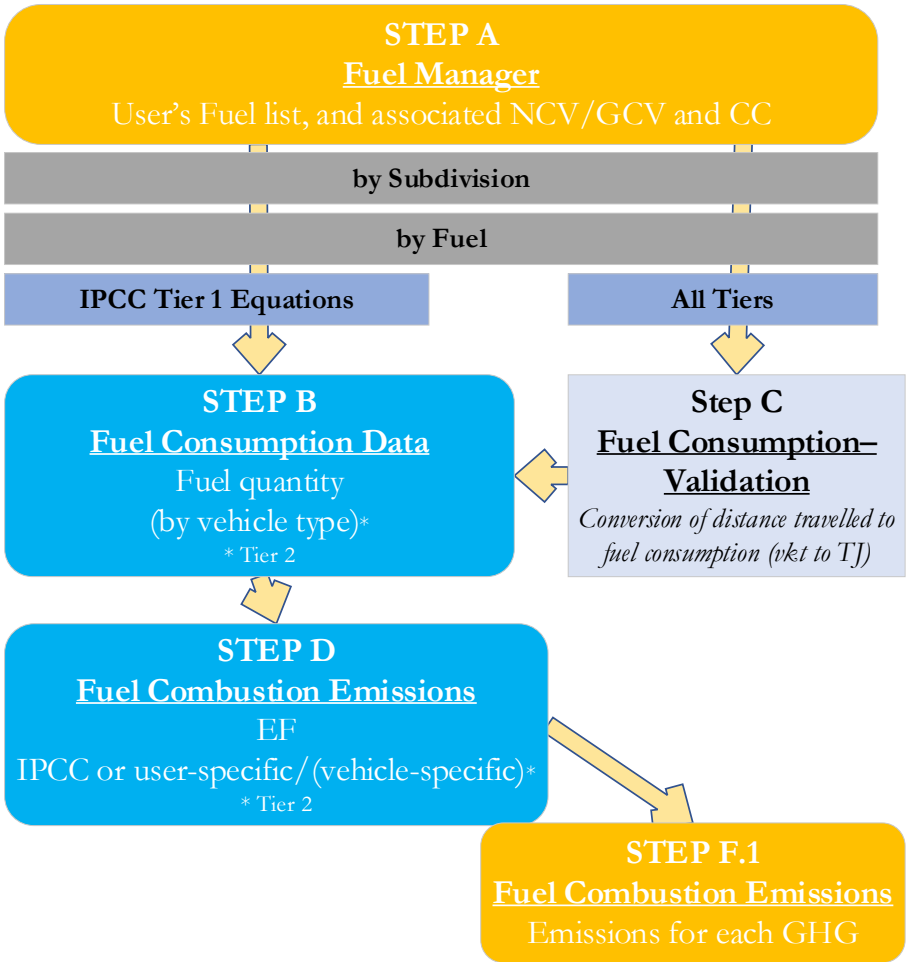
Data compilation of each of the 1.A.3.b subcategories is operated independently, following for each subcategory the entire set of instructions below.

User's work Flowchart

Consistent with the key category analysis and the decision trees of the *2006 IPCC Guidelines* -Figures 3.2.1 - 3.2.2 for CO_2 and Figure 3.2.3 for CH_4 and N_2O-, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[25] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowcharts:

Mobile combustion - Road transport – flowchart - (CO_2 All Tiers; CH_4 & N_2O Tier 1 & Tier 2)



Thus, for the relevant source-category:

Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

When Tier 1 & Tier 2 Equations are applied:

Step B, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel, for each subdivision/ vehicle type/ECT.

Step C, worksheet **Fuel Consumption - Validation**, for each subdivision/vehicle type/road type the *Software* calculates fuel consumption in mass units (Gg) based on the number of vehicles, distance travelled (km) and specific fuel consumption rate per km travelled (l/km). Total fuel consumption calculated in this worksheet can be compared to the total consumption in **Fuel Consumption Data** as a quality check.

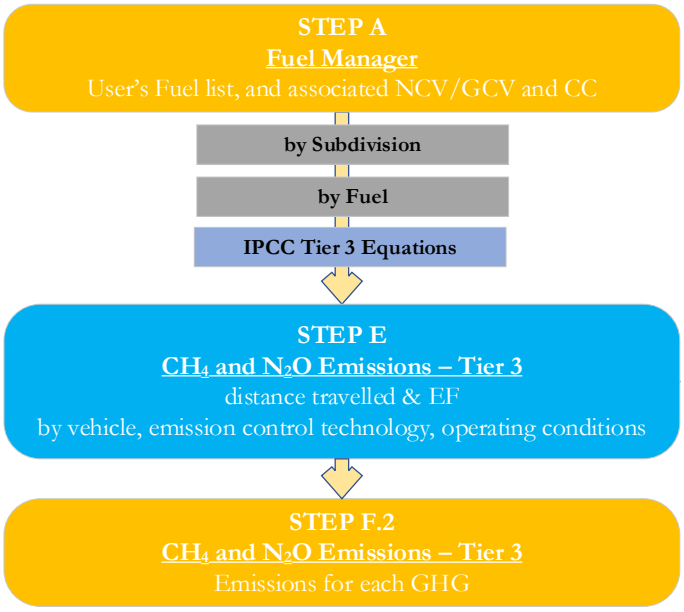
Step D, worksheet **Fuel Combustion Emissions**, for each subdivision/fuel/vehicle type/ECT, users collect and enter associated EFs for each GHG.

Step F.1, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

[25] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

Mobile combustion - Road transport – flowchart - (CH_4 & N_2O Tier 3)



When Tier 3 Equation [CH_4 & N_2O] is applied:

Step E, worksheet **CH_4 and N_2O Emissions – Tier 3**, for each subdivision/fuel/vehicle/ECT/operating conditions, users collect and enter data on the distance travelled -i.e. vehicle kilometres travelled (VKT)- stratified by ECT and by operating conditions. Further, for each combination users collect and enter associated EFs for CH_4 and N_2O as well as enter CH_4 and N_2O emissions during warm-up.

Step F.2, worksheet **CH_4 and N_2O Emissions – Tier 3**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg), based on distance travelled *plus* emissions during warm-up. In addition, for each GHG, total emissions are calculated.

Activity data input

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and apply energy statistics data. Specific guidance on collecting AD for road transportation may be found in Section 3.2.1.3.

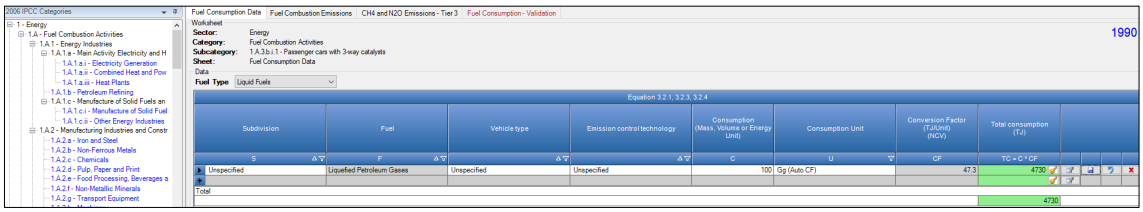
Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the calculation worksheets, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter a user-defined conversion factor (TJ/unit). In addition, data on distance travelled by vehicles can be converted to fuel consumed in TJ units, where applicable (see **Fuel Consumption – Validation worksheet** below).

Thus, for the relevant source-category:

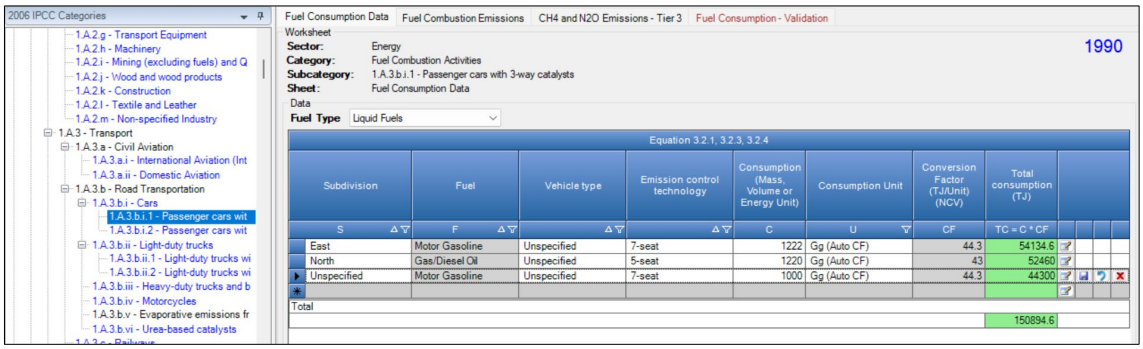
As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



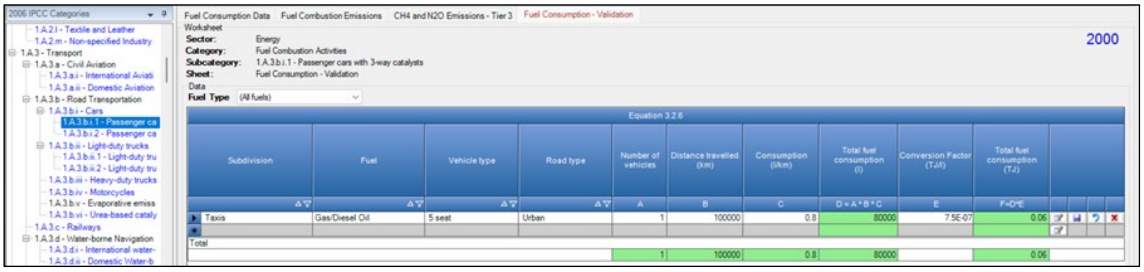
When Tier 1 & Tier 2 Equations are applied:

For each subdivision in Column |S| data are entered in worksheet **Fuel Consumption Data** row by row as follows:

1. Column |F|: select each fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
2. Column |VT|: enter vehicle type (e.g. sedan, 2-seat, 5-seat, etc.); where no data are available select *Unspecified* from the dropdown menu.
3. Column |ECT|: enter applicable emission control technology (e.g. three-way catalyst, oxidation catalyst, etc.); where no data are available select *Unspecified* from the dropdown menu. The ECT is relevant for Tier 2 and for CH_4 and N_2O emissions only; indeed, the ECT does not impact the estimate of CO_2 emissions given that IPCC methods assume that the entire C content of fuels is oxidised to CO_2.
4. Column |C|: enter amount of fuel consumed by the relevant combination fuel/vehicle type/ECT.
5. Column |U|: enter unit in which fuel consumption data are entered (e.g. Gg, TJ, m^3). To enter a user-specific unit (e.g. m^3) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-defined unit.
6. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ).
   Note that where Gg of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as a conversion factor; while if the consumption unit is TJ the Software compiles the conversion factor with the value 1. Where other units are applied (e.g. m^3) the user shall enter the relevant conversion unit here.

Fuel consumption data (TJ) can be validated in comparison to the distance travelled using the **Fuel Consumption – Validation** worksheet, where the following data will be entered for each combination of subdivision/fuel/vehicle type/road type:

Example: **fuel validation**



1. Column |F|: select fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager.
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
2. Column |VT|: enter vehicle type.
3. Column |RT|: enter road type.
4. Column |A|: enter number of vehicles of the relevant type.
5. Column |B|: enter annual average kilometres travelled, per vehicle, by the relevant type of vehicles, in km.
6. Column |C|: enter average fuel consumption rate by the relevant type of vehicles, in l/km.
7. Column |E|: enter conversion factor, in TJ/l.

Thus, the *Software* will calculate in Column |F| the fuel consumption, in TJ.

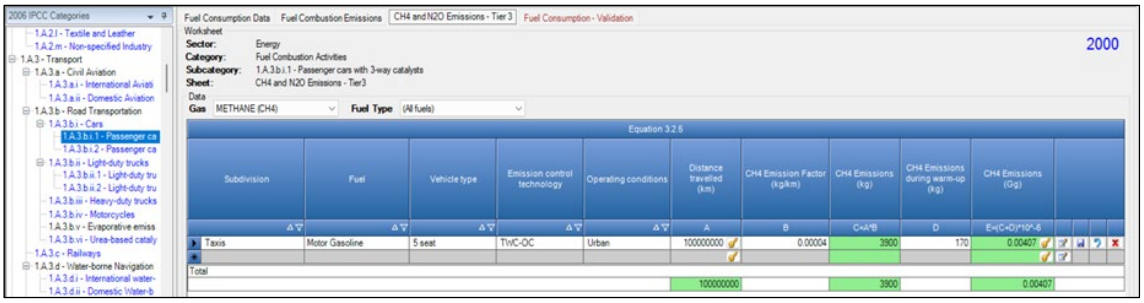
Note that calculated quantities in this worksheet are not reported. However, the inventory compiler may wish to investigate further if there are significant differences between the fuel used, as calculated in this worksheet, and fuel sold entered in worksheet Fuel Consumption Data.

When Tier 3 Equation [CH_4 & N_2O] is applied:

For each subdivision in Column |S| data are entered in each row of a unique combination of fuel/vehicle type/ECT/operating conditions, in worksheet **CH_4 and N_2O Emissions – Tier 3**, as follows:

1. Column |F|: select fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
2. Column |VT|: enter vehicle type (e.g. sedan, 2 seat, 5 seat, etc.) using that fuel.
3. Column |ECT|: enter applicable emission control technology (e.g. three-way catalyst, oxidation catalyst, etc.) for that combination of fuel/vehicle type.
4. Column |Operating Conditions|: enter operating conditions (e.g., urban or rural road type, climate, or other environmental factors) for that combination of fuel/vehicle type/ECT.
5. Column |A|: enter total distance travelled in km for that combination of fuel/vehicle type/ECT/operating conditions.

Example: **CH_4 Tier 3 calculation**



Emission factor input

IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel carbon content, where the fuel carbon content is expressed in C units of mass per unit of energy (IPCC default values in Table 1.3 are in kg/GJ).

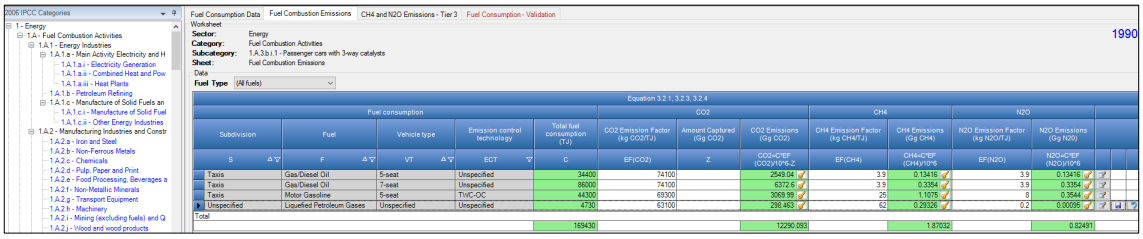
IPCC default EFs are provided in tables 3.2.1, for CO_2, and 3.2.2, for CH_4 and N_2O, in kg/TJ. Further, in tables 3.2.3 and 3.2.5 N_2O and CH_4 EFs for gasoline and diesel vehicles in USA and Europe, respectively, are compiled, and N_2O and CH_4 EFs for alternative fuels are compiled in Table 3.2.4.

When Tier 1 & Tier 2 Equations are applied:

The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel/vehicle type/ECT combinations entered in worksheet **Fuel Consumption Data**. Then, for each row:

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value or, for user-specific fuels the value calculated by the *Software* as the CC multiplied by 44/12; otherwise enter a user-specific value, kg of CO_2 per TJ.
2. Column |EF(CH_4)|: select from the drop-down menu the IPCC default value for the given fuel or enter a user-specific value, kg of CH_4 per TJ.
3. Column |EF(N_2O)|: select from the drop-down menu the IPCC default value for the given fuel or enter a user-specific value, kg of N_2O per TJ.

Example: **multiple subdivisions**

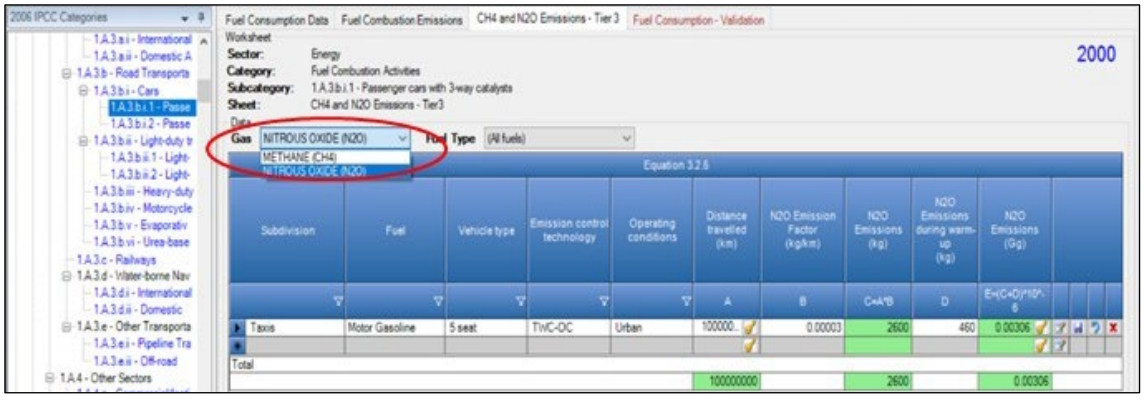


When Tier 3 Equation [CH_4 & N_2O] is applied:

In worksheet **CH_4 and N_2O Emissions – Tier 3**, for each GHG for each row:

1. Column |B|: enter EF, in kg/km.
   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one
2. Column |D|: select from drop-down menu *Specified* or *Calculated*.
   - ✓ When *Specified* is selected, enter in Column |D| emissions during warm-up (cold start), in kg.
   - ✓ When *Calculated* is selected, a table opens to allow the user to enter the number of cold starts and the user-specific CH_4 or N_2O EF per cold start.
3. See section 3.2.1.1 of the *2006 IPCC Guidelines* for more information on how to estimate these emissions.
   Note that user shall select "Methane (CH_4)" or "Nitrous oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: **N_2O emissions – Tier 3**



Results

Then, for Tier 1 and Tier 2, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data in worksheet **Fuel Combustion Emissions**.

While, for Tier 3, for CH_4 and N_2O only, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data **CH_4 and N_2O Emissions – Tier 3**.

Thus, for each GHG, total emission from each source of road transportation is the sum of all emissions from combustion of all fuels by all vehicle types listed in all subdivisions reported in worksheets **Fuel Combustion Emissions** and **CH_4 and N_2O Emissions – Tier 3**.

There are no emissions of main GHGs from this source category, thus no calculation worksheets are provided in the *Software*.

Regarding NMVOC emissions from this category, users can enter those in the *Energy sectoral table*. Further, it can enter those also in category 5.B of the *Software* to calculate indirect CO_2 emissions (*A Guidebook for calculating indirect emissions is under development*).

Example: **NMVOC emissions entered in Table 1 Energy Sectoral Table**

Table 1 Energy Sectoral Table | Memo and Information Items

Categories	Emissions (Gg) CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1.A.2.j - Wood and wood products							
1.A.2.k - Construction	0.000	0.936	0.125				
1.A.2.l - Textile and Leather							
1.A.2.m - Non-specified Industry							
1.A.3 - Transport	95841.912	1056.545	35.999			100.000	
1.A.3.a - Civil Aviation	12534.812	0.389	1.179				
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	12534.812	0.389	1.179				
1.A.3.b - Road Transportation	63489.742	62.774	16.961			100.000	
1.A.3.b.i - Cars	31920.185	8.867	3.069				
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	18901.905	5.012	1.638				
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	6878.300	0.932	1.148				
1.A.3.b.ii - Light-duty trucks	1346.400	12.000	1.200				
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	1346.400	12.000	1.200				
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts							
1.A.3.b.iii - Heavy-duty trucks and buses	19890.000	32.667	12.576				
1.A.3.b.iv - Motorcycles	1105.000	0.442	0.088				
1.A.3.b.v - Evaporative emissions from vehicles						100	
1.A.3.b.vi - Urea-based catalysts	274.267						
1.A.3.c - Railways	3275.468	2.665	9.914				

GHGs

Emissions from use of urea-based additives in catalytic converters (non-combustive emissions) in road transportation and off-road transportation include only CO_2:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

1. Tier 1: IPCC Tier 1 equations 3.2.2 (road transportation) and 3.3.4 (off-road transportation)
2. Tier 2: Same equation as Tier 1, although with user-specific EFs
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates CO_2 emissions using worksheets **Urea-based Catalysts**.

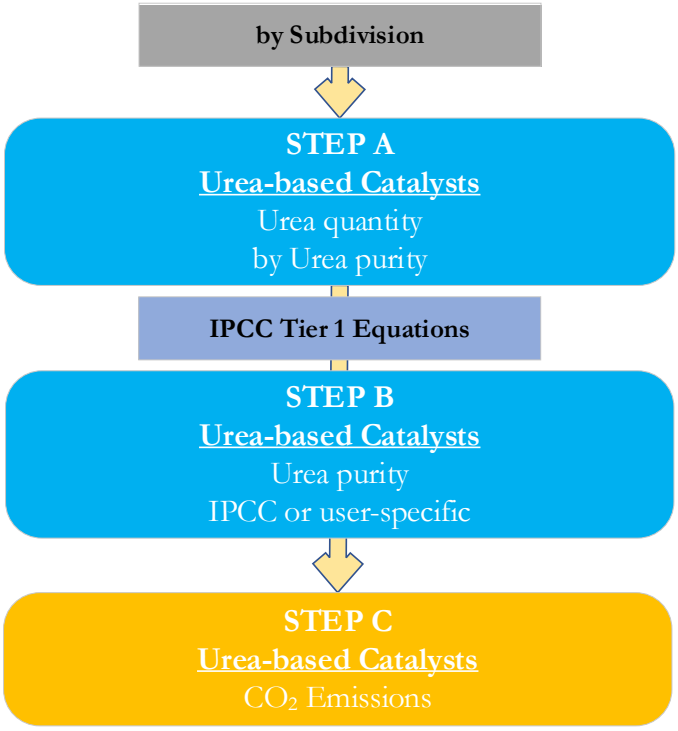
Note that although CO_2 emissions are calculated here, under the energy sector, these emissions are reported in the IPPU sector under category 2.D.4 other (non-energy products from fuels and solvent use) for the purposes of Reporting.

User's work Flowchart

Consistent with the key category analysis GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[26] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:

Mobile combustion - Urea-based catalysts - flowchart



For each subdivision, if any:

Step A, worksheet **Urea-based Catalysts**, users collect and enter data on the amount of urea-based additive consumed for use in catalytic converters for both road transport and off-road transportation, in Gg.

Step B, worksheet **Urea-based Catalysts**, users collect and enter data on purity (i.e. the mass fraction of urea in the urea-based additive).

Step C, worksheet **Urea-based Catalysts**, for each row of data, the *Software* calculates CO_2 emissions in mass units (Gg). In addition, total CO_2 emissions are calculated.

Activity data input

Input of AD for use of urea-based additives in catalytic converters requires the following steps:

First, users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|.

Then, for each subdivision, Column |A|: enter amount of urea-based additive consumed for use in catalytic converters, in Gg.

Emission factor input

For each subdivision, Column |B|: enter purity values (i.e. the fraction of urea in the urea-based additive).

Results

Then, CO_2 emissions are calculated by the *Software*, in mass unit (Gg), for each row of data and total emission from urea-based catalysts is the sum of all emissions from all urea-based additive consumed for use in catalytic converters listed in all subdivisions reported in worksheet **Urea-based Catalysts**.

Note that Urea consumption for catalytic converters in vehicles is directly related to the vehicle fuel consumption and technology.

[26] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

GHGs

Mobile combustion sources in railway transport emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 3.4.1
2. Tier 2 (CO_2): Same equation as Tier 1, although with user-specific EFs
3. Tier 2 (CH_4, N_2O): IPCC Tier 2 Equations 3.4.2, 3.4.4 and 3.4.5
4. Tier 3 (CH_4, N_2O): IPCC Tier 3 Equation 3.4.3
5. Tier 3 (CO_2): no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets **Fuel Consumption Data** and **Fuel Combustion Emissions**, for Tier 1 and Tier 2 and for CH_4 and N2O at Tier 3 using worksheet **CH_4 and N_2O Emissions – Tier 3**. In particular:

- ✓ **Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel type used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains for each subdivision/fuel/locomotive type the amount of fuel consumed.
- ✓ **Fuel Combustion Emissions**: contains for each subdivision/fuel/locomotive type the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.
- ✓ **CH_4 and N_2O emissions – Tier 3:** contains for each subdivision/fuel/locomotive type, the number of locomotives, the rated power of these as well as the annual average hours of use per locomotive and the load factor, and calculates associated GHG emissions.

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

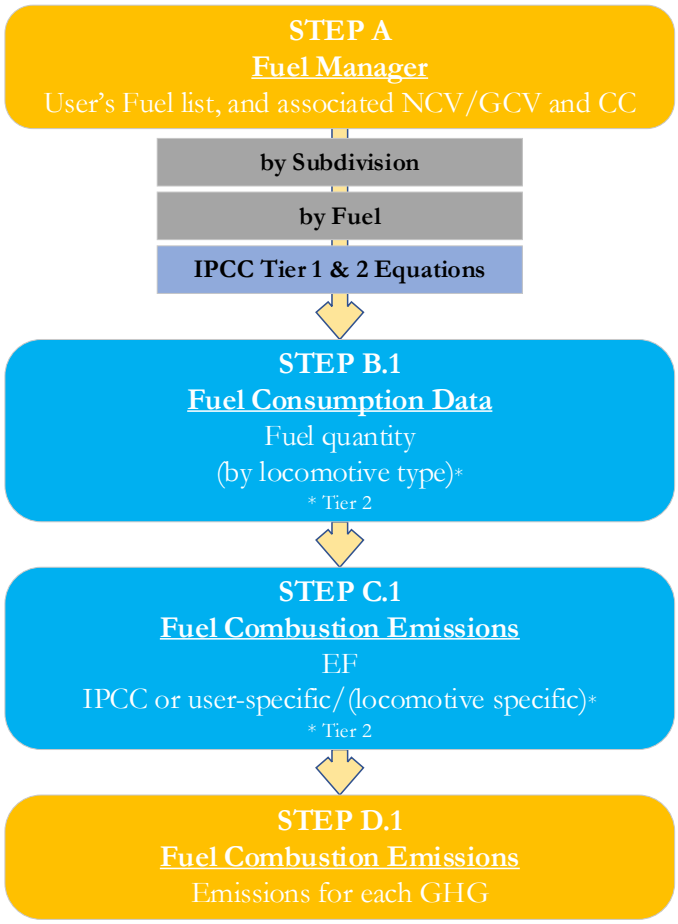
In the upper part of worksheet **CH_4 and N_2O emissions – Tier 3**, users select the greenhouse *Gas* for which to enter data.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.4.1 for CO_2 and Figure 3.4.2 for CH_4 and N_2O, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[27] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse the users apply steps described in the following flowcharts:

Mobile combustion - Railways – flowchart - (CO_2 All Tiers; CH_4 & N_2O Tier 1 & 2)



Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

When Tier 1 & Tier 2 Equations are applied:

Step B.1, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel, for each subdivision/locomotive type combination.

Step C.1, worksheet **Fuel Combustion Emissions**, for each subdivision/locomotive type/fuel users collect and enter associated EFs for each GHG.

Step D.1, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

While for Tier 3 Equation [CH_4 & N_2O]:

Step B.2, worksheet **CH_4 and N_2O Emissions – Tier 3**, for each subdivision/locomotive type/fuel type users collect and enter data on number of locomotives, annual average hours of use, average rated power, and typical load factors.

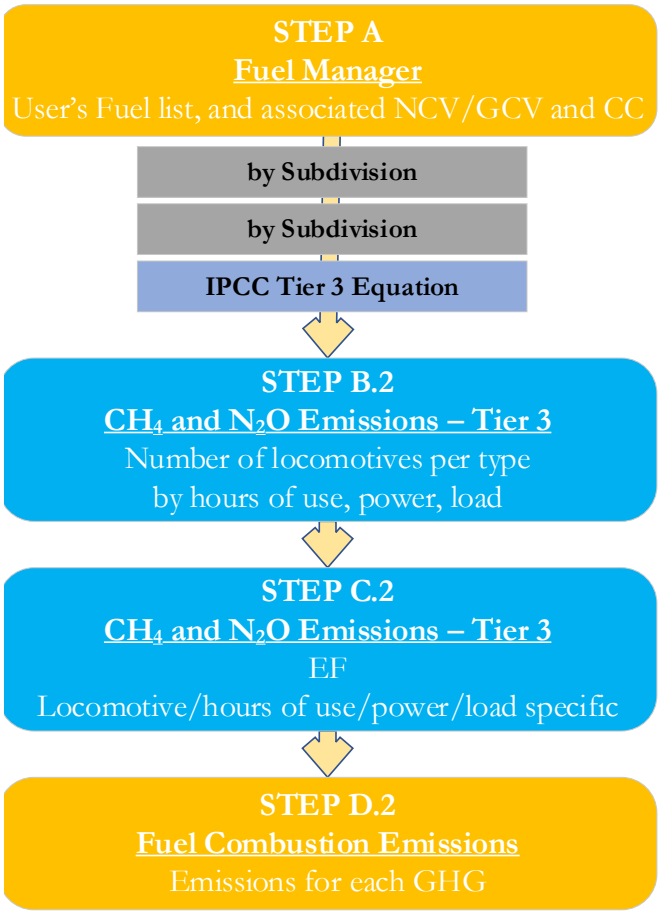
Step C.2, worksheet **CH_4 and N_2O Emissions – Tier 3**, for each subdivision/locomotive/fuel type users collect and enter associated EFs for each GHG.

Step D.2, worksheet **CH_4 and N_2O Emissions – Tier 3**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

[27] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented by either applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then reported at the level at which corresponding emissions are calculated.

Mobile combustion - Railways - flowchart - (CH_4 & N_2O Tier 3)



Activity data input

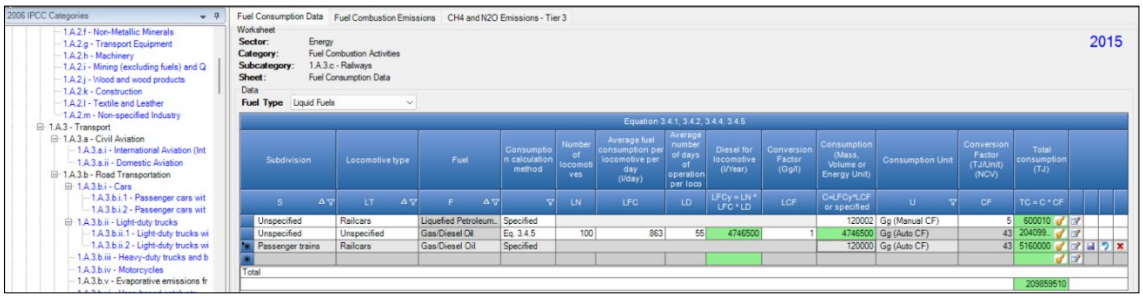
The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and apply energy statistics data. Specific guidance on collecting AD for road transportation may be found in Section 3.2.1.3.

Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the calculation worksheets, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter user-defined conversion factor (TJ/unit).

Thus, for the relevant source-category:

As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* (either *NCV* or *GCV*) and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Example: **multiple subdivisions**



Second, users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

When Tier 1 & Tier 2 Equations are applied:

For each subdivision in Column |S|, data are entered in worksheet **Fuel Consumption Data** row by row as follows:

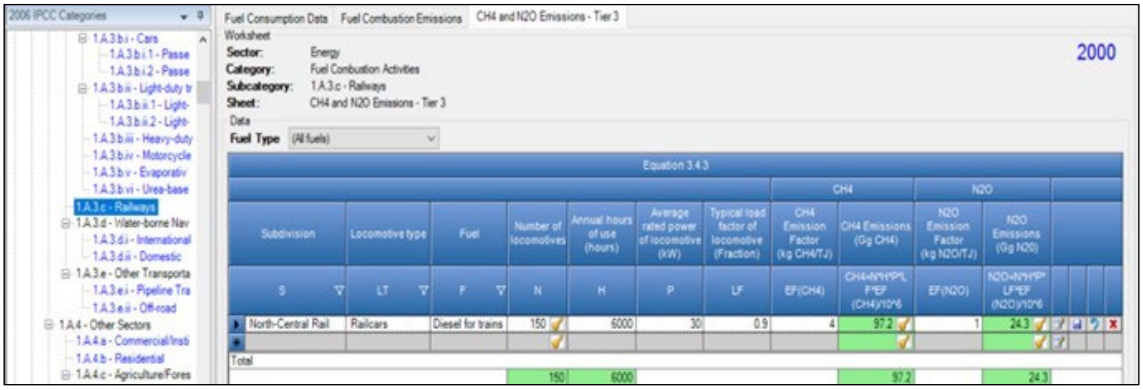
1. Column |LT|: enter locomotive type (e.g. railcars, yard locomotives, etc.).
2. Column |F|: select fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
3. Column |Consumption calculation method|: select from drop-down menu *Eq. 3.4.5* or *Specified.*
   - ✓ When *Specified* is selected, enter amount of fuel consumed in Column |C|.
   - ✓ When *Eq. 3.4.5* is selected, enter data required in steps 4-7 below.
4. Column |LN|: enter number of locomotives.
5. Column |LFC|: enter amount of daily average fuel consumption by locomotive, in l/day.
6. Column |LD|: enter average number of days of locomotives' operation per year.
7. Column |LCF|: enter conversion factor for liquid fuels to convert volume units (litres) into mass units (Gg).
8. Column |C|: enter amount of fuel consumed.
   Note that the amount of fuel consumption would be calculated by the Software if the user selected "Eq. 3.4.5" as a consumption calculation method
9. Column |U|: enter unit of the fuel consumption data entered (e.g. Gg, TJ). To enter a user-specific unit (e.g. BTUs) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-defined unit.
10. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ).
    Note that, where (Gg) of fuel are converted to (TJ), the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as a conversion factor; while if the consumption unit is (TJ) the Software compiles the conversion factor with the value 1. Where other units are applied (e.g. m³) the user shall enter the relevant conversion unit here.

When Tier 3 Equation [CH_4 & N_2O] is applied:

For each subdivision in Column |S| data are entered in each row of a unique combination of fuel/locomotive type, in worksheet **CH_4 and N_2O Emissions – Tier 3**, as follows:

1. Column |LT|: enter locomotive type (e.g. railcars, yard locomotive, etc.).
2. Column |F|: select fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager
3. Column |N|: enter number of locomotives.
4. Column |H|: enter annual average hours of operation for that locomotives type (h).
5. Column |P|: enter average rated power of that type of locomotive in (kW).
6. Column |LF|: enter typical load factor of that type of locomotive (fraction).

Example: **Tier 3 calculation worksheet**



Emission factor input

IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel carbon content, where the fuel carbon content is expressed in carbon units of mass per unit of energy (IPCC default values in Table 1.3 are in kg/GJ).

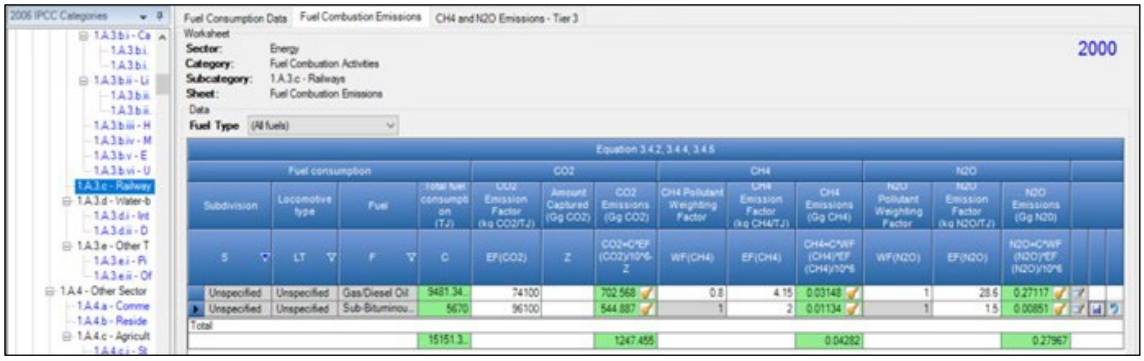
IPCC default EFs are provided in Table 3.4.1, and pollutant weighting factors in Table 3.4.2.

When Tier 1 & Tier 2 Equations are applied:

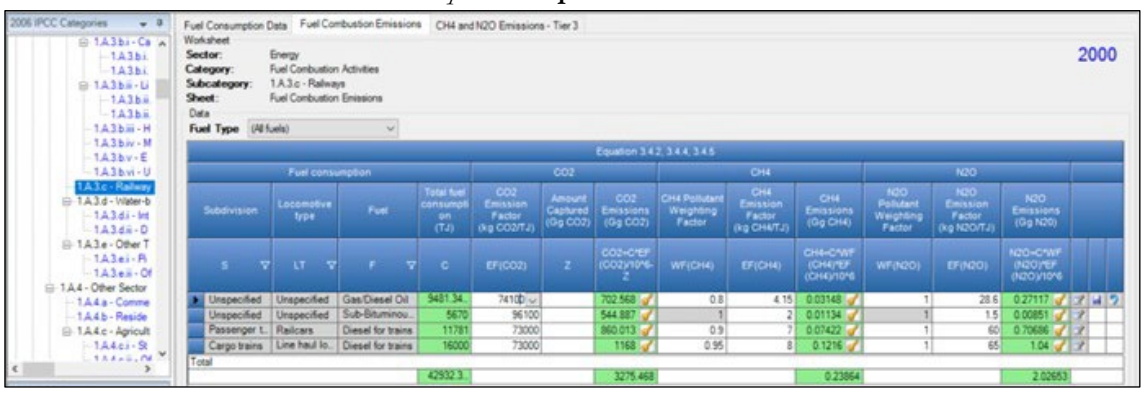
The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/locomotive type/fuel combinations entered in the **Fuel Consumption Data** worksheet. Then, for each row:

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value or, for user-specific fuels, the value calculated by the *Software* as the CC multiplied by 44/12; otherwise enter a user-specific value, in kg of CO_2 per TJ.
2. Column |WF(CH_4)|: select from the drop-down menu the IPCC default value or enter the user-specific value for CH_4 Pollutant Weighting Factor, based on the engine type. For more information on the pollutant weighting factors, see Section 3.4.1.2 of the *2006 IPCC Guidelines*.
3. Column |EF(CH_4)|: select from the drop-down menu the IPCC default value for the given fuel or enter a user-specific value, in kg of CH_4 per TJ.
4. Column |WF(N_2O)|: select from the drop-down menu the IPCC default value or enter the user-specific value for N_2O Pollutant Weighting Factor, based on the engine type. For more information on the pollutant weighting factors, see Section 3.4.1.2 of the *2006 IPCC Guidelines*.
5. Column |EF(N_2O)|: select from the drop-down menu the IPCC default value for the given fuel or enter a user-specific value, in kg of N_2O per TJ.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



When Tier 3 Equation [CH_4 & N_2O] is applied:

In worksheet **CH_4 and N_2O Emissions – Tier 3**, for each GHG for each row:

1. Column |EF(CH_4)|: enter a value for CH_4 EF, in kg/kWh.
2. Column |EF(N_2O)|: enter a value for N_2O EF, in kg/kWh.

Results

Then, for Tier 1 and Tier 2, in worksheet **Fuel Combustion Emissions**, for each GHG, emissions are calculated by the *Software* in mass unit (Gg).

While, for Tier 3, in worksheet **CH_4 and N_2O Emissions – Tier 3**, for CH_4 and N_2O only, emissions are calculated by the *Software* in mass unit (Gg).

For each GHG, total emission from railway transport is the sum of all emissions from combustion of all fuels by all locomotive types listed in all subdivisions reported in worksheets **Fuel Combustion Emissions** and **CH_4 and N_2O Emissions – Tier 3**.

GHGs

Mobile combustion source categories in water-borne navigation emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 3.5.1
2. Tier 2: IPCC Tier 1 equations, although with user-specific EFs, stratified by fuel type and transportation modes (e.g. ocean-going ships or boats) with engine type (e.g. diesel)
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains for each subdivision/fuel/vessel+engine type the amount of fuel consumed, in the source category, for each fuel.
- ✓ **Fuel Combustion Emissions**: contains for each subdivision/fuel/vessel+engine type the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

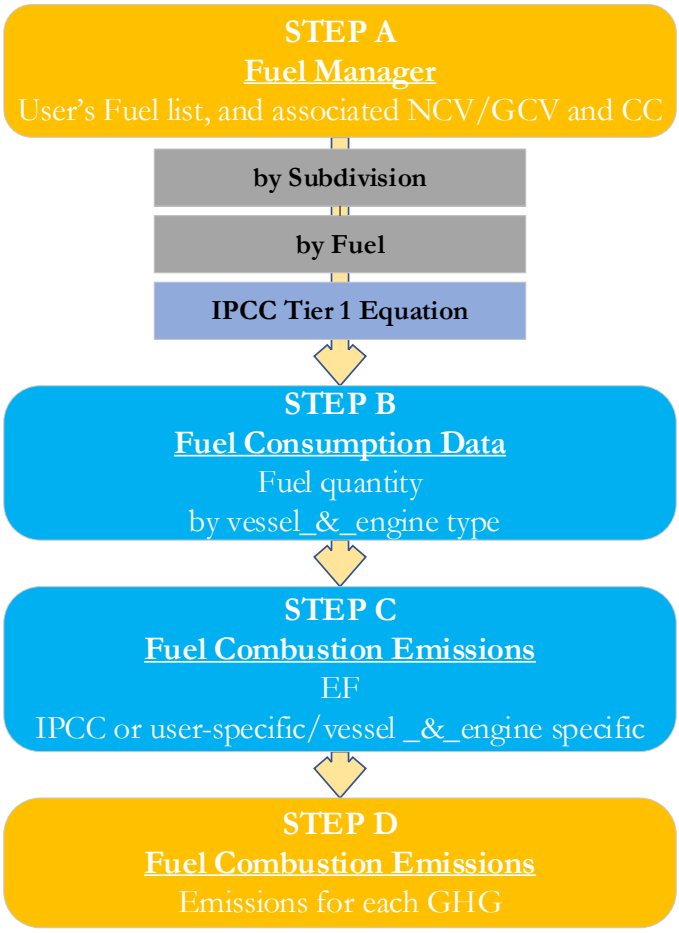
Data compilation of each of 1.A.3.d subcategories is operated independently, following for each subcategory the entire set of instructions below.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.5.1, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[28] and/or vessel+engine-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:

Mobile combustion - Water-borne navigation - flowchart



Thus, for the relevant source-category:

Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

Step B, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel for each vessel[29]+engine combination[30].

Step C, worksheet **Fuel Combustion Emissions**, users collect and enter in each row associated EFs for each GHG.

Step D, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[28] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.
[29] e.g. ocean-going ships, bulk carriers, boats.
[30] e.g. diesel, slow speed, two stroke.

Activity data input

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and use energy statistics data. Section 3.5.1.3 describes how to disaggregate AD between domestic water-borne navigation (described as journeys that arrive and depart in the same country) and international water-borne navigation (journeys departing from one country and arriving in another), since emissions from domestic and international water-borne navigation are reported separately.

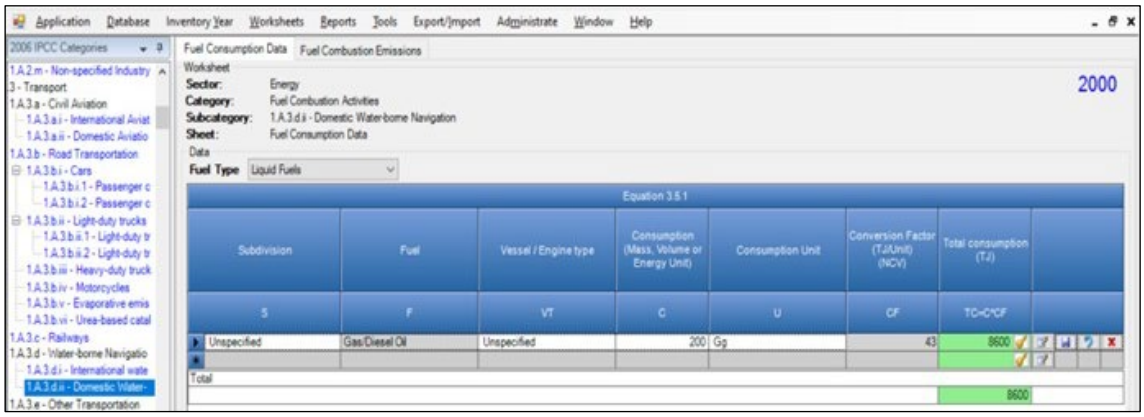
Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the **Fuel Consumption Data** worksheet, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter a user-defined conversion factor (TJ/unit).

Thus, for the relevant source-category:

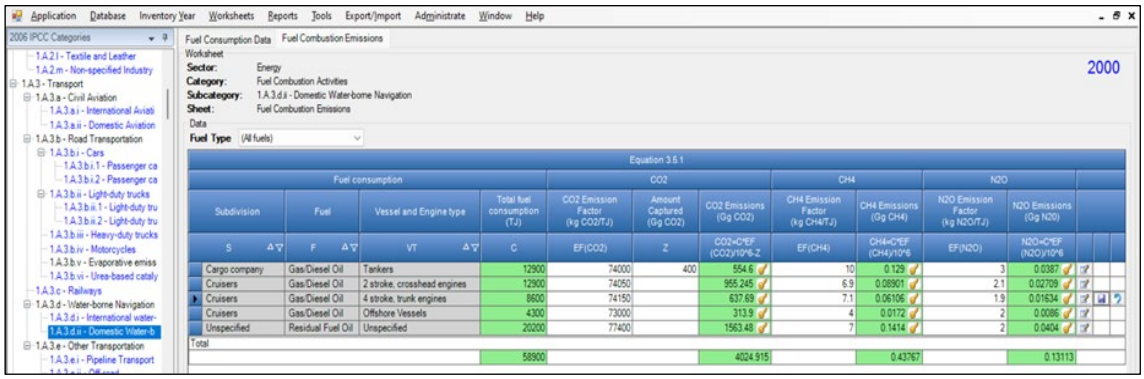
As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the worksheet **Fuel Consumption Data** either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Then, for each subdivision in Column |S| data are entered in worksheet **Fuel Consumption Data** row by row as follows:

1. Column |F|: select each fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager.
   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
2. Column |VT|: enter data on the vessel type (e.g. ocean-going ships, bulk carriers, boats) and, if known, the engine type (e.g. diesel, two stroke, etc.). The *Software* combines information on vessel and engine type in a single column. If this information is unknown, select *Unspecified* as per Tier 1.
3. Column |C|: enter amount of fuel consumed.
4. Column |U|: enter unit of fuel consumption data (e.g. Gg, TJ, m^3). To enter a user-specific unit (e.g. m^3) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-specific unit.
5. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ)
   Note that, where (Gg) of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as the conversion factor; while if the consumption unit is TJ the Software compiles the conversion factor with the value 1. Where other units are applied (e.g. BTU) the user shall enter the relevant conversion unit here.

Emission factor input

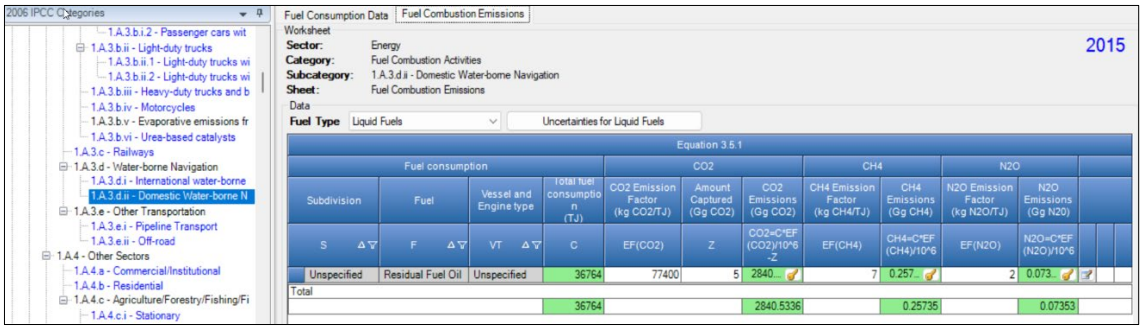
IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel C content, where the fuel C content is expressed in C units of mass per unit of energy (IPCC default values in Table 1.3 are in kg C/GJ).

IPCC default values for EFs are provided in Table 3.5.2, for CO_2, and in Table 3.5.3, for CH_4 and N_2O, in kg/TJ.

The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel/vessel+engine type combinations entered in worksheet **Fuel Consumption Data**. Then:

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value or, for user-specific fuels, the value calculated by the *Software* as the CC multiplied by 44/12; otherwise enter the vessel+engine type-specific value, in kg of CO_2 per TJ.
2. Column |EF(CH_4)|: select from the drop-down menu the IPCC default value for the given fuel or enter the vessel+engine type-specific value, in kg CH_4/TJ.
3. Column |EF(N_2O)|: select from the drop-down menu the IPCC default value for the given fuel or enter the vessel+engine type-specific value. value, in kg N_2O/TJ.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**

Results

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data and total emission from international or domestic water-borne navigation is the sum of all emissions from combustion of all fuels by all vessel types listed in all subdivisions reported in worksheets **Fuel Combustion Emissions**.

Information

Emissions of each GHG from pipeline transport are calculated by multiplying fuel consumption (AD) by the corresponding EF.

GHGs

Pipeline transport source emits the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

Given that there are no specific equations in the *2006 IPCC Guidelines* for this category, GHG emissions from mobile combustion in the pipeline transport source category are estimated in the *Software* by applying the following IPCC equations provided for road transportation, although no stratification[31] by equipment type is provided:

1. Tie 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*
2. Tier 2: IPCC Tier 1 equations 3.2.1 for CO_2 emissions and 3.2.3 for CH_4 and N_2O emissions (taken from road transportation), although with user-specific EFs
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains for each subdivision/fuel the amount of fuel consumed, in the source category, for each fuel.
- ✓ **Fuel Combustion Emissions**: contains for each subdivision/fuel the relevant CO_2, CH_4 and N_2O EFs, the CO_2 captured, if any, and calculates associated GHG emissions.

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

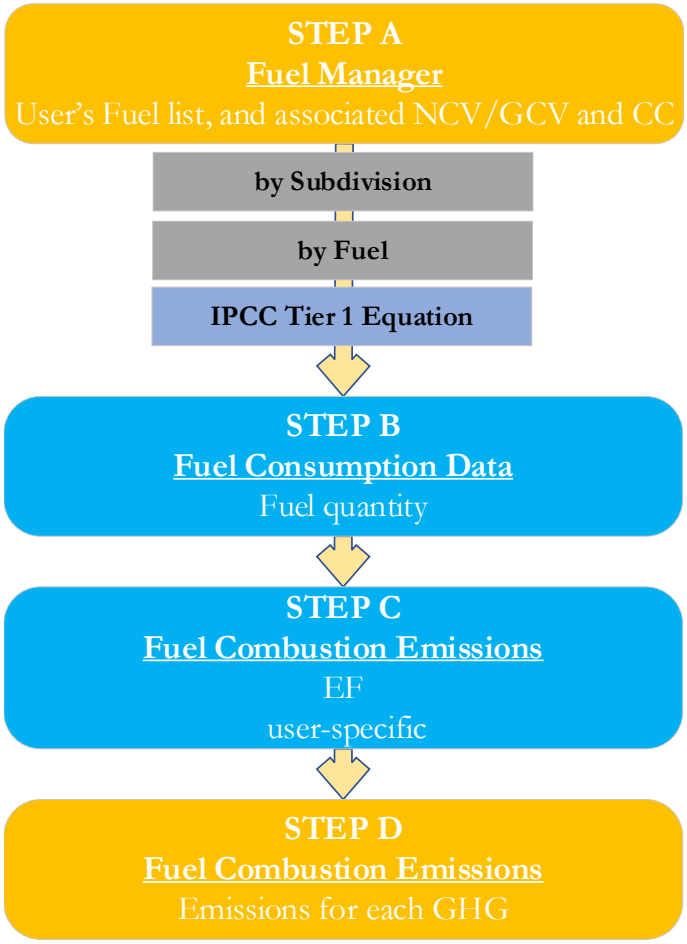
[31] Such stratification can be implemented through the coding of the subdivision name.

User's work Flowchart

GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[32] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:

Mobile combustion - Pipeline transport - flowchart



Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

Step B, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel.

Step C, worksheet **Fuel Combustion Emissions**, for each subdivision/fuel users collect and enter associated EFs for each GHG.

Step D, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which data are collected.

[32] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and apply energy statistics data.

Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the calculation worksheets, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter a user-defined conversion factor (TJ/unit).

As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|.

For each subdivision in Column |S| data are entered in worksheet **Fuel Consumption Data**, row by row, as follows:

1. Column |C|: enter amount of fuel consumed.

   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.

2. Column |U|: enter unit of fuel consumption data (e.g. Gg, TJ, m^3). To enter a user-specific unit (e.g. m^3) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-specific unit.

3. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ).

   Note that, where (Gg) of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as conversion factor; while if the consumption unit is TJ the Software compiles the conversion factor with the value 1. Where other units are applied (e.g. BTU) the user shall enter the relevant conversion unit here.

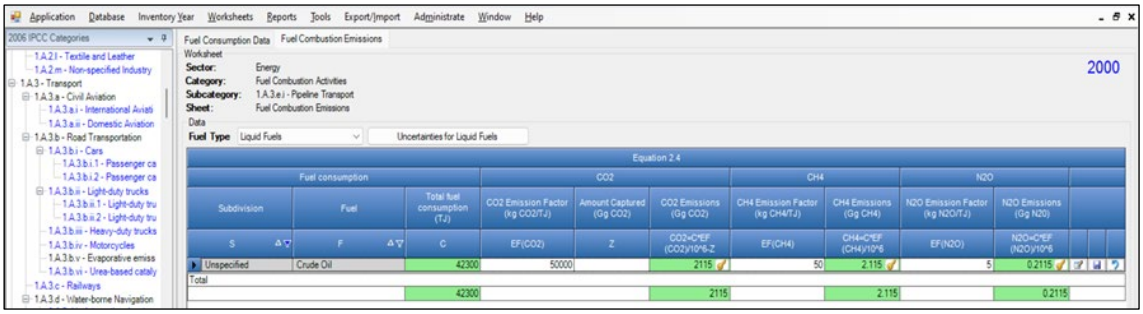
Emission factor input

IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel C content, where the fuel C content is expressed in C units of mass per unit of energy (IPCC default values in Table 1.3 are in kg C/GJ).

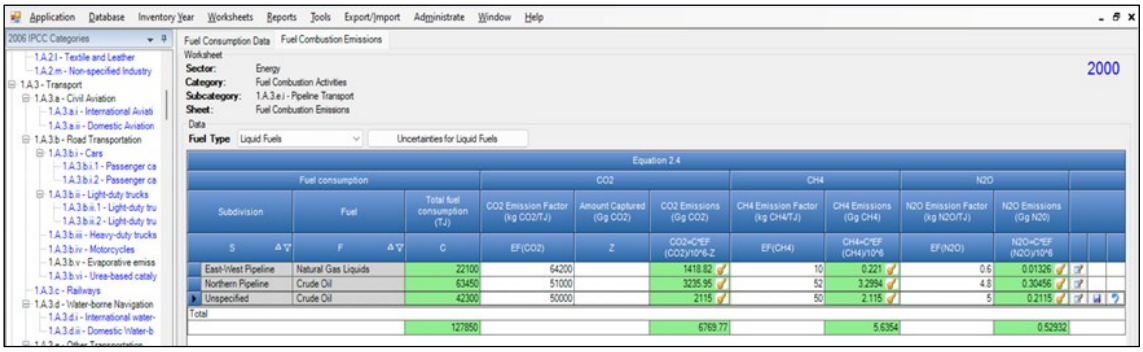
The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel combinations entered in worksheet **Fuel Consumption Data**. Then:

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value or, for user-specific fuels, the value calculated by the Software as the CC multiplied by 44/12; otherwise enter the user-specific value, in kg of CO_2 per TJ.
2. Column |EF(CH_4)|: enter the user-specific value, in kg CH_4/TJ.
4. Column |EF(N_2O)|: enter the user-specific value, in kg N_2O/TJ.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 produced across the process from that fuel used by that technology in that subdivision that has been captured instead of emitted into the atmosphere is to be entered in Gg CO_2 in Column |Z| of **Fuel Combustion Emissions** worksheet.

*Note that Column |Z| is accessed in worksheet **Fuel Combustion Emissions** by clicking the symbol "⊞" on the left of the row (a drop-down table opens and Column |Z| becomes visible:*

Then, for each GHG, emissions from each source are calculated by the *Software*, in mass unit (Gg). Total emission from pipeline transport is the sum of all emissions from combustion of all fuels listed in all subdivisions reported in worksheet **Fuel Combustion Emissions**.

Off-road transportation emissions are also estimated and reported in IPCC categories: *1.A.4.c.ii – Off-road vehicles and other machinery*; *1.A.5b.iii – Mobile (other)*.

GHGs

Mobile combustion sources in off-road transport emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 3.3.1
2. Tier 2: IPCC Tier 2 Equation 3.3.2
3. Tier 3: IPCC Tier 3 Equation 3.3.3

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets **Fuel Consumption Data** and **Fuel Combustion Emissions**, for Tier 1 and Tier 2, and using worksheet **Fuel Combustion Emissions – Tier 3** for Tier 3. In particular:

- ✓ **Fuel Manager**: contains information on *carbon content* and *calorific value* of each fuel type used in the NGHGI.
- ✓ **Fuel Consumption Data**: contains for each subdivision/fuel/vehicle/equipment type the amount of fuel consumed.
- ✓ **Fuel Combustion Emissions**: contains for each subdivision/fuel/vehicle/equipment type the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.
- ✓ **Fuel Combustion Emissions – Tier 3:** contains for each subdivision/fuel/vehicle/equipment type, the number of vehicles/equipment, annual average hours of use, rated power and load factor of vehicle/equipment and calculates associated GHG emissions.

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

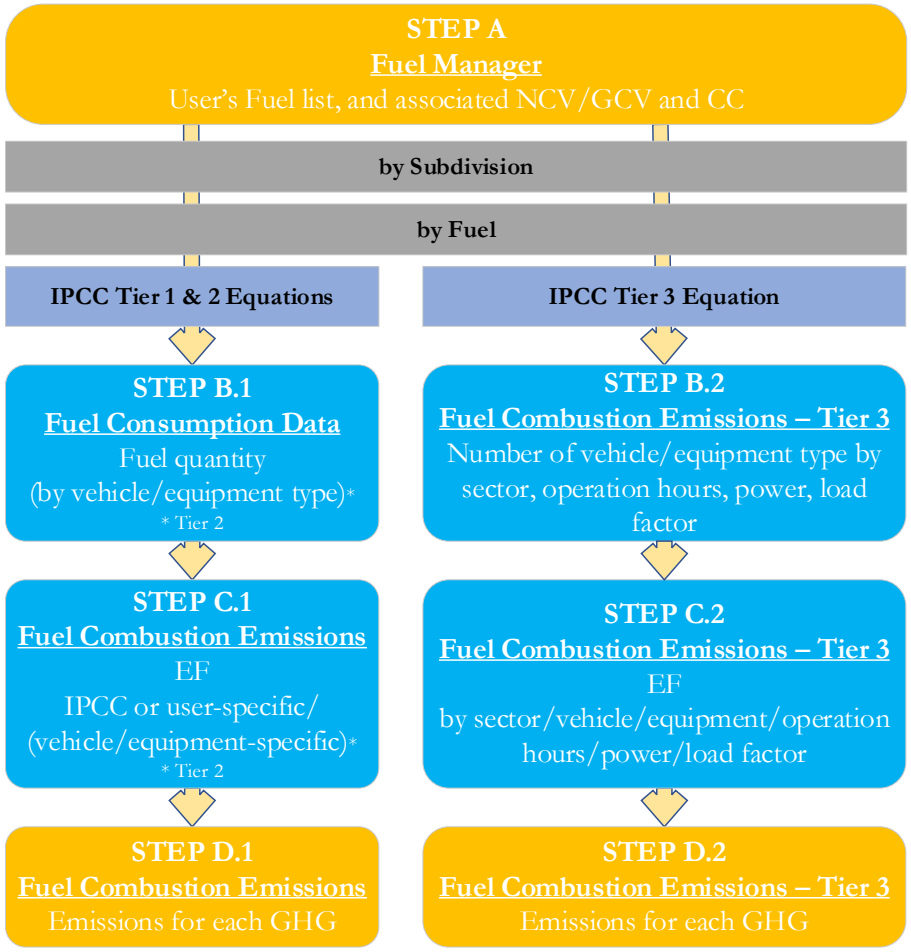
Data compilation of each of subcategories 1.A.3.e.ii, 1.A.4.c.ii, and 1.A.5.b.iii is operated independently, following for each category the entire set of instructions below.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.3.1, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[33] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse the users apply steps described in the following flowchart:

Mobile combustion - Off-road transport - flowchart



Thus, for the relevant source-category:

Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

When Tier 1 & Tier 2 Equations are applied:

Step B.1, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel, for each subdivision/vehicle or equipment type combination.

Step C.1, worksheet **Fuel Combustion Emissions**, for each subdivision/vehicle or equipment type/fuel users collect and enter associated EFs for each GHG.

Step D.1, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

While for Tier 3 Equation:

Step B.2, worksheet **Fuel Combustion Emissions – Tier 3**, for each subdivision/vehicle or equipment type users collect and enter data on fuel used, number of vehicle or equipment type, annual hours of use, average rated power, typical load factors.

Step C.2, worksheet **Fuel Combustion Emissions – Tier 3**, for each subdivision/ vehicle or equipment type/fuel users collect and enter EFs for each GHG.

[33] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Step D.2, worksheet **Fuel Combustion Emissions – Tier 3**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.c

Where data are available, CO_2 capture can be reported in **Fuel Combustion Emissions** and **Fuel Combustion Emissions – Tier 3** worksheets. CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

Activity data input

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to find and apply energy statistics data. Specific guidance on collecting AD for off-road transport may be found in Section 3.3.1.3.

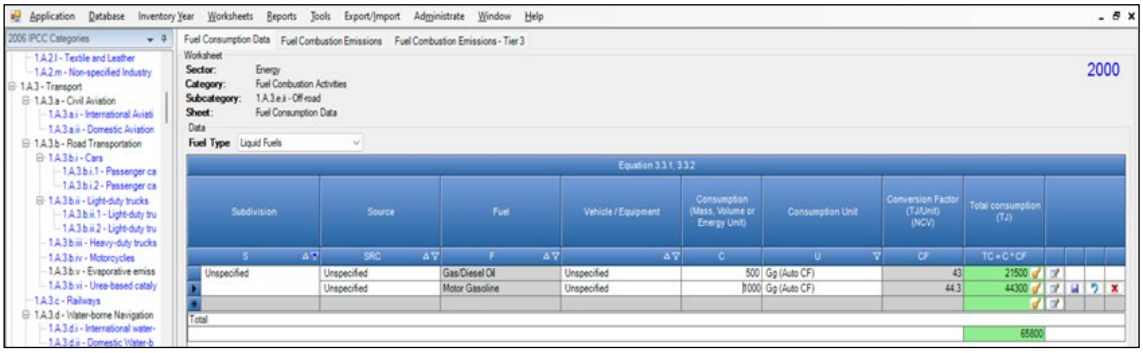
Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2). Other units may be entered into the calculation worksheets, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter user-defined conversion factor (TJ/unit).

Thus, for the relevant source-category:

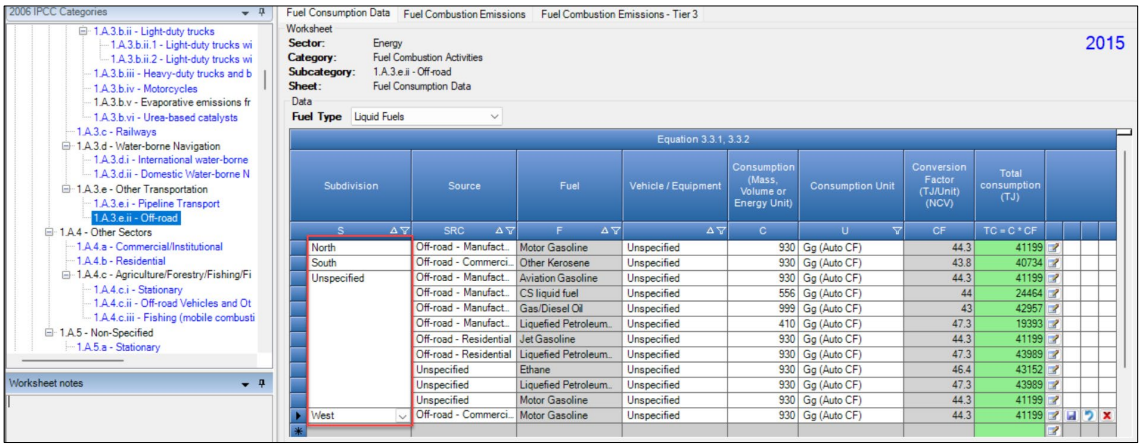
As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* (either *NCV* or *GCV*) and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



When Tier 1 & Tier 2 Equations are applied:

For each subdivision in Column |S|, data are entered in worksheet **Fuel Consumption Data** row by row as follows:

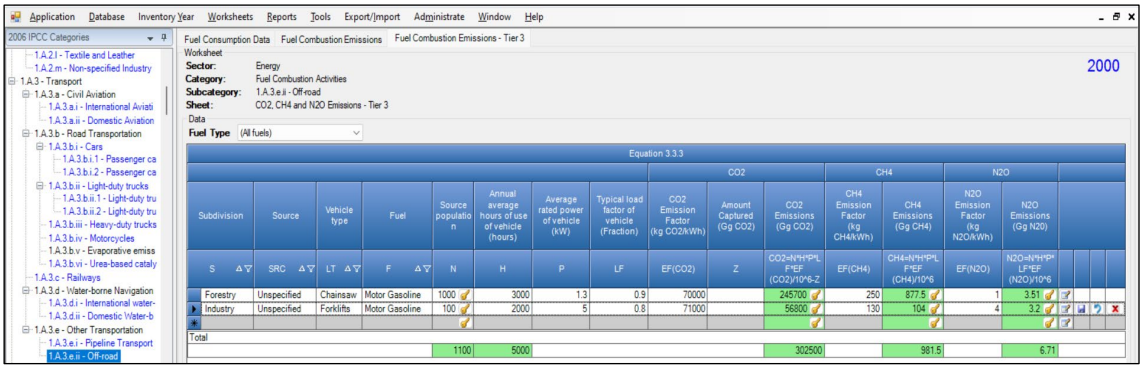
1. Column |SRC|: select from the drop-down menu the reporting category in UNFCCC CRTs. In case the *Software* is not used for reporting under the UNFCCC, users may select *Unspecified* from the drop-down menu.
   Note that this step is relevant for IPCC category 1.A.3.e.ii - Off-road transportation only[34].
2. Column |F|: select fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager
3. Column |VE|: users collect and enter data on vehicle and equipment types (e.g. tractors, snowmobiles, compression-ignition engines, 2-stroke engines, etc.).
4. Column |C|: enter amount of fuel consumed.
5. Column |U|: enter unit of the fuel consumption data entered (e.g. Gg, TJ). To enter a user-specific unit (e.g. BTU's) select *Gg (Manual CF)* from the dropdown menu and overwrite *Gg* with the user-defined unit.
6. Column |CF|: enter conversion factor to convert the consumption unit to an energy unit (TJ)
   Note that, where (Gg) of fuel are converted to (TJ), the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as a conversion factor; while if the consumption unit is (TJ) the Software compiles the conversion factor with the value 1. Where other units are applied (e.g. m³) the user shall enter relevant conversion unit here.

[34] It does not apply to the other 2 IPCC categories that contains calculation worksheets for off-road transportation.

When Tier 3 Equation is applied:

1. Column |SRC|: select from the drop-down menu the reporting category in UNFCCC CRTs. In case the *Software* is not used for reporting under the UNFCCC, users may select *Unspecified* from the drop-down menu.
   Note that this step is relevant for IPCC category 1.A.3.e.ii - Off-road transportation only[35].
2. Column |VE|: users collect and enter data on vehicle and equipment types (e.g. tractors, snowmobiles, compression-ignition engines, 2-stroke engines, etc.);
3. Column |F|: select fuel used from the drop-down menu (one row for each fuel).
   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager
4. Column |N|: enter number of vehicles or equipment types.
5. Column |H|: enter annual average hours of operation per vehicle or equipment type.
6. Column |P|: enter average rated power per vehicle or equipment type, in kW.
7. Column |LF|: enter typical load factor of vehicle or equipment type (fraction).

Example: **Tier 3 calculation worksheet**



Emission factor input

IPCC default EFs for CO_2 are calculated assuming 100% oxidation to CO_2 of fuel carbon content, where the fuel C content is expressed in C units of mass per unit of energy (IPCC default values in Table 1.3 are in kg/GJ).

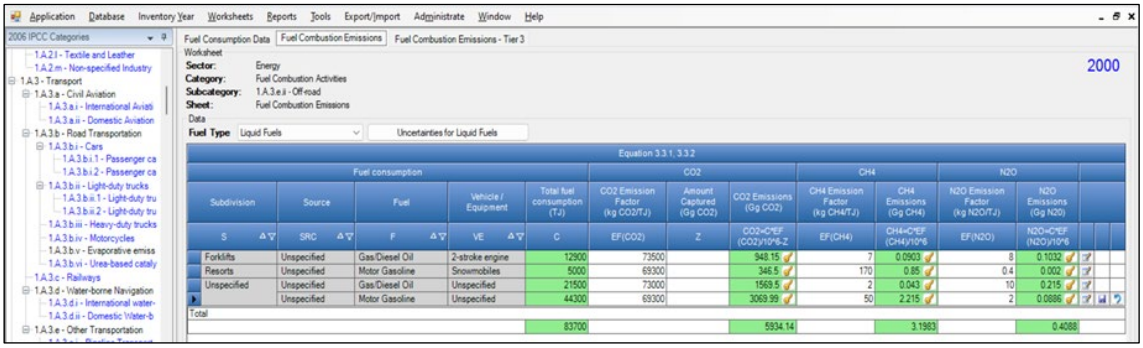
IPCC default EFs are provided in Table 3.3.1.

When Tier 1 & Tier 2 Equations are applied:

The **Fuel Combustion Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/fuel/vehicle or equipment type combinations entered in the **Fuel Consumption Data** worksheet. Then, for each row:

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value or, for user-specific fuels, the value calculated by the *Software* as the CC multiplied by 44/12; otherwise enter a user-specific value, in kg of CO_2/TJ.
2. Column |EF(CH_4)|: select from the drop-down menu the IPCC default EF values for the given fuel and sector in which the off-road source is used (e.g. agriculture or household) or enter it, in kg of CH_4/TJ.
3. Column |EF(N_2O)|: select from the drop-down menu the IPCC default EF values for the given fuel and sector in which the off-road source is used or enter it, in kg of N_2O/TJ.
   Note that any combination of subdivision/fuel/vehicle/equipment is allowed, including singling out one or more specific technologies or sectors and reporting all remaining together under the notation "unspecified".

Example: **multiple subdivisions**



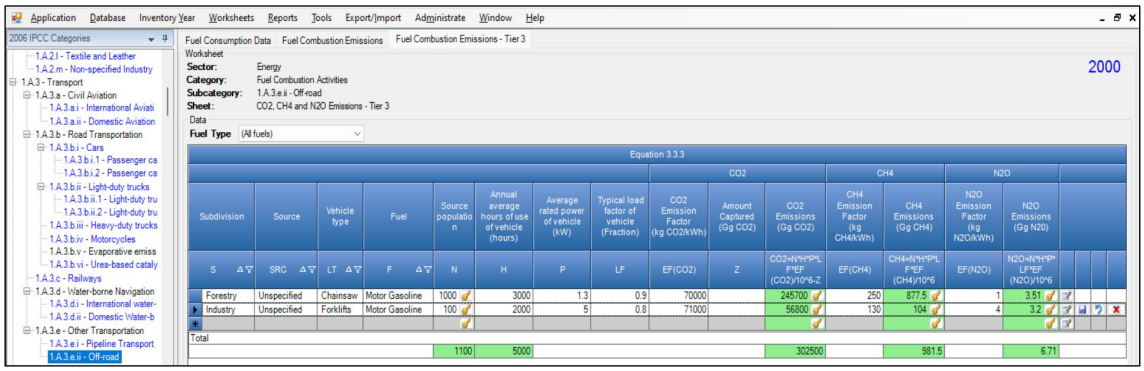
[35] It does not apply to the other 2 IPCC categories that contains calculation worksheets for off-road transportation.

When Tier 3 Equation [CO_2, CH_4 & N_2O] is applied:

In worksheet **Fuel Combustion Emissions – Tier 3**, for each row:

1. Column |EF(CO_2)|: enter EF for CO_2, in kg/kWh;
2. Column |EF(CH_4)|: enter EF for CH_4, in kg/kWh;
3. Column |EF(N_2O)|: enter EF for N_2O, in kg/kWh.

Example: **Tier 3 calculation**



Results

Then, for Tier 1 and Tier 2 in worksheet **Fuel Combustion Emissions** and for Tier 3 in worksheet **Fuel Combustion Emissions – Tier 3**, for each GHG, emissions are calculated by the *Software* in mass unit (Gg).

Thus, for each GHG, total emission from each off-road transportation source is the sum of all emissions from combustion of all fuels by all vehicle and equipment types listed in all subdivisions reported in worksheets **Fuel Combustion Emissions** and **Fuel Combustion Emissions – Tier 3**.

1.B - Fugitive emissions from fuels

Information

Fugitive emissions from fuels are released due to fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases. In general, emissions are calculated based on the amount of fuel produced, transported, stored, or distributed and the corresponding EF.

NGHGI Fugitive Emissions source categories are shown in **Table 1**.

1.B.1. Solid Fuels

Information

Hereafter, the use of the *Software* to estimate emissions associated with coal production is illustrated. The following sections are separated, as emissions from various activities/categories are estimated via different methods and correspondingly using different worksheets of the *Software*:

- ✓ **1.B.1.a.i Underground Mines** & **1.B.1.a.i.2 Post-mining** - calculates fugitive emissions during underground mining/post-mining operations.
- ✓ **1.B.1.a.i.3 Underground Abandoned Mines** - calculates fugitive emissions from abandoned underground mines.
- ✓ **1.B.1.a.i.4 - Flaring or Conversion of drained CH_4 to CO_2** - calculates emissions from methane drained and flared, or ventilation gas converted to CO_2 by an oxidation process.
- ✓ **1.B.1.a.ii Surface Mining** - calculates fugitive emissions during surface mining/post-mining operations.
- ✓ **1.B.1.b Uncontrolled combustion and burning coal dumps** - calculates emissions of CO_2 from uncontrolled combustion.
- ✓ **1.B.1.c.i Charcoal and Biochar production** – calculates fugitive emissions during the production of charcoal and biochar.
- ✓ **1.B.1.c.ii Coke production** – calculates fugitive emissions during the production of coke.
- ✓ **1.B.1.c.iv Gasification transformation** – calculates fugitive emissions from the transformation of biomass, coal or natural gas into syngas, composed by H_2, CO, CO_2 and CH_4, and, then, into liquid hydrocarbons fuels.

Fugitive emissions from underground mining arise from both ventilation and degasification systems. These emissions are normally emitted at a small number of centralised locations and can be considered as point sources. Those are amenable to standard measurement methods.

GHGs

Underground mining source categories consist of mining and post-mining activities and emit the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X					

IPCC Equations

CH_4 emissions from underground mining and post-mining source categories are estimated by applying the following IPCC equations:

1. Tier 1: IPCC Tier 1 Equations 4.1.3 (underground mining) and 4.1.4 (post mining)
2. Tier 2: Tier 1 equations, although with user-specific (e.g. basin-specific) EFs
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

CO_2 emissions from underground mining are estimated by applying the following IPCC equation from the *2019 Refinement:*

1. Tier 1: IPCC Tier 1 Equation 4.1.3A
2. Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

There are no equations for CO_2 emissions from post-mining in the *2006 IPCC Guidelines* or the *2019 Refinement*. A generic worksheet is provided to enable calculation of fugitive CO_2 emissions from post mining activities.

Software Worksheets

The *Software* calculates emissions of the two GHGs using worksheets:

- ✓ **Coal production from underground mines**: contains for each subdivision the production volumes.
- ✓ **Emissions from underground mines**: contains for each subdivision the CO_2 and CH_4 EFs and corresponding conversion factors, CO_2 captured and/or CH_4 recovered, and calculates associated GHG emissions.

In the upper part of worksheet **Emissions from underground mines**, users select the GHG for which to enter data.

Data compilation of each subcategory is operated following the entire set of instructions below.

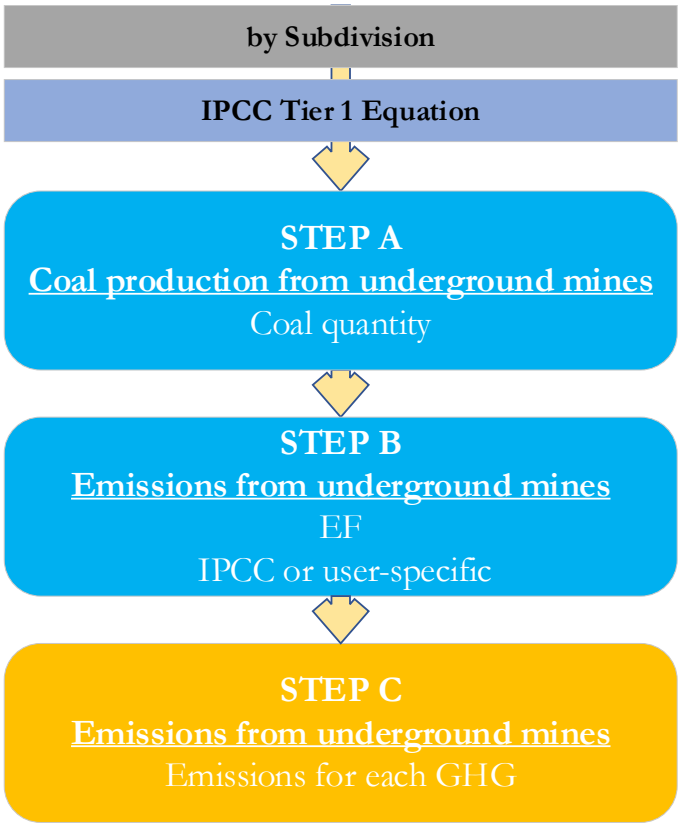
*Note that activity data input in worksheet **Coal production from underground mines** in one of the subcategories (1.B.1.a.i Underground Mines and 1.B.1.a.i.2 Post-mining) is automatically filled by the Software in the corresponding worksheet **Coal production from underground mines** in the other subcategory.*

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.1.1, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[36] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitive - Underground mining – flowchart



Thus, for the relevant source-category, for each subdivision, if any:

Step A, worksheet **Coal production from underground mines**, users collect and enter data on the amount of raw coal produced from underground coal mines.

Step B, worksheet **Emissions from underground mines**, users collect and enter in each row associated EFs for each GHG.

Step C, worksheet **Emissions from underground mines**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture and/or CH_4 recovery can be reported in **Emissions from underground mines** worksheet. The CO_2 captured and/or CH_4 recovered is entered at the level at which corresponding emissions are calculated.

[36] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2006 IPCC Guidelines*, Section 4.1.3.3, contain information on collecting AD for underground coal mines.

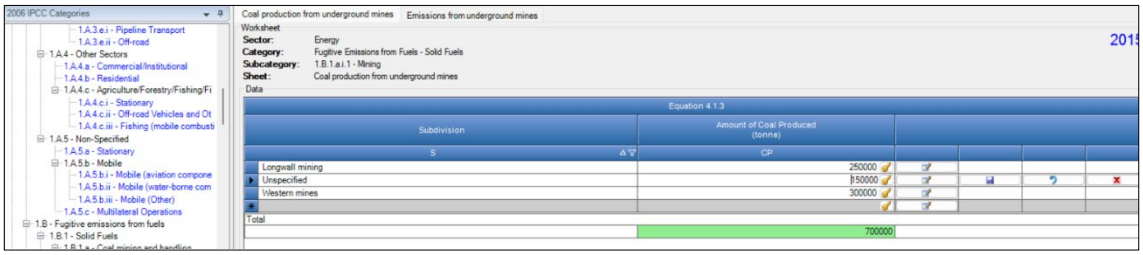
Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|.

Thus, for the relevant source-category:

For each subdivision in Column |S|, data are entered in worksheet **Coal production from underground mines**, row by row, as follows:

1. Column |CP|: enter annual amount of raw coal produced, in tonnes.
   Note that once a user adds underground coal production data into one of the two source categories (either mining or post-mining seam emissions), the coal production for each subdivision is automatically pre-filled in the other source category. A change to the AD in one source category will also change the AD in the other.

Examples: **multiple subdivisions**



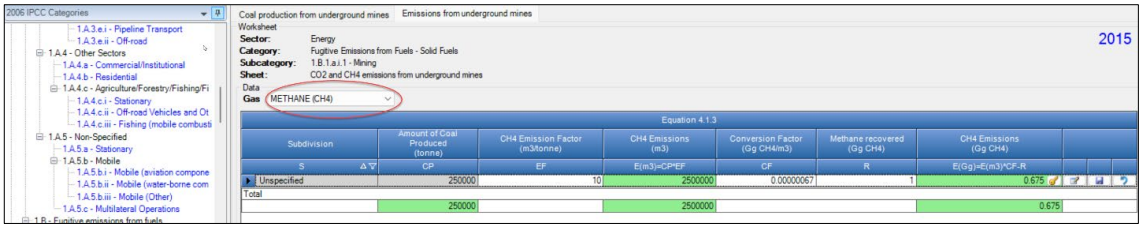
Emission factor input

IPCC default EFs are provided in Section 4.1.3.2 in m^3 per tonne of coal produced.

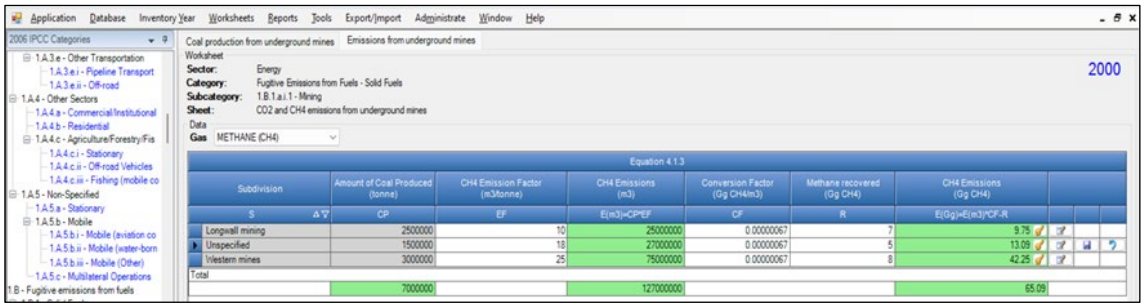
The **Emissions from underground mines** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of subdivisions entered in worksheet **Coal production from underground mines**. Then:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in m^3 per tonne of coal produced.
   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" in the "Gas" bar at the top, to enter data for each GHG one by one.
2. Column |CF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value. The Conversion Factors represent the density of the corresponding GHG, in Gg GHG per m^3 of gas emitted. The default density of CH_4, $0.67*10^{-6}$, is sourced from the *2006 IPCC Guidelines* while the default CO_2 density, $1.84*10^{-6}$, is sourced from the *2019 Refinement*.

Example: **single subdivision, CH_4**



Example: **multiple subdivisions, CH_4**



Results

To estimate the total CO_2 and total CH_4 emitted into the atmosphere, the amount of CO_2 and of CH_4 released from that subdivision that has been instead captured or recovered, respectively, are to be entered in Gg CO_2 in Column |Z| and/or Gg CH_4 in Column |R| of worksheet **Emissions from underground mines**.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions in each subcategory are reported in worksheet **Emissions from underground mines**.

This category estimates emissions from underground coal mines after extraction activities have been ended. Methodologies do not yet exist for abandoned or decommissioned surface mines, and therefore are not included in this chapter.

GHGs

Underground abandoned coal mines source category emits the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X					

IPCC Equations

CH_4 emissions from underground abandoned coal mines source category are estimated by applying the following IPCC equations:

1. Tier 1:IPCC Tier 1 Equations 4.1.9, 4.1.10
2. Tier 2: IPCC Tier 2 Equations 4.1.11, 4.1.12 country-/basin-specific approach
3. Tier 3: IPCC Tier 3 Equation 4.1.13 mine-specific approach

There are no equations for CO_2 emissions in the *2006 IPCC Guidelines*. A generic worksheet is thus provided to enable calculation of fugitive CO_2 emissions from Abandoned Underground Mines.

1. Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*.
2. Tier 2: IPCC basic equation with user-specific EF
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the two GHGs using worksheets.

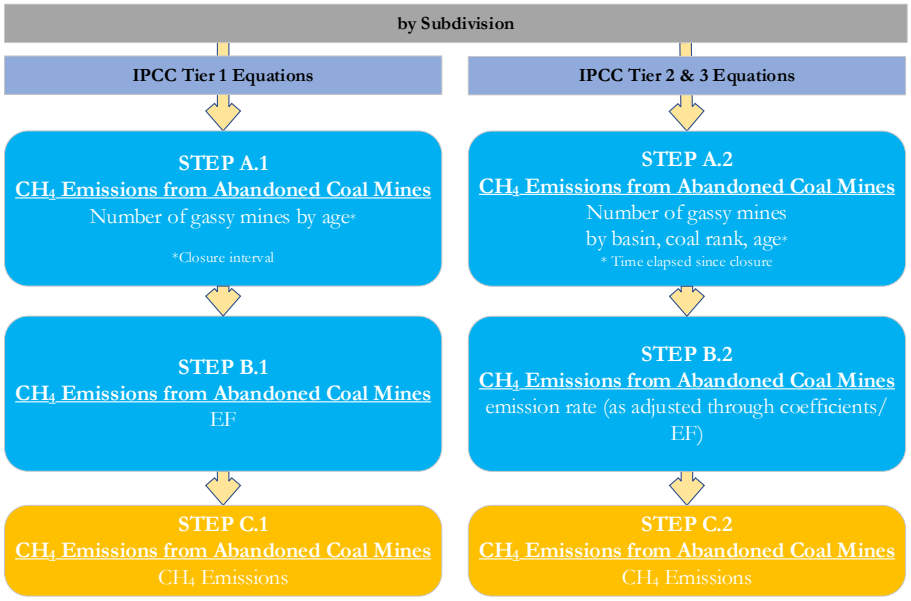
- ✓ **CH_4 Emissions from Abandoned Coal Mines:** calculates Tier 1 emissions for each subdivision based on closure interval, number of abandoned mines, fraction of gassy mines, emission and conversion factors and CH_4 recovered for each subdivision.
- ✓ **CH_4 Emissions from Abandoned Coal Mines – Tier 2 & 3:** calculates Tier 2 and Tier 3 emissions for each subdivision and region/basin based on coal rank, number of abandoned mines, fraction of gassy mines, average emission rate prior to abandonment, coefficients A & B, years elapsed since abandonment, emission and conversion factors and CH_4 recovered.
- ✓ **CO_2 Emissions from Abandoned Coal Mines:** calculates associated CO_2 emissions for each subdivision based on AD and EF entered.

User's work Flowchart

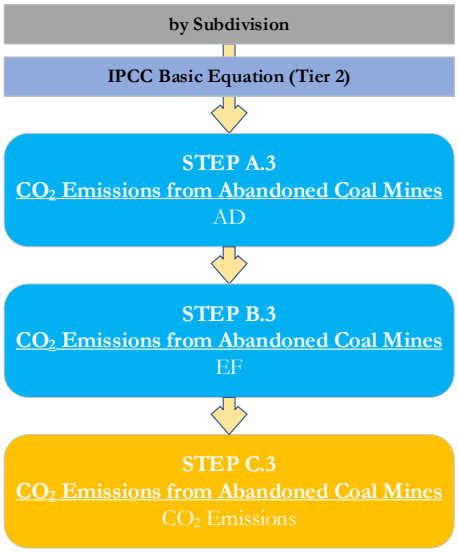
Consistent with the key category analysis and the decision tree in Figure 4.1.3, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[37] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitive - Abandoned underground coal mines - flowchart [CH_4 only]



Fugitive - Abandoned underground coal mines - flowchart [CO_2 only]



For each subdivision, if any:

When Tier 1 Equation is applied [CH_4 only]

Step A.1, in worksheet **CH_4 Emissions from Abandoned Coal Mines**, users collect and enter data on the closure interval, number of mines, fraction of gassy mines.

Step B.1, in worksheet **CH_4 Emissions from Abandoned Coal Mines**, users collect and enter in each row associated EFs.

Step C.1, in worksheet **CH_4 Emissions from Abandoned Coal Mines**, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

When Tier 2 & Tier 3 Equations are applied [CH_4 only]

Step A.2, in worksheet **CH_4 Emissions from Abandoned Coal Mines – Tier 2&3**, users collect and enter data on the region/basin, coal rank, number of mines, fraction of gassy mines.

[37] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Step B.2, in worksheet **CH_4 Emissions from Abandoned Coal Mines – Tier 2&3**, users collect and enter in each row associated average emission rate, coefficients A & B, years elapsed, emission and conversion factors.

Step C.2, in worksheet **CH_4 Emissions from Abandoned Coal Mines**, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

When IPCC Basic Equation applied [CO_2 only]

Step A.3, in worksheet **CO_2 Emissions from Abandoned Coal Mines**, users collect and enter data on the source and activity data.

Step B.3, in worksheet **CO_2 Emissions from Abandoned Coal Mines**, users collect and enter in each row the associated EF.

Step C.3, in worksheet **CO_2 Emissions from Abandoned Coal Mines**, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

Activity data input

The *2006 IPCC Guidelines*, Section 4.1.5.3, contain information on collecting AD for underground abandoned coal mines

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then:

When Tier 1 Equation is applied for CH_4 emissions:

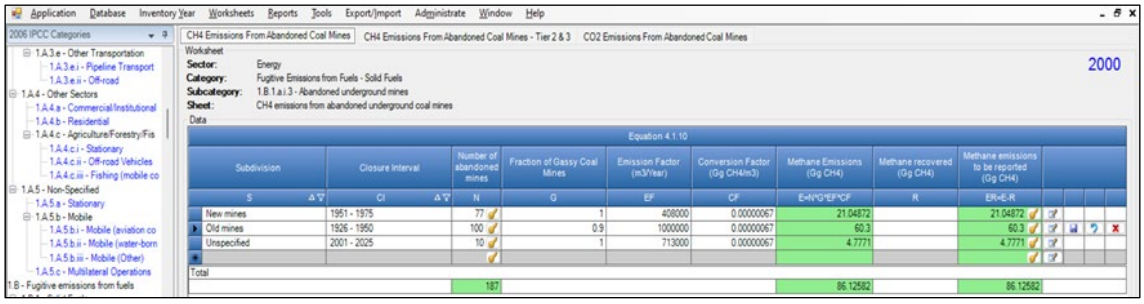
For each subdivision in Column |S|, data are entered in worksheet **CH_4 Emissions from Abandoned Coal Mines**, row by row, as follows:

1. Column |Cl|: select closure interval of mines (i.e. the period during which the mine was abandoned), or enter a user-specific value.

   Note that the closure intervals found in Table 4.1.6 of the 2006 IPCC Guidelines end in inventory year 2016. For inventory years after 2016, a country may consult Table 4.1.6 (Updated) of the 2019 Refinement. This table includes the time series for inventory year 1990 to 2050, with the information provided for all years between 1990 and 2016 the same as that in Table 4.1.6 of the 2006 IPCC Guidelines.

2. Column |N|: enter the number of abandoned mines remaining unflooded in that subdivision during that time interval. If no information is available on the flooded status, assume 100% remain unflooded.
3. Column |G|: enter the fraction of gassy coal mines among those abandoned. IPCC default values can be found in Table 4.1.5 of the *2006 IPCC Guidelines*.

Example: **multiple subdivisions – Tier 1**



When Tier 2&3 Equations are applied for CH_4 emissions:

For each subdivision in Column |S|, data are entered in worksheet **CH_4 Emissions from Abandoned Coal Mines – Tier 2 & 3**, row by row, as follows:

Note that for Tier 3, all information below shall be mine-specific:

1. Column |CR|: select coal rank.
2. Column |N|: enter the number of abandoned mines remaining unflooded in that subdivision during that time interval. If no information is available on the flooded status, assume 100% remain unflooded.
3. Column |G|: enter the fraction of gassy coal mines.

To estimate CO_2 emissions:

For each subdivision in Column |S| and source Column |SRC|, data are entered in worksheet **CO_2 Emissions from Abandoned Coal Mines**, row by row, as follows:

1. Column |AD|: enter the activity value.
2. Column |U|: specify measurement unit for the activity.

Emission factor input

IPCC default emission factors for the designated time intervals of mine closure are provided in Table 4.1.6.

IPCC default active mine emissions prior to abandonment are provided in Table 4.1.8, in million m^3 per year, and default coefficients are provided in Table 4.1.9.

When Tier 1 Equation is applied for CH_4 emissions:

For each row of data entered in worksheet **CH_4 Emissions from Abandoned Coal Mines**, data are entered row by row, as follows:

1. Column |EF|: CH_4 EF in million m^3/year is automatically populated by the *Software* based on the closure interval selected. Users can retain that value, or enter a user-specific value.
2. Column |CF|: conversion factor (density of CH_4 $6.7*10^{-7}$) in Gg CH_4/m^3 is automatically populated by the *Software*.

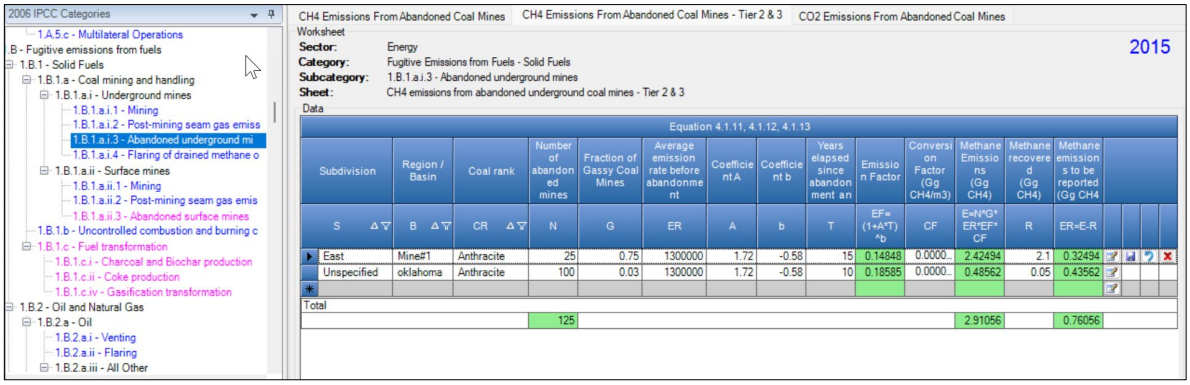
When Tier 2&3 Equations are applied for CH_4 emissions:

For each row of data entered in worksheet **CH_4 Emissions from Abandoned Coal Mines – Tier 2 & 3**, data are entered as follows:

1. Column |ER|: enter the average emission rate before abandonment in million m^3/year.
2. Column |A|: enter value of coefficient A.
3. Column |b|: enter value of coefficient b.

   Note that default coefficients "A" and "b" are automatically populated when a coal rank for anthracite, bituminous or sub-bituminous is selected. These default values can be retained for the Tier 2 method, or a user-specific (e.g. basin-specific) value is entered. Mine-specific information are entered for Tier 3.
4. Column |T|: enter number of years elapsed since abandonment and the inventory year.
5. Column |EF|: the *Software* calculates the EF based on Equation 4.1.12.
6. Column |CF|: conversion factor (density of methane $6.7*10^{-7}$) in Gg CH_4/m^3 is automatically populated by the *Software*.

Example: **multiple subdivisions – Tier 2 & 3**

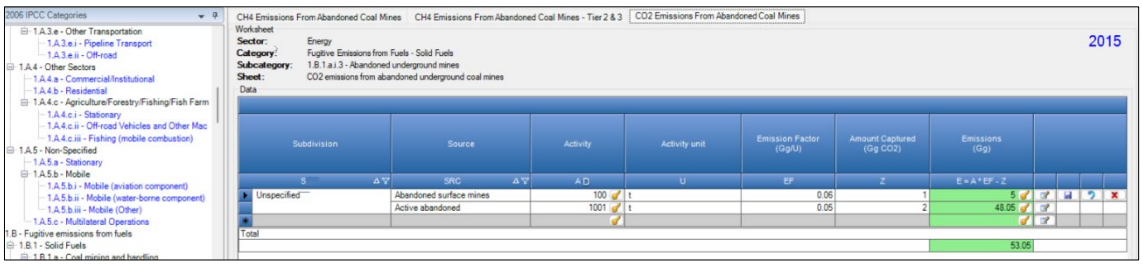


To estimate CO_2 emissions:

For each row of data entered in worksheet **CO_2 Emissions from Abandoned Coal Mines**, data are entered row by row, as follows:

1. Column |EF|: enter the user-specific value, in Gg CO_2/U, with U being the measurement unit entered in Column|U|.

Example: **single subdivision – CO_2**



Results

Then, for Tier 1 in worksheet **CH_4 Emissions from Abandoned Coal Mines** and for Tier 2 and Tier 3 in worksheet **CH_4 Emissions from Abandoned Coal Mines – Tier 2 & 3**, CH_4 emissions are calculated by the *Software* in mass unit (Gg). While in worksheet for **CO_2 Emissions from Abandoned Coal Mines**, CO_2 emissions are calculated by the *Software* in mass unit (Gg). When the users apply a hybrid of tiers, total emissions from the source category of abandoned coal mines are those included in all three worksheets.

1.B.1.a.i.4 Flaring of drained methane or conversion of methane to CO_2

When the methane is simply combusted in active or abandoned mines with no energy recovery, as in flaring or catalytic oxidation to CO_2, the corresponding CO_2 production shall be added to the total GHG emissions from coal mining activities. During flaring and oxidation, not all CH_4 is converted to CO_2; unburned methane is also included in total GHG emissions.

GHGs

Flaring of drained methane or conversion of methane to CO_2 emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X					

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 4.1.5.
2. Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs.
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the two GHGs using worksheet:

- ✓ **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized**: calculates emissions for each subdivision based on the volume of combusted methane, a CH_4 or CO_2 conversion factor, combustion efficiency factor and stochiometric mass factor.

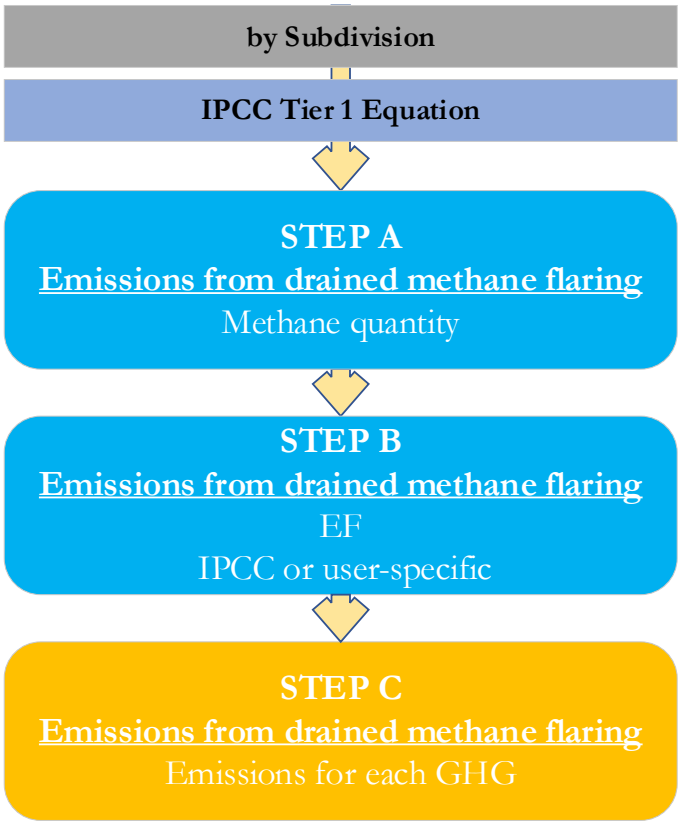
In the upper part of **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized** worksheet, users select the GHG for which to enter data.

User's work Flowchart

GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[38] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Drained methane flaring - flowchart



For each subdivision, if any:

Step A, worksheet **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized**, users collect and enter data on the volume of combusted methane.

Step B, worksheet **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized**, users collect and enter in each row, for each GHG, associated conversion factor, combustion efficiency factor and stochiometric mass factor.

Step C, worksheet **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Activity data input

The *2006 IPCC Guidelines*, Section 4.1.3.3, contain information on collecting AD for flaring of drained methane or conversion of methane to CO_2.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then:

For each subdivision in Column |S|, data are entered in worksheet **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized**, row by row, as follows:

1. Column |C| enter volume of methane combusted, in m^3.

[38] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Emission factor input

IPCC default EFs are provided in Section 4.1.3.2 in m^3 per tonne of coal produced.

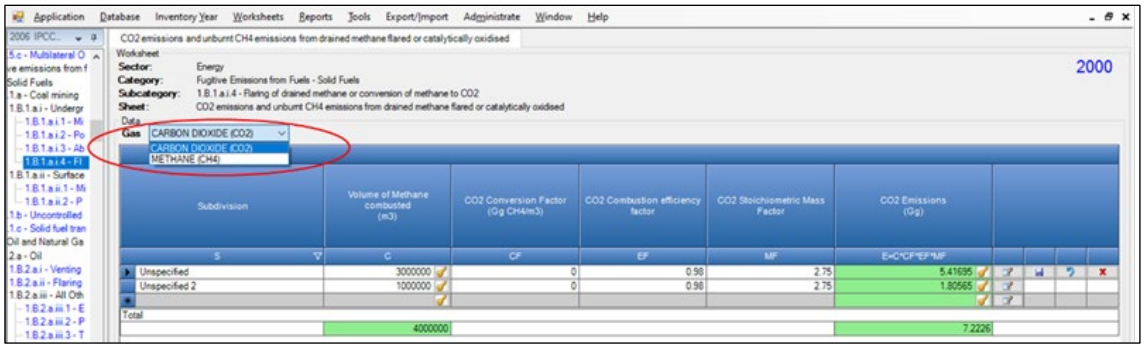
For each row of data entered in worksheet **CO_2 emissions and unburnt CH_4 emissions from drained methane flared** or **catalytically oxidized**, data are entered as follows:

1. Column |CF|: the CH_4 and CO_2 conversion factors, in Gg GHG/m^3 are automatically populated by the *Software*. Users can retain these values, or enter user-specific values.
2. Column |CE|: the CH_4 and CO_2 combustion efficiency factors are automatically populated by the *Software*. Users can retain these values, or enter user-specific values.

   Note that 0.98 represents the default combustion efficiency of natural gas that is flared. Country or basin-specific information may be input here.
3. Column |MF|:
   - ✓ for CO_2, the stochiometric mass factor, which is the mass ratio of CO_2 produced from full combustion of unit mass of methane is equal to 2.75.
   - ✓ for CH_4, the stochiometric mass factor is set automatically to "1", and shall not be changed given it refers to the unburnt fraction.

Note that user needs to select the corresponding GHG from the "Gas" tab as shown on the screenshot below.

Example: **multiple subdivisions**



Results

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions in each subcategory are reported in worksheet **CO_2 emissions and unburnt CH_4 emissions from drained methane flared or catalytically oxidized**.

1.B.1.a.ii Surface Mines (1.B.1.a.ii.1 Mining & 1.B.1.a.ii.2 Post-mining seam gas emissions)

These categories include all seam gas emissions arising from mining and post-mining activities at surface mines.

This section covers emissions in active surface mines, as per IPCC categories 1.B.1.a.ii.1 and 1.B.1.a.ii.2, while the next section covers emissions from abandoned surface mines.

GHGs

Surface mining source categories consist of surface mining and post-mining activities and emit the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X					

IPCC Equations

CH_4 emissions from surface mining and post-mining source categories are estimated by applying the following IPCC equations:

1. Tier 1: Equations 4.1.7 (surface mining) and 4.1.8 (post-mining)
2. Tier 2: Tier 1 equations, although with user-specific (e.g. basin-specific) EFs
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

CO_2 emissions from surface post mining are estimated by applying the following IPCC equations:

1. Tier 1: Equations 4.1.7A (mining)
2. Tier 2:
   - ✓ (mining) Tier 1 equation, although with user-specific (e.g. basin-specific) EFs
   - ✓ (post-mining) IPCC basic equation with user-specific EF
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

Software Worksheets

The *Software* calculates emissions of the two GHGs using worksheets:

- ✓ **Coal production from surface mines**: contains for each subdivision the production volumes.
- ✓ **Emissions from surface mines**: contains for each subdivision the CO_2 and CH_4 EFs and corresponding conversion factors and calculates associated GHG emissions.

In the upper part of **Emissions from surface mines** worksheet, users select the GHG for which to enter data.

Data compilation of each subcategory is operated following the entire set of instructions below.

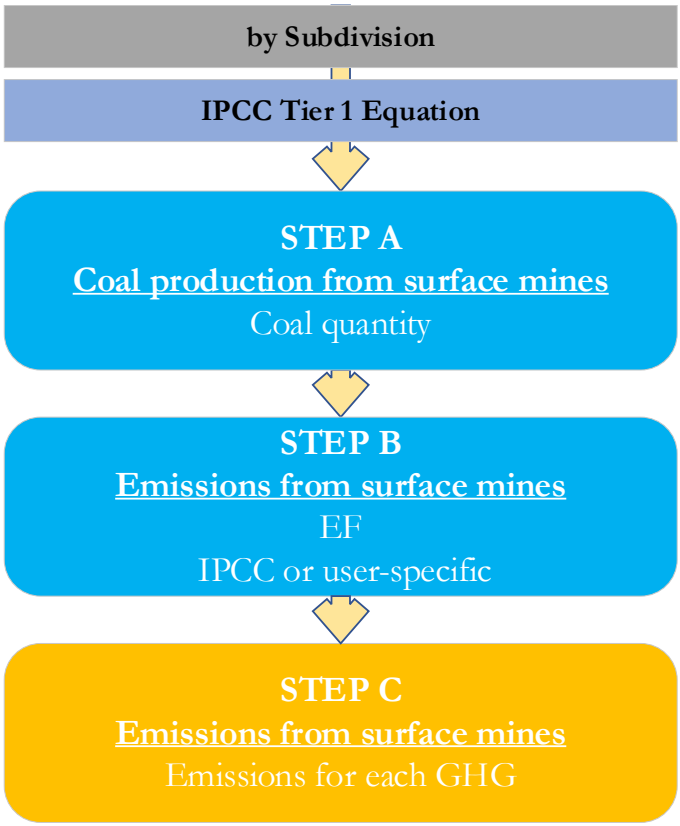
*Note that activity data input in worksheet **Coal production from surface mines** in one of the subcategories (1.B.1.a.ii Surface Mines and 1.B.1.a.ii.2 Post-mining) is automatically filled by the Software in the corresponding worksheet **Coal production from surface mines** in the other subcategory.*

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.1.2, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[39] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitive - Surface mining - flowchart



Step A, worksheet **Coal production from surface mines**, users collect and enter data on the amount of coal produced from surface coal mines.

Step B, worksheet **Emissions from surface mines**, users collect and enter in each row associated EFs for each GHG.

Step C, worksheet **Emissions from surface mines**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

[39] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2006 IPCC Guidelines*, Section 4.1.3.3 and Section 4.1.4.3, contain information on collecting AD for surface coal mines.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|.

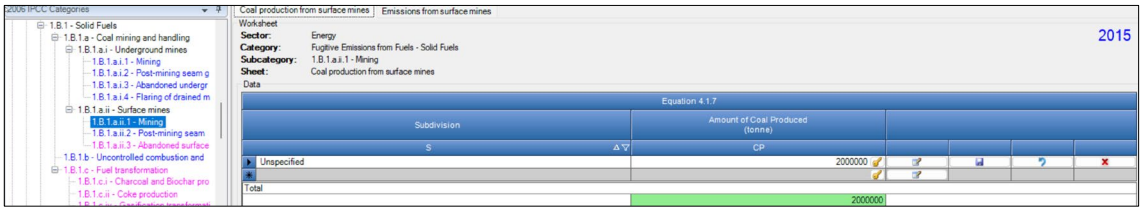
Thus, for the relevant source-category:

For each subdivision in Column |S|, data are entered in worksheet **Coal production from surface mines**, row by row, as follows:

1. Column |CP|: enter annual amount of raw coal produced, in tonne.

   Note that once a user adds surface coal production data into one of the two source categories (either mining or post-mining seam emissions), the coal production for each subdivision is automatically pre-filled in the other source category. A change to the AD in one source category will also change the AD in the other.

Example: **single subdivision**



Emission factor input

IPCC default EFs are provided in Section 4.1.4.2, for CH_4, Section 4.1.4.2, for CO_2, in m^3 per tonne of coal produced.

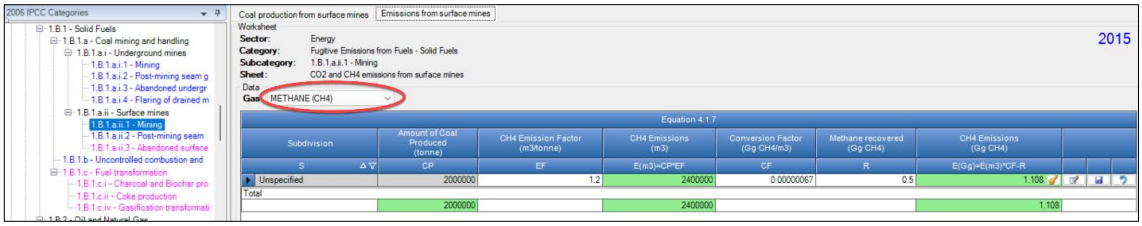
The **Emissions from surface mines** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of subdivisions entered in worksheet **Coal production from surface mines**. Then:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in m^3 per tonne of coal produced.

   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" in the "Gas" bar at the top, to enter data for each GHG one by one.

2. Column |CF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value. The Conversion Factors represent the density of the corresponding GHG, in Gg GHG per m^3 of gas emitted. The default density of CH_4, $0.67*10^{-6}$, is sourced from the *2006 IPCC Guidelines* while the default CO_2 density, $1.84*10^{-6}$, is sourced from the *2019 Refinement*.

Example: **single subdivision, CH_4 emissions**



Results

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions in each subcategory are reported in worksheet **Emissions from surface mines**.

1.B.1.a.ii.3 Abandoned surface mines

This section describes calculation of emissions from abandoned surface mines. After closure, emissions from abandoned surface mines may include the following: the standing highwall; leakage from the pit floor; low temperature oxidation and uncontrolled combustion.

This category has been added to facilitate interoperability with the UNFCCC CRT, where other emissions from surface mines can be reported.

GHGs

Emissions from abandoned surface mines includes the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X					

IPCC Equations

The *2019 Refinement* qualitatively discusses this category in Appendix 4.A.1.1. Given that there are no specific equations in the *2006 IPCC Guidelines* for this category, a generic worksheet is thus provided to enable calculation of fugitive GHG emissions from Abandoned Surface Mines.

1. Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*.
2. Tier 2: IPCC basic equation with user-specific EF
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

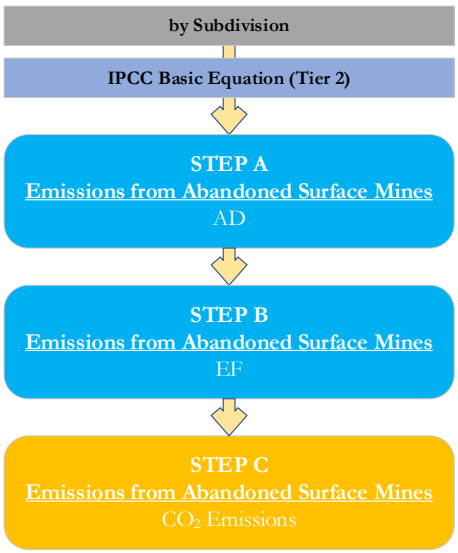
Software Worksheets

The *Software* allows to calculate emissions of the two GHGs using the following worksheet:

- ✓ **Emissions from abandoned surface mines**: calculates GHG emissions for each subdivision based on user-defined AD and EF.

In the upper part of **Emissions from abandoned surface mines** worksheet, users select the GHG for which to enter data.

Fugitive - Abandoned surface mines - flowchart



Step A, in worksheet **Emissions from Abandoned Surface Mines**, users collect and enter data on the source and activity data.

Step B, in worksheet **Emissions from Abandoned Surface Mines**, users collect and enter in each row the associated EF.

Step C, in worksheet **Emissions from Abandoned Surface Mines**, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

Activity data input

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then:

For each subdivision in Column |S|, data are entered in worksheet **Emissions from abandoned surface mines**, row by row, as follows:

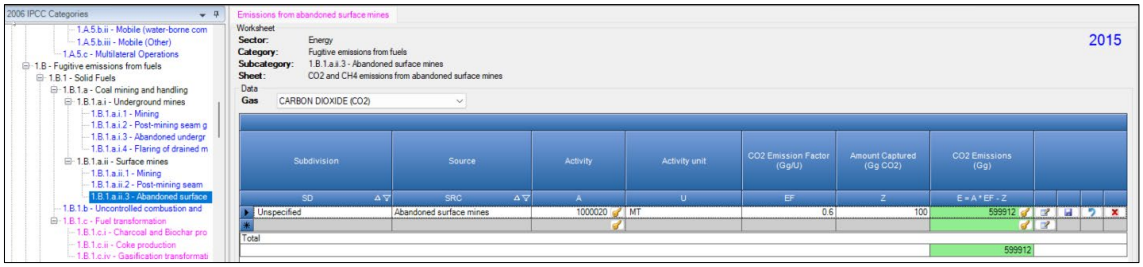
1. Column |SRC|: describe the type of activity emitting GHG emissions from this category (e.g. abandoned surface mines).
2. Column |AD|: enter AD (quantity).
3. Column |U|: enter the unit of the AD.

Emission factor input

For each row of data entered in worksheet **Emissions from abandoned surface mines**, data are entered as follows:

1. Column |EF|: enter the user-specific CH_4 or CO_2 EF in Gg CO_2/U, with U being the measurement unit entered in Column|U|;

Example: **single subdivision**



Results

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions are reported in worksheet **Emissions from abandoned surface mines**.

1.B.1.b Uncontrolled combustion and burning coal dumps

This category covers uncontrolled combustion only due to coal exploration activities. While emissions from this source may be significant for an individual coal mine, it is unclear as to how significant these emissions may be for an individual country. In some countries where such fires are widespread, the emissions may be very significant. There are no clear methods available at present to systematically measure or precisely estimate the activity data, though where countries have data on amounts of coal burned, the CO_2 are estimated based on the carbon content of the coal and reported in this subcategory 1.B.1.b. Care needs to be taken to avoid double counting with fugitive CH_4 and low oxidation CO_2 emissions.

GHGs

Uncontrolled combustion and burning of coal dumps emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

Given that there are no specific equations in the *2006 IPCC Guidelines* for this category, GHG emissions from the uncontrolled combustion source category are estimated in the *Software* by applying the following IPCC equations provided for stationary combustion:

1. Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*.
2. Tier 2: IPCC Tier 1 equations 2.1 and 2.2, although with user-specific EFs
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

   Note that since Tier 3 of IPCC equation 2.4 is NOT applicable to this category (by definition the category is "uncontrolled" combustion), the user shall compile "unspecified" in Column |T| - Technology type - and must input "100" in the next Column |P| – Technology penetration -.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

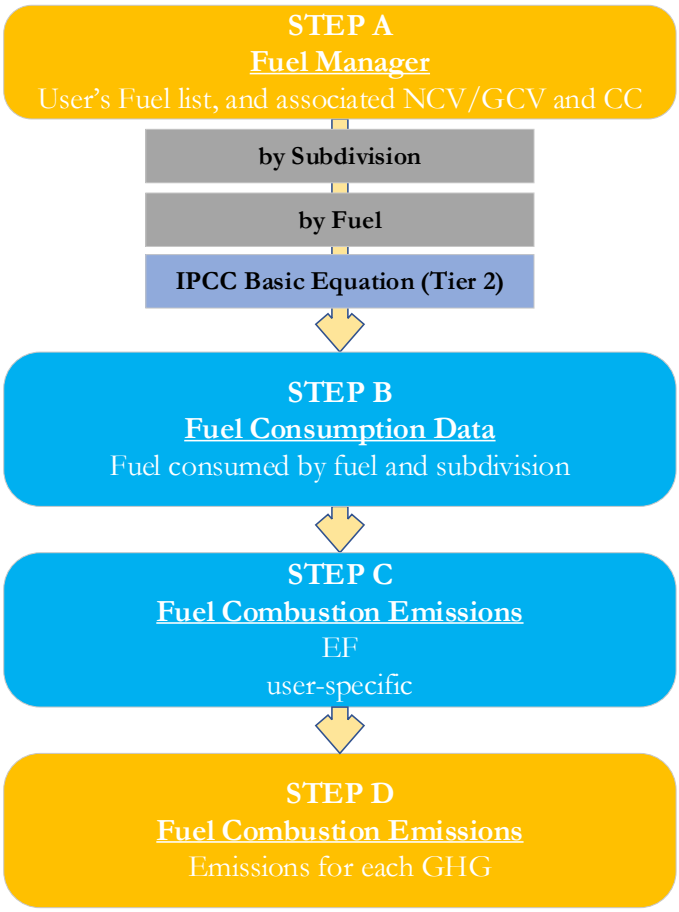
- ✓ **Fuel Manager**: contains information on the *carbon content* and the *calorific value* of each solid fuel type used in the NGHGI. Although, for this category is not good practice to apply IPCC defaults given the assumption of full oxidation to CO_2 does not apply.
- ✓ **Fuel Consumption Data**: contains for each solid fuel type the amount subject to uncontrolled combustion.
- ✓ **Fuel Combustion Emissions**: contains for each subdivision and solid fuel type the relevant CO_2, CH_4 and N_2O EFs and calculates associated GHG emissions.

In the upper part of each worksheet, users select the *Fuel type* for which to enter data. The *All Fuels* option is selected to visualize all fuels entered, with no *Fuel type* limitation.

User's work Flowchart

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Uncontrolled combustion - flowchart



Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name and the *calorific value* and the *carbon content* of each fuel.

Then, for each subdivision, if any:

Step B, worksheet **Fuel Consumption Data**, users collect and enter data on the amount consumed of each fuel.

Step C, worksheet **Fuel Combustion Emissions**, users collect and enter in each row associated EFs for each GHG.

Step D, worksheet **Fuel Combustion Emissions**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Activity data input

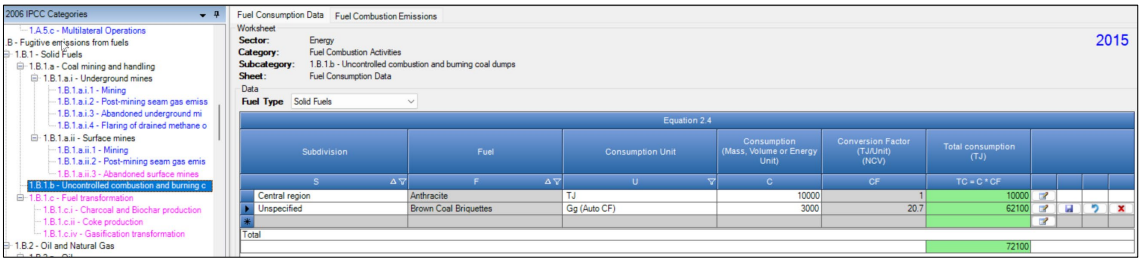
The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and apply energy statistics data. Due to the nature of this category, uncontrolled combustion, the information may not be in official statistics and efforts may need to be made to collect information on the amount of uncontrolled combustion.

Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ. Other units may be entered into the **Fuel Consumption Data** worksheet, e.g. British Thermal Units (BTUs). However, when alternative units are used, the column for GCV/NCV becomes blank and the user shall enter a user-defined conversion factor (TJ/unit).

As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the worksheet **Fuel Consumption Data** either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

Example: **multiple subdivisions**



Then, for each subdivision in Column |S| data are entered in worksheet **Fuel Consumption Data** row by row as follows:

1. Column |F|: select each solid fuel subject to uncontrolled combustion from the drop-down menu, one row for each fuel,

   Note that fuels shown in the dropdown menu are those listed in the Fuel Manager.

   Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.

2. Column |U|: enter the unit in which fuel consumption data are available (e.g. Gg, TJ). To enter a user-specific unit (e.g. m^3) select **Gg (Manual CF)** from the dropdown menu and overwrite *Gg* with the user-defined unit.
3. Column |C|: enter amount of fuel consumed.
4. Column |CF|: enter conversion factor to convert the consumption unit to energy units (TJ).

   Note that where Gg of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as the conversion factor; while if the consumption unit is TJ the Software compiles the conversion factor cell with the value 1. Where other units are applied (e.g. m^3) the user shall enter the relevant conversion factor here.

Emission factor input

The **Fuel Combustion Emissions** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of subdivision/fuel combinations entered in worksheet **Fuel Consumption Data**. Then:

i. For each row, users click the symbol "⊞" on the left of the row to open a drop-down table where EF values are to be compiled.

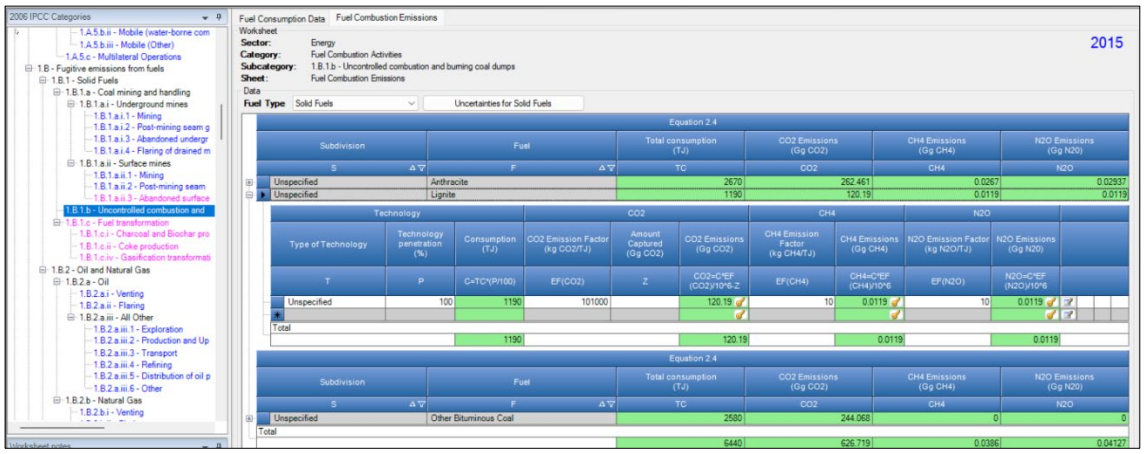
Note that the drop-down table will be filled with a single row of data as technology type is not applicable.

Note that user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.

ii. Compile each row as follows:

1. Column |T|: given that Tier 3 of IPCC Equation 2.4 is not applicable to this category, the user shall select *Unspecified* from the drop-down menu.

Example: **Tier 2**



2. Column |P|: given that Tier 3 of IPCC Equation 2.4 is not applicable to this category, the user shall leave the pre-filled, by the *Software*, value of 100.
3. Column |EF(CO_2)|: enter user-specific value.
4. Column |EF(CH_4)|: There are no IPCC default values for this category; enter value, if available.

   Note that the unit to be used is kg CH_4/TJ.
5. Column |EF(N_2O)|: There are no IPCC default values for this category; enter value, if available.

   Note that the unit to be used is kg N_2O/TJ.

Results

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data and total emissions from each source of uncontrolled combustion and burning coal dumps is the sum of all emissions from all subdivisions reported in worksheet **Fuel Combustion Emissions**.

1.B.1.c Fuel Transformation

The category 1.B.1.c Solid Fuel Transformation is included in the *2006 IPCC Guidelines*[40], but no specific equations are provided. To facilitate interoperability with the UNFCCC CRT Reporting tool, the corresponding category 1.B.1.c Fuel Transformation of the *2019 Refinement* has been included in the *Software*.

Specifically, instructions are provided for the worksheets in the *Software* to calculate fugitive emissions from charcoal and biochar production, coke production and gasification transformation:

- ✓ **1.B.1.c.i Charcoal and Biochar production**
- ✓ **1.B.1.c.ii Coke production**
- ✓ **1.B.1.c.iv Gasification transformation**

[40] It includes fugitive emissions arising during the manufacture of secondary and tertiary products from solid fuels.

This section describes calculation of fugitive emissions arising from charcoal and biochar production. Charcoal is produced by the carbonization of wood, through thermal decomposition in the absence of oxygen at a temperature above 300°C. The carbonization of wood produces charcoal[41] as well as direct greenhouse gases (CO_2, CH_4 and N_2O). Emissions of biogenic CO_2 from charcoal production are reported here as an information item, and are covered under Agriculture, Forestry and Other Land Use (AFOLU). Fugitive emissions of CH_4 and N_2O are reported here.

GHGs

Charcoal and biochar production emit the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 4.3.1(New).
2. Tier 2: IPCC Tier 1 Equation with user-specific EFs
3. Tier 3: IPCC Tier 1 Equation with emission-stage-specific EFs and thus detailed AD

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheet:

- ✓ **Emissions from Charcoal and Biochar production**: contains AD and EF, CO_2 captured and/or CH_4 recovered, if any, and calculates associated GHG emissions.

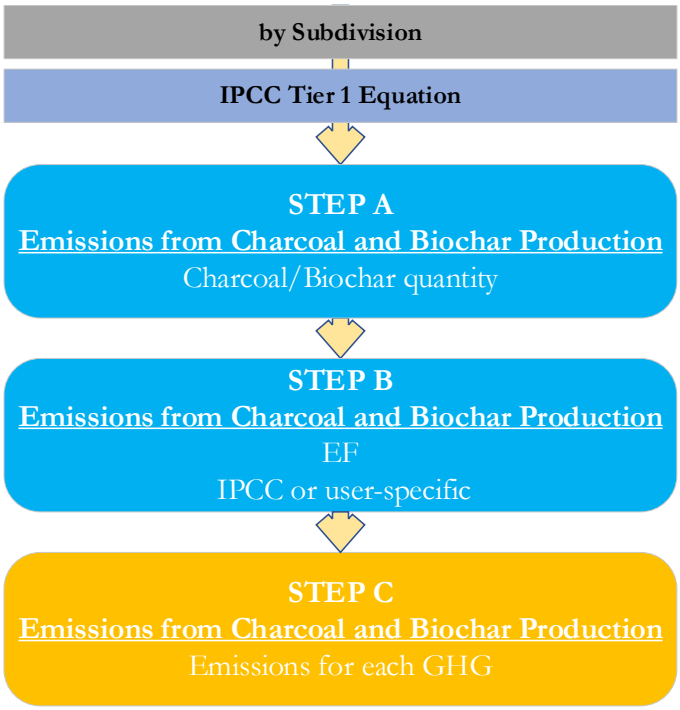
[41] Biochar is charcoal applied to soil.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.3.1 (New), GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[42] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitive – Charcoal and biochar production - flowchart



Step A, in worksheet **Emissions from Charcoal and Biochar production**, users collect and enter in the *Software* the amount of charcoal or biochar produced, by each subdivision. Data can be entered as a single total for each product or stratified, where information is available, in subdivisions.

Step B, in worksheet **Emissions from Charcoal and Biochar production**, for each subdivision, users enter CO_2, CH_4 or N_2O EFs. For this category, the user may also select and estimate nitrogen oxides (NO_X) and carbon monoxide (CO) emissions.

Step C, in worksheet **Emissions from Charcoal and Biochar production**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture and/or CH_4 recovery can be reported in **Emissions from Charcoal and Biochar production** worksheet. CO_2 capture and/or CH_4 recovery are only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured and/or CH_4 recovered is known. The CO_2 captured and/or CH_4 recovered is then entered at the level at which corresponding emissions are calculated.

[42] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2019 Refinement*, Section 4.3.2, contain information on how to find data on charcoal and biochar production.

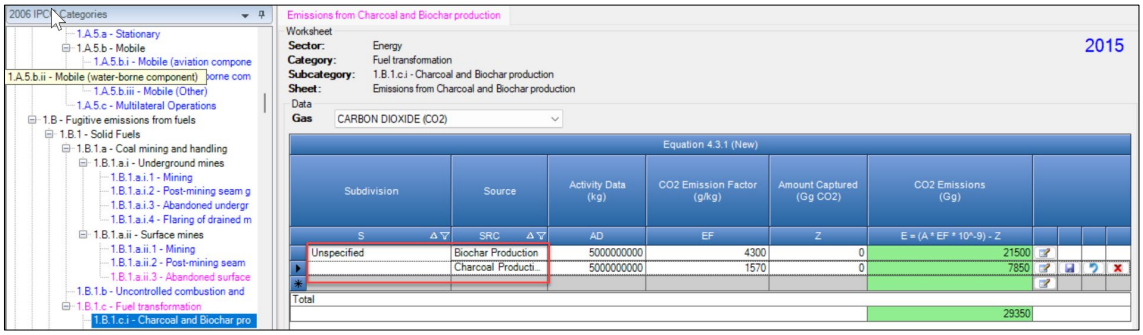
Input of AD for this category requires the following steps:

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Further, for each subdivision, there is a separate row for charcoal and one for biochar.

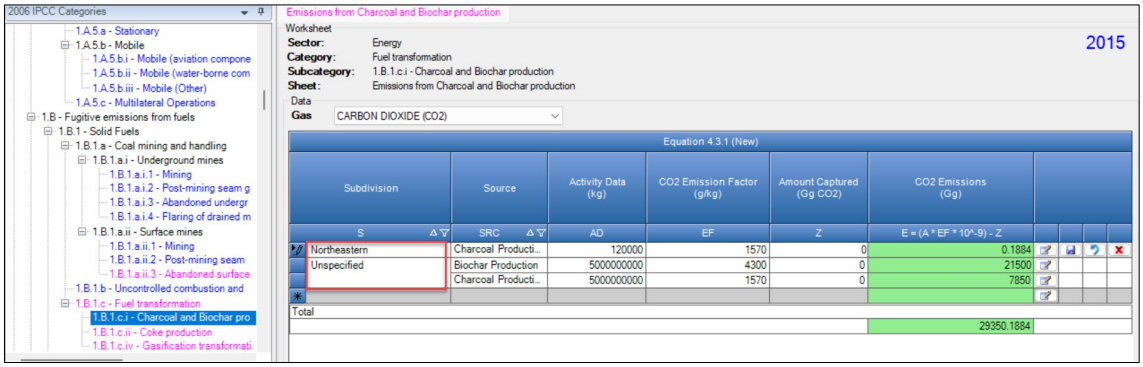
Then, for each subdivision in Column |S|, data are entered in worksheet **Emissions from Charcoal and Biochar production**, row by row, as follows:

1. Column |SRC| enter source of solid fuel transformation (biochar or charcoal production);
2. Column |A| enter AD for each source of solid fuel transformation
   Note that once AD are entered for one gas, the same AD apply for all three GHGs (see multiple subdivisions below)

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



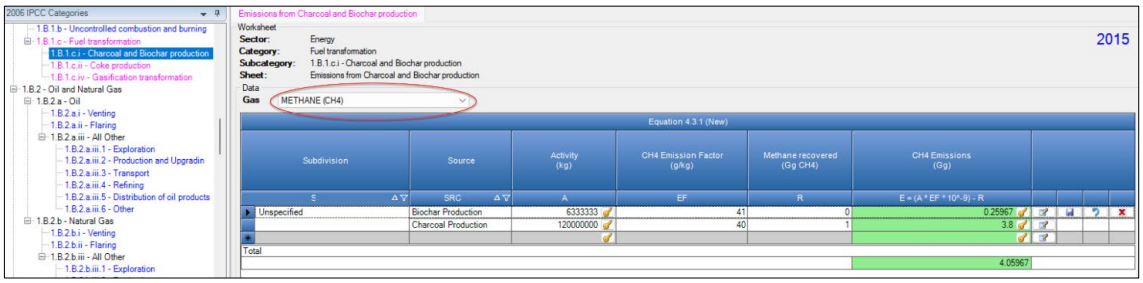
Emission factor input

IPCC default charcoal and biochar production EFs in Section 4.3.3 of the *2019 Refinement*, in g/kg.

For each row of data entered in worksheet **Emissions from Charcoal and Biochar production**, data are entered as follows:

1. Column |EF|: for each GHG, select from the drop-down menu the IPCC default value or enter a user-specific value;
   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one.
   Note that the Software can calculate also NOx and CO emissions where those gases are selected, and the relevant EF is entered.

Example: **single subdivision, CH_4 emissions**



Results

To estimate the total CO_2 and total CH_4 emitted into the atmosphere, the amount of CO_2 and of CH_4 released from that subdivision that has been instead captured or recovered, respectively, are to be entered in Gg CO_2 in Column |Z| and/or in Gg CH_4 in Column |R| of worksheet **Emissions from Charcoal and Biochar production**.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions in each subcategory are reported in worksheet **Emissions from Charcoal and Biochar production**.

This section describes calculation of emissions from coke production. While emissions from the carbonisation process and from combustion are reported in category 1.A.1.c, fugitive emissions are reported in this category. For a detailed description of processing stages and associated GHG emissions see Table 4.3.4(New).

GHGs

Coke production emits the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

Note that inventory compilers who are using a carbon mass balance approach to estimate emissions from iron and steel production, and are including fugitive emissions in that balance, shall not estimate CO_2 fugitive emissions from coke production to avoid double counting.

IPCC Equations

I. Fugitive emissions from coke production

1. Tier 1: IPCC Tier 1 Equation 4.3.2(New). IPCC defaults are not available for CO_2 and N_2O.
2. Tier 2: IPCC Tier 1 Equation with user-specific EFs.
3. Tier 3: IPCC Tier 1 Equation with emission-stage-specific EFs, and thus detailed AD.

II. Emissions from coke oven gas flaring

1. Tier 1: IPCC Tier 1 Equation 4.3.3(New) for CO_2 emissions and Equation 4.3.4(New) for CH_4 and N_2O emissions.
2. Tier 2 (CO_2 only): IPCC Tier 1 Equation with user-specific EFs.
3. Tier 3: IPCC Tier 1 Equation with facility-specific measurement data with or without a carbon balance of remaining carbon sources.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Fuel Manager**: contains information on the *carbon content* and the *calorific value* for coke oven gas.
- ✓ **Coke and Coke Oven Gas production**: contains for each subdivision the total amount of coke and coke oven gas produced.
- ✓ **Emissions from Coke production**: contains for each subdivision the relevant CO_2, CH_4 and N_2O EFs and calculates associated emissions from coke production.
- ✓ **Emissions from Coke Oven Gas flaring**: contains for each subdivision the relevant CO_2, CH_4 and N_2O EFs, CO_2 captured and CH_4 recovered, if any, and calculates associated emissions from flaring of coke oven gas.

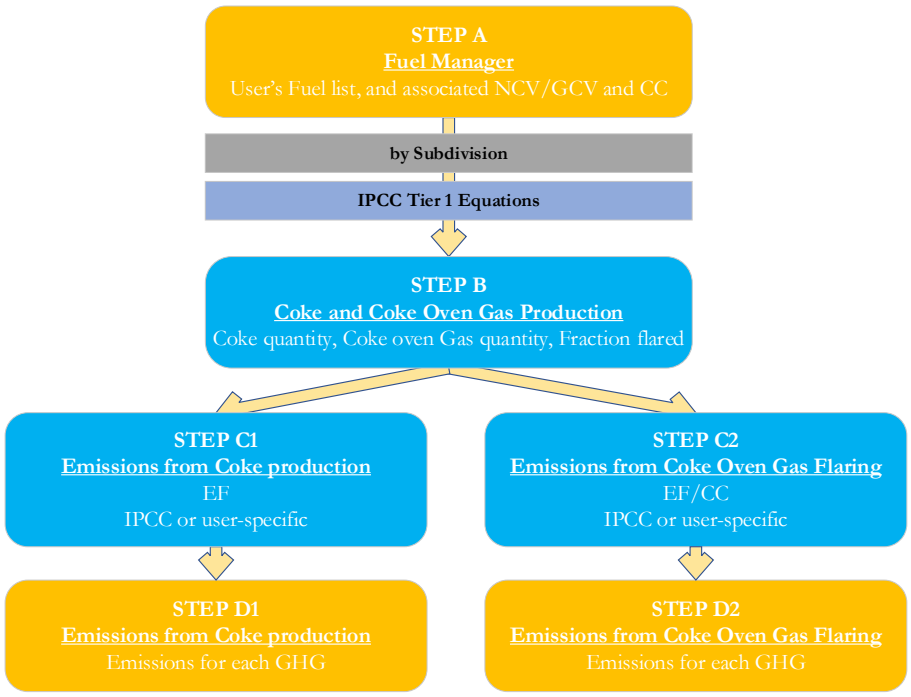
In the upper part of **Emissions from Coke production** and **Emissions from Coke Oven Gas flaring** worksheets, users select the GHG for which to enter data.

User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 4.3.3 (New) (fugitive emissions from coke production) and Figure 4.3.4 (New) and Figure 4.3.5 (New) (flaring of coke oven gas), GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[43] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Coke production - flowchart



Step A, Fuel Manager, users collect and enter data on each fuel used in the relevant source category: its name, if not present among IPCC defaults, and the *calorific value* and the *carbon content* of each fuel, including for IPCC default fuels if user-specific values are available.

Then, for each subdivision, if any:

Step B, worksheet **Coke and Coke Oven Gas production**, users collect and enter data on the amount of coke produced, as well as the coke oven gas produced per unit of coke produced and the fraction of that coke oven gas that is flared.

Step C1, worksheet **Emissions from Coke production**, users collect and enter in each row associated EFs for each GHG.

Step C2, worksheet **Emissions from Coke Oven Gas flaring**, users collect and enter in each row associated EFs for each GHG.

Step D1, worksheet **Emissions from Coke production**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Step D2, worksheet **Emissions from Coke Oven Gas flaring**, for each row of data and GHG, the *Software* calculates emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture and/or CH_4 recovery can be reported in each worksheet**.** CO_2 capture and/or CH_4 recovery are only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured and/or CH_4 recovered is known. The CO_2 captured and/or CH_4 recovered may then be assigned to a specific subdivision.

[43] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

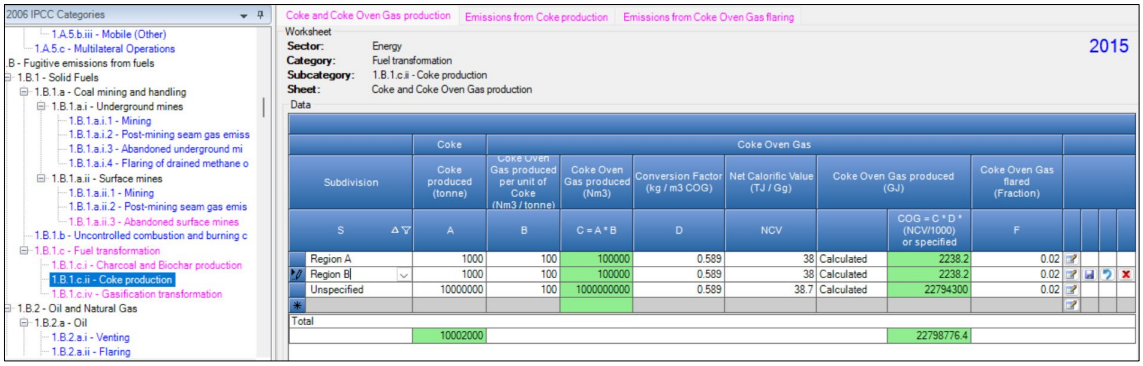
The *2019 Refinement*, Section 4.3.2, contain information on how to find data on the quantities of coke produced. Unlike data entry for stationary combustion, these AD are to be entered in the *Software* in mass units (tonnes).

As a **Starting step**, users enter in the **Fuel Manager** all user-specific fuels to be reported in the NGHGI; and for each fuel listed in the **Fuel Manager** the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the dropdown menu.

Second, users compile the worksheet **Coke and Coke Oven Gas production** either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|:

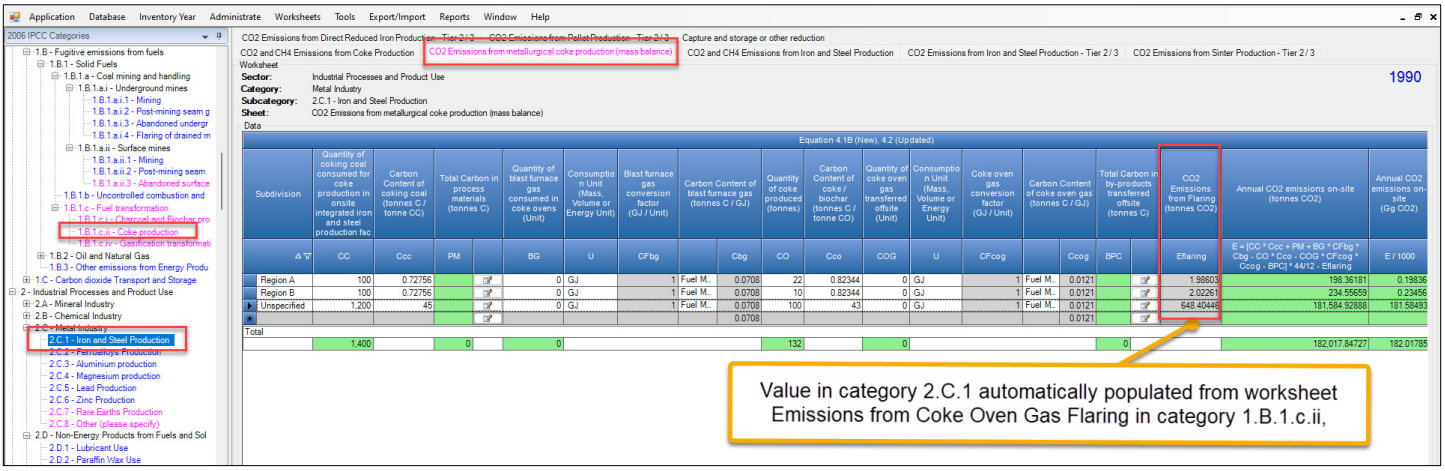
Example: **single subdivision (unspecified)**

Example: **multiple subdivisions**



Important: There is a linkage between naming of subdivisions in category 1.B.1.c.ii Coke Production and worksheet CO_2 **Emissions from metallurgical coke production (mass balance)** in category 2.C.1 Iron and Steel Production. Specifically, CO_2 emissions from coke oven gas flaring that are estimated in worksheet **Emissions from Coke Oven Gas flaring** and reported in category 1.B.1.c.ii must be subtracted from worksheet **CO_2 Emissions from metallurgical coke production (mass balance)** in category 2.C.1 Iron and Steel Production to avoid double counting. The *Software* automatically subtracts these CO_2 emissions, but ONLY where the subdivision names in these two worksheets are the same. Users should ensure consistency in the naming of subdivisions between these two categories.

Example: **Consistent naming of subdivisions in categories 1.B.1.c.ii and 2.C.1 for coke production**



Then, for each subdivision in Column |S| data are entered in worksheet **Coke and Coke Oven Gas production** row by row as follows:

1. Column |A| enter AD on coke produced, in tonnes.
   Note that the user should not include AD here in category 1.B.1.c.ii of the Energy sector, for subdivisions where the Tier 1b method (a simplified carbon balance) contained in worksheet CO_2 Emissions from metallurgical coke production (mass balance) of category 2.C.1 of the IPPU sector is used to estimate CO_2 emissions. The simplified carbon balance assumes that all carbon (fugitive emissions and flaring) is released, and thus is already captured in the IPPU sector.
2. Column |B| enter AD on coke oven gas produced per unit of coke, in Nm^3/tonne.
3. Column |D| enter conversion factor to convert the calculated amount of coke oven gas produced to mass (kg),
4. Column |NCV| enter NCV to convert the calculated amount of coke oven gas produced to energy units (GJ).
   Note that the NCV entered in the Fuel Manager will be available as the dropdown option.
5. Column |F| input the fraction of the calculated amount of coke oven gas produced that is flared.
   *Note that AD on coke produced, coke oven gas produced, and coke oven gas flared are automatically pre-filled in worksheets **Emissions from Coke production** and **Emissions from Coke Oven Gas flaring**.*

Emission factor input

IPCC default EFs for fugitive emissions from coke production are provided in Section 4.3.2 while those for flaring of coke oven gas are provided in Section 4.3.2; both of the *2019 Refinement*.

The **Emissions from Coke Production** worksheet and the **Emissions from Coke Oven Gas flaring** worksheet are pre-filled by the *Software* with a number of rows corresponding to the number of subdivisions entered in worksheet **Coke and Coke Oven Gas production**.

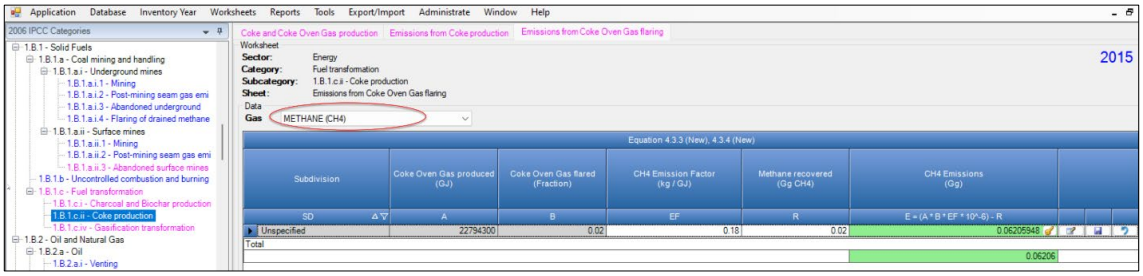
Then, for each row, in worksheet **Emissions from Coke Production** data are entered as follows:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in kg per tonne of coal produced.
   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous Oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Then, for each row, in worksheet **Emissions from Coke Oven Gas flaring** data are entered as follows:

2. Column |CC| or Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in kg C per GJ (for carbon content) or kg/GJ (for EF).
   Note that for CH_4 and N_2O an EF is entered used while for CO_2 the carbon content is entered.

Example: **single subdivision- CH_4**



Results

To estimate the total CO_2 and total CH_4 emitted into the atmosphere, the amount of CO_2 and of CH_4 released from that subdivision that has been instead captured or recovered, respectively, are to be entered in Gg CO_2 in Column |Z| and/or Gg CH_4 in Column |R| of **Emissions from Coke production** and **Emissions from Coke Oven Gas flaring** worksheets.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions in each subcategory are reported in worksheets **Emissions from Coke production** and **Emissions from Coke Oven Gas flaring**. The sum of emissions calculated in the two worksheets gives the total emissions from the category.

Gasification transformation processes are related to the transformation of biomass, coal or natural gas into syngas, composed of H_2, CO, CO_2 and CH_4, and, then, into a liquid hydrocarbons fuel. These processes are called biomass to gaseous (BtG), biomass to liquid (BtL), coal to liquid (CtL) and gas to liquid (GtL); as shown in Figure 4.3.6 (New).

GHGs

Gasification transformation include fugitive emissions from gas to liquids, coal to liquids and from other gasification processes, and emits the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

- ✓ **Fugitive emissions from Gas to Liquids and from Coal to Liquids**
  1. Tier 1: IPCC Tier 1 Equation 4.3.5 (New).
  2. Tier 2: IPCC Tier 1 Equation with user-specific EFs
  3. Tier 3: no IPCC Tier 3 Equation provided in the *2019 Refinement*, although it refers to a mass balance method.
- ✓ **Fugitive emissions from other gasification**
  1. Tier 1: no IPCC Tier 1 Equation provided in the *2019 Refinement*.
  2. Tier 2: IPCC basic equation, based on user provided AD and EFs, has been implemented in the *Software* to enable reporting of other user-specific gasification activities in addition to gas to liquids and coal to liquids.
  3. Tier 3: no IPCC Tier 3 Equation provided in the *2019 Refinement*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Emissions from Gas to Liquids**: calculates emissions for each subdivision based on the type of feedstock consumed.
- ✓ **Emissions from Coal to Liquids**: calculates emissions for each subdivision based on the gasification process (Syngas, Syngas/H_2, Synthetic Natural Gas) and the amount of syngas produced.
- ✓ **Emissions from Other Gasification**: calculates emissions for each subdivision based on the user-defined input on the amount of activity driving the gasification process (e.g. feedstock consumption or production).

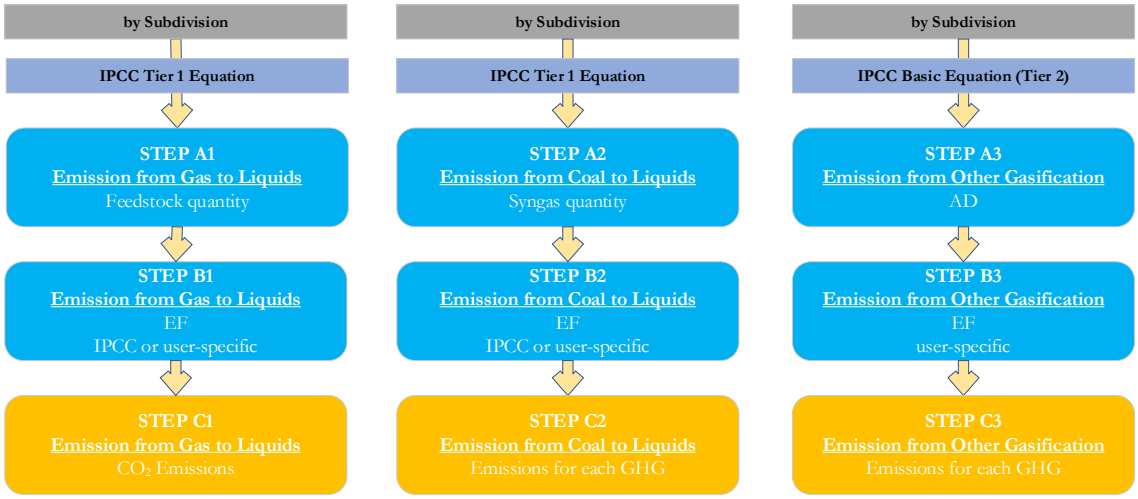
In the upper part of each worksheet, users select the GHG for which to enter data.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.3.7 (New), GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[44] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitive - Gasification transformation - flowchart



Step A, in each worksheet, enter amount of feedstock consumed or product produced, by each subdivision.

Step B, in each worksheet**,** enter CO_2, CH_4 or N_2O EFs.

Step C, in each worksheet the *Software* calculates the emissions in Gg.

Where data are available, CO_2 capture and/or CH_4 recovery can be reported in the relevant worksheet. CO_2 capture and/or CH_4 recovery are only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured and/or CH_4 recovered is known. The CO_2 captured and/or CH_4 recovered may then be assigned to a specific subdivision.

[44] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2019 Refinement*, Section 4.3.2, contain information on gas to liquids and coal to liquids and may be useful when collecting AD for other gasification processes.

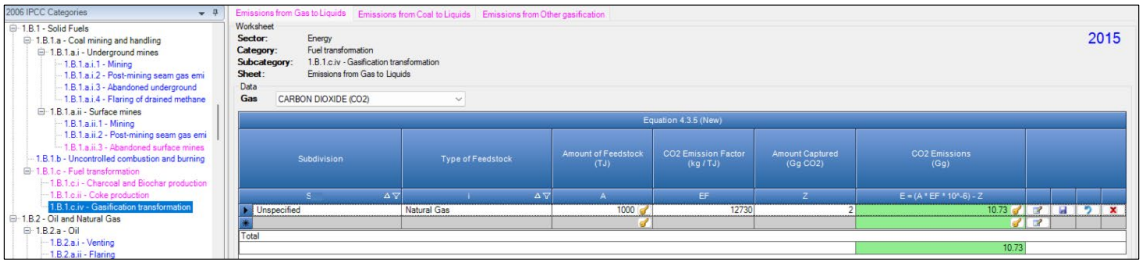
Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|.

Thus, for the relevant source-category:

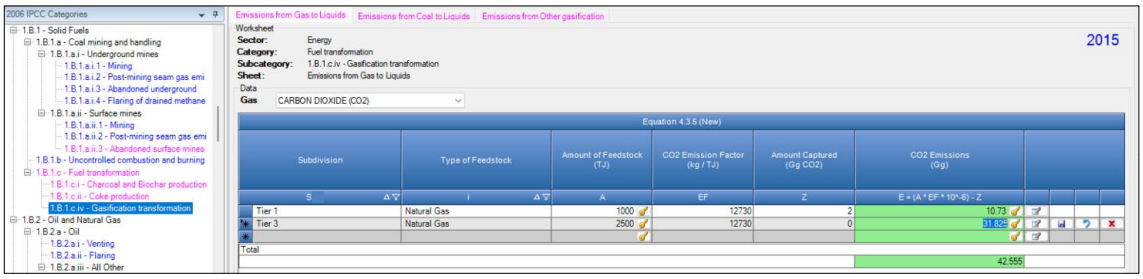
For each subdivision in Column |S|, data are entered in the relevant worksheet, row by row, as follows:

1. Column |i|: enter type of Feedstock produced (for gas to liquids) or gasification process (for coal to liquids)
2. Column |AD|: enter feedstock, in worksheet **Emissions from Gas to Liquids**, or amount of syngas produced, in worksheet **Emissions from Coal to Liquids**, in TJ. While for **Emissions from other gasification** the AD are entered in the unit collected, and the unit is to be entered in Column |U|.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Emission factor input

IPCC default EFs are provided in Table 4.3.10 (NEW) of the *2019 Refinement*, in kg/TJ (for coal to liquids) and Table 4.3.11 (NEW) (for gas to liquids).

For each row of data entered in the relevant worksheet, data are entered as follows:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value;

Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous Oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: **single subdivision- CH_4**

Results

To estimate the total CO_2 and total CH_4 emitted into the atmosphere, the amount of CO_2 and of CH_4 released from that subdivision that has been instead captured or recovered, respectively, are to be entered in Gg CO_2 in Column |Z| and/or in Gg CH_4 in Column |R| of the relevant worksheet.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions in each subcategory are reported in the relevant worksheet. The sum of emissions calculated in the three worksheets gives the total emissions from the category.

1.B.2.a Oil

Hereafter, the use of the *Software* to estimate fugitive emissions associated with all infrastructure required to produce, collect, process, or refine and deliver oil to market is illustrated. The following sections are separated, as emissions from various activities/categories are estimated via different approaches and correspondingly using different worksheets of the *Software*:

- ✓ **1.B.2.a.i Oil - Venting** - calculates emissions from venting at oil facilities.
- ✓ **1.B.2.a.ii Oil - Flaring** - calculates emissions from flaring of natural gas and waste gas/vapour streams at oil facilities.
- ✓ **1.B.2.a Oil - Fugitives (1.B.2.a.iii.1-1.B.2.a.iii.6)** – calculates fugitive emissions from all activities at oil facilities that are not associated with venting and flaring, as follows:
  - Exploration - fugitive emissions from oil well drilling, drill stem testing, and well completion.
  - Production and Upgrading - fugitive emissions from well servicing, oil sands or shale oil mining, transport of untreated production to treating or extraction facilities.
  - Transport - fugitive emissions related to the transport of marketable crude oil to upgraders and refineries.
  - Refining - fugitive emissions at petroleum refineries.
  - Distribution of oil products - fugitive emissions from the transport and distribution of refined products, including those at bulk terminals and retail facilities.
  - Other - fugitive emissions from oil systems not otherwise accounted for in the above categories.

This category excludes the following activities, which are covered in other parts of this Guidebook or in other sectors of the *Software*:

- Combustion-related activities at oil facilities are covered under **Stationary Combustion Source Categories** of this Guidebook.
- Fugitive CO_2 emissions from carbon capture and storage activities, including release of CO_2 during enhanced oil recovery activities, are included in **1.C - Carbon Dioxide Transport and Storage**.

Emissions from venting of associated gas and waste gas/vapour streams at oil facilities.

GHGs

Venting at oil facilities emits the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

N_2O is included here for completeness and recognizing that some categories may have N_2O emissions. However, there are no default N_2O EFs provided in the *2006 IPCC Guidelines* for venting from oil facilities.

Note that this category includes only venting activities (i.e. intentional releases of gas). GHG emissions from flaring of associated gas are covered in **Oil - Flaring**. Fugitive releases of CH_4 and CO_2 are calculated in section on **Oil – Fugitives**

IPCC Equations

1. Tier 1: IPCC Tier 1 Equation 4.2.1
2. Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs, or alternative IPCC Tier 2 Equation 4.2.3
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Activity Data**: contains for each subdivision/industry segment/subcategory the annual amount of oil production, and if Tier 2 is selected, the user enters the gas-to-oil ratio, gas conservation efficiency factor, and fraction of waste gas flared.
- ✓ **Emissions**: contains for each subdivision/industry segment/subcategory the EFs and calculates associated GHG emissions following the default method (using Equation 4.2.1). If user-specific EFs are applied, this would be considered a Tier 2 method.
- ✓ **Emissions – Tier 2**: contains for each industry segment/subcategory the molecular weight and associated gas fraction of the GHG of interest and calculates associated GHG emissions for Tier 2 using the alternative Tier 2 method.

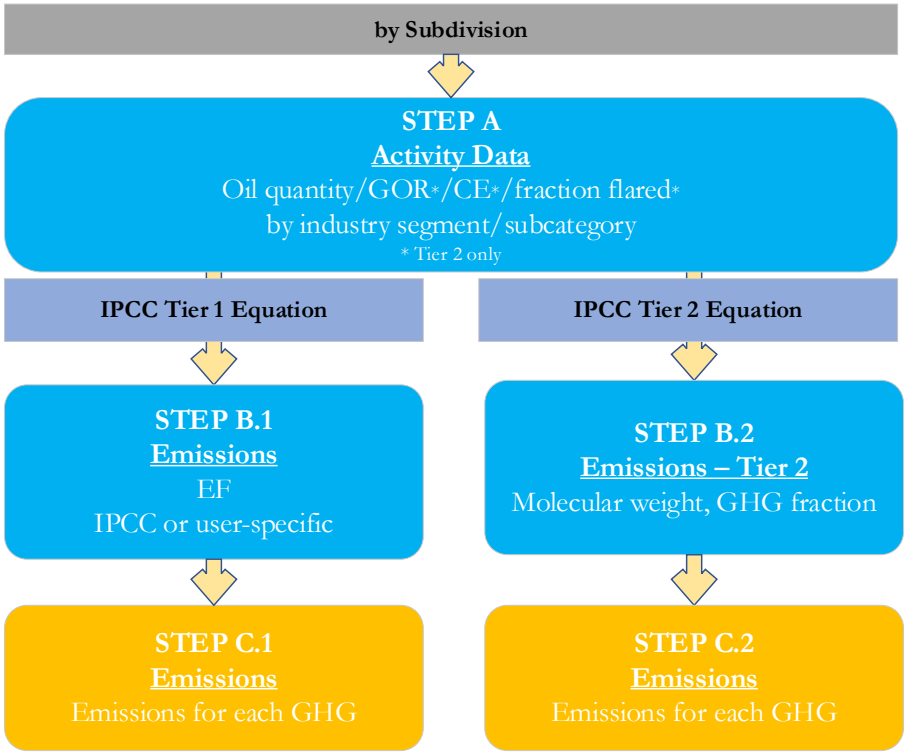
In the upper part of **Emissions** and **Emissions – Tier 2** worksheets, users select the GHG for which to enter data.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.2.2, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[45] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Oil – Venting - flowchart



Thus, for each subdivision, if any:

Step A, worksheet **Activity Data**, users input the annual amount of oil production or activity by industry segment/subcategory. Data can be input as a single total or stratified (e.g. regions/companies, etc.).

When Tier 1 Equation is applied

Step B.1, worksheet **Emissions**, users input in the *Software* the EFs. The user shall select in the drop-down menu at the top "Gas" bar the corresponding GHG, "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous Oxide (N_2O)".

Step C.1, worksheet **Emissions**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

When Tier 2 Equation is applied

Step B.2, worksheet **Emissions – Tier 2**, for each subdivision/industry segment/subcategory users input in the *Software* molecular weight and fraction of associated gas that is composed of the GHG that is being estimated.

Step C.2, worksheet **Emissions – Tier 2**, for each row of data and GHG, the *Software* calculates the emissions in mass units (Gg). In addition, for each GHG, total emissions are calculated.

Where data are available, CO_2 capture can be reported in worksheets **Emissions** and **Emissions – Tier 2**. CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

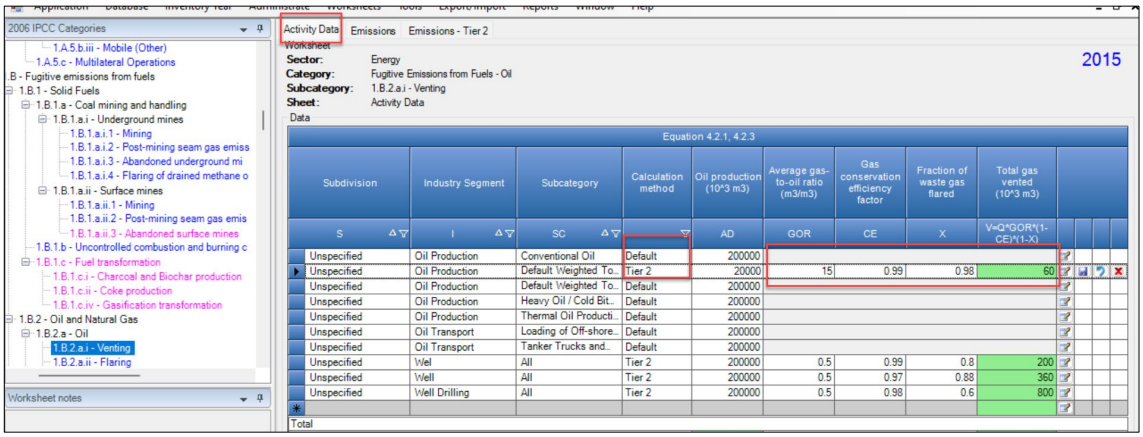
[45] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

The *2006 IPCC Guidelines*, Section 4.2.2.4, including Tables 4.2.6 & 4.2.7 for the Tier 1 method, provide information on the minimum data needs and where to find and how to apply statistics data.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then, for each subdivision in Column |S|, data are entered in worksheet **Activity Data**, row by row, as follows:

1. Column |I |: select from the drop-down menu or enter the corresponding industry segment. Default industry segments are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
2. Column |SC|: select from the drop-down menu or enter the subcategory corresponding to the industry segment selected. Default subcategories are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
3. Column |Calculation Method|: select the approach to prepare estimates: *Default* or *Tier 2*. Based on the selection in this column, data are transferred by the *Software* to the relevant worksheet **Emissions** or **Emissions – Tier 2**.
   Note that a Tier 2 estimate can be calculated using either a user-specific EF in the Default equation, or the alternative Tier 2 equation based on the mass balance approach. Where a user-specific EF is applied, select "Default" here.

Example: **selection of *Calculation method***



4. Column |AD|: enter total amount of oil production, in 10^3 m^3

When *Tier 2* is selected in step 3:

5. Column |GOR|: enter average gas-to-oil ratio in m^3/m^3, noting the value shall be referenced at 15°C and 101.325 kPa.
6. Column |CE|: enter gas conservation efficiency factor.
7. Column |X|: enter fraction of waste gas flared.
8. Column |V|: *Software* calculates the amount of total gas vented, in 10^3 m^3.

Emission factor input

IPCC default EFs are provided in Tables 4.2.4 & 4.2.5 of the *2006 IPCC Guidelines*. Where a range of factors is provided in the Tables, the mid-point has been selected for the dropdown. Users can overwrite this value, as necessary.

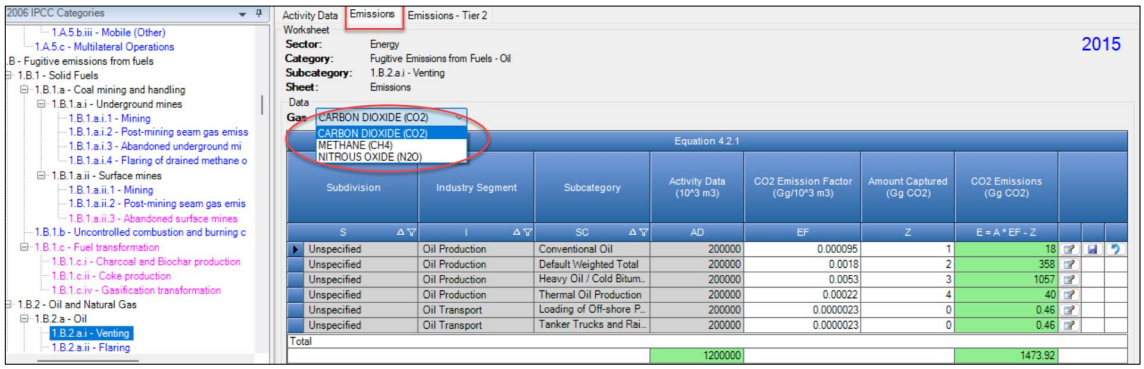
Note that this category includes all venting at oil facilities, from exploration through to distribution. When using the default EFs for well drilling, well testing and well servicing, be sure not do double count emissions between oil venting and oil flaring.

When Tier 1 Equation is applied:

The **Emissions** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of combinations of subdivision/industry segment/subcategory entered in worksheet **Activity Data**, for which *Default* method is selected. Then:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in Gg per 1,000 m^3 of oil.
   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous Oxide (N_2O) in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: **Emissions, CO_2**

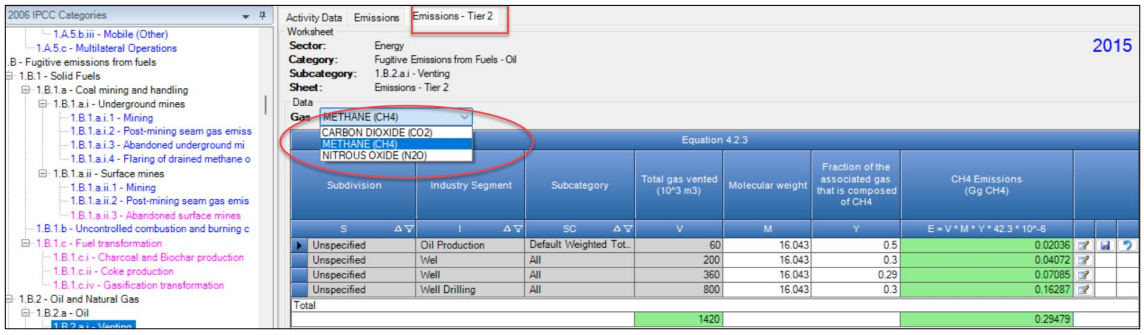


When Tier 2 Equation is applied:

The **Emissions – Tier 2** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of combinations of subdivision/industry segment/subcategory entered in worksheet **Activity Data**, for which *Tier 2* method is selected. Then:

1. Column |M|: *Software* pre-fills the molecular weight of the corresponding GHG (16.043 for CH_4, 44.011 for CO_2 and 44.013 for N_2O).
2. Column |Y |: enter fraction of associated gas that is composed of the GHG of interest.
   Note that the selection of GHG shall be done from the bar "Gas".

Example: **Emissions – Tier 2, CH_4**



Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead captured is to be entered in Gg CO_2 in Column |Z| of worksheets **Emissions** and **Emissions – Tier 2**.

Then, for Tier 1 in worksheet **Emissions** and for Tier 2 in worksheet **Emissions – Tier 2**, for each GHG, emissions are calculated by the *Software* in mass unit (Gg).

Thus, for each GHG, total emission is the sum of all emissions from all subdivisions reported in worksheets **Emissions** and **Emissions – Tier 2**.

Emissions from flaring of natural gas and waste gas/vapour streams at oil facilities

GHGs

Flaring at oil facilities emits the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

Note that this category includes only GHG emissions from flaring of associated gas are covered. Estimation of emissions from intentional releases of gas are described above in Oil - Venting. Fugitive releases of CH_4 and CO_2 are described in the section on Oil – Fugitives

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 Equation 4.2.1
- ✓ Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs, or alternative IPCC Tier 2 Equations 4.2.4 for CH_4, 4.2.5 for CO_2, 4.2.8 for N_2O
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheets:

- ✓ **Activity Data**: contains, for each subdivision/industry segment/subcategory, annual amount of oil production, and if Tier 2 is selected, gas-to-oil ratio, gas conservation efficiency factor, and fraction of waste gas flared.
- ✓ **Emissions**: contains, for each subdivision/industry segment/subcategory, EFs, and CO_2 captured and calculates associated GHG emissions.
- ✓ **CH_4 Emissions – Tier 2**: contains, for each subdivision/industry segment/subcategory: flaring destruction efficiency, molecular weight, CH_4 fraction in flared gas, and calculates associated emissions for Tier 2.
- ✓ **CO_2 Emissions – Tier 2**: contains, for each subdivision/industry segment/subcategory, molecular weight, fraction of non-CO_2 carbon in waste gas stream that is converted to soot, fractions of flared gas composed of CO_2, CH_4 and NMVOCs, number of moles of carbon per mole of compound, CO_2 captured, if any, and calculates associated CO_2 emissions for Tier 2.
- ✓ **N_2O Emissions – Tier 2**: contains, for each subdivision/industry segment/subcategory, N_2O EFs and calculates associated N_2O emissions for Tier 2.

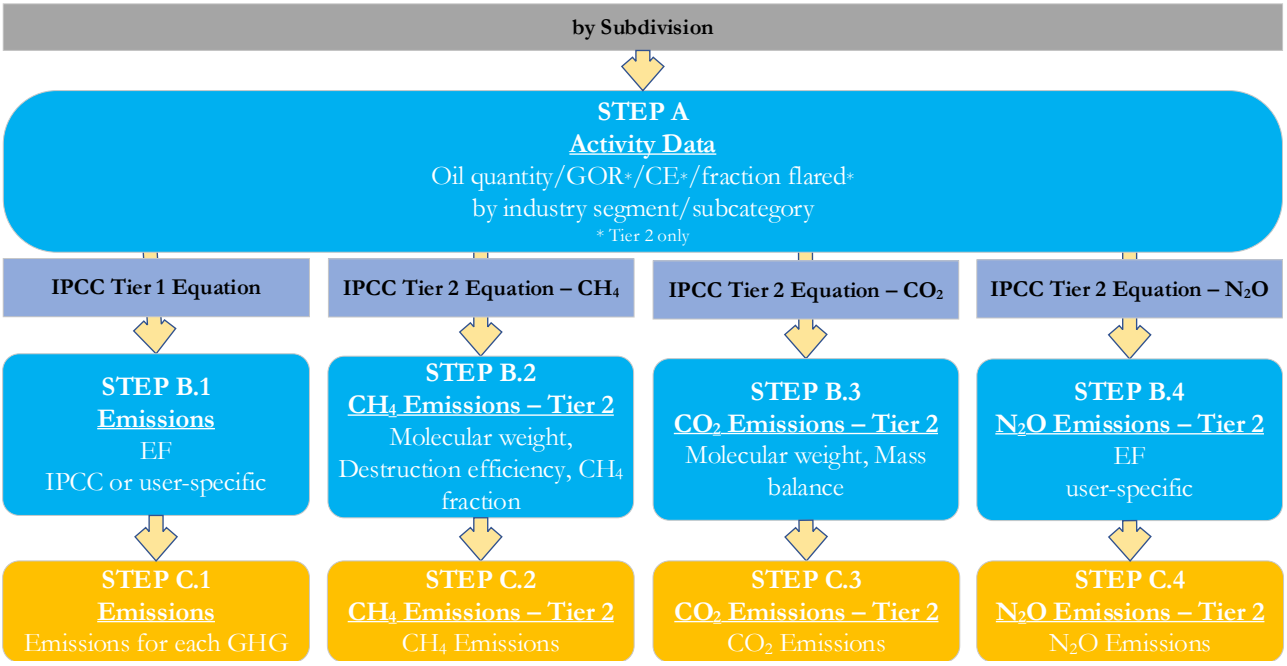
In the upper part of **Emissions** worksheet, users select the GHG for which to enter data.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.2.2, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[46] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Oil – Flaring - flowchart



Step A, worksheet **Activity Data**, users input the annual amount of oil production by subdivision/industry segment/subcategory. Data can be input as a single total or stratified in subdivisions (e.g. regions/companies, etc.).

When Tier 1 Equation is applied

Step B.1, worksheet **Emissions**, users input in the software the EFs for all GHGs. The user shall select in the drop-down menu at the top "Gas" bar the corresponding GHG, "Carbon dioxide (CO_2)", "Methane (CH_4)" or "Nitrous Oxide (N_2O)".

Step C.1, worksheet **Emissions**, the software estimates GHG emissions for each subdivision/industry segment/subcategory.

When Tier 2 Equations are applied

Step B.2, worksheet **CH_4 Emissions – Tier 2**, for each subdivision/industry segment/subcategory users input in the software flaring destruction efficiency, molecular weight and fraction of associated gas.

Step B.3, worksheet **CO_2 Emissions – Tier 2**, for each subdivision/industry segment/subcategory users input in the software molecular weight, fraction of the non-CO_2 carbon in the input waste gas stream that is converted to soot, fractions of associated gas composed of CO_2, CH_4 and NMVOCs, and the number of moles of carbon per mole of compound.

Step B.4, worksheet **N_2O Emissions – Tier 2**, for each subdivision/industry segment/subcategory users input in the software EFs for N_2O.

Step C., worksheets in steps B.2.-B.4, the *Software* calculates corresponding GHG emissions for each subdivision/industry segment/subcategory.

Where data are available, CO_2 capture can be reported in worksheets **Emissions** and **CO_2 Emissions – Tier 2**. CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[46] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

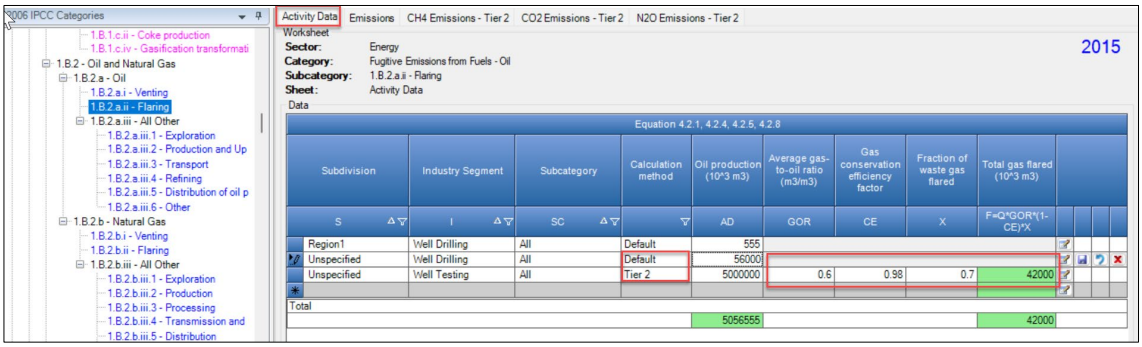
The *2006 IPCC Guidelines*, Section 4.2.2.4, including Tables 4.2.6 & 4.2.7 for the Tier 1 method, provide information on the minimum data needs and where to find and how to apply statistics data.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then, for each subdivision in Column |S|, data are entered in worksheet **Activity Data**, row by row, as follows:

1. Column |I|: select from the drop-down menu or enter the corresponding industry segment. Default industry segments are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
2. Column |SC|: select from the drop-down menu or enter the subcategory corresponding to the industry segment selected. Default subcategories are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
3. Column |Calculation Method|: select the approach to prepare estimates: *Default* or *Tier 2*. Based on the selection in this column, data are transferred by the *Software* to the relevant worksheet **Emissions** or **Emissions – Tier 2**.

   Note that a Tier 2 estimate can be calculated using either a user-specific EF in the Default equation, or the alternative Tier 2 equation based on the mass balance approach. Where a user-specific EF is applied, select "Default" here.

Example: **selection of *Calculation method***



4. Column |AD|: enter total amount of oil production, in 10^3 m^3.

When *Tier 2* is selected in step 3:

5. Column |GOR|: enter average gas-to-oil ratio in m^3/m^3, noting the value shall be referenced at 15°C and 101.325 kPa.
6. Column |CE|: enter gas conservation efficiency factor.
7. Column |X|: enter fraction of waste gas flared.
8. Column |F|: *Software* calculates the amount of total gas flared, in 10^3 m^3.

Emission factor input

IPCC default EFs are provided in Tables 4.2.4 & 4.2.5 of the *2006 IPCC Guidelines*. Where a range of factors is provided in the Tables, the mid-point has been selected for the dropdown. Users can overwrite this value, as necessary.

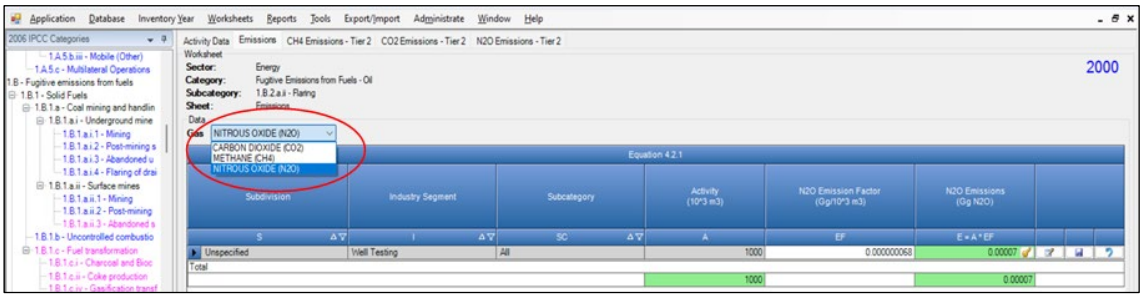
Note that this category includes all flaring at oil facilities, from exploration through to distribution. When using the default EFs for well drilling, well testing and well servicing, be sure not do double count emissions between oil venting and oil flaring.

When Tier 1 Equation is applied:

The **Emissions** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of combinations of subdivision/industry segment/subcategory entered in worksheet **Activity Data**, for which *Default* method is selected. Then:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in Gg per 1,000 m^3 of oil.
   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)" or "Nitrous Oxide (N_2O) in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: **Emissions, N_2O**

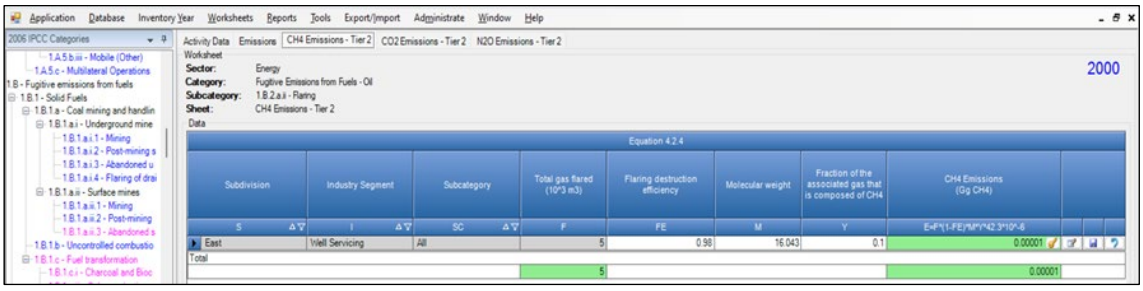


When Tier 2 Equation is applied:

The **CH_4 Emissions – Tier 2** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of combinations of subdivision/industry segment/subcategory entered in worksheet **Activity Data**, for which *Tier 2* method is selected. Then:

1. Column |FE|: enter flaring destruction efficiency. In the absence of user-specific information typically a value of 0.995 is assumed for flares at refineries and a value of 0.98 is assumed for those used at production and processing facilities.
2. Column |M|: enter molecular weight of the corresponding GHG (16.043 for CH_4);
3. Column |Y |: enter fraction of associated gas that is composed of CH_4.

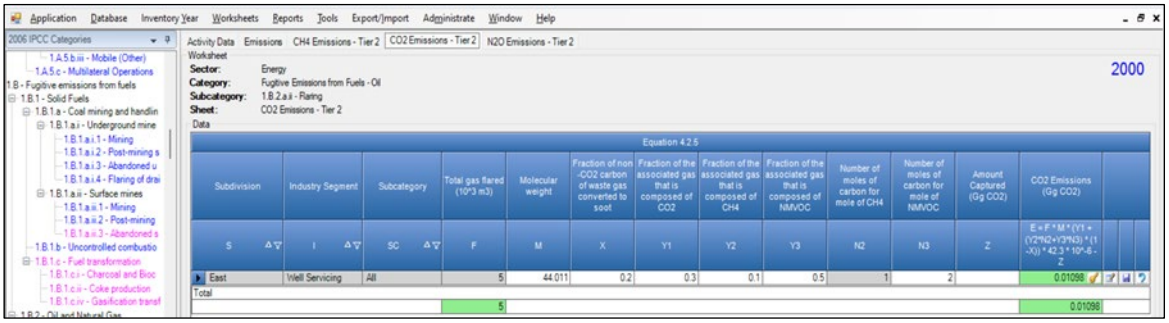
Example: **CH_4 Emissions – Tier 2**



The **CO_2 Emissions – Tier 2** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of combinations of subdivision/industry segment/subcategory entered in worksheet **Activity Data**, for which the *Tier 2* method is selected. Then:

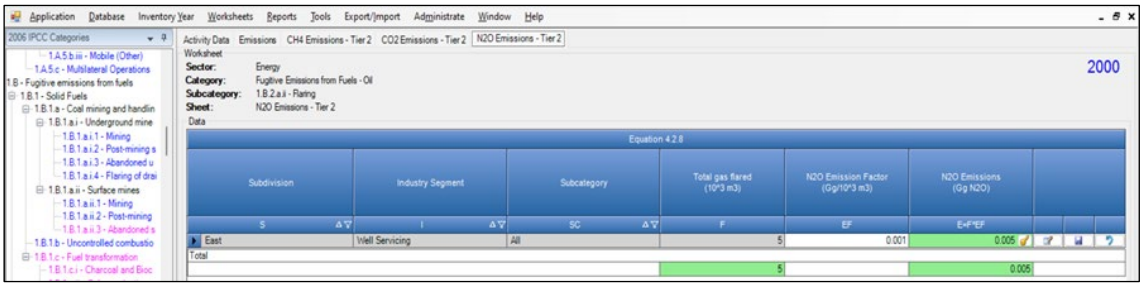
1. Column |M|: *Software* pre-fills the molecular weight of the corresponding GHG (44.011 for CO_2).
2. Column |X|: enter fraction of the non-CO_2 carbon in the input waste gas stream that is converted to soot.
3. Column |Y1|: enter fraction of associated gas that is composed of CO_2.
4. Column |Y2|: enter fraction of associated gas that is composed of CH_4.
5. Column |Y3|: enter fraction of associated gas that is composed of NMVOC.
6. Column |N2|: *Software* pre-fills the number of moles of carbon per mole of CH_4.
7. Column |N3|: input the number of moles of carbon per mole of NMVOC. Default values in the *2006 IPCC Guidelines* range from 2.1 to 2.7 for the NMVOC fraction in natural gas and 4.6 for the NMVOC fraction of crude oil vapours.

Example: **CO_2 Emissions – Tier 2**



The **N_2O Emissions – Tier 2** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of combinations of subdivision/industry segment/subcategory entered in worksheet **Activity Data**, for which the *Tier 2* method is selected. The total gas flared for each combination from worksheet **Activity Data** also is automatically pre-filled.

Example: **N_2O Emissions – Tier 2**



Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead captured is to be entered in Gg CO_2 in Column |Z| of worksheets **Emissions** and **CO_2 Emissions – Tier 2**.

Then, for Tier 1 in worksheet **Emissions** and for Tier 2 in worksheets **CH_4 Emissions – Tier 2**, **CO_2 Emissions – Tier 2** and **N_2O Emissions – Tier 2**, for each GHG, emissions are calculated by the *Software* in mass unit (Gg).

Thus, for each GHG, total emission is the sum of all emissions from all subdivisions reported in worksheets **Emissions** and **CH_4 Emissions – Tier 2**, **CO_2 Emissions – Tier 2** and **N_2O Emissions – Tier 2**.

This section provides instructions to use the IPCC Sofwtare to estimate fugitive emissions (i.e. unintentional releases) from:

1.B.2.a.iii.1 Oil Exploration,
1.B.2.a.iii.2 Production and Upgrading,
1.B.2.a.iii.3 Transport,
1.B.2.a.iii.4 Refining,
1.B.2.a.iii.5 Distribution of oil products
1.B.2.a.iii.6 Other, segments of oil industry.

The guide below is provided as an example for the segment **Oil Production and Upgrading**, although the same calculation worksheet, and thus instructions, apply to all other segments.

GHGs

Oil industry emits the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

N_2O is included here for completeness and recognizing that some categories may have N_2O emissions. However, there are no default N_2O EFs provided in the *2006 IPCC Guidelines* for fugitive emissions from the oil industry.

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 Equations 4.2.1 and 4.2.2
- ✓ Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs.
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheet:

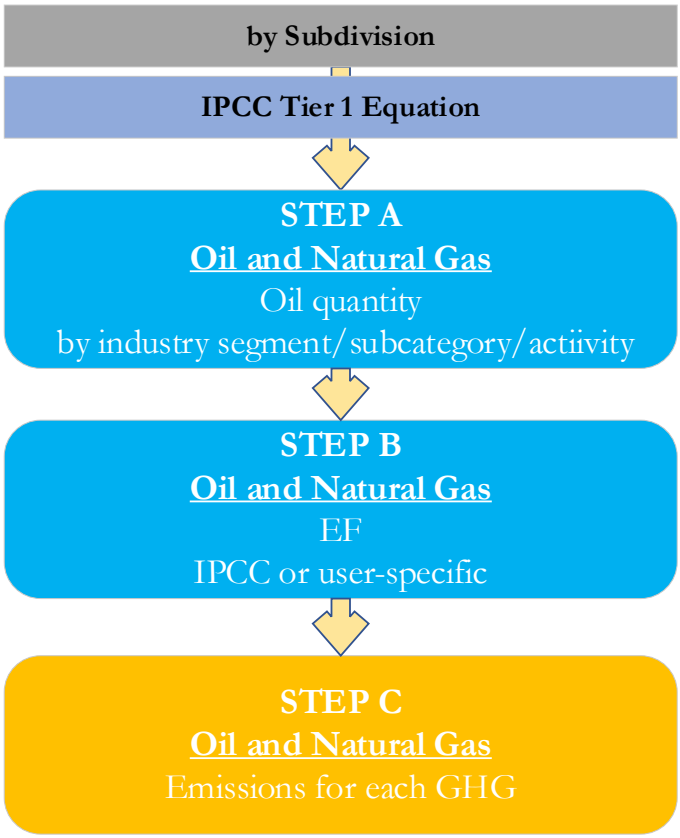
- ✓ **Oil and Natural Gas**: contains, for each subdivision/industry segment/subcategory, total oil production, EFs for each GHG, and CO_2 captured, and calculates associated emissions.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.2.2 and Figure 4.2.3, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[47] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitives - Oil industry - flowchart



Step A, in the **Oil and Natural Gas** worksheet, users input the total activity (e.g. annual amount of oil production) by subdivision/industry segment/subcategory. Data can be input as a single total or stratified in subdivisions (e.g. regions/companies, etc.).

Step B, in the **Oil and Natural Gas** worksheet, users input in the software the EFs for all GHGs, either IPCC defaults or user-specific values.

Step C, in the same **Oil and Natural Gas** worksheet, software estimates GHG emissions for each subdivision/industry segment/subcategory.

Where data are available, CO_2 capture can be reported in worksheet **Oil and Natural Gas**. CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[47] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The 2006 IPCC Guidelines, Section 4.2.2.4, including Tables 4.2.6 & 4.2.7 for the Tier 1 method, provide information on the minimum data needs and where to find and how to apply statistics data. It is important to remember that this category includes only fugitive emissions. GHG emissions from oil venting are covered in **Oil - Venting** and GHG emissions from flaring are covered in **Oil - Flaring**.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then, for each subdivision in Column |S|, data are entered in worksheet **Oil and Natural Gas**, row by row, as follows:

1. Column |I|: select from the drop-down menu or enter the corresponding industry segment. Default industry segments are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
2. Column |SC|: select from the drop-down menu or enter the subcategory corresponding to the industry segment selected. Default subcategories are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
3. Column |AT|: select from the drop-down menu or enter the activity type.
4. Column |AD|: enter AD, corresponding to the activity type selected in Column |AT|, e.g. total amount of annual oil production.
5. Column |U|: enter AD unit. The AD unit for which the IPCC default EFs were developed are contained in Tables 4.2.4 & 4.2.5.

Emission factor input

IPCC default EFs are provided in Tables 4.2.4 & 4.2.5 of the *2006 IPCC Guidelines*. Where a range of factors is provided in the Tables, the mid-point has been selected for the dropdown. Users can overwrite this value, as necessary.

For each row of data entered in worksheet **Oil and Natural Gas**, data are entered as follows:

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default CO_2 EF or enter a user-specific value; in Gg CO_2/U.

   Note that U is the unit of the corresponding AD entered in Column |U|.
2. Column |EF(CH_4)|: select from the drop-down menu the IPCC default CH_4 EF or enter a user-specific value; in Gg CH_4/U.

   Note that U is the unit of the corresponding AD entered in Column |U|.
3. Column |EF(N_2O)|: select from the drop-down menu the IPCC default N_2O EF or enter a user-specific value; in Gg N_2O/U.

   Note that U is the unit of the corresponding AD entered in Column |U|.

Example: **oil production and upgrading**

Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead captured is to be entered in Gg CO_2 in Column |Z| of **Oil and Natural Gas** worksheet.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions are reported in worksheet **Oil and Natural Gas**.

1.B.2.b Natural Gas

Hereafter, the use of the *Software* to estimate fugitive emissions associated with all infrastructure required to produce, collect, process, or refine and deliver natural gas to market is illustrated. The following sections are separated, as emissions from various activities/categories are estimated via different approaches and correspondingly using different worksheets of the *Software*:

- ✓ **21.B.2.b.i Natural Gas – Venting**- Emissions from venting of natural gas and waste gas/vapour streams at gas facilities
- ✓ **1.B.2.b.ii Natural Gas – Flaring** - Emissions from flaring of natural gas and waste gas/vapour streams at gas facilities
- ✓ **1.B.2.b Natural Gas – Fugitives** – this section provides an example of calculation for all activities at gas facilities that are not related to venting and flaring, as it follows
  - ➢ Exploration - fugitive emissions from gas well drilling, drill stem testing and well completions
  - ➢ Production - fugitive emissions related to well servicing, gas gathering, processing and associated waste water and acid gas disposal activities
  - ➢ Processing - fugitive emissions from gas processing facilities
  - ➢ Transmission and Storage - fugitive emissions systems used to transport processed natural gas to market and from storage systems
  - ➢ Distribution - fugitive emissions from the distribution of natural gas to end users
  - ➢ Other - fugitive emissions from natural gas systems not otherwise accounted for in the above categories

This category excludes the following activities, which are covered in other parts of this Guidebook or in other sectors of the *Software*:

- ✓ Combustion-related activities at natural gas facilities are covered under **Stationary Combustion Source Categories** of this Guidebook.
- ✓ Fugitive CO_2 emissions from carbon capture and storage activities are explained under **1.C - Carbon Dioxide Transport and Storage**.

GHG emissions from venting of natural gas and waste gas/vapour streams at gas facilities.

Venting at natural gas facilities emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

N_2O is included here for completeness and recognizing that some categories may have N_2O emissions. However, there are no default N_2O EFs provided in the *2006 IPCC Guidelines* for venting from natural gas facilities.

Note that this category includes only venting activities (i.e. intentional releases of gas). GHG emissions from flaring of associated gas are covered in **Natural Gas – Flaring**. Fugitive releases of CH_4 and CO_2 are calculated in section on **Natural Gas – Fugitives**.

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 Equation 4.2.1
- ✓ Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs.
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheet:

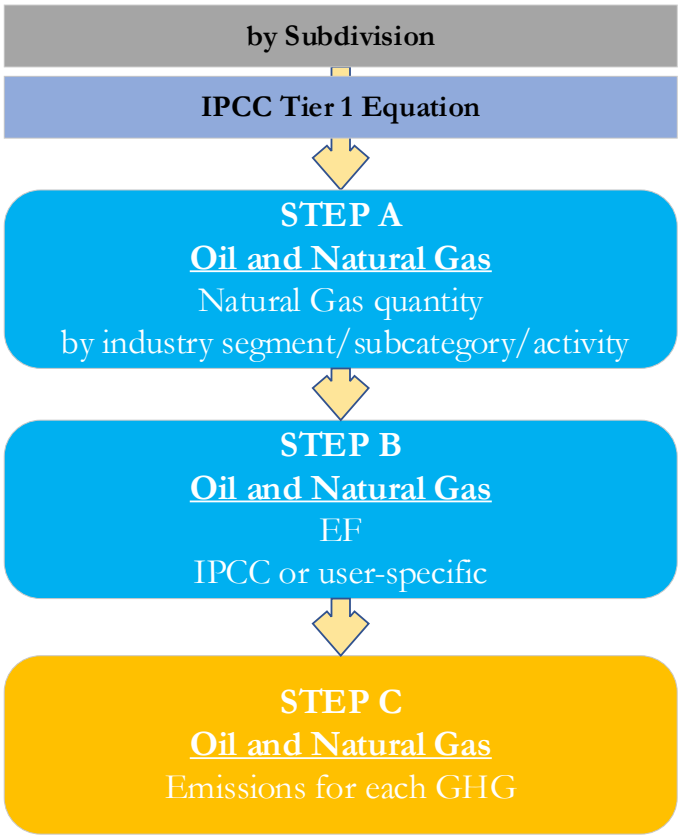
- ✓ **Oil and Natural Gas**: contains, for each subdivision/industry segment/subcategory, volume of activity, EF for each GHG, CO_2 captured, if any, and calculates associated GHG emissions.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.2.1, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[48] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Natural gas - Venting - flowchart



Step A, in the **Oil and Natural Gas** worksheet, users input the annual amount of natural gas activity (e.g. marketable gas production) by subdivision/industry segment/subcategory/activity type. Data can be input as a single total or stratified in subdivisions (e.g. regions/companies, etc.).

Step B, in the **Oil and Natural Gas** worksheet, users input in the software the EFs for all GHGs, either IPCC defaults, user-specific or facility/equipment-specific values.

Step C, in the same worksheet, the *Software* estimates GHG emissions for each subdivision/industry segment/subcategory/activity type.

Where data are available, CO_2 capture can be reported in **Oil and Natural Gas** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[48] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2006 IPCC Guidelines*, Section 4.2.2.4, including Tables 4.2.6 & 4.2.7 for the Tier 1 method, provide information on the minimum data needs and where to find and how to apply statistics data.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then, for each subdivision in Column |S|, data are entered in worksheet **Oil and Natural Gas**, row by row, as follows:

1. Column |I|: select from the drop-down menu or enter the corresponding industry segment. Default industry segments are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
2. Column |SC|: select from the drop-down menu or enter the subcategory corresponding to the industry segment selected. Default subcategories are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
3. Column |AT|: select from the drop-down menu or enter the activity type corresponding to the industry segment subcategory selected.
4. Column |AD|: enter AD, corresponding to the type selected in Column |AT|, e.g. total marketable gas production or raw gas feed;
5. Column |U|: enter Unit of AD entered in Column |AD|. The AD units for which the IPCC default EFs were developed are contained in Tables 4.2.4 & 4.2.5..

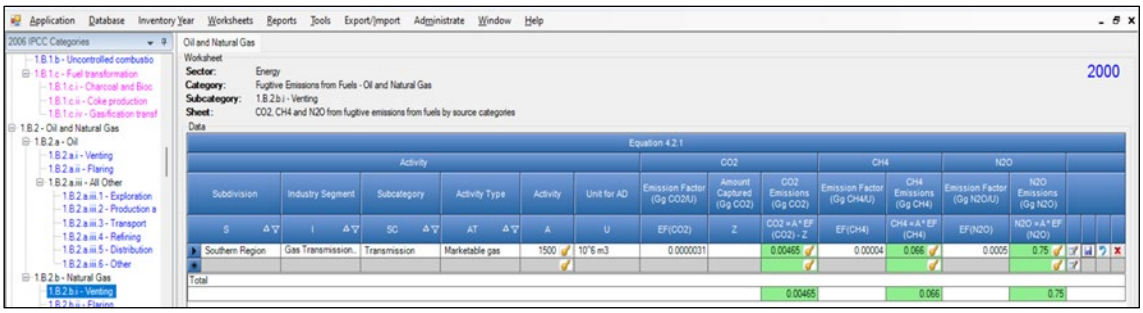
Emission factor input

IPCC default EFs are provided in Tables 4.2.4 & 4.2.5 of the *2006 IPCC Guidelines*. Where a range of factors is provided in the Tables, the mid-point has been selected for the dropdown. Users can overwrite this value, as necessary.

Note that this category includes all venting at gas facilities, from exploration through to distribution. When using the default EFs for well drilling, well testing and well servicing, be sure not do double count emissions between oil venting and oil flaring.

1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in Gg CO_2/U (IPCC defaults are available for some AT).
2. Column |EF(CH_4)|: enter a user-specific CH_4 EF, in Gg CH_4/U (IPCC defaults are available for some AT).
3. Column |EF(N_2O)|: input the N_2O EF in Gg N_2O/U.

Example: **all tiers**



Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead captured is to be entered in Gg CO_2 in Column |Z| of worksheet **Oil and Natural Gas**.

Then, GHG emissions are calculated in units of mass (Gg) in **Oil and Natural Gas** worksheet.

GHG emissions from flaring of natural gas and waste gas/vapour streams at gas facilities.

GHGs

Flaring at natural gas facilities emit the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

Note that this category includes only flaring activities. GHG emissions from venting of natural gas are covered in 1.B.2.b.i Natural Gas – Venting. Fugitive releases of CH_4 and CO_2 are calculated in section on 1.B.2.b Natural Gas – Fugitives

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 Equation 4.2.1
- ✓ Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs.
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheet:

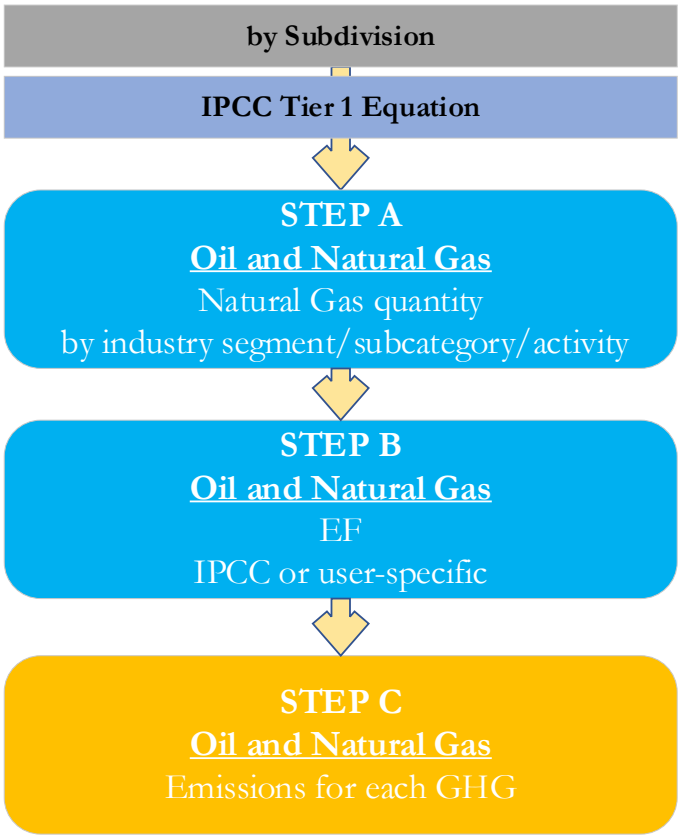
- ✓ **Oil and Natural Gas**: contains for each subdivision/industry segment/subcategory, volume of activity, EF for each GHG, CO_2 captured, if any, and calculates associated GHG emissions.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.2.1, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[49] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Natural gas - Flaring - flowchart



Step A, in the **Oil and Natural Gas** worksheet, users input the annual amount of natural gas activity (e.g. gas production) by subdivision/industry segment/subcategory/activity type. Data can be input as a single total or stratified in subdivisions (e.g. regions/companies, etc.).

Step B, in the **Oil and Natural Gas** worksheet, users input in the software the EFs for all GHGs, either IPCC defaults, user-specific or facility/equipment-specific values.

Step C, in the same worksheet, software estimates GHG emissions for each subdivision/industry segment/subcategory/activity type.

Where data are available, CO_2 capture can be reported in **Oil and Natural Gas** worksheet. CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[49] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The *2006 IPCC Guidelines*, Section 4.2.2.4, including Tables 4.2.6 & 4.2.7 for the Tier 1 method, provide information on the minimum data needs and where to find and how to apply statistics data.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then, for each subdivision in Column |S|, data are entered in worksheet **Oil and Natural Gas**, row by row, as follows:

1. Column |I|: select from the drop-down menu or enter the corresponding industry segment. Default industry segments are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
2. Column |SC|: select from the drop-down menu or enter the subcategory corresponding to the industry segment selected. Default subcategories are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
3. Column |AT|: select from the drop-down menu or enter the activity type corresponding to the industry segment subcategory selected.
4. Column |AD|: enter total AD, corresponding to the activity type selected in Column |AT|, e.g. raw gas feed.
5. Column |U|: enter Unit of AD entered in Column |AD|, IPCC defaults are available that correspond with the default AT.

Emission factor input

IPCC default EFs are provided in Tables 4.2.4 & 4.2.5 of the *2006 IPCC Guidelines*. Where a range of factors is provided in the Tables, the mid-point has been selected for the dropdown. Users can overwrite this value, as necessary.

Note that this category includes all flaring at gas facilities, from exploration through to distribution. When using the default EFs for well drilling, well testing and well servicing, be sure not do double count emissions between oil venting and oil flaring.

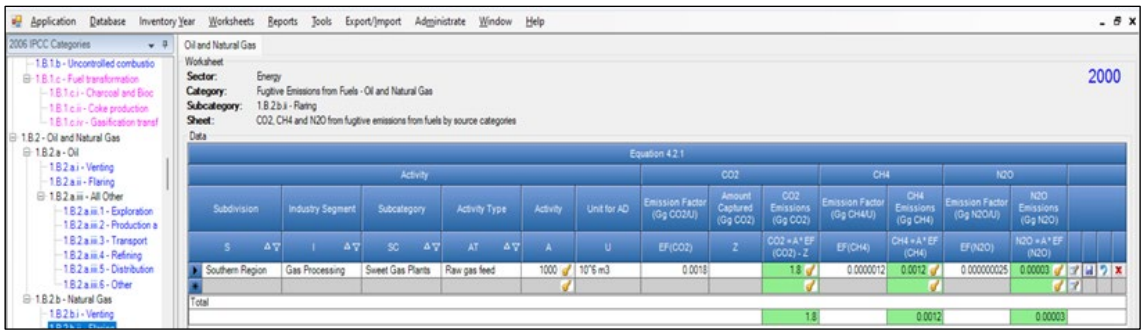
1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in Gg CO_2/U (IPCC defaults are available for some AT).

   Note that U is the unit of the corresponding AD entered in Column |U|;
2. Column |EF(CH_4)|: enter a user-specific CH_4 EF, in Gg CH_4/U (IPCC defaults are available for some AT).

   Note that U is the unit of the corresponding AD entered in Column |U|;
3. Column |EF(N_2O)|: input the N_2O EF in Gg N_2O/U (IPCC defaults are available for some AT)

   Note that U is the unit of the corresponding AD entered in Column |U|;

Example: **Flaring**



Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead captured is to be entered in Gg CO_2 in Column |Z| of worksheet **Oil and Natural Gas**.

Then, GHG emissions are calculated in units of mass (Gg) in **Oil and Natural Gas** worksheet.

This section provides instructions to calculate fugitive GHG emissions (i.e. unintentional released) from:

1.B.2.b.iii.1 Natural Gas Exploration,
1.B.2.b.iii.2 Production,
1.B.2.b.iii.3 Processing,
1.B.2.b.iii.4 Transmission and Storage,
1.B.2.b.iii.5 Distribution,
1.B.2.b.iii.6 Other, segments of natural gas industry.

The guide below is provided as an example for the segment **Transmission and Storage**, although same calculation worksheet, and thus instructions, apply to all other segments.

GHGs

Natural gas industry emits the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

N_2O is included here for completeness and recognizing that some categories may have N_2O emissions. However, there are no default N_2O EFs provided in the *2006 IPCC Guidelines* for fugitive emissions from natural gas facilities.

IPCC Equations

- ✓ Tier 1: IPCC Tier 1 Equations 4.2.1 and 4.2.2
- ✓ Tier 2: Tier 1 equation, although with user-specific (e.g. basin-specific) EFs.
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheet:

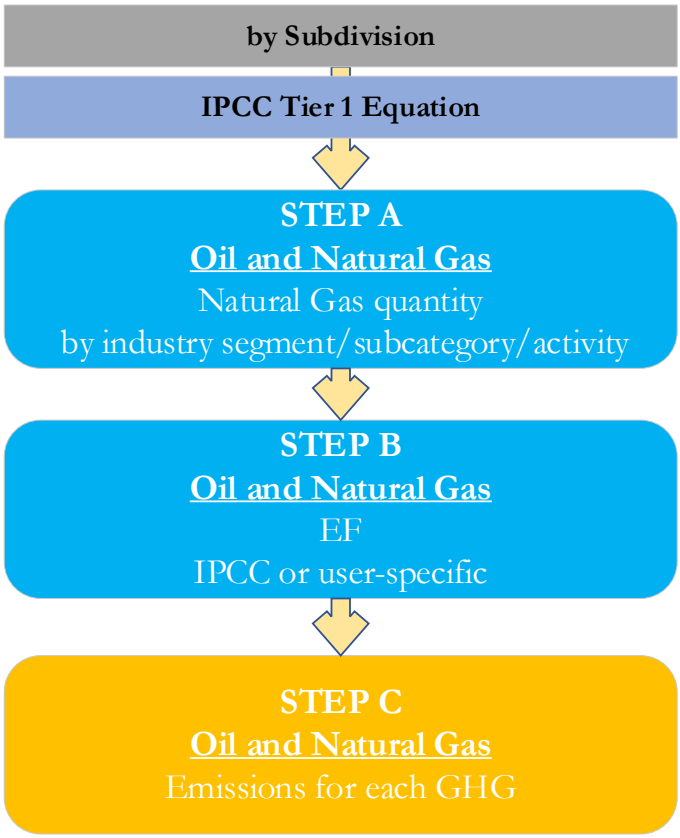
- ✓ **Oil and Natural Gas**: contains, for each subdivision/industry segment/subcategory, AD, e.g. marketable CH_4, EF for each GHG, and CO_2 captured, if any, and calculates associated emissions.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.2.1, GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[50] and/or technology-specific EFs

To ease the use of the *Software* as well as to avoid its misuse, the users apply steps described in the following flowchart:

Fugitives – Natural gas industry - flowchart



Step A, in **Oil and Natural Gas** worksheet, users input the annual amount of natural gas activity (transmission or storage) by subdivision/industry segment/subcategory/activity type. Data can be input as a single total or stratified in subdivisions (e.g. regions/companies, etc.).

Step B, in **Oil and Natural Gas** worksheet, users input in the software the EFs for all GHGs, either IPCC defaults or user-specific values.

Step C, in **Oil and Natural Gas** worksheet, software estimates GHG emissions for each subdivision/industry segment/subcategory/activity type.

Where data are available, CO_2 capture can be reported in **Oil and Natural Gas** worksheet**.** CO_2 capture is only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured is known. The CO_2 captured is then entered at the level at which corresponding emissions are calculated.

[50] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Activity data input

The 2006 IPCC Guidelines, Section 4.2.2.4, including Tables 4.2.6 & 4.2.7 for the Tier 1 method, provide information on the minimum data needs and where to find and how to apply statistics data. It is important to remember that this category includes only fugitive emissions. GHG emissions from natural gas venting are covered in **Natural Gas – Venting** and GHG emissions from flaring are covered in **Natural Gas – Flaring**.

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then, for each subdivision in Column |S|, data are entered in worksheet **Oil and Natural Gas**, row by row, as follows:

1. Column |I |: select from the drop-down menu or enter the corresponding industry segment. Default industry segments are listed in Table 4.2.2 of the *2006 IPCC Guidelines*;
2. Column |SC|: select from the drop-down menu or enter the subcategory corresponding to the industry segment selected. Default subcategories are listed in Table 4.2.2 of the *2006 IPCC Guidelines*.
3. Column |AT|: select from the drop-down menu or enter the activity type;
4. Column |AD|: enter AD, corresponding to the type selected in Column |AT|, e.g. total amount of annual gas production.
5. Column |U|: enter Unit of AD entered in Column |AD|. The AD units for which the IPCC default EFs were developed are contained in Tables 4.2.4 & 4.2.5.

Emission factor input

Input of EFs for natural gas transmission and storage is to be performed in the same worksheet **Oil and Natural Gas**. Information on selection of EFs for fugitive emissions from gas systems may be found in Section 4.2.2.3 of the *2006 IPCC Guidelines*. The IPCC defaults available in the dropdown menu are from Tables 4.2.4 and 4.2.5 of this section and were developed separately for developed countries (Table 4.2.4) and developing countries and economies in transition (Table 4.2.5). Be sure to select the appropriate value for the country circumstances. Where a range of factors is provided in the Tables, the mid-point has been selected for the dropdown. The user may overwrite this value, as necessary.

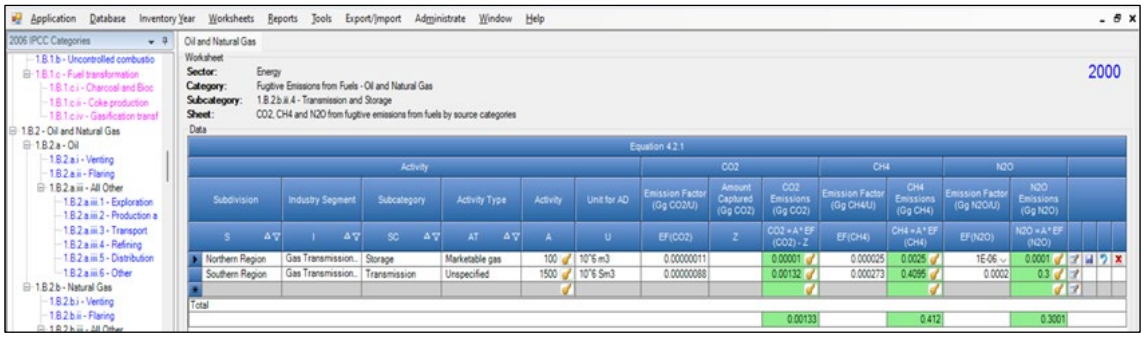
1. Column |EF(CO_2)|: select from the drop-down menu the IPCC default CO_2 EF or enter a user-specific value; in Gg CO_2/U (IPCC defaults are available for some AT).

   Note that U is the unit of the corresponding AD entered in Column |U|
2. Column |EF(CH_4)|: select from the drop-down menu the IPCC default CH_4 EF or enter a user-specific value; in Gg CH_4/U (IPCC defaults are available for some AT).

   Note that U is the unit of the corresponding AD entered in Column |U|;
3. Column |EF(N_2O)|: select from the drop-down menu the IPCC default N_2O EF or enter a user-specific value; in Gg N_2O/U (IPCC defaults are available for some AT).

   Note that U is the unit of the corresponding AD entered in Column |U|;

Example: **natural gas transmission and storage**



Results

To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead captured is to be entered in Gg CO_2 in Column |Z| of **Oil and Natural Gas** worksheet.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions are reported in worksheet **Oil and Natural Gas**.

1.B.3 Other Emissions from Energy Production

This section describes calculation of emissions from geothermal energy production and other energy production that is not included in categories 1.B.1 or 1.B.2.

GHGs

Other emissions from energy production include the following fugitive GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

Given that there are no specific equations in the *2006 IPCC Guidelines* for this category, a generic worksheet is thus provided to enable calculation of other fugitive GHG emissions from Energy production.

1. Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*.
2. Tier 2: IPCC basic equation with user-specific EF
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*.

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

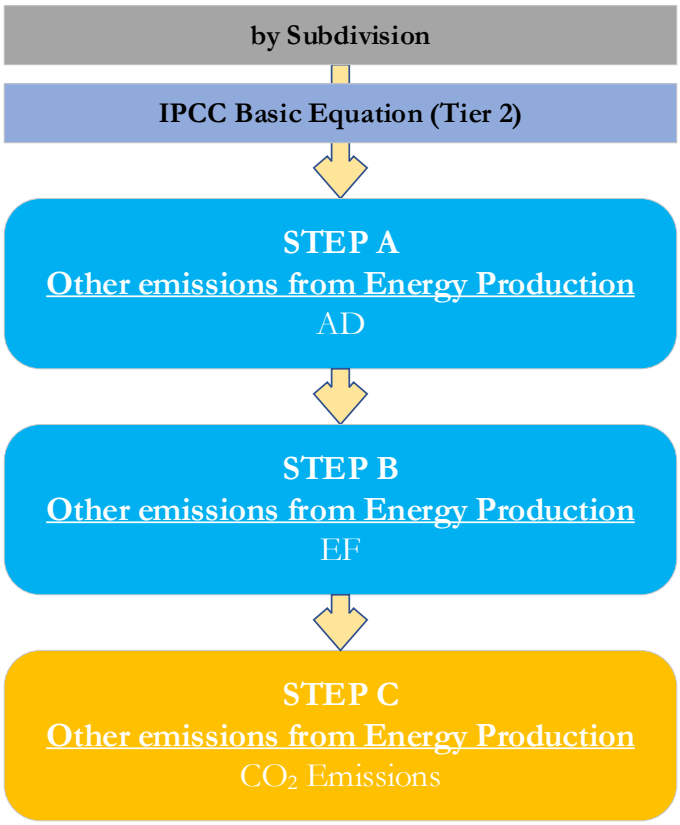
Software Worksheets

The *Software* calculates emissions of the three GHGs using worksheet:

- ✓ **Other emissions from Energy Production**: contains AD, EF for each GHG, CO_2 captured and/or CH_4 recovered, and calculates associated emissions.

In the upper part of **Other emissions from Energy Production** worksheet, users select the GHG for which to enter data.

Fugitive – Other emissions from energy production - flowchart



Step A, in **Other emissions from Energy Production** worksheet, users collect and enter data on the source and activity data.

Step B, in **Other emissions from Energy Production** worksheet, users collect and enter in each row the associated EF.

Step C, in **Other emissions from Energy Production** worksheet, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

Where data are available, CO_2 capture and/or CH_4 recovery can be reported in **Other emissions from Energy Production** worksheet. CO_2 capture and/or CH_4 recovery are only expected to be reported when applying a Tier 3 method, and information on the amount of CO_2 captured and/or CH_4 recovered is known. The CO_2 captured and/or CH_4 recovered is then entered at the level at which corresponding emissions are calculated.

Activity data input

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|.

For each subdivision in Column |S|, data are entered in worksheet **Other emissions from Energy Production**, row by row, as follows:

1. Column |SRC|: describe the type of activity emitting GHG emissions from this category (e.g. geothermal energy production).
2. Column |AT|: enter the activity type corresponding to the source selected.
3. Column |AD|: enter AD (quantity).
4. Column |U|: enter Unit of the AD.

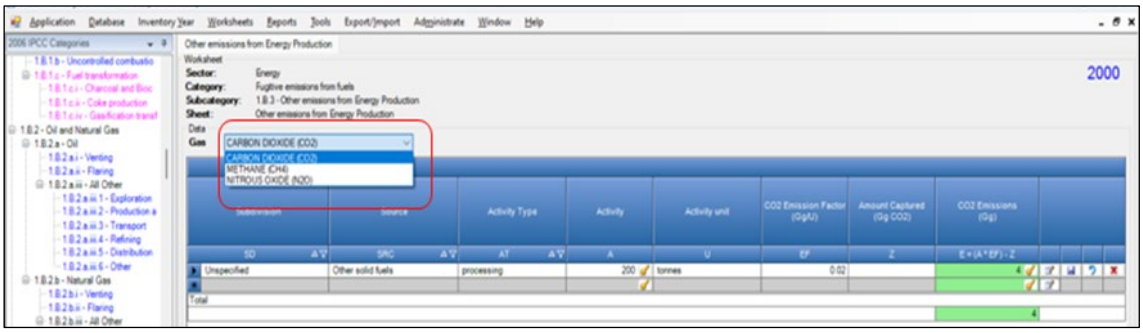
Emission factor input

For each row of data entered in worksheet **Other emissions from Energy Production**, data are entered as follows:

1. Column |EF|: enter CH_4 or CO_2 or N_2O EF;

   Note that user shall select "Carbon dioxide (CO_2)" or "Methane (CH_4)"or "Nitrous Oxide (N_2O)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: **single subdivision**



Results

To estimate the total CO_2 and total CH_4 emitted into the atmosphere, the amount of CO_2 and of CH_4 released from that subdivision that has been instead captured or recovered, respectively, are to be entered in Gg CO_2 in Column |Z| and/or Gg CH_4 in Column |R| of worksheet **Other emissions from Energy Production**.

Then, for each GHG, emissions are calculated by the *Software*, in mass unit (Gg), for each row of data, and total emission from all subdivisions are reported in worksheet **Other emissions from Energy Production**.

1.C - Carbon Dioxide Transport and Storage

This section provides instructions to calculate CO_2 emissions from:

- ✓ **1.C.1. - Transport of CO_2**:
  - ➢ **1.C.1.a - Pipeline**
  - ➢ **1.C.1.b - Ships**
  - ➢ **1.C.1.c - Other**
- ✓ **1.C.2. - Injection & Storage**:
  - ➢ **1.C.2.a - Injection**
  - ➢ **1.C.2.b - Storage**

Emissions estimation methods are not provided for any other type of storage option such as ocean storage or conversion of CO_2 into inert inorganic carbonates.

Emissions resulting from fossil fuels used for capture, compression, transport, and injection of CO_2 are not addressed here. Those emissions are covered by the appropriate stationary or mobile energy use categories described in this Guidebook.

Carbon dioxide transported, injected, and stored can have been originated from combustion/oxidation of fossil fuels as well as of organic matter.

1.C.1. - Transport of CO_2

Pipelines and ships are considered the most likely means of large-scale CO_2 transport. The upstream systems boundary is the outlet of the compression/conditioning plant in the capture and compression system. The downstream systems boundary is the downstream end of a transport pipeline, or a ship offloading facility. Fugitive emissions from compressor stations located along the pipeline system are part of this category.

GHGs

Carbon dioxide transport emits the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

Given that there are no specific equations in the *2006 IPCC Guidelines* for this category, a generic worksheet is thus provided to enable calculation of fugitive CO_2 emissions from CO_2 transport. However, in Box 5.1 the *2006 IPCC Guidelines* provide an outline of the derivation of a default fugitive CO_2 EF for pipeline CO_2 transport. Thus, for

- ✓ CO_2 transport in pipelines:
  - Tier 1: IPCC Tier 1 Equation 4.2.1 is provided in the *Software*, and the default CO_2 EF from Box 5.1
  - Tier 2: Same equation as Tier 1, although with user-specific values
  - Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

  Note that when intermediate storage sites are needed along the transport route, emissions are estimated like CO_2 transport (when the storage is a tank) or geologic storage (when a natural formation).
- ✓ CO_2 transport by ship:
  - Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*
  - Tier 2: IPCC Tier 1 Equation 4.2.1 although with user-specific values
  - Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheet

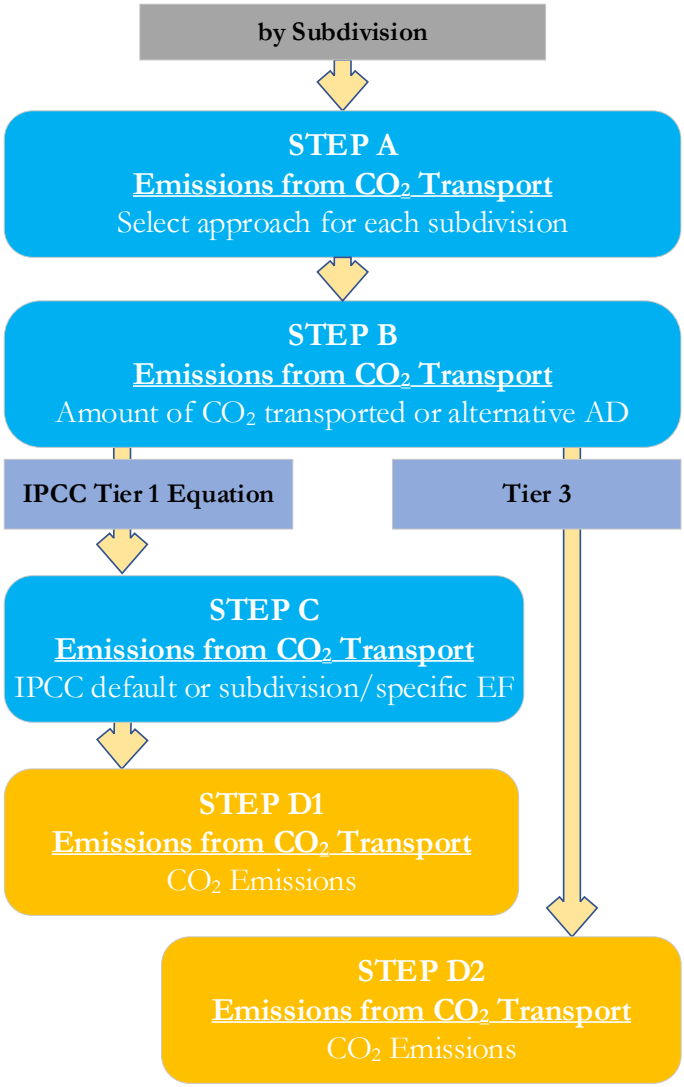
CO_2 emissions from transport of CO_2 are estimated using three worksheets, one for each subcategory -1.C.1.a, 1.C.1.b, 1.C.1.c-, that are similar in structure but differ for the means of transport: pipelines, ships, or others.

Data compilation of each of those subcategories is operated independently, following for each subcategory the entire set of instructions below.

User's work Flowchart

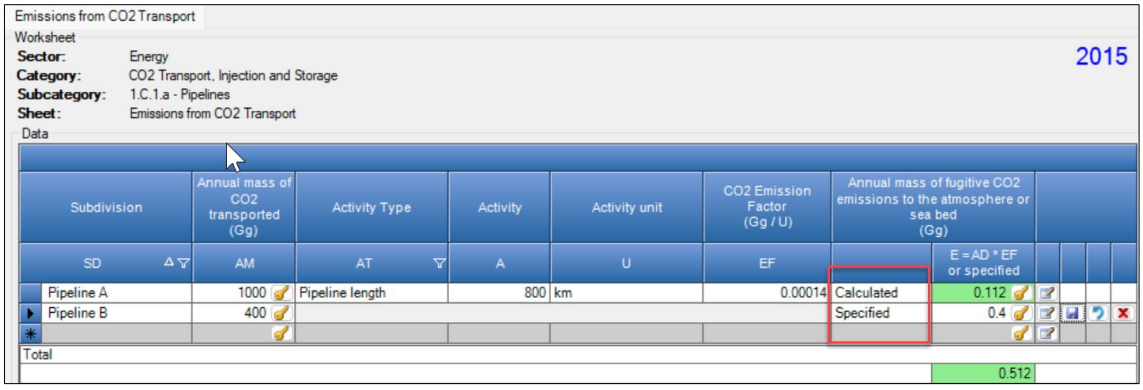
GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[51] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:



For each subcategory, and for each subdivision in the subcategory, if any:

Step A, worksheet **Emissions from CO_2 Transport**, users select whether to calculate the annual CO_2 emissions (this is the case for Tier 1 and Tier 2 estimates), and in such case the next step is **B**, or enter the value of annual fugitive CO_2 emissions as estimated through a user-specific model, and in such case next step is **D.2**.



[51] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Step B, worksheet **Emissions from CO_2 Transport**, users collect and enter the annual mass of CO_2 transported and an activity type (e.g. pipeline length).

Step C, worksheet **Emissions from CO_2 Transport**, users collect and enter in each row the associated CO_2 EF.

Step D1, worksheet **Emissions from CO_2 Transport**, for each row of data, the *Software* calculates fugitive CO_2 emissions in mass units (Gg). In addition, total emissions are calculated.

Step D2, worksheet **Emissions from CO_2 Transport**, users collect and enter annual mass of fugitive CO_2 emissions.

Activity data input

Sections 5.4.1 and 5.4.2 of the *2006 IPCC Guidelines* provide information on the collection of AD for transport of CO_2 in units of mass (Gg).

Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "*country name*" or "*unspecified*" as selected from the dropdown menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |S|. Then:

First, users select the approach to apply to report annual CO_2 emissions i.e. either *Calculated* or *Specified*, where *Specified* means that the amount of annual fugitive CO_2 emissions is entered (see **Results**).

Second, for each subdivision in Column |S|, data are entered in worksheet **Emissions from CO_2 Transport**, as follows:

1. Column |AM|: enter annual mass of transported CO_2, in Gg.
   Note that this information is not used by the Software to calculate the annual CO_2 emissions from CO_2 transport in pipelines or in ships; however, given that this information is needed for interoperability with UNFCCC CRTs it shall always be input by users wishing to use the UNFCCC electronic reporting tool.

Where the approach *Specified* is selected, AD are not needed; otherwise where the approach *Calculated* is selected:

2. Column |AT|: select[52] from the dropdown menu *Pipeline length* activity type, or enter a user-specific Activity Type.[53]
3. Column |AD|: enter AD.
4. Column |U|: select from dropdown menu *km*, or enter unit of AD.

Emission factor input

Where the approach *Calculated* is selected, for each row:

✓ Column |EF|: select the IPCC default EF from the drop-down menu or enter a user specific EF, in Gg/U.

Otherwise no EF is entered, and users enter annual amount of fugitive CO_2 emissions from CO_2 transport in Column |E|.

Results

Fugitive CO_2 emissions are either calculated by the *Software,* or specified, in mass unit (Gg), for each row of data, and total fugitive emissions from transport of CO_2 are the sum of all emissions listed in all subdivisions reported in worksheet **Emissions from CO_2 Transport**.

[52] Note that this applies to subcategory 1.C.1.a – Pipeline only.

[53] The user-specific AD can be the annual mass of transported CO_2. In such a case this information is to be entered in this column and the value of annual mass of transported CO_2 is to be entered in Column |AD|.

The injection system comprises surface facilities at the injection site, e.g. storage facilities, any distribution manifold at the end of the transport pipeline, distribution pipelines to wells, additional compression facilities, measurement and control systems, wellhead(s) and the injection wells.

Geological storage of carbon dioxide may take place onshore or offshore, in: deep saline formations; depleted or partially depleted oil fields; depleted or partially depleted natural gas fields; and coal seams.

For both injection and storage, the only emissions pathways that need to be considered in category 1.C.2 are CO_2 leakage.

GHGs

Carbon dioxide injection and storage emits the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

The *Software* calculates fugitive CO_2 emissions in a single worksheet for Tier 2

IPCC Equations

Given that there are no specific equations in the *2006 IPCC Guidelines* for this category, fugitive CO_2 emissions from CO_2 injection and storage are calculated in the *Software* with the IPCC basic equation for fugitive emissions:

1. Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines*
2. Tier 2: IPCC Tier 1 Equation 4.2.1 (taken from fugitive emissions from oil and gas systems) although with user-specific values
3. Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section I.2. Use of multiple tiers for reporting, GHG estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheet

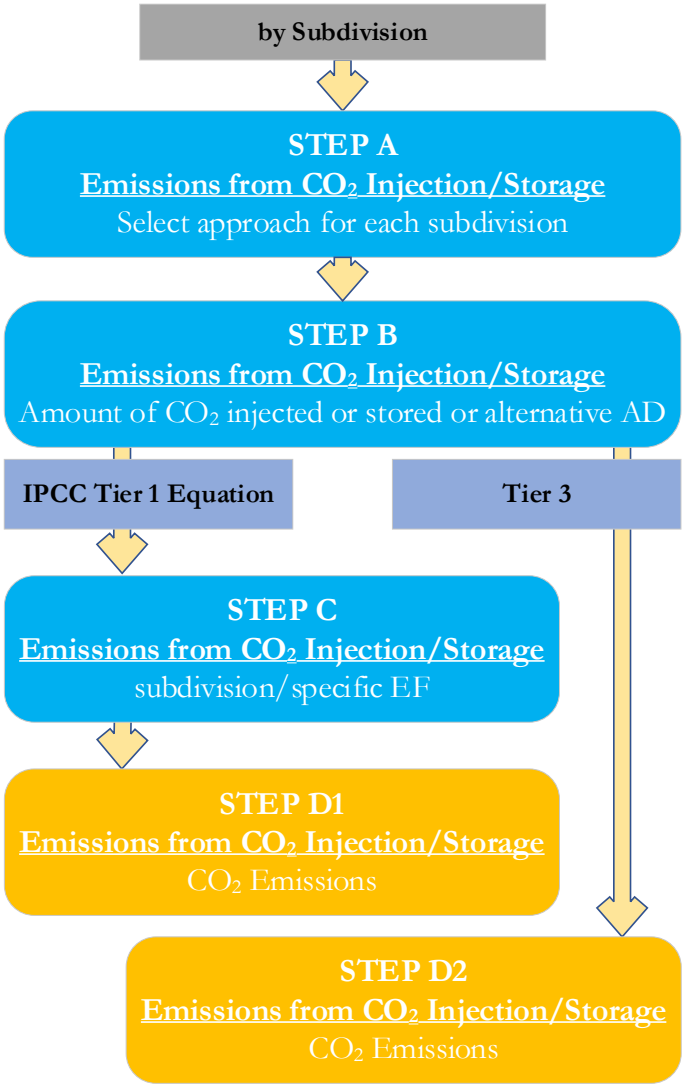
CO_2 emissions from CO_2 injection and storage are estimated using two worksheets, one for each subcategory 1.C.2.a and 1.C.2.b, that are similar in structure but differ for the activity: injection *vs* storage.

Data compilation of each of those subcategories is operated independently, following for each subcategory the entire set of instructions below.

User's work Flowchart

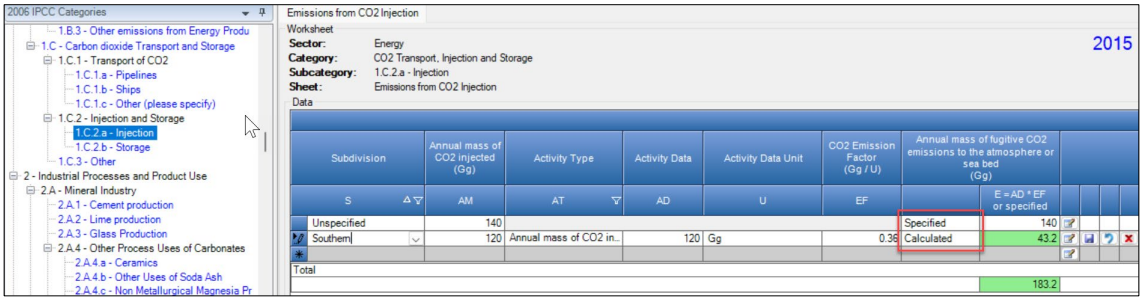
GHG estimates are calculated using a single methodological tier or applying a combination of tiers according to the availability of AD and of user-specific[54] and/or technology-specific EFs.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:



For each subcategory, and for each subdivision in the subcategory, if any:

Step A, worksheet **Emissions from CO_2 Injection/Storage**, users select whether to calculate the annual CO_2 emissions -this is the case for Tier 2 estimates-, and in such case next step is **B**, or enter the value of annual fugitive CO_2 emissions as estimated through a user-specific model, and in such case next step is **D.2**.



Step B, worksheet **Emissions from CO_2 Injection/Storage**, users collect and enter the annual mass of CO_2 injected/stored and an activity type.

Step C, worksheet **Emissions from CO_2 Injection/Storage**, users collect and enter in each row the associated CO_2 EF.

[54] Where the inventory of the source-category is stratified by subdivisions instead of a single aggregate, subdivision-specific EFs can be applied to prepare estimates at Tier 2. For instance, Region A and Region B are two subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either by applying different region-specific EFs or by applying to both regions the user-specific EF, as the weighted average EF across the two regions.

Step D1, worksheet **Emissions from CO_2 Injection/Storage**, for each row of data, the *Software* calculates the emissions in mass units (Gg). In addition, total emissions are calculated.

Step D2, worksheet **Emissions from CO_2 Injection/Storage**, users collect and enter the annual mass of fugitive CO_2 emissions.

Activity data input

Section 5.7.2 provide information on the collection of AD for CO_2 injection/storage.

First, users select the approach to apply to report annual CO_2 emissions i.e. either *Calculated* or *Specified*, where *Specified* means that the amount of annual fugitive CO_2 emissions is entered (see **Results**).

Second, for each subdivision in Column |S|, data are entered in worksheet **Emissions from CO_2 Injection/Storage**, as follows:

1. Column |AM|: enter annual mass of CO_2 injected/stored, in Gg.
   Note that this information is not used by the Software to calculate the annual CO_2 emissions from CO_2 injected/stored; however, given that this information is needed for interoperability with UNFCCC CRTs it shall always be input by users wishing to use the UNFCCC electronic reporting tool for CRT.

Where the approach *Specified* is selected, AD are not needed; otherwise where the approach *Calculated* is selected:

2. Column |AT|: enter a user-specific Activity Type.[55]
3. Column |AD|: enter AD.
4. Column |U|: enter unit of AD.

Emission factor input

Where the approach *Calculated* is selected, enter user-specific CO_2 EF in Column |EF|, in Gg/U. Otherwise no EF is entered, and users enter annual amount of fugitive CO_2 emissions from CO_2 injection/storage in Column |E|.

Results

Fugitive CO_2 emissions are either calculated by the *Software*, or specified, in mass unit (Gg), for each row of data, and total fugitive emissions from CO_2 injection/storage are the sum of all emissions listed in all subdivisions reported in worksheet **Emissions from CO_2 Injection/Storage**.

[55] The user-specific AD can be the annual mass of transported CO_2. In such a case this information is to be entered in this column and the value of annual mass of transported CO_2 is to be entered in Column |AD|.

Reference Approach

The Reference Approach is designed to calculate the emissions of CO_2 from fuel combustion, starting from high level energy supply data. This approach does not distinguish between different source categories within the energy sector and only estimates total emissions from source category 1.A Fuel Combustion.

GHGs

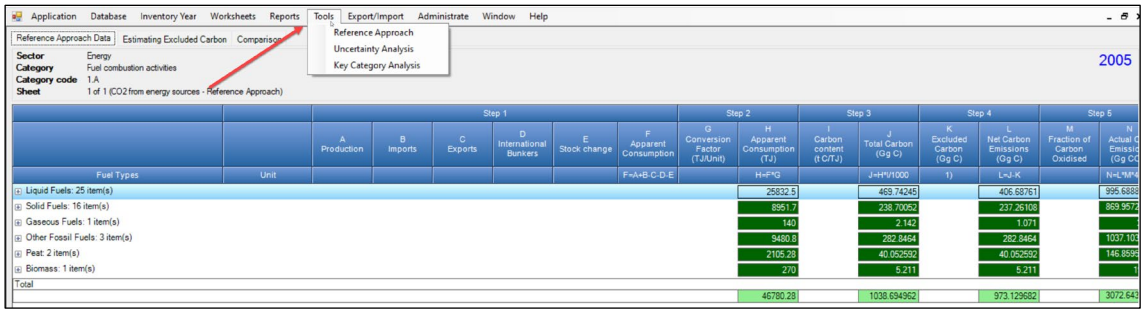
The Reference Approach estimates the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

The *Software* prepares Reference Approach estimates of CO_2 within two worksheets -i.e. Reference Approach Data and Estimating Excluded Carbon- and provides in addition:

- ✓ one worksheet for comparison of the results of the Reference and Sectoral Approaches,
- ✓ one worksheet to report the quantity of CO_2 emissions from NEU reported elsewhere in the NGHGI and where in the inventory those emissions are reported.

The Reference Approach worksheets may be found under "Tools" on the main ribbon.



IPCC Equations

1. IPCC Equation 6.1 calculates the CO_2 emissions
2. IPCC equations 6.2 and 6.3 estimate the apparent consumption of primary fuel and secondary fuel, respectively
3. Equation 6.4 estimates the amount of excluded carbon

Software Worksheets

The *Software* calculates CO_2 emissions from Stationary combustion source categories for the top-down reference approach using worksheets:

- ✓ **Fuel Manager**: contains information on the *carbon content* and the *calorific value* of each fuel type applied to the NGHGI.
- ✓ **Reference Approach Data**: contains for each fuel type the amount produced, imported, exported, and used for international bunkers, as well as stock changes for that fuel. This worksheet also contains for each fuel the *calorific value* and *carbon content* (filled in automatically from the **Fuel Manager**), the excluded carbon, and the fraction oxidized. From this information the worksheet calculates actual CO_2 emissions.
- ✓ **Estimating Excluded Carbon**: contains for specific fuels the amount of the total estimated quantity of carbon which does not lead to fuel combustion emissions and, using *calorific value* and *carbon content* data, calculates the amount of carbon that shall be excluded from the emissions.

Two additional worksheets complete the reference Approach Tool:

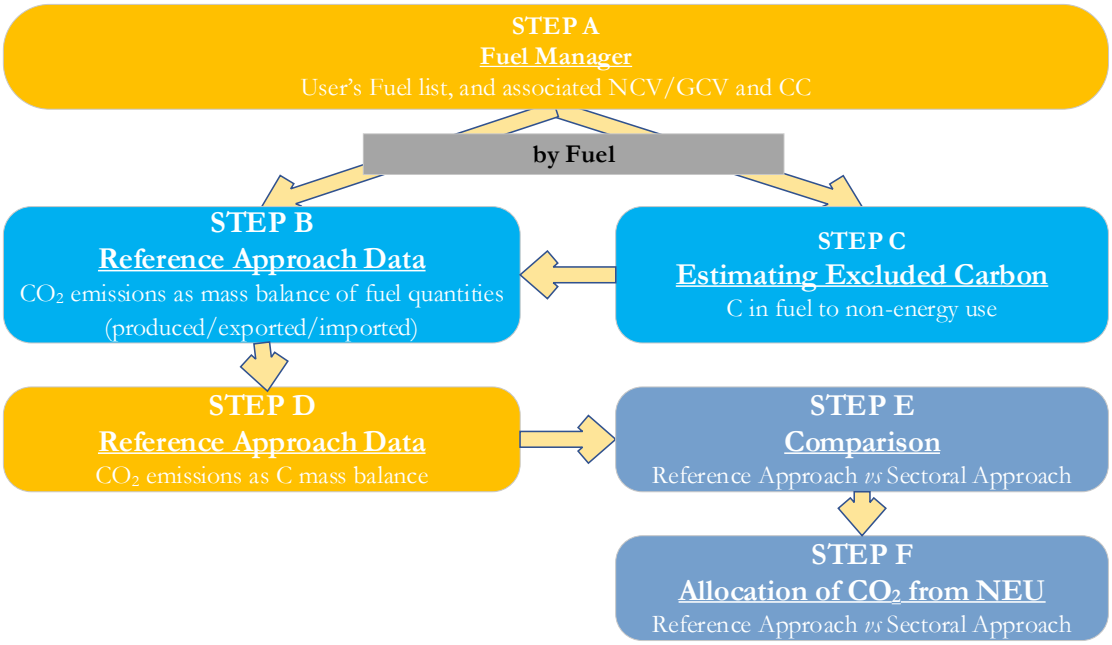
- ✓ **Comparison**: provides summary information on total estimated AD and CO_2 emissions from the Reference and Sectoral approaches, and performs a comparison between the two methods results.
- ✓ **Allocation of CO_2 from NEU** summarizes the total CO_2 excluded from the reference approach, by fuel. The CO_2 excluded is either emitted from another sector (e.g. IPPU) or stored for long periods of time in a product manufactured from the fuel (e.g. bitumen/asphalt used for road paving). This worksheet includes the CO_2 emissions from NEU that are reported elsewhere in the NGHGI, and in which category they are reported.

User's work Flowchart

To estimate emissions under the Reference approach, the user utilizes the five worksheets of the *Software* referred above.

To ease the use of the *Software* as well as to avoid its misuse, for each source category, the users apply steps described in the following flowchart:

Reference approach - flowchart



Step A, in the **Fuel Manager**, users collect and input in the *Software* information on each fuel type used in the relevant source category: the *calorific value* and the *carbon content*.

Step B, in worksheet **Reference Approach Data**, users input the supply of each fuel (production, import, export, international bunker, stock change), *calorific value* and *carbon content* (being filled automatically from the **Fuel Manager**) and fraction of carbon oxidized. The *Software* then estimates CO_2 emissions for each fuel.

Step C, in worksheet **Estimating Excluded Carbon**, users input estimated quantities for specific fuels that do not lead to fuel combustion emissions, *calorific value* and *carbon content* (being filled automatically from the **Fuel Manager**). The *Software* estimates the amount of carbon that shall be excluded from the calculations. This amount goes automatically to the worksheet **Reference Approach Data** into the Column |K|.

Step D, in worksheet **Reference Approach Data**, the *Software* estimates CO_2 emissions for each fuel based on the information from **Step B and C**.

Step E, in worksheet **Comparison**, the *Software* provides results of CO_2 estimations under the Reference and Sectoral approaches and performs a comparison between the two approaches by each fuel, fuel type and total for the NGHGI.

Step F, in worksheet **Allocation of CO_2 from NEU,** the *Software* allows inclusion of information on the quantity of any CO_2 excluded that is ultimately released in another category of the NGHGI, and where those emissions are reported. This information is not included in the IPCC inventory tables, but it is used for mapping to the UNFCCC ETF Reporting Tool.

Activity data input

The *2006 IPCC Guidelines*, Sections 1.4.1.2 and 1.4.1.3, contain information on how to collect and apply energy statistics data. Further information on collecting information on apparent consumption of primary fuel and secondary fuels is provided in Section 6.4.

Fuel consumption data in mass or volume units shall first be converted into the energy content of these fuels in Terajoule units (TJ). The GCV/NCV are used to convert Gg of fuels into TJ (IPCC default values for NCV are in Table 1.2) Other units may be entered (e.g. British Thermal Units (BTUs)). However, when alternative units are used, the Column |Conversion Factor| becomes blank and the user shall enter user-defined conversion factor (TJ/unit).

Input of AD for the Reference Approach requires the following steps:

i. **Fuel Manager**: input all fuel types used and the associated *calorific value* and *carbon content*. All fuels entered in the Fuel Manager are considered in the Reference Approach.

ii. **Reference Approach Data** worksheet:

For each fuel, enter the following information:

1. Column |Unit|: select or enter manually the measurement unit used (e.g. Gg, TJ, m^3).

   Note that worksheet rows for each fuel type are closed by default, "+" sign at the left side of the row shall be clicked to expand to the full fuel list.

2. Column |A|: input the amount of production of the certain fuel.

   Note that production amount is to be entered only for primary fuels, not secondary. Fuels are designated as primary or second in the Fuel Manager.

3. Column |B|: input the amount of imported fuel.
4. Column |C|: input the amount of exported fuel.
5. Column |D|: input the amount of fuel used for international bunkers.
6. Column |E|: input the amount of stock change.

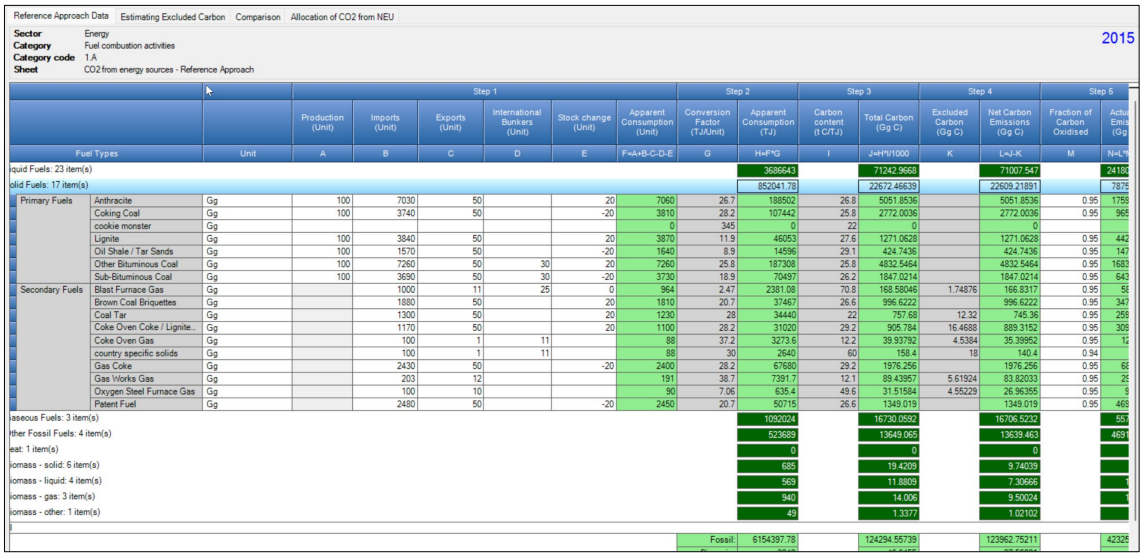
   Note that an increase in stocks is a positive stock change which withdraws supply from consumption. A stock reduction is a negative stock change which, when subtracted in the equation, causes an increase in apparent consumption

7. Column |F|: the *Software* estimates the amount of apparent consumption of the fuel.
8. Column |G|: conversion factor in (TJ/Unit) is filled automatically from the **Fuel Manager**.

   Note that where Gg of fuel are converted to TJ, the NCV/GCV is sourced from the Fuel Manager and compiled by the Software as a conversion factor; while if the consumption unit is TJ, the Software compiles the conversion factor cell with the value 1. Where other units are applied (e.g. m^3) the user shall enter relevant conversion unit here

9. Column |K|: this column will be automatically filled by information entered in the next worksheet (**Estimating Excluded Carbon**).

Example: **reference approach data**



Reference Approach Data | Estimating Excluded Carbon | Comparison | Allocation of CO2 from NEU

Sector: Energy
Category: Fuel combustion activities
Category code: 1.A
Sheet: CO2 from energy sources - Reference Approach

2015

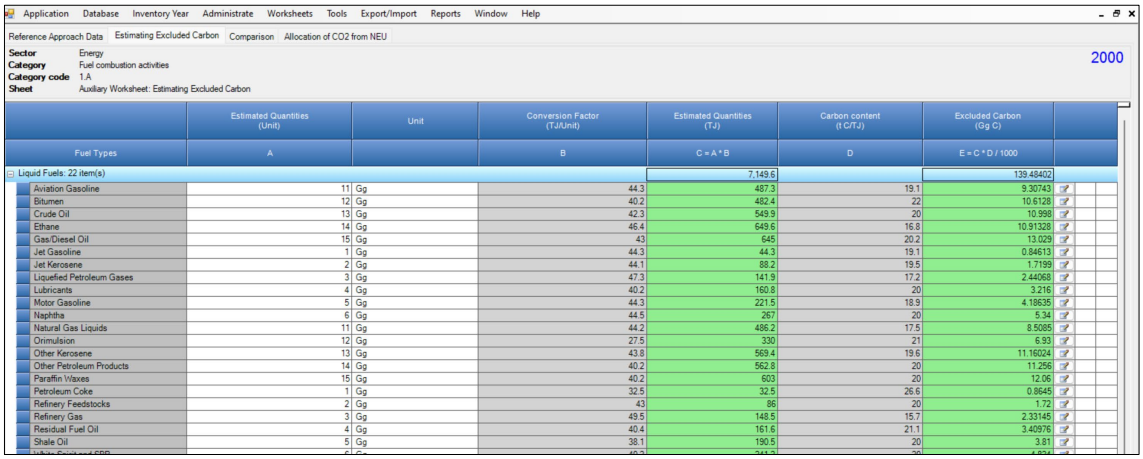
			Step 1						Step 2	Step 3		Step 4		Step 5	
			Production (Unit)	Imports (Unit)	Exports (Unit)	International Bunkers (Unit)	Stock change (Unit)	Apparent Consumption (Unit)	Conversion Factor (TJ/Unit)	Apparent Consumption (TJ)	Carbon content (t C/TJ)	Total Carbon (Gg C)	Excluded Carbon (Gg C)	Net Carbon Emissions (Gg C)	Fraction of Carbon Oxidised	Actu Emis (Gg
Fuel Types		Unit	A	B	C	D	E	F=A+B-C-D-E	G	H=F*G	I	J=H*I/1000	K	L=J-K	M	N=L*M
iquid Fuels: 23 item(s)										3686643		71242.9668		71007.547		24180
olid Fuels: 17 item(s)										852041.78		22672.46639		22609.21891		7875
Primary Fuels	Anthracite	Gg	100	7030	50		20	7060	26.7	188502	26.8	5051.8536		5051.8536	0.95	1759
	Coking Coal	Gg	100	3740	50		-20	3810	28.2	107442	25.8	2772.0036		2772.0036	0.95	965
	cookie monster	Gg						0	345	0	22	0		0		
	Lignite	Gg	100	3840	50		20	3870	11.9	46053	27.6	1271.0628		1271.0628	0.95	442
	Oil Shale / Tar Sands	Gg	100	1570	50		-20	1640	8.9	14596	29.1	424.7436		424.7436	0.95	147
	Other Bituminous Coal	Gg	100	7260	50	30	20	7260	25.8	187308	25.8	4832.5464		4832.5464	0.95	1683
	Sub-Bituminous Coal	Gg	100	3690	50	30	-20	3730	18.9	70497	26.2	1847.0214		1847.0214	0.95	643
Secondary Fuels	Blast Furnace Gas	Gg		1000	11	25	0	964	2.47	2381.08	70.8	168.58046	1.74876	166.8317	0.95	58
	Brown Coal Briquettes	Gg		1880	50		20	1810	20.7	37467	26.6	996.6222		996.6222	0.95	347
	Coal Tar	Gg		1300	50		20	1230	28	34440	22	757.68	12.32	745.36	0.95	259
	Coke Oven Coke / Lignite..	Gg		1170	50		20	1100	28.2	31020	29.2	905.784	16.4688	889.3152	0.95	309
	Coke Oven Gas	Gg		100	1	11		88	37.2	3273.6	12.2	39.93792	4.5384	35.39952	0.95	12
	country specific solids	Gg		100	1	11		88	30	2640	60	158.4	18	140.4	0.94	
	Gas Coke	Gg		2430	50		-20	2400	28.2	67680	29.2	1976.256		1976.256	0.95	68
	Gas Works Gas	Gg		203	12			191	38.7	7391.7	12.1	89.43957	5.61924	83.82033	0.95	29
	Oxygen Steel Furnace Gas	Gg		100	10			30	7.06	635.4	49.6	31.51584	4.55229	26.96355	0.95	9
	Patent Fuel	Gg		2480	50		-20	2450	20.7	50715	26.6	1349.019		1349.019	0.95	469
aseous Fuels: 3 item(s)										1092024		16730.0592		16706.5232		557
ther Fossil Fuels: 4 item(s)										523689		13649.065		13639.463		469
eat: 1 item(s)										0		0		0		
iomass - solid: 6 item(s)										685		19.4209		9.74039		
iomass - liquid: 4 item(s)										569		11.8809		7.30666		1
iomass - gas: 3 item(s)										940		14.006		9.50024		1
iomass - other: 1 item(s)										49		1.3377		1.02102		
									Fossil:	6154397.78		124294.55739		123962.75211		42325

iii. **Estimating Excluded Carbon** worksheet:

For each fuel in the Column |Fuel Types|, enter the following information:

1. Column |A|: enter the estimated quantity of the fuel not used for combustion purposes (e.g. natural gas used as a feedstock for ammonia production, or coking coal used in the iron and steel industry).
2. Column |Unit|: select or enter manually the measurement unit used (e.g. Gg, TJ, m^3).
3. Column |B|: conversion factor in TJ/Unit is filled automatically from the **Fuel Manager**.

Example: **estimating excluded carbon**

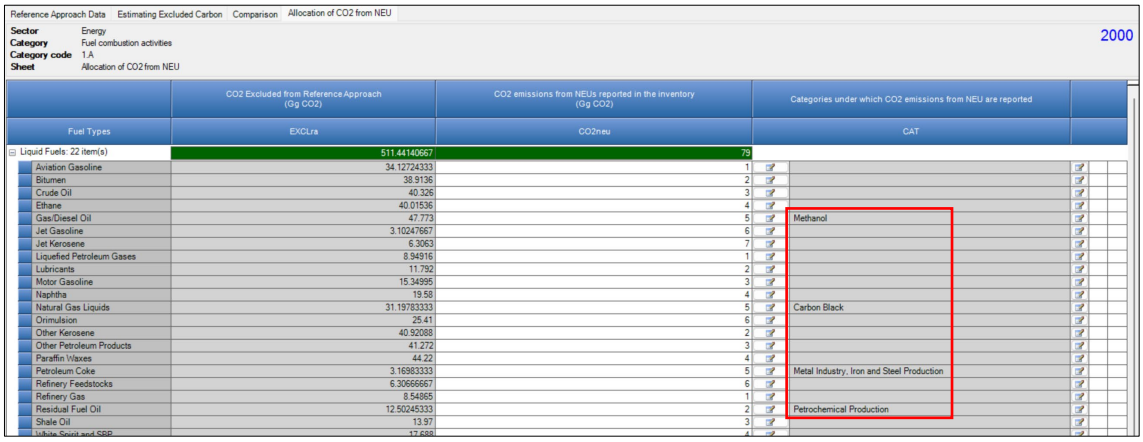


iv. **Allocation of CO_2 from NEU** worksheet:

For each relevant fuel in Column |Fuel Types| that is used for NEU and for which CO_2 emissions from the use of that fuel are reported elsewhere, enter the following information:

1. Column |CO_2neu|: enter the quantity of CO_2 emissions from NEU that is reported elsewhere in the NGHGI, in $GgCO_2$ (e.g. CO_2 emissions from the liquified petroleum gases used in petrochemical production).
2. Column |CAT|: for each relevant fuel, click on the editing box in the left-hand side of the column and select one or more categories of the inventory where these CO_2 emissions are reported.

Example: **CO_2 emissions from NEU reported elsewhere**



Emission factor input

Input of EFs for the Reference Approach requires the following steps:

i. **Reference Approach Data** worksheet:

For each fuel, enter following information:

1. Column |I|: carbon content is filled automatically from the **Fuel Manager** in t C/TJ.
2. Column |M|: enter fraction of oxidized carbon.
   Note if no information on this factor is available, the value "1" shall be entered to proceed with calculations

ii. In the **Estimating Excluded Carbon** worksheet, Column |D| is filled automatically from the **Fuel Manager** in t C/TJ.

Results

CO_2 emissions are estimated in mass units (Gg) by the *Software* in the **Reference Approach Data** worksheet in Column |N| by fuel, fuel type, and total.

Worksheet **Comparison** also presents the results for the Reference Approach, as well as main AD (apparent consumption). This worksheet also summarizes the main AD and CO_2 emissions calculated under the Sectoral Approach, by fuel type. In the Columns |Difference|, the *Software* provides the comparative difference between the Reference and Sectoral approaches in terms of energy consumption and CO_2 emissions.

The *2006 IPCC Guidelines*, Section 6.8, provide possible reasons for a gap between the two approaches, which is generally expected to be less than 5%. For higher percent differences, reporting programs typically require users to provide a clear explanation and justification.

Example: **comparison**

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

Reference Approach Data | Estimating Excluded Carbon | Comparison | Allocation of CO2 from NEU

Sector Energy
Category Fuel combustion activities
Category code 1.A
Sheet Comparison of CO2 Emissions from Fuel Combustion

Fuel Types	Reference Approach				Sectoral Approach		Difference	
	Apparent Consumption (TJ)	Excluded consumption (TJ)	Apparent Consumption (excluding non-energy use and feedstocks) (TJ)	CO2 Emissions (Gg)	Energy Consumption (TJ)	CO2 Emissions (Gg)	Energy Consumption (%)	CO2 Emissions (%)
Liquid Fuels: 22 item(s)	5,462,686.8	7,149.6	5,455,537.2	371,524.667...	1,384,861.3	143,420.549...	293.94105388	159.04563127
Solid Fuels: 16 item(s)	1,572,586	1,034.94	1,571,551.06	118,304.336...	385,308.52	20,919.9903...	307.86823504	465.50856393
Gaseous Fuels: 1 item(s)	10,036	0	10,036	563.0196	951,560	65,381.0903...	-98.94531086	-99.13886477
Other Fossil Fuels: 3 item(s)	151,815.6	122.4	151,693.2	11,033.8503	267,654.4	14,096.9858...	-43.3249743	-21.72901042
Peat: 1 item(s)	28,362.56	97.6	28,264.96	2,695.62923...	105,587.84	10,477.18416	-73.23085689	-74.27143406
Total								
	7,225,486.96	8,404.54	7,217,082.42	504,121.503...	3,094,972.06	254,295.800...	133.1873206	98.2421666

Reference Approach Data | Estimating Excluded Carbon | Comparison | Allocation of CO2 from NEU

Sector Energy
Category Fuel combustion activities
Category code 1.A
Sheet Comparison of CO2 Emissions from Fuel Combustion

Fuel Types		Reference Approach				Sectoral Approach		Difference	
		Apparent Consumption (TJ)	Excluded consumption (TJ)	Apparent Consumption (excluding non-energy use and feedstocks) (TJ)	CO2 Emissions (Gg)	Energy Consumption (TJ)	CO2 Emissions (Gg)	Energy Consumption (%)	CO2 Emissions (%)
Liquid Fuels: 22 item(s)		5,462,686.8	7,149.6	5,455,537.2	371,524.667...	1,384,861.3	143,420.549...	293.94105388	159.04563127
Solid Fuels: 16 item(s)		1,572,586	1,034.94	1,571,551.06	118,304.336...	385,308.52	20,919.9903...	307.86823504	465.50856393
	Primary Fuels: Anthracite	53,667	26.7	53,640.3	5,271.05348	156,331.9	8,672.48595	-65.68819288	-39.22096259
	Coking Coal	85,164	169.2	84,994.8	8,040.50808	81,075	915.75964	4.83478261	778.01511759
	Lignite	47,957	11.9	47,945.1	4,852.04412	3,570	34.27	1,243	14,058.28456376
	Northern Coal Mine	0	0	0	0			0	0
	Oil Shale / Tar Sands	44,856	17.8	44,838.2	4,305.812346	5,927.4	11.8548	656.45645646	36,221.25675676
	Other Bituminous Coal	156,090	77.4	156,012.6	13,282.9127...	3,173.4	295.20364	4,816.2601626	4,399.57621254
	Sub-Bituminous Coal	133,434	37.8	133,396.2	11,533.4354...			100	100
	Secondary Fuels: Blast Furnace Gas	2,445.3	4.94	2,440.36	570.1657104	2,593.5	664.31	-5.9047619	-14.17174054
	Brown Coal Briquettes	41,193	62.1	41,130.9	3,610.470402	4,761	463.1975	763.91304348	679.46672899
	Coal Tar	83,720	112	83,608	6,069.9408	12,600	459.92	563.55555556	1,219.78187511
	Coke Oven Coke / Lignite...	112,518	0	112,518	10,842.23448	76,597.4	8,004.18383...	46.89532543	35.45708976
	Coke Oven Gas	193,113	193.5	192,919.5	7,703.275635	7,740	11.48	2,392.5	67,001.70413763
	Gas Coke	168,918	197.4	168,720.6	16,257.9170...	15,058.8	1,336.3396	1,020.411985...	1,116.60070659
	Gas Works Gas	270,513	0	270,513	10,801.58409	14,312.8	45.65648684	1,790.007545...	23,558.37767494
	Oxygen Steel Furnace Gas	-7,095.3	0	-7,095.3	-1,161.3587...	1,567.32	5.328888	-552.7027027	-21,893.640699...
	Patent Fuel	186,093	124.2	185,968.8	16,324.3412...			100	100
	Total								
		1,572,586	1,034.94	1,571,551.06	118,304.336...	385,308.52	20,919.9903...	307.86823504	465.50856393
Gaseous Fuels: 1 item(s)		10,036	0	10,036	563.0196	951,560	65,381.0903...	-98.94531086	-99.13886477
Other Fossil Fuels: 3 item(s)		151,815.6	122.4	151,693.2	11,033.8503	267,654.4	14,096.9858...	-43.3249743	-21.72901042
Peat: 1 item(s)		28,362.56	97.6	28,264.96	2,695.62923...	105,587.84	10,477.18416	-73.23085689	-74.27143406
Total									
		7,225,486.96	8,404.54	7,217,082.42	504,121.503...	3,094,972.06	254,295.800...	133.1873206	98.2421666

Next Steps

This Guidebook is to be considered a work-in-progress given it will be periodically revised by IPCC TFI-TSU with the aim to increase the amount of information, in particular with real case examples, as well as to correct the information provided for any error and/or any further enhancement of the *Software*.

Users are therefore required to check periodically the version of the Guidebook published on the TFI website at https://www.ipcc-nggip.iges.or.jp/software/index.html.

Annex I: Mapping between the IPCC Inventory Software and the UNFCCC ETF Reporting Tool

The *Software* enables users to calculate national GHG emissions in accordance with the *2006 IPCC Guidelines*. The methods contained in the *Software* are consistent with those required to be used by Parties in preparing a national GHG inventory, consistent with decision 18/CMA.1, under the Enhanced Transparency Framework (ETF) of the Paris Agreement. However, Parties to the UNFCCC have agreed to a specific format for reporting the GHG inventory information, called the common reporting tables (CRT), that differ from the IPCC reporting tables contained in volume 1, chapter 8 of the *2006 IPCC Guidelines*.

Thus, Parties to the UNFCCC, acknowledging the importance of the *Software* in aiding countries to estimate their national GHG inventory, have invited IPCC to work together to facilitate interoperability between the *Software* and the UNFCCC electronic reporting tool. Consequently, the *Software* has been upgraded to operationalize the interoperability. Specifically, users of the *Software* can estimate GHG emissions and removals for all categories and gases that are required to be reported pursuant to the CRT. Once data are entered into the *Software*, users wishing to use these data to facilitate reporting to the UNFCCC must generate a file in the *Software* (in JSON format). This file, can then subsequently, through a separate UNFCCC platform, be uploaded and further processed through the UNFCCC electronic reporting tool to transfer to UNFCCC their national GHG inventory, as compiled in the CRTs and as required under the Paris Agreement.

Preparing a JSON file that can be imported into the UNFCCC ETF Reporting Tool required a cell-by-cell mapping of the CRT to document where each of the AD and GHG emissions estimates contained in each worksheet of the *Software* reside in the CRT.

This annex contains detailed information to illustrate the mapping of fuels (Table A.1.1) and categories/gases (Table A.1.2) between the IPCC reporting categories and the CRT. The specific information presented in this annex related to reporting of emissions from the energy sector in the CRT is supplemental to the general information provided in the IPCC Inventory Software -UNFCCC Interoperability – CRT Export Quick Start Guide.

Table 2 includes the list of the fuels included in Table 1.1 Definitions of Fuel Types Used in the *2006 IPCC Guidelines* and the corresponding fuel to which that fuel is mapped in the CRT. For example, reporting of "Gasoline" in the CRT includes the following consumption of fuels from the *Software:* aviation gasoline, jet gasoline and motor gasoline.

Table 2. Mapping of Fuels between the *Software* and the UNFCCC Common Reporting Tables

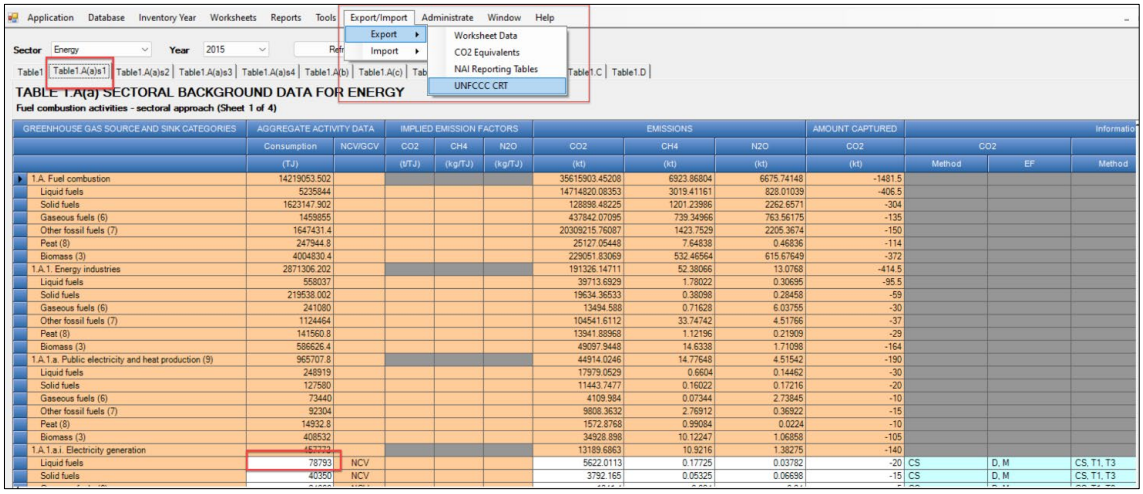
2006 IPCC Guidelines Fuel Name	CRT Reference Approach Fuel Name
Liquid Fuels	
Aviation Gasoline	Gasoline
Jet Gasoline	
Motor Gasoline	
Bitumen	Bitumen
Crude Oil	Crude Oil
Ethane	Ethane
Gas/diesel oil	Gas/diesel oil
Jet Kerosene	Jet Kerosene
Liquified Petroleum Gases	Liquefied petroleum gases (LPG)
Lubricants	Lubricants
Naphtha	Naphtha
Natural Gas Liquids	Natural Gas Liquids
Orimulsion	Orimulsion
Other Kerosene	Other Kerosene
Other Petroleum Products	Other oil
Paraffin Waxes	
Refinery Gas	
White Spirit and SBP	
Petroleum Coke	Petroleum Coke
Refinery Feedstocks	Refinery Feedstocks
Residual Fuel oil	Residual fuel oil
Shale oil	Shale oil
Country specific fuels	Other liquid fossil (*please specify*)
Solid Fuels	
Anthracite	Anthracite
Brown Coal Briquettes	Brown coal briquettes and patent fuel
Patent Fuel	
Coal Tar	Coal tar
Coke Oven Gas /Lignite Coke	Coke oven/gas coke
Gas Coke	
Coking coal	Coking coal
Lignite	Lignite
Oil Shale / Tar Sands	Oil shale and tar sand
Other Bituminous Coal	Other bituminous coal
Sub-Bituminous Coal	Sub-bituminous coal
Blast Furnace Gas	Other solid fossil (*please specify*)
Gas Works Gas	
Oxygen Steel Furnace Gas	
Country specific fuels	

2006 IPCC Guidelines Fuel Name	CRT Reference Approach Fuel Name
Gaseous Fuels	
Natural Gas *(dry)*	Natural gas *(dry)*
Country specific fuels	Other gaseous fuels *(please specify)*
Other Fossil Fuels	
Municipal Wastes *(non-biomass fraction)*	Waste *(non-biomass fraction)*
Industrial Wastes	Other fossil fuels
Waste Oils	
Country specific fuels	
Peat	
Peat	Peat
Biomass	
Biodiesels	Liquid biomass
Biogasoline	
Other Liquid Biofuels	
Charcoal	Solid biomass
Other Primary Solid Biomass	
Sulphite lyes (Black Liquor)	
Wood / Wood Waste	
Landfill Gas	Gas biomass
Sludge Gas	
Other Biogas	
Municipal Wastes *(biomass fraction)*	Other non-fossil fuels *(biogenic waste)*

CRT visualization tables in the IPCC Inventory Software

To allow the user to properly understand, and keep for internal use, thus enhancing transparency, the results of conversion of IPCC category GHG estimates into UNFCCC NGHGI categories the mapping between the *Software* and the CRT are visualized in the *Software*.

To generate the visualization tables, select from the ribbon "Export/Import" and then "UNFCCC CRT" so you generate the tables. For complete guidance on how to do this, refer to the **IPCC Inventory Software -UNFCCC Interoperability – CRT Export Quick Start Guide**. The result of the generated tables is presented below.



GREENHOUSE GAS SOURCE AND SINK CATEGORIES	AGGREGATE ACTIVITY DATA		IMPLIED EMISSION FACTORS			EMISSIONS			AMOUNT CAPTURED			
	Consumption	NCV/GCV	CO2	CH4	N2O	CO2	CH4	N2O	CO2	CO2		
	(TJ)		(t/TJ)	(kg/TJ)	(kg/TJ)	(kt)	(kt)	(kt)	(kt)	Method	EF	Method
1.A. Fuel combustion	14219053.502					35615903.45208	6923.86804	6675.74148	-1481.5			
Liquid fuels	5235844					14714820.08353	3019.41161	828.01039	-406.5			
Solid fuels	1623147.902					128898.48225	1201.23986	2262.6571	-304			
Gaseous fuels (6)	1459855					437842.07095	739.34966	763.56175	-135			
Other fossil fuels (7)	1647431.4					20309215.76087	1423.7529	2205.3674	-150			
Peat (8)	247944.8					25127.05448	7.64838	0.46836	-114			
Biomass (3)	4004830.4					229051.83069	532.46564	615.67649	-372			
1.A.1. Energy industries	2871306.202					191326.14711	52.38066	13.0768	-414.5			
Liquid fuels	558037					39713.6929	1.78022	0.30695	-95.5			
Solid fuels	219538.002					19634.36533	0.38098	0.28458	-59			
Gaseous fuels (6)	241080					13494.588	0.71628	6.03755	-30			
Other fossil fuels (7)	1124464					104541.6112	33.74742	4.51766	-37			
Peat (8)	141560.8					13941.88968	1.12196	0.21909	-29			
Biomass (3)	586626.4					49097.9448	14.6338	1.71098	-164			
1.A.1.a. Public electricity and heat production (9)	965707.8					44914.0246	14.77648	4.51542	-190			
Liquid fuels	248919					17979.0529	0.6604	0.14462	-30			
Solid fuels	127580					11443.7477	0.16022	0.17216	-20			
Gaseous fuels (6)	73440					4109.984	0.07344	2.73845	-10			
Other fossil fuels (7)	92304					9808.3632	2.76912	0.36922	-15			
Peat (8)	14932.8					1572.8768	0.99084	0.0224	-10			
Biomass (3)	408532					34928.898	10.12247	1.06858	-105			
1.A.1.a.i. Electricity generation	452779					13189.6863	10.9216	1.38275	-140			
Liquid fuels	78793	NCV				5622.0113	0.17725	0.03782	-20	CS	D, M	CS, T1, T3
Solid fuels	40350	NCV				3792.165	0.05325	0.06698	-15	CS	D, M	CS, T1, T3

IMPORTANT: these visualization tables have been prepared to enhance transparency and demonstrate to the user how the data entered in the *Software* are mapped to the UNFCCC CRT. The data entered in the *Software* are not automatically used to meet the UNFCCC reporting requirements. The user will still be required to formally submit the information through the UNFCCC ETF Reporting Tool, and the user is responsible for reviewing first the information compiled in the CRT visualization tables and second the information once imported into that tool.

How to read mapping tables

The mapping tables have been developed to enhance transparency of the relationship between the categories in the *Software* and the UNFCCC ETF Reporting Tool. For each cell in the CRT, the mapping tables describe the source of the data from the *Software* that is reported in that cell. The majority of cells in the CRT map from the underlying category-specific worksheets of the *Software*. In limited cases (e.g. for some short-lived climate forcer emissions in the sector summary tables, the reference approach, and some additional background information) data are mapped from the IPCC background or sectoral reporting tables, or in the case of the Reference Approach, from the "Tools" tab in the *Software*.

The specific instructions vary, depending on the nature of the category, and how many calculation worksheets from the *Software* map to that cell, but generally, the instruction is written to direct the user to:

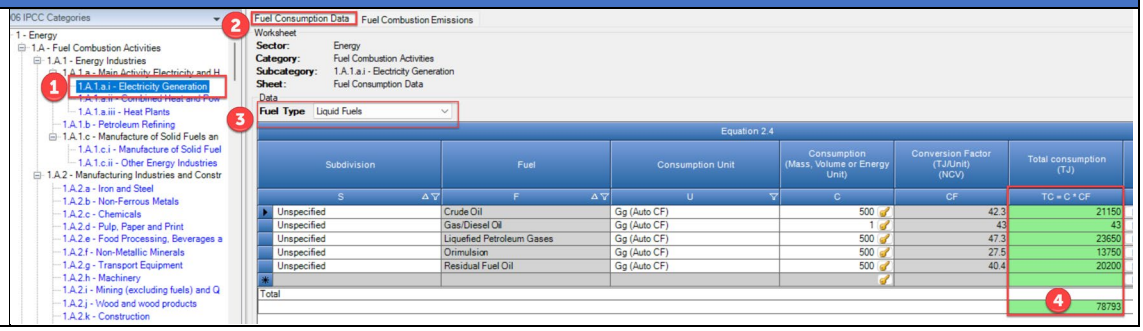
1. The specific IPCC category in the category tree
2. The tab in that worksheet that contains the relevant information
3. The fuel (or gas) of interest
4. The column that contains the relevant information, with an indication of any mathematical operation needed (e.g. SUM, MULTIPLY BY, etc)
5. Any conversions needed to ensure correct units map to the UNFCCC CRT (e.g. DIVIDE by 1,000 to convert tonnes to kilo tonnes)

By illustration, the directions in the mapping file to report total liquid fuel consumption for electricity generation in the CRT, and the corresponding location of the information in the *Software* are shown below. Generally, white cells in the CRT are mapped from the *Software*. Orange, green, or blue cells in the visualized CRT in the *Software* will be calculated by the UNFCCC ETF Reporting Tool, upon import of the JSON file.

***Example:* How to read mapping between the *Software* and the UNFCCC CRT**

UNFCCC CRT	1.A.1.a.i. Electricity generation	SUM(C33:C38)
	Liquid fuels	IPCC 1.A.1.a.i <Fuel Consumption Data> SUM by fuel type (Liquid Fuels) Column TC

IPCC Inventory Software



The example above is a simple illustration. In some cases, multiple worksheets and even multiple categories may map to a single cell in the CRT. This would be illustrated by reference to the two key instructions "PLUS" or "AND" to denote consideration of multiple data elements from the *Software*.

The following recurrent key instructions in the mapping are:

- ✓ The sign **"SUM"** indicates a summatory of information (numerical or alphabetical) contained across the column/row to which applies.
- ✓ The sign **"-SUM"** indicates that the result of the summatory is to be reported as a negative value.
- ✓ The sign **"AND"** indicates an additional element for mapping in the cell, which pertains to the same IPCC category.
- ✓ The sign **"PLUS"** indicates an additional element for mapping in the cell, which pertains to an additional IPCC category.
- ✓ The signs **"MINUS"** indicates an additional element for mapping in the cell, which information pertains to a different IPCC category and it is to be subtracted.
- ✓ The signs **"EXCEPT"** indicates an element for mapping to be excluded because this element (e.g. fuel or IPCC category) is already included elsewhere.
- ✓ The signs **"MULTIPLY"** and **"DIVIDE"** and **"SUBTRACT"** indicate the corresponding mathematical operation to be applied to information sourced from the *Software*.
- ✓ The signs **"ISNOT"** means ≠.

There are two elements for the mapping of energy sector emissions that are relevant to highlight for users:

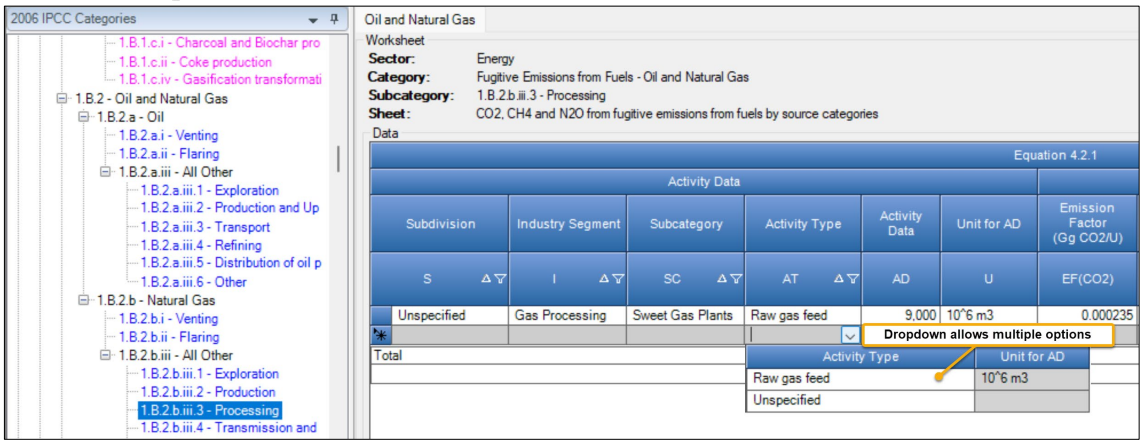
1. The user will notice one additional marking in the tables; a red "**T1**". T1 is designated in cases where it is not logical to simply sum up the underlying activity data. This happens when a user uses more than one tier to estimate GHG emissions for a particular category, and those tiers do not use the same activity data in their respective calculation. For example, this occurs in category 1.A.2.g.vii Off-road vehicles and other machinery, where the Tier 1 and Tier 2 methods rely on TJ of fuel

consumption, whereas the Tier 3 method relies on the source population and average annual hours of use. To add these two different types of activity data would not yield a meaningful value. In these cases, to ensure an accurate calculation of the implied emission factor, the user is encouraged to overwrite the value for activity data in the visualization table to a value that reflects the activity across the entire country. This can typically be done by inserting the total national activity data that would be calculated had the user applied Tier 1 across the entire country. In the visualization tables in the *Software* the user will be able to recognize those cells designated as "T1" by their pale green shading.

You will notice in CRT table 1.B.2 there is a column for "Description" and "Unit". The CRT, and thus the UNFCCC ETF Reporting Tool, allows for only a single description and unit for each category to be included in the reporting tables.

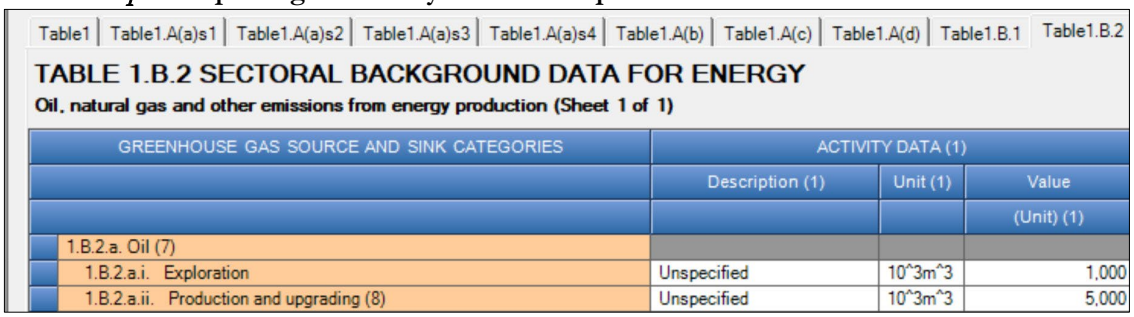
2. However, for estimating emissions the *Software* allows a user to select, from a dropdown list, a description (Column AT) and units (Column U), for each subdivision (i.e. row). To ensure meaningful reporting to the UNFCCC ETF Reporting Tool, users reporting emissions in these categories should ideally choose only a single type of description from the dropdown list in column AT. For this same reason, if the user selects "Unspecified" in Column AT, he/she should enter data using only a single type of units from the following pre-defined list: m^3, 10^3m^3, 10^6m^3, 10^9ft^3, t, kt, Mt, PJ, TJ, GJ, GWh, 10^10 kCal, toe, ktoe, Mtoe, 10^3 l, 10^6 l, 10^6Bbl (oil US), 10^12 btu.

Example:* Reporting of Activity Data Descriptions and Units in the *Software



Recognizing that it may not always be possible for a user to use a common type of activity data and units across the entire country for a given category, the Software automatically includes a description of "Unspecified" for transfer to the UNFCCC ETF Reporting Tool, and allows the user to update the units and values populated in the corresponding columns of the visualized CRT in cases where different types of AD have been used to estimate GHG emissions. Where this occurs, the user should select only one type of AD description (e.g. volume throughout) and unit and insert values that correspond to total national activity. These updated units/values will transfer to the UNFCCC and allow for the calculation of a meaningful implied emission factor. The user should describe the AD and units used in the national inventory document.

***Example:* Reporting of Activity Data Descriptions and Units in the visualized CRT**



Detailed Mapping between the Software and the UNFCCC ETF Reporting Tool

The attached tables reflect the UNFCCC CRT agreed by Parties for reporting under the Paris Agreement, and the corresponding mapping instructions from the *Software*.

Table 3. Detailed mapping between the Software and the UNFCCC ETF reporting tool

Please note that the tables are accessible by clicking the ATTACH icon (paper-clip) on the left-hand side of your screen.

You will notice that notation keys are automatically populated in some cells of the visualized CRT for the energy sector. Table A.1 3 explains the existence of notation keys for each table relevant for reporting of GHG emissions from the energy sector.

Table 4. Automatic Reporting of Notation Keys in the Energy Sector of the CRT

CRT Table	CRT category	Parameter/ Gas	Automatic mapping	Explanation
1.A(a)s2	1.A.2.g.viii Other (please specify) *(Off-road- Manufacturing industries and construction-solid fuels)*	All fuels, except solid fuels	NA	This category, specific to users of the *Software*, has been added to accommodate reporting of emissions from solid fuels used in off-road-manufacturing industries and construction. It is possible to calculate these emissions *Software*. As this category is referring only to solid fuels, the other fuels are listed as "NA". Emissions from other fuel types, if applicable, are included in the designated CRT category 1.A.2.g.vii Off-road vehicle and other machinery.
1.A(a)s3	1.A.3.b.v	All	NO	The category 1.A.3.b.v in the 2006 IPCC Guidelines refers to "Evaporative Emissions from Vehicles". As there are no direct emissions from this category, and no other sources of emissions from road transportation, this category has automatically been completed as "NO".
1.A(a)s4	Information item Waste incineration with energy recovery included as biomass and fossil fuels	All	NE (but can be overwritten with a value)	This information item is currently not automatically mapped in the CRT visualization tables. These cells are mapped as "NE" in the visualized CRT and shaded green. You may change the "NE" to a value. This value will then be transferred in the JSON to the UNFCCC ETF Reporting Tool.
1.A(b)	Reference approach – Other solid fossil fuels (please specify)	Production of: *Blast furnace gas* *Coke oven gas* *Gas works gas* *Oxygen steel furnace gas* *Other solid fossil fuel*	NA	As these are secondary fuels, production is not applicable.
1.B.2	1.B.2.c.i.3	All	IE	The methods in the IPCC Inventory Software instruct you to separate oil and gas venting with the definition of natural gas including both associated and non-associated gas. Any emissions are included elsewhere (either under 1.B.2.c.i.1 or 1.B.2.c.i.2.
1.B.2	1.B.2.c.ii.3	All	IE	The methods in the IPCC Inventory Software instruct you to separate oil and gas flaring with the definition of natural gas including both associated and non-associated gas. Any emissions are included elsewhere (either under 1.B.2.c.ii.1 or 1.B.2.c.ii.2.
1.B.2	1.B.2.d	N_2O	NA	The category "N_2O emissions from Oil and Natural Gas Systems" has been added as a default category to the CRT for users of the IPCC Inventory Software, because users are able to add N_2O emissions from these industries in the *Software*, but the CRT does not allow for reporting of N2O emissions for most subcategories under Oil (1.B.2.a) and Natural Gas (1.B2.b). By default, the assumption is that this category is not applicable, and activity for this category is reported as "NA". However, if N_2O emissions are reported, the user should revise columns "Description" "Unit" and "Value" to include the relevant AD (given this unique situation, this cell has also been shaded pale green, and is editable). CO_2 and CH_4 emissions are reported as "NA" because the category includes only "N_2O emissions from Oil and Natural Gas Systems."