Version 1
Draft_January 2025

IPPU SECTOR USERS' GUIDEBOOK

IPCC Inventory Software, version 2.95

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This Guidebook is prepared by IPCC TFI TSU.
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Contents

Introduction....5

1. IPPU Sector – General Guidance....8

1.1 Cross-cutting issues.... 13

1.1.1 Fuel Manager.... 13

1.1.2 F-gases Manager.... 16

1.1.3 Use of multiple Tiers for reporting.... 22

1.1.4 Reporting of Subdivisions.... 23

1.1.5 Biogenic fuels, feedstocks and reductants.... 25

1.1.6 Uncertainty and Time Series data entry.... 26

1.1.7 Capture and storage or other reduction.... 29

2. IPPU Sector – Categories Guidance.... 30

2.A Mineral Industry.... 30

2.A.1 Cement Production.... 30

2.A.2 Lime Production.... 40

2.A.3 Glass Production.... 49

2.A.4 Other Process Uses of Carbonates.... 56

2.A.5 Other.... 61

2.B Chemical Industry.... 65

2.B.1 Ammonia Production.... 65

2.B.2, 2.B.3 and 2.B.4 Nitric Acid, Adipic Acid, and Caprolactam, Glyoxal and Glyoxylic Acid Production.... 72

2.B.5 Carbide Production.... 78

2.B.6 Titanium Dioxide Production.... 85

2.B.7 Soda Ash Production.... 92

2.B.8 Petrochemical and Carbon Black Production.... 96

2.B.9 Fluorochemical Production.... 119

2.B.10 Hydrogen Production.... 145

2.B.11 Other.... 156

2.C Metal Industry.... 160

2.C.1 Iron and Steel Production.... 160

2.C.2 Ferroalloys Production.... 178

2.C.3 Aluminium Production.... 189

2.C.4 Magnesium Production.... 206

2.C.5 Lead Production and 2.C.6 Zinc Production.... 215

2.C.7 Rare Earths Production.... 223

2.C.8 Other ... 231

2.D Non-Energy Products from Fuels and Solvent Use ... 232

2.D.1 and 2.D.2 Lubricant Use and Paraffin Wax Use ... 233

2.D.3 Solvent Use ... 238

2.D.4 Other ... 239

2.F Product Uses as Substitutes for Ozone Depleting Substances (ODS) ... 240

2.F.1 and 2.F.3 Refrigeration and Air Conditioning, and Fire Protection ... 240

2.F.2 Foam Blowing Agents ... 269

2.F.3 Fire Protection ... 289

2.H Other ... 290

Annex I: Mapping between the IPCC Inventory Software and the UNFCCC ETF Reporting Tool ... 291

Abbreviations

Revised 1996 IPCC Guidelines	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories
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
AFOLU	agriculture, forestry and other land use
BFG	blast furnace gas
BOF	blast oxygen furnace
DRI	direct reduced iron
CH_4	methane
CKD	cement kiln dust
CO_2	carbon dioxide
COG	coke oven gas
CS	country specific
EAF	electric arc furnace
EDC/VCM	ethylene dichloride/vinyl chloride monomer
EF	emission factor
ETF	Enhanced Transparency Framework
F-gases	fluorinated gases
Gg	gigagram
GHG	greenhouse gas
GJ	gigajoule
GWP	global warming potential
HFC	hydrofluorocarbon
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LKD	lime kiln dust
m^2	square meters
m^3	cubic meter
MPGs	Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement
Nd	neodymium
NGHGI	national GHG inventory
NF_3	nitrogen trifluoride
N_2O	nitrous oxide
NGHGI	national GHG inventory
ODS	ozone depleting substances
OHF	open hearth furnace
PFC	perfluorocarbons
RAC	refrigeration and air conditioning
RE	rare earth
s	second
SF_6	sulphur hexafluoride
TFI	IPCC Task Force on National Greenhous Gas Inventories
TJ	terajoule
TSU	Technical Support Unit
µg	microgram

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 factors (EFs) selection and input, to GHG estimation and reporting.

Software users must be familiar with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines) methods and read the *Software* 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*. Elements of the *2019 Refinement*[1] are introduced in limited cases, where needed to enable interoperability between the *Software* and the United Nations Framework Convention on Climate Change (UNFCCC) electronic reporting tool for common reporting tables (CRT) under the Enhanced Transparency Framework (ETF) of the Paris Agreement (hereafter referred to as the UNFCCC ETF Reporting Tool).

The Users' Guidebook is still under development. Detailed instructions are provided for estimating GHG emissions from 2.A Mineral Industry, 2.B Chemical Industry, 2.C Metal Industry, 2.D Non-Energy Products from Fuels and Solvents Use, 2.F Product Uses as Substitutes for Ozone Depleting Substances (ODS) (refrigeration and air conditioning, foam blowing agents and fire protection only) and 2.H Other (IPPU). The guidebook will be updated with detailed instructions for the remaining categories, although it should be noted that the general principles and approaches described in this existing manual may provide useful insight for these additional categories.

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*[2] Multiple categories (e.g. category 2.A.4. Other process uses of carbonates) are grouped together when the underlying instructions are the same for entering information in the Software. Table 1 below provides the definitions of categories included in the IPPU sector, as well as a hyperlink to the relevant section of the guidebook where further information may be found, if available.

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 (AD), emission factors (EF) 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 AD and EF 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:

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

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

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[1] methodology, Tier 1 equations can be used to enter AD and implied emission factor(s) (IEFs), 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 2.B.7 Soda Ash Production).

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

Stratification[2] of variables[3] 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 two ways: 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[4] while all remaining are reported within a single aggregation[5], as e.g. *unspecified*[6].

However, the *Software* allows the user to enter each combination of variables, e.g. subdivision/product type/type of process in the case of ethylene dichloride and vinyl chloride monomer production, only once. A way to further disaggregate such a combination across the 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 ETF Reporting Tool for the Common Reporting Tables

The *Software* has been upgraded for the IPPU sector to be interoperable with the UNFCCC ETF Reporting Tool for the CRT under the ETF of the Paris Agreement.[7] 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

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[1] User-specific methodologies need to be in accordance with IPCC good practice to satisfy the transparency, completeness, consistency, accuracy and thus comparability reporting principles.
[2] The larger the number of strata, the more accurate and precise the estimates are.
[3] Stratification is the act of sorting data into distinct groups or layers.
[4] By applying a higher tier method
[5] By applying a lower tier method
[6] This does not apply to variables required by IPCC Tier 1 method.
[7] As requested by Parties in decision 5/CMA.3, paragraphs 19 and 20.

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 ETF Reporting Tool.

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 ETF Reporting Tool. Categories that have been added to the *Software* from the *2019 Refinement* to enable interoperability are highlighted in magenta, and, where relevant, in the elaboration for individual categories of this Guidebook.

There are several unique considerations for the IPPU sector when preparing the visualized CRT in the *Software* for reporting to the UNFCCC. The issues are noted below for consideration while reviewing the manual for a particular category, and are elaborated in Annex I.

- For some categories of the IPPU sector, different Tiers for estimating GHG emissions rely on different types of AD (for example, for cement production, the Tier 1 and Tier 2 methods rely on clinker production, while the Tier 3 method is based on consumption of carbonates). While the use of different Tiers does not have an impact on the use of the *Software* to calculate GHG emissions (indeed it can be *good practice* to use higher tiers, even if only for a fraction of a country as long as completeness is ensured), this introduces challenges for aggregating the AD as it is not meaningful to different types of AD into a single value. When mapping to the visualized CRT and preparing a file for UNFCCC reporting, the *Software* ensures that only a single type of AD are added (e.g. the Tier 1 AD if available). This will however require the user to update the AD to reflect total national AD prior to submitting the file to the UNFCCC.

- The *Software* allows for estimation of GHG emissions for all gases with a global warming potential in an IPCC Assessment Report (the latest values included in the *Software* are from the 5th Assessment Report). AR5 includes additional gases, not included for reporting pursuant to the Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (MPGs), which is limited to CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3; Should users calculate GHG emissions for these additional gases (e.g. ethers) they may wish to explain the differences in the totals for these fluorinated gases (F-gases).

- Confidentiality – Calculation of GHG emissions in the *Software* requires entry of AD, EFs and other parameters. In some cases, users may identify some input data as confidential. Although the data are required for calculation of GHG emissions in the calculation worksheets, users may designate some data as confidential (through use of the notation key "C") for purposes of reporting to the UNFCCC ETF Reporting Tool. There are multiple ways of designating information as confidential, which is further discussed in Annex I. Users are responsible for understanding how confidentiality is addressed in the *Software.* Also important to note; emissions labelled as confidential are still included in totals for transfer to the UNFCCC to ensure complete reporting.

Annex I illustrates the mapping of AD and GHG estimates for categories/gases from the *Software* to the corresponding UNFCCC CRT category/ies.

1. IPPU Sector – General Guidance

The Industrial Processes and Product Use (IPPU) sector covers GHG emissions occurring from industrial processes, from the use of GHGs in products, and from non-energy uses of fossil fuel carbon.

GHG emissions are produced from a wide variety of industrial activities. The main emission sources are releases from industrial processes that chemically or physically transform materials (for example, the blast furnace in the iron and steel industry, ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock and the cement industry are notable examples of industrial processes that release a significant amount of CO_2). During these processes, many different GHGs, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), can be produced.

In addition, GHGs often are used in products such as refrigerators, foams or aerosol cans. For example, HFCs are used as alternatives to ozone depleting substances (ODS) in various types of product applications. Similarly, sulphur hexafluoride (SF_6) and N_2O are used in a number of products used in industry (e.g., SF_6 used in electrical equipment, N_2O used as a propellant in aerosol products primarily in the food industry) or by end-consumers (e.g., SF_6 used in running-shoes, N_2O used during anaesthesia). A notable feature of these product uses is that, in almost all cases, significant time can elapse between the manufacture of the product and the release of the greenhouse gas. The delay can vary from a few weeks (e.g., for aerosol cans) to several decades as in the case of rigid foams. In some applications (e.g., refrigeration) a fraction of the greenhouse gases used in the products can be recovered at the end of product's life and either recycled or destroyed. In addition, HFCs, PFCs, SF_6, NF_3, and several other fluorinated greenhouse gases may be used in and/or emitted by processes such as electronics manufacturing.

Product use is combined with the industrial process guidance because in many cases production and import/export data are needed to estimate emissions in products and because product use may also occur as part of industrial activities, apart from the non-industrial sectors (retail, services, households.) It is therefore desirable to link estimation of emissions associated with production and product use. The non-energy uses of fossil fuels encompass their uses as feedstock, reductants and as non-energy products in which their physical properties are used directly rather than combusted for energy purposes.

Table 1 lists all categories included from the IPPU 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. This Users' Guidebook is under development. Users may click on the category name to navigate to completed sections of the Users' Guidebook.

Table 1. Categories included in the IPPU 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
2 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	Emissions from industrial processes and product use, excluding those related to energy combustion (reported under category 1.A), extraction, processing and transport of fuels (reported under category 1.B) and CO_2 transport, injection and storage (reported under category 1.C).
2.A Mineral Industry	
2.A.1 Cement Production	Process-related emissions from the production of various types of cement (ISIC: D2694).
2.A.2 Lime Production	Process-related emissions from the production of various types of lime (ISIC: D2694).
2.A.3 Glass Production	Process-related emissions from the production of various types of glass (ISIC: D2610).
2.A.4 Other Process Uses of Carbonates	Includes limestone, dolomite and other carbonates etc. Emissions from the use of limestone, dolomite and other carbonates should be included in the industrial source category where they are used. For example, where a carbonate is used as a flux for iron and steel production, resultant emissions should be reported under category 2.C.1 Iron and Steel Production rather than this subcategory.
2.A.4.a Ceramics	Process-related emissions from the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives (ISIC: D2691, D2692 and D2693).
2.A.4.b Other Uses of Soda Ash	Emissions from soda ash use that are not included elsewhere under an existing category (for example, emissions from soda ash used in glass production are accounted for under 2.A.3 Glass production)
2.A.4.c Non-Metallurgical Magnesia Production	Emissions from magnesia production that are not included elsewhere. For example, where magnesia production is used for primary and secondary magnesium production, emissions should be reported in the relevant source category in Metals.

Categories	Definitions
2.A.4.d Other (please specify)	Process-related emissions from all other miscellaneous uses of limestone, dolomite and other carbonates, except from uses already listed in the sub-categories above, and uses as fluxes or slagging agents in the Metals and Chemicals industries, or for the liming of soils and wetlands in Agriculture, Forestry and Other Land Uses (ISIC D269).
2.A.5 Other	Includes any other mineral industry emissions not otherwise included above or reported elsewhere in the GHG inventory.
2.B Chemical Industry	
2.B.1 Ammonia Production	Ammonia (NH_3) is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid ester and nitro compound manufacture, explosives of various types, and as a refrigerant. Amines, amides, and miscellaneous other organic compounds, such as urea, are made from ammonia. The main GHG emitted from NH_3 production is CO_2. CO_2 used in the production of urea, a downstream process, should be subtracted from the CO_2 generated and accounted for in the AFOLU Sector.
2.B.2 Nitric Acid Production	Nitric acid is used as a raw material mainly in the manufacture of nitrogenous-based fertiliser. Nitric acid may also be used in the production of adipic acid and explosives (e.g., dynamite), for metal etching and in the processing of ferrous metals. The main GHG emitted from HNO_3 production is N_2O.
2.B.3 Adipic Acid Production	Adipic acid is used in the manufacture of a large number of products including synthetic fibres, coatings, plastics, urethane foams, elastomers and synthetic lubricants. The production of Nylon 6.6 accounts for the bulk of adipic acid use. The main GHG emitted from adipic acid production is N_2O.
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	Most of the annual production of caprolactam ($NH(CH_2)_5CO$) is consumed as the monomer for nylon-6 fibres and plastics, with a substantial proportion of the fibre used in carpet manufacturing. All commercial processes for the manufacture of caprolactam are based on either toluene or benzene. This subcategory also covers production of glyoxal (ethanedial) and glyoxylic acid production. The main GHG emitted from this subcategory is N_2O.
2.B.5 Carbide Production	The production of carbide can result in emissions of CO_2, CH_4, CO and SO_2. Silicon carbide is a significant artificial abrasive. It is produced from silica sand or quartz and petroleum coke. Calcium carbide is used in the production of acetylene, in the manufacture of cyanamide (a minor historical use), and as a reductant in electric arc steel furnaces. It is made from calcium carbonate (limestone) and carbon-containing reductant (petroleum coke).
2.B.6 Titanium Dioxide Production	Titanium dioxide (TiO_2) is the most important white pigment. The main use is in paint manufacture followed by paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink, and other miscellaneous uses. The main production process is the chloride route, giving rise to CO_2 emissions that are likely to be significant. This category also includes synthetic rutile production using the Becher process, and titanium slag production, both of which are reduction processes using fossil fuels and resulting in CO_2 emissions. Synthetic rutile is the major input to TiO_2 production using the chloride route.
2.B.7 Soda Ash Production	Soda ash (sodium carbonate, Na_2CO_3) is a white crystalline solid that is used as a raw material in a large number of industries including glass manufacture, soap and detergents, pulp and paper production and water treatment. Emissions of CO_2 from the production of soda ash vary dependent on the manufacturing process. Four different processes may be used to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes. The fourth, the Solvay process, is classified as a synthetic process.
2.B.8 Petrochemical and Carbon Black Production	
2.B.8.a Methanol	Methanol production covers production of methanol from fossil fuel feedstocks [natural gas, petroleum, coal] using steam reforming or partial oxidation processes. According to Volume 1, chapter 8 of the *2006 IPCC Guidelines,* production of methanol from biogenic feedstocks (e.g., by fermentation) is not included in this source category. It should be noted that users can enter in the *Software* information on the use of biogenic feedstocks. Consistent with the *2006 IPCC Guidelines*, the *Software* does not include CO_2 emissions from biogenic fuels in the national total, although any capture and subsequent storage of this CO_2 are included
2.B.8.b Ethylene	Ethylene production covers production of ethylene from feedstocks at petrochemical plants by the steam cracking process. Production of ethylene from processes situation within the boundaries of petroleum refineries is not included in this source category. The GHGs produced from ethylene production are CO_2 and CH_4.
2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer	Ethylene dichloride and vinyl chloride monomer production covers production of ethylene dichloride by direct oxidation or oxychlorination of ethylene, and the production of vinyl chloride monomer from ethylene dichloride. The GHGs produced from production of ethylene dichloride production and vinyl chloride monomer production are CO_2 and CH_4.
2.B.8.d Ethylene Oxide	Ethylene oxide production covers production of ethylene oxide by reaction of ethylene and oxygen by catalytic oxidation. The GHGs produced from ethylene oxide production are CO_2 and CH_4.
2.B.8.e Acrylonitrile	Acrylonitrile production covers production of acrylonitrile from ammoxidation of propylene, and associated production of acetonitrile and hydrogen cyanide from the ammoxidation process. The GHGs produced from production of acrylonitrile are CO_2 and CH_4.

Categories	Definitions
2.B.8.f Carbon Black	Carbon black production covers production of carbon black from feedstocks (petroleum or coal-derived carbon black feedstock, natural gas, acetylene). It should be noted that users can enter in the *Software* information on the use of biogenic feedstocks. Consistent with the 2006 IPCC Guidelines, the Software does not include CO_2 emissions from biogenic fuels in the national total, although any capture and subsequent storage of this CO_2 are included
2.B.8.x Other petrochemical production	This category has been added to the *Software* (without a specific IPCC category code) to allow users to implement section 3.9.1 of chapter 3, volume 3 of the *2006 IPCC Guidelines*, which reads "There are a number of other petrochemical processes that emit small amounts of greenhouse gases for which specific guidance is not provided (e.g., styrene production)."
2.B.9 Fluorochemical Production	
2.B.9.a By-product Emissions	Fluorochemical Production covers the complete range of fluorochemicals, whether or not the principal products are GHGs. Emissions encompass HFCs, PFCs, SF_6 and all other halogenated gases with global warming potentials (GWP) listed in IPCC assessment reports. The most significant by-product emission is that of HFC-23 from the manufacture of HCFC-22 and this is described separately.
2.B.9.b Fugitive Emissions	These are emissions of the principal product from the process to manufacture it and so fluorochemical production in this context is limited to HFCs, PFCs, SF_6 and other halogenated gases with GWP listed in IPCC assessment reports.
2.B.10 Hydrogen Production	Emissions from hydrogen production when it is produced as a main product at a stand-alone facility. Also, emissions from production of hydrogen as a by-product or intermediate product at refineries, ammonia production facilities and at other chemical production facilities, insofar as the emissions are not reported under the respective sectors.
2.B.11 Other (Please specify)	Includes any other chemical industry emissions not otherwise included above. For example, gases with GWP listed in IPCC assessment reports that do not fall within any categories above could be reported here, if they are estimated.
2.C Metal Industry	
2.C.1 Iron and Steel Production	CO_2 is the predominant gas emitted from the production of iron and steel. The sources of the CO_2 emissions include that from carbon-containing reducing agents such as coke and pulverized coal, and, from minerals such as limestone and dolomite added.
2.C.2 Ferroalloys Production	Ferroalloys production covers emissions from primary metallurgical reduction production of the most common ferroalloys, i.e. ferro-silicon, silicon metal, ferro-manganese, silicon manganese, and ferro-chromium, excluding those emissions relating to fuel use. From the production of these alloys, CO_2, N_2O and CH_4 originating from ore- and reductant raw materials, is emitted.
2.C.3 Aluminium Production	Aluminium production covers primary production of aluminium, except the emissions related to the use of fuel. CO_2 emissions result from the electrochemical reduction reaction of alumina with a carbon-based anode. Tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) are also produced intermittently. No GHGs are produced in recycling of aluminium other than from the fuels uses for metal remelting. SF_6 emissions are not associated with primary aluminium production; however, casting of some high magnesium containing alloys does result in SF_6 emissions and these emissions are accounted for in Section 2.C.4, Magnesium Production.
2.C.4 Magnesium Production	Magnesium production covers GHG emissions related to both primary magnesium production as well as oxidation protection of magnesium metal during processing (recycling and casting), excluding those emissions relating to fuel use. In the primary production of magnesium, CO_2 is emitted during calcination of dolomite and magnesite raw materials. Primary production of magnesium from non-carbonate raw materials does not emit carbon dioxide. In the processing of liquid magnesium, cover gases containing CO_2, SF_6, the hydrofluorocarbon HFC 134a or the fluorinated ketone FK 5-1-12 ($C_3F_7C(O)C_2F_5$) may be used. Partial thermal decomposition and/or reaction between these compounds and liquid magnesium generates secondary compounds such as PFCs, which are emitted in addition to unreacted cover gas constituents.
2.C.5 Lead Production	Lead production covers production by the sintering/smelting process as well as direct smelting. CO_2 emissions result as a product of the use of a variety of carbon-based reducing agents in both production processes.
2.C.6 Zinc Production	Zinc production covers emissions from both primary production of zinc from ore as well as recovery of zinc from scrap metals, excluding emissions related to fuel use. Following calcination, zinc metal is produced through one of three methods; 1-electro-thermic distillation, 2-pyro-metallurgical smelting or 3-electrolysis. If method 1 or 2 is used, CO_2 is emitted. Method 3 does not result in CO_2 emissions. Recovery of zinc from metal scrap often uses the same methods as primary production and may thus produce CO_2 emissions, which is included in this section.
2.C.7 Rare Earths Production	Rare Earth Production covers primary production of rare earth metals and alloys, except the emissions related to the use of fuel. CO_2 emissions result from the electrochemical reduction reaction of rare earth oxides with a carbon-based anode. PFCs, mainly tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), are also produced intermittently.
2.C.8 Other (please specify)	Includes any other metal industry emissions not otherwise included above.

Categories	Definitions
2.D Non-Energy Products from Fuels and Solvent Use	The use of oil products and coal-derived oils primarily intended for purposes other than combustion.
2.D.1 Lubricant Use	Lubricating oils, heat transfer oils, cutting oils and greases.
2.D.2 Paraffin Wax Use	Oil-derived waxes such as petroleum jelly, paraffin waxes and other waxes.
2.D.3 Solvent Use	NMVOC emissions from solvent use e.g. in paint application, degreasing and dry cleaning should be contained here. Emissions from the use of HFCs and PFCs as solvents should be reported under 2.F.5.
2.D.4 Other (please specify)	For example, CH_4, CO and NMVOC emissions from asphalt production and use (including asphalt blowing), as well as NMVOC emissions from the use of other chemical products than solvents should be contained here, if relevant.
2.E Electronics Industry	
2.E.1 Integrated Circuit or Semiconductor	Emissions of CF4, C_2F_6, C_3F_8, c-C_4F_8, C_4F_6, C_4F_8O, C_5F_8, CHF_3, CH_2F_2, NF_3 and SF_6 from uses of these gases in Integrated Circuit (IC) manufacturing in rapidly evolving ways and in varying amounts, which depend on product (e.g., memory or logic devices) and equipment manufacturer.
2.E.2 TFT Flat Panel Display	Uses and emissions of predominantly CF_4, CHF_3, NF_3 and SF_6 during the fabrication of thin-film transistors (TFTs) on glass substrates for flat panel display manufacture. In addition to these gases, C_2F_6, C_3F_8 and c-C_4F_8 may also be used and emitted during the manufacture of thin and smart displays.
2.E.3 Photovoltaics	Photovoltaic cell manufacture may use and emit CF_4 and C_2F_6 among others.
2.E.4 Heat Transfer Fluid	Heat transfer fluids, which include several fully fluorinated carbon compounds (either in pure form or in mixtures) with six or more carbon atoms, used and emitted during IC manufacture, testing and assembly. They are used in chillers, temperature shock testers and vapour phase reflow soldering.
2.E.5 Other (please specify)	
2.F Product Uses as Substitutes for Ozone Depleting Substances	
2.F.1 Refrigeration and Air Conditioning	Refrigeration and air-conditioning systems are usually classified in six application domains or categories. These categories utilise different technologies such as heat exchangers, expansion devices, pipings and compressors. The six application domains are domestic refrigeration, commercial refrigeration, industrial processes, transport refrigeration, stationary air conditioning, mobile air-conditioning systems. For all these applications, various HFCs are selectively replacing CFCs and HCFCs. For example, in developed countries, HFC-134a has replaced CFC-12 in domestic refrigeration and mobile air conditioning systems, and blends of HFCs such as R-407C (HFC-32/HFC-125/HFC-134a) and R-410A (HFC-32/HFC-125) are replacing HCFC-22 mainly in stationary air conditioning. Other, non-HFC substances are used to replace CFCs and HCFCs such as iso-butane in domestic refrigeration or ammonia in industrial refrigeration. HFC-152a is also being considered for mobile air conditioning in several regions.
2.F.1.a Refrigeration and Stationary Air Conditioning	The application domains are domestic refrigeration, commercial refrigeration, industrial processes, transport refrigeration and stationary air conditioning.
2.F.1.b Mobile Air Conditioning	The application domains are mobile air-conditioning systems used in passenger cars, truck cabins, buses, and trains.
2.F.2 Foam Blowing Agents	HFCs are being used as replacements for CFCs and HCFCs in foams, particularly in closed-cell insulation applications. Compounds that are being used include HFC-245fa, HFC-365mfc, HFC-227ea, HFC-134a, and HFC-152a. The processes and applications for which these various HFCs are being used include insulation boards and panels, pipe sections, sprayed systems and one-component gap filling foams. For open-cell foams, such as integral skin products for automotive steering wheels and facias, emissions of HFCs used as blowing agents are likely to occur during the manufacturing process. In closed-cell foam, emissions not only occur during the manufacturing phase, but usually extend into the in-use phase and often the majority of emission occurs at the end-of-life (de-commissioning losses). Accordingly, emissions can occur over a period of up to 50 years or even longer.
2.F.3 Fire Protection	There are two general types of fire protection (fire suppression) equipment that use GHGs as partial replacements for halons: portable (streaming) equipment, and fixed (flooding) equipment. The non-ozone depleting, industrial gases HFCs, PFCs and more recently a fluoroketone are mainly used as substitutes for halons, typically halon 1301, in flooding equipment. PFCs played an early role in halon 1301 replacement but current use is limited to replenishment of previously installed systems. HFCs in portable equipment, typically replacing halon 1211, are available but have achieved very limited market acceptance due primarily to their high cost. PFC use in new portable extinguishers is currently limited to a small amount (few percent) in an HCFC blend.
2.F.4 Aerosols	Most aerosol packages now contain hydrocarbon (HC) as propellants but, in a small fraction of the total, HFCs and PFCs may be used as propellants or solvents. Emissions from aerosols usually occur shortly after production, on average six months after sale. During the use of aerosols, 100% of the chemical is emitted. The five main sources are metered dose inhalers (MDIs), personal care products (e.g. hair care, deodorant, shaving cream), household products (e.g. air-fresheners, oven and fabric cleaners), industrial products (e.g. special cleaning sprays such as those for operating electrical contact, lubricants, pipe-freezers) and other general products (e.g. silly string, tire inflators, claxons), although in some regions the use of such general products is restricted. The HFCs currently used as propellants are HFC 134a, HFC 227ea, and HFC 152a. The substance HFC 43 10mee and a PFC, perfluorohexane, are used as solvents in industrial aerosol products.

Categories	Definitions
2.F.5 Solvents	HFCs and, to a much lesser extent PFCs, are being used as substitutes for ODS (most notably CFC-113). Typical HFCs used are HFC-365mfc and HFC-43-10mee. Use of these fluorinated replacements is much less widespread than the ODS they replace. Re-capture and re-use is also much more widely practiced The primary areas of use are precision cleaning, electronics cleaning, metal cleaning and deposition applications. Emissions from aerosols containing solvents should be reported under category 2.F.4 Aerosols rather than under this category.
2.F.6 Other Applications (please specify)	The properties of ODS have made them attractive for a variety of niche applications not covered in other sub-source categories. These include electronics testing, heat transfer, dielectric fluid and medical applications. The properties of HFCs and PFCs are equally attractive in some of these sectors and they have been adopted as substitutes. There are also some historical uses of PFCs, as well as emerging use of HFCs, in these applications. These applications have leakage rates ranging from 100% emissive in year of application to around 1% per annum.
2.G Other Product Manufacture and Use	
2.G.1 Electrical Equipment	Electrical equipment is used in the transmission and distribution of electricity above 1 kV. SF_6 is used in gas-insulated switchgear (GIS), gas circuit breakers (GCB), gas-insulated transformers (GIT), gas-insulated lines (GIL), outdoor gas-insulated instrument transformers, reclosers, switches, ring main units and other equipment.
2.G.1.a Manufacture of Electrical Equipment	
2.G.1.b Use of Electrical Equipment	
2.G.1.c Disposal of Electrical Equipment	
2.G.2 SF_6 and PFCs from Other Product Uses	
2.G.2.a Military Applications	Military applications include AWACS, which are military reconnaissance planes of the Boeing E-3A type. In AWACS (and possibly other reconnaissance planes), the SF_6 is used as an insulating gas in the radar system.
2.G.2.b Accelerators	Particle accelerators are used for research purposes (at universities and research institutions), for industrial applications (in cross-linking polymers for cable insulation and for rubber parts and hoses), and in medical (radiotherapy) applications.
2.G.2.c Other (please specify)	This source includes adiabatic uses, sound-proof glazing, PFCs used as heat transfer fluids in consumer and commercial applications, PFCs used in cosmetic and medical applications, and PFCs and SF_6 used as tracers.
2G3 N_2O from Product Uses	
2.G.3.a Medical Applications	This source covers evaporative emissions of N_2O that arise from medical applications (anaesthetic use, analgesic use and veterinary use). N_2O is used during anaesthesia for two reasons: a) as an anaesthetic and analgesic and as b) a carrier gas for volatile fluorinated hydrocarbon anaesthetics such as isoflurane, sevoflurane and desflurane.
2.G.3.b Propellant for Pressure and Aerosol Products	This source covers evaporative emissions of nitrous oxide (N_2O) that arise from use as a propellant in aerosol products primarily in food industry. Typical usage is to make whipped cream, where cartridges filled with N_2O are used to blow the cream into foam.
2.G.3.c Other (Please specify)	
2.G.4 Other (Please specify)	
2.H Other	
2.H.1 Pulp and Paper Industry	
2.H.2 Food and Beverages Industry	
2.H.3 Other (please specify)	

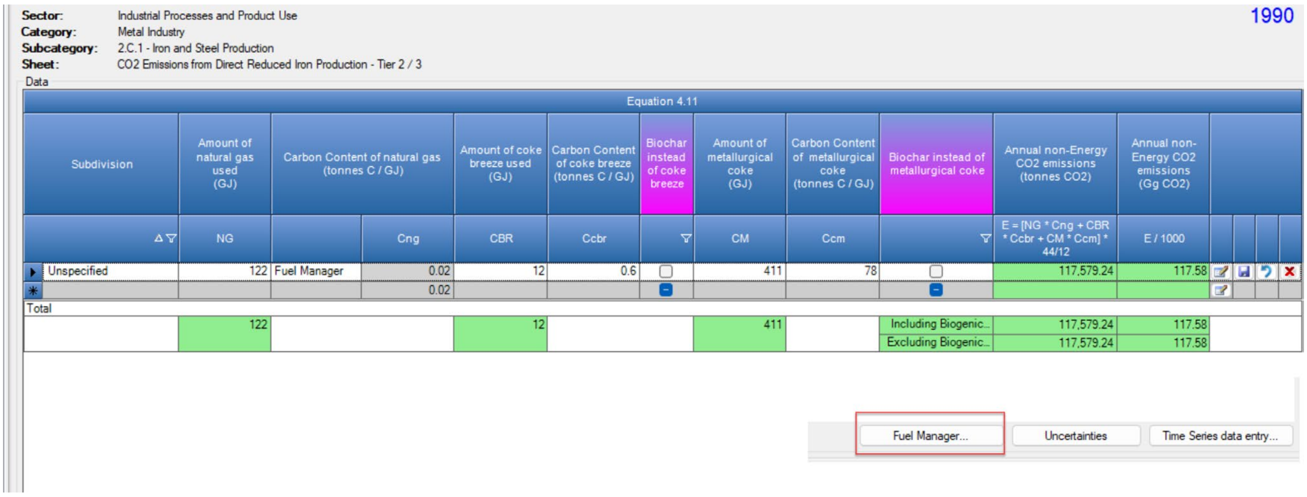
Note: The category tree in the *Software* reflects the categories included in the *2006 IPCC Guidelines*, as refined by the *2019 Refinement* for those categories relevant for interoperability with the UNFCCC ETF Reporting Tool, plus those added by the *Wetlands Supplement*. Categories from the *2019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

1.1 Cross-cutting issues

1.1.1 Fuel Manager

In the IPPU the data from Fuel Manager is used for several categories, including in Chemical Industry (e.g. 2.B.8 Petrochemical and Carbon Black Production) and Metal Industry (e.g. 2.C.1 Iron and Steel Production).

Example: **Reference to the Fuel Manager for Iron and Steel Production**

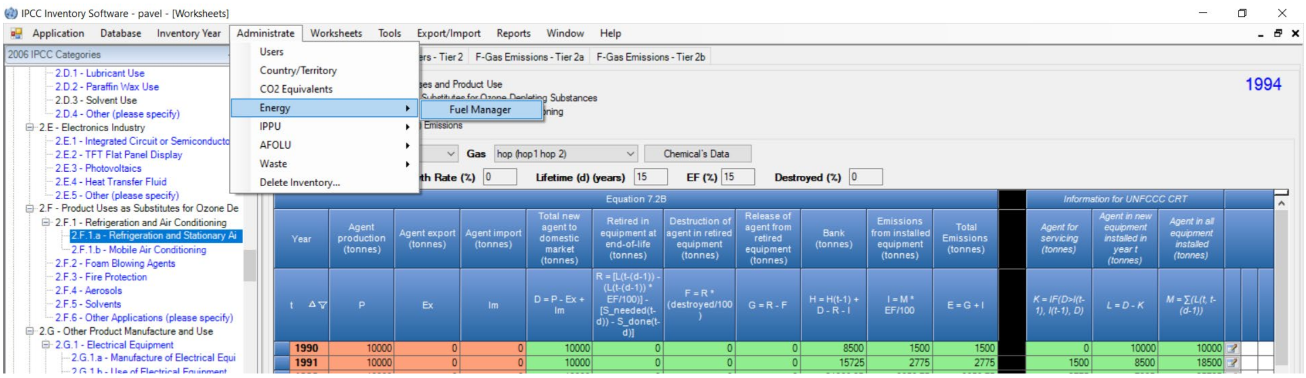


Before inputting data in the Energy and IPPU worksheets, the Fuel Manager shall be populated with all relevant

The Fuel Manager contains information on carbon content and calorific value for each fuel type used in the country. All IPCC default fuels are included here, and in addition users can input user-specific fuels and reductants and associated characteristics. To set the Fuel Manager the following steps are followed:

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

   *Note that the **Administrate** tab is available only to the Administrator. Other users may access the Fuel Manager by selecting **Fuel Manager** from the lower right-hand side of relevant worksheets relying on data from the Fuel Manager (e.g. from 2.C.1 Iron and Steel Production).*



2. In the top of the window select either **NCV** (net calorific value) or **GCV** (gross calorific value) for the **Conversion Factor Type**. Note that:
   - ✓ For each IPCC default fuel, when NCV is selected, the **Calorific Value** and the **Carbon Content** are pre-filled with IPCC defaults for each fuel. These 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.
3. To add user-specific fuels the following steps are performed for each new fuel entry:
   - ✓ Click on the asterisk in the bottom-most row to add the user-specific fuel,
   - ✓ Select **fuel type** from the drop-down list,
   - ✓ Enter the specific **fuel name**,

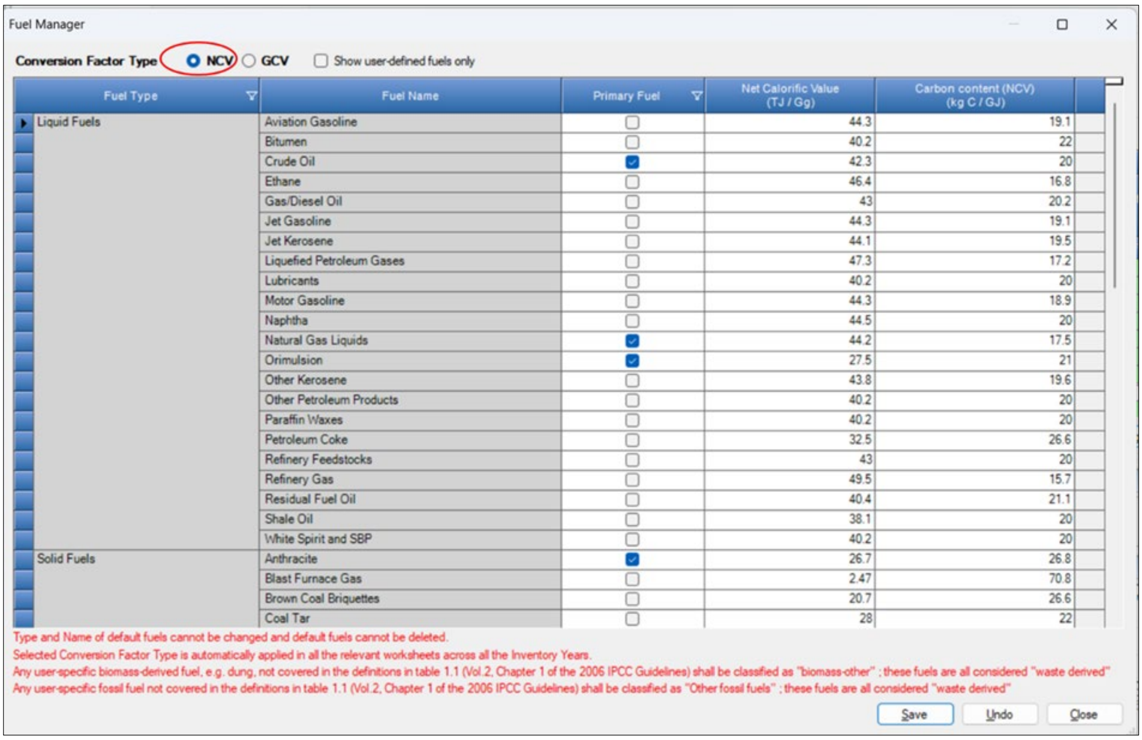
✓ Indicate (checkbox) if it is a **primary fuel**[1] or not,

✓ Enter its **calorific value** in TJ/Gg, (either *NCV* or *GCV* according to the selection made for the entire Fuel Manager),

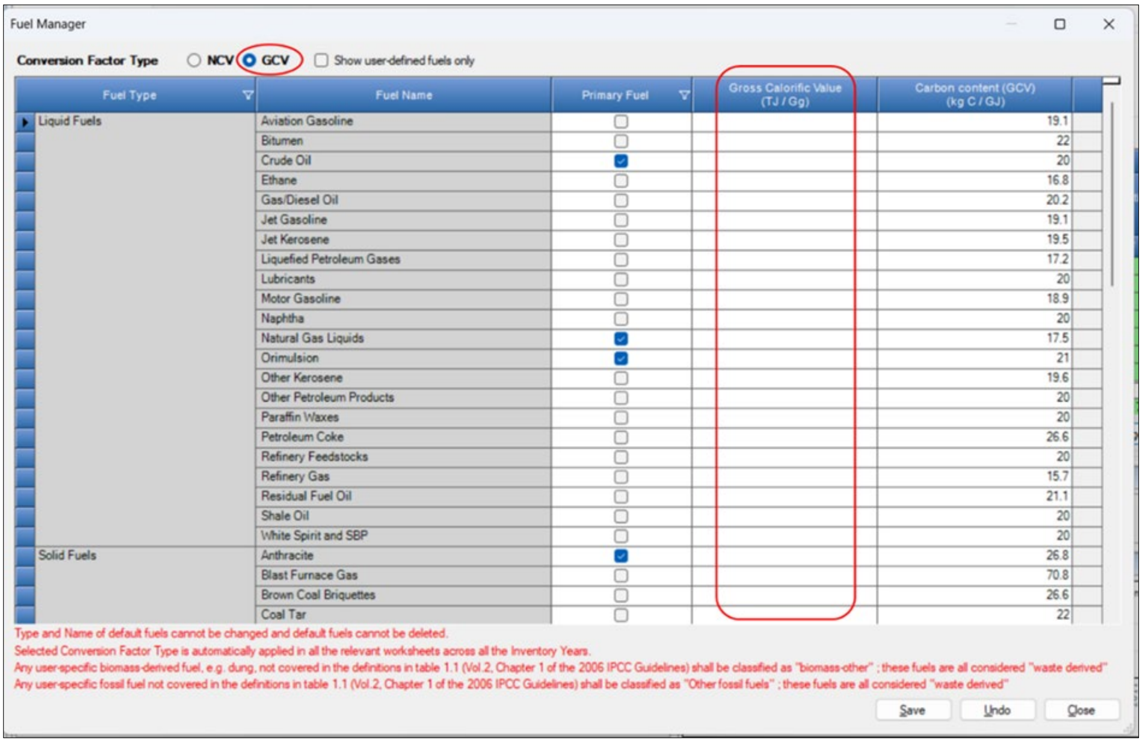
✓ Enter the **carbon content** in kg C/GJ.

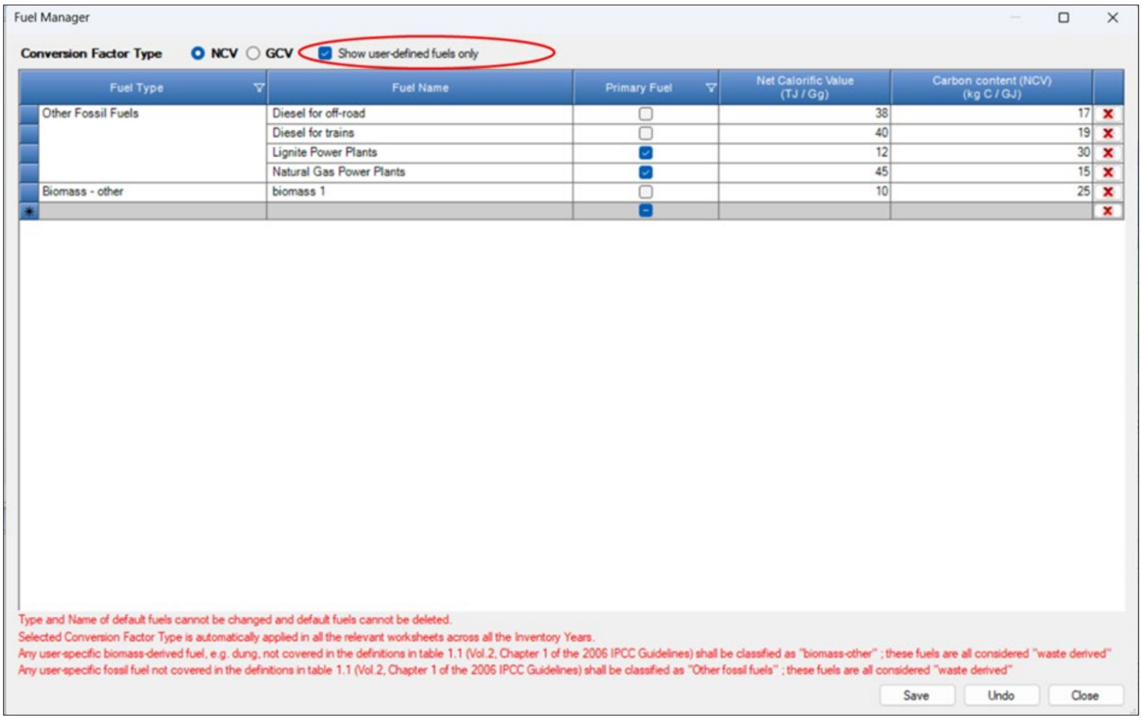
To see listed the user-defined fuels only, check the corresponding box on the top of the window.

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.



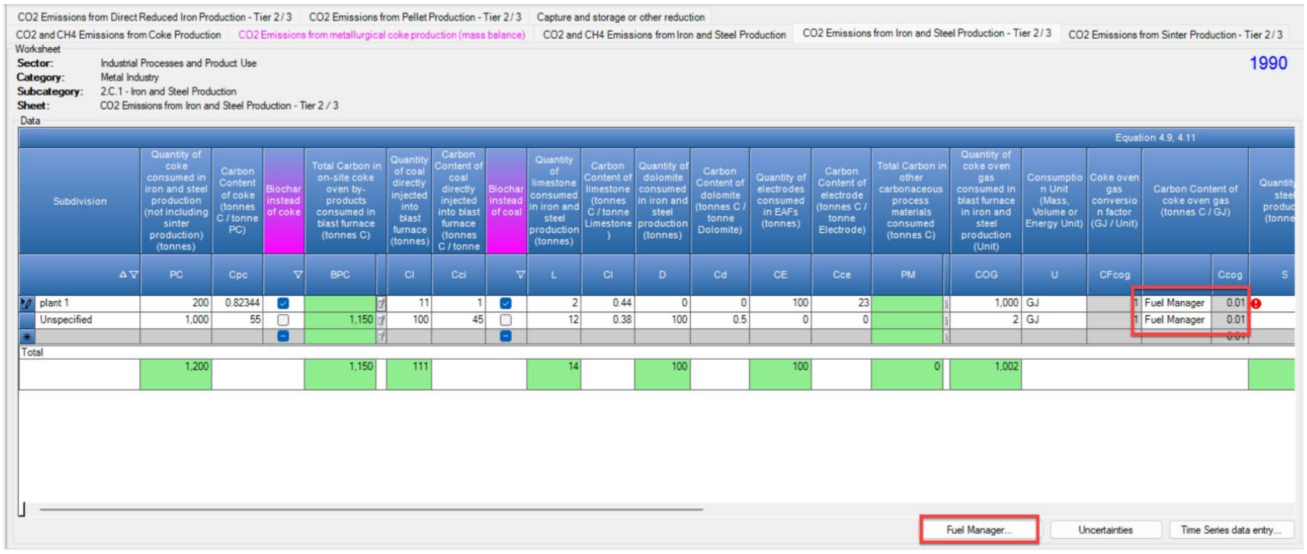
[1] Primary fuels are fuels found in nature such as coal, crude oil, and natural gas, while secondary fuels or fuel products are derived from primary fuels, such as gasoline and lubricants. A complete list of fuels is provided in Section 1.4.1.1 of the *2006 IPCC Guidelines*.





Then the data from the Fuel Manager can be used in the IPPU worksheets. See example below for 2.C.1 Iron and Steel.

Example: **Use of data from Fuel Manager in IPPU**



1.1.2 F-gases Manager

Fluorochemicals (including HFCs, PFCs, SF_6 and NF_3, collectively referred to as "F-gases") are produced (in category 2.B) and used in a variety of applications (categories 2.C, 2.E, 2.F, 2.G, 2.H). Further, two or more chemicals may be combined into a blend (GHG and non-GHG, ozone depleting substance (ODS) and non-ODS). The list of F-gases is substantial. Thus, there is a need to handle these gases efficiently.

For easy and convenient use of the *Software*, all F-gases consumed (including those imported) and/or exported in the country can be specified and organized to facilitate reporting, with the help of an F-gases Manager containing two components:

i) F-gases Manager-Chemicals – contains a list of the F-gases listed in the 5th Assessment Report, and allows for the addition of country-specific F-gases.
ii) F-gases Manager-Blends – provides a list of the blends contained in table 7.8 of volume 3, chapter 7 of the 2006 IPCC Guidelines, and allows for the addition of country-specific blends.

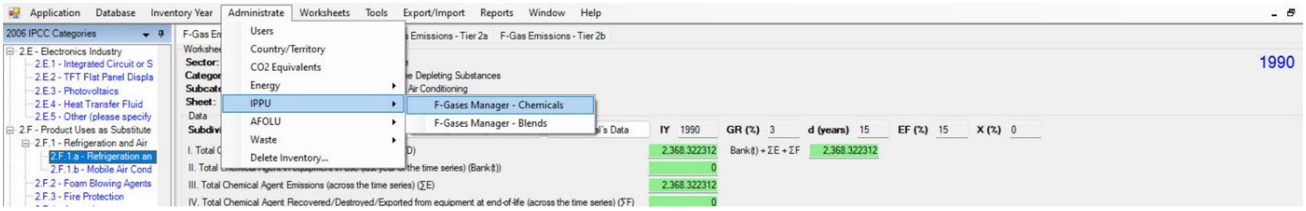
The overall approach to use of the F-gases Manager is that the user must first specify which of the F-gases/ blends are either produced or consumed within the country. Only the selected list of F-gases/blends will be available for emission calculations at an individual IPCC category (i.e. worksheet) level. Then, the user refines the list of chemicals/blends consumed (including imported) and/or exported at the category level to include only those gases relevant for an individual category.

Entering information on F-gases and blends at the country level

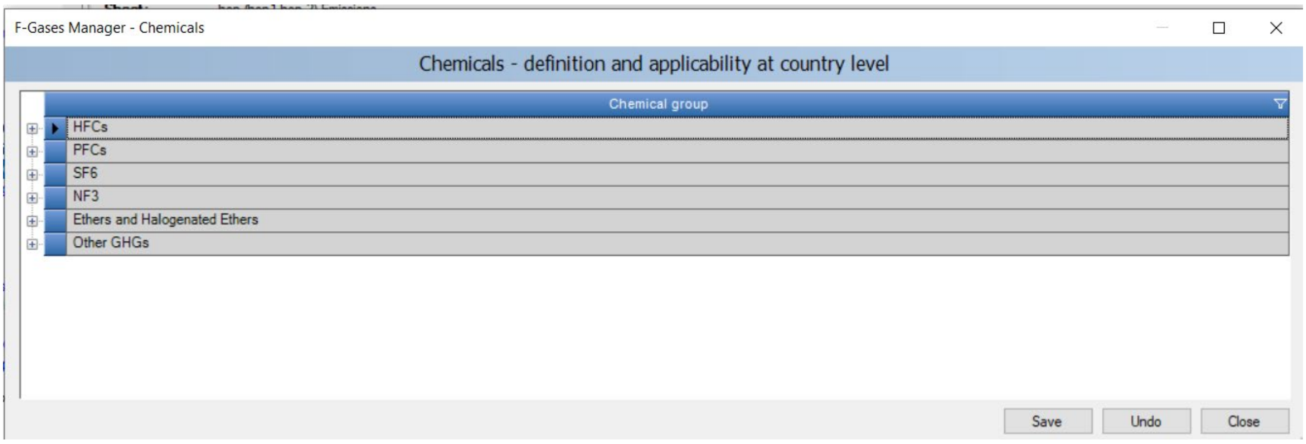
Users first need to populate the F-gases Manager to identify the relevant F-gases/blends in the country before being able to input AD in the relevant category worksheets to estimate F-gas emissions.

To enter the relevant F-gases/blends:

1. On the **Administrate** tab, click **IPPU** and then **F-gases Manager - Chemicals**.

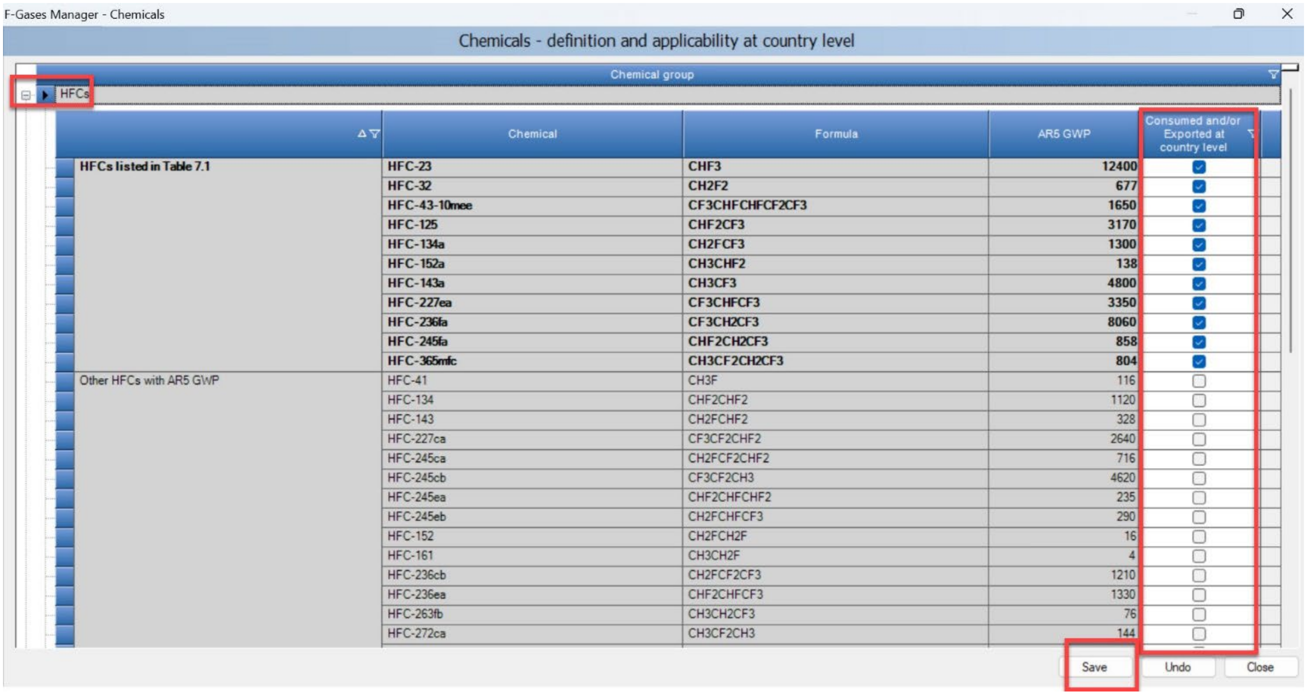


Then a new window will appear.



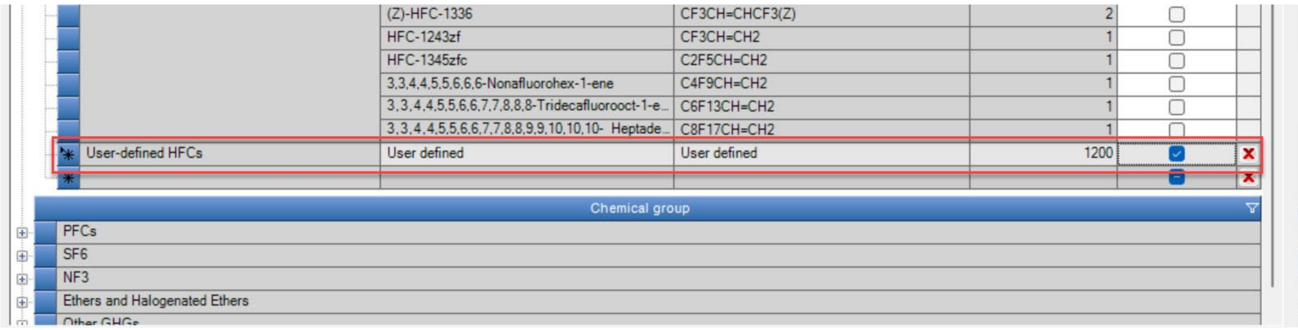
Click on the [+] symbol to expand each group of species and select all F-gases which are used in the country or those that were produced in the country and not used, but exported.
Note that by default, the F-gases listed in Table 7.1 of volume 3, chapter 7 of the 2006 IPCC Guidelines are checked.

Click **Save** after selecting all F-gases.

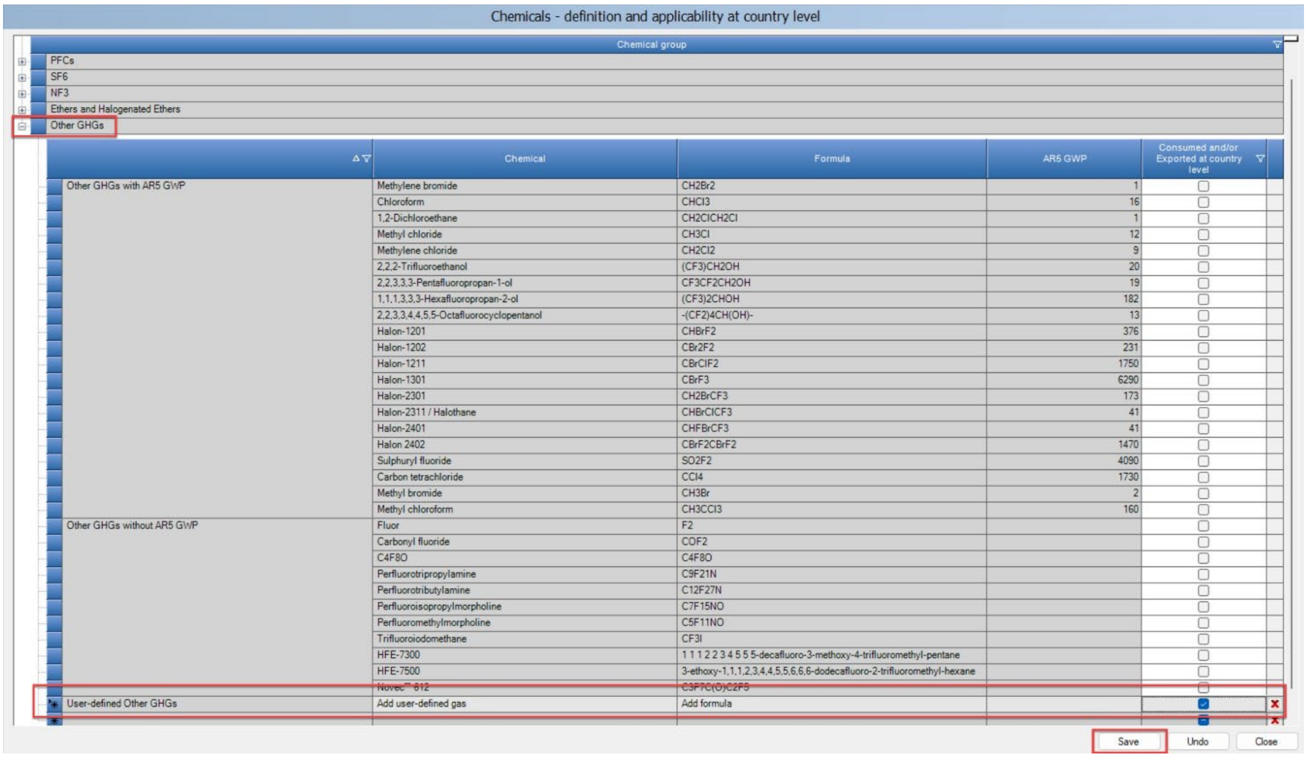


2. Users may add F-gases that are not listed in the **F-gases Manager-Chemicals**. They may add additional species for a particular group of chemics (e.g. user-defined HFCs) or for other groups not specifically listed.

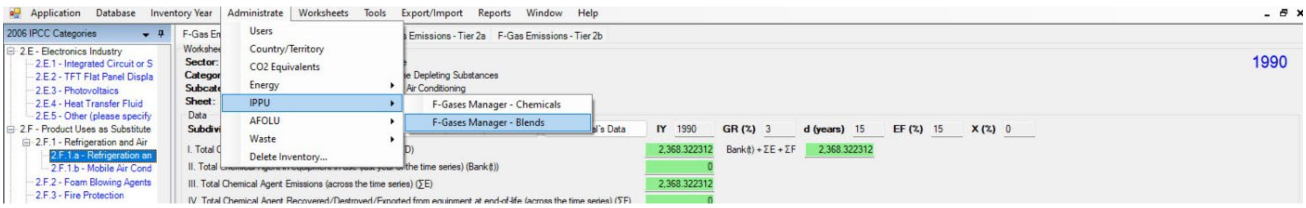
To add a user-defined species, the user navigates to the bottom of the listed chemicals for that group (e.g. HFCs) and selects the asterisk. Information on the chemical name, formula and GWP value should be entered, and the box checked.



To add a new type of chemical, users must click on the [+] symbol for Other GHGs and manually input information for the user-defined chemical and select **Save.** See example below.



3. Then users can then proceed to enter information for the F-gases Manager-Blends via the **Administrate** tab, click **IPPU** and then **F-gases Manager - Blends**.

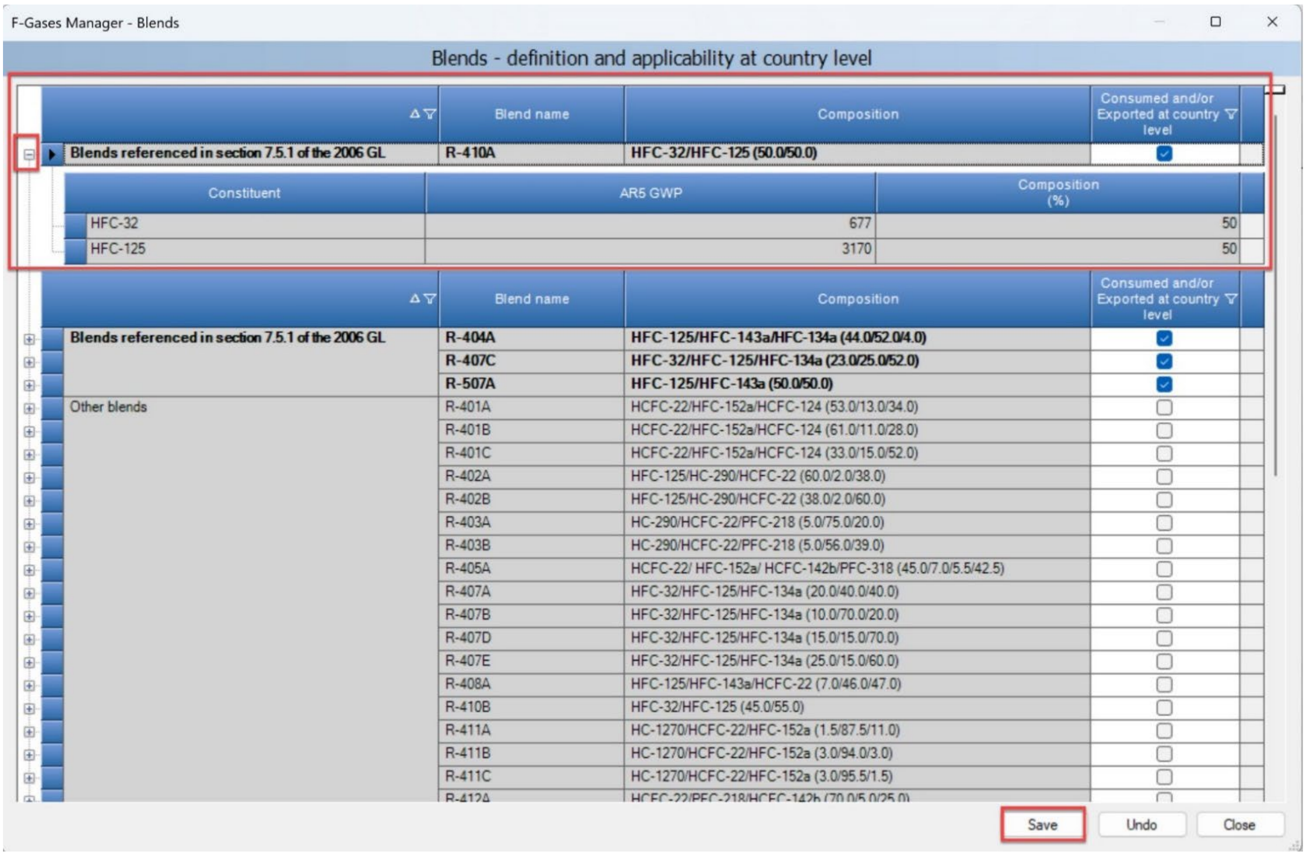


A new window will appear.

4. Users need to select blends used (e.g. in the country if the inventory is being done at the national level).
Note that: By default, the F-gases listed in section 7.5.1 of volume 3, chapter 7 of the 2006 IPCC Guidelines are checked. The full list of common blends is consistent with the blends identified in Table 7.8.

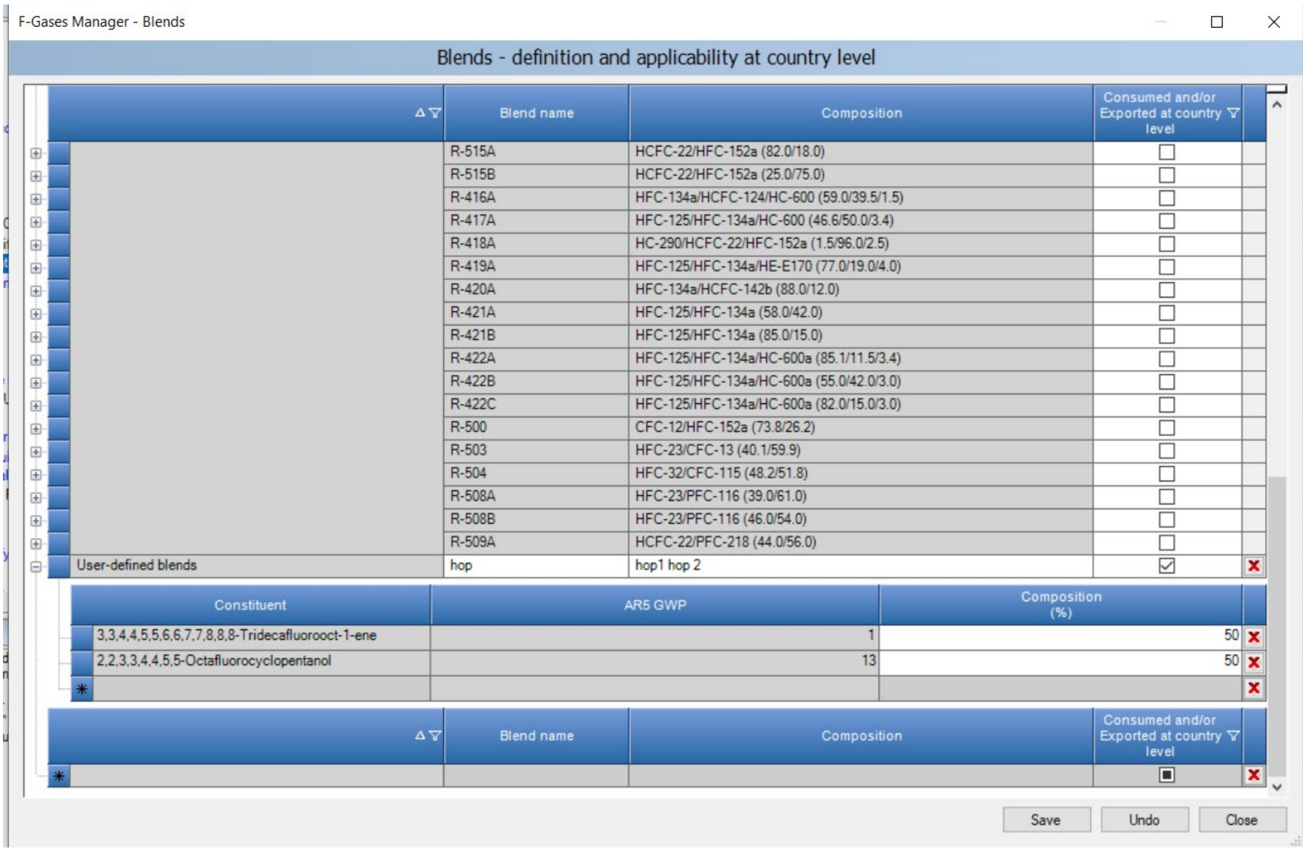
Ideally, the AD used to estimate GHG emissions for categories that consume F-gases in calculation worksheets should be the individual chemical(s). In some cases, if information only on the blends consumed is known, they can be selected here and used for the purposes of calculating GHG emissions in the calculation worksheets. When emissions are calculated or reported for blends, the blends are broken down into constituents and thus emissions are calculated and reported for each constituent in the blend according to its % of composition (e.g. when emissions are calculated or reported for blend R-410A (figure below), 50% of emissions will be calculated and reported for HFC-32 and another 50% for HFC-125. The default composition is taken from table 7.8.

Care should be taken when estimating emissions to understand the source of AD and avoid double counting for a category. This could be possible if a user has information for consumption of two species of F-gas for the category, but those F-gases are then used to produce a blend, which is subsequently consumed. The user should not double count both consumption of the F-gases and the blend.



5. Also, users can input manually user-defined blends by clicking on the [+] symbol at the bottom of the window. To add a user-defined blend, the use must enter, row by row, each constituent of the blend, the GWP as taken from the AR5, and the composition of that constituent in the total blend. Only HFCs, PFCs, SF_6 and NF_3 contained in the blend that have a AR5 GWP need to be listed as constituents, and the respective % fraction of the entire blend recorded. Thus, the total composition need not equal 100%.

Example: **Adding a user-defined blend**

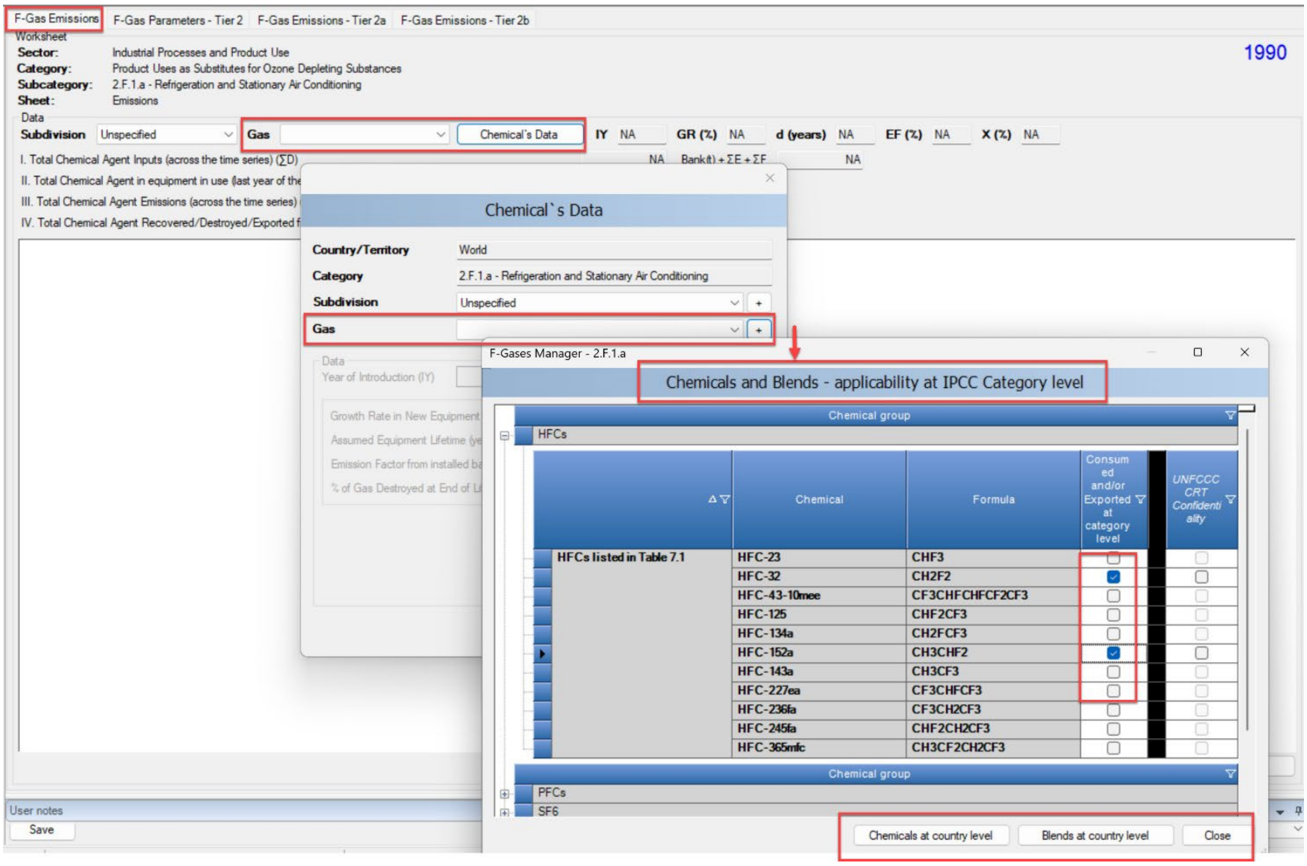


Entering information on F-gases and blends at the IPCC category level

Identifying the list of F-gases/blends relevant for the country is not sufficient to enter data on those chemicals and estimate GHG emissions, the user must then enter specific information in each category-level worksheet to identify the relevant F-gases for that category. After selecting the F-gases and blends relevant for the country in the **Administrate** tab, refinement of the list of F-gases/blends for consumption in a specific IPCC category level is carried out from within any relevant worksheet that handles calculations of F-gas emissions. In this step, the user may also flag if the consumption of an F-gas/blend for an individual category is considered confidential.

The figures below demonstrate how to identify the relevant F-gases for each category worksheet. There are two primary workflows to enter this information; one relevant for the tier 1 estimation methodology in category 2.F.1 Refrigeration and Air Conditioning and 2.F.2 Foams and for all tiers in 2.F.3 Fire Protection and one for all other categories.

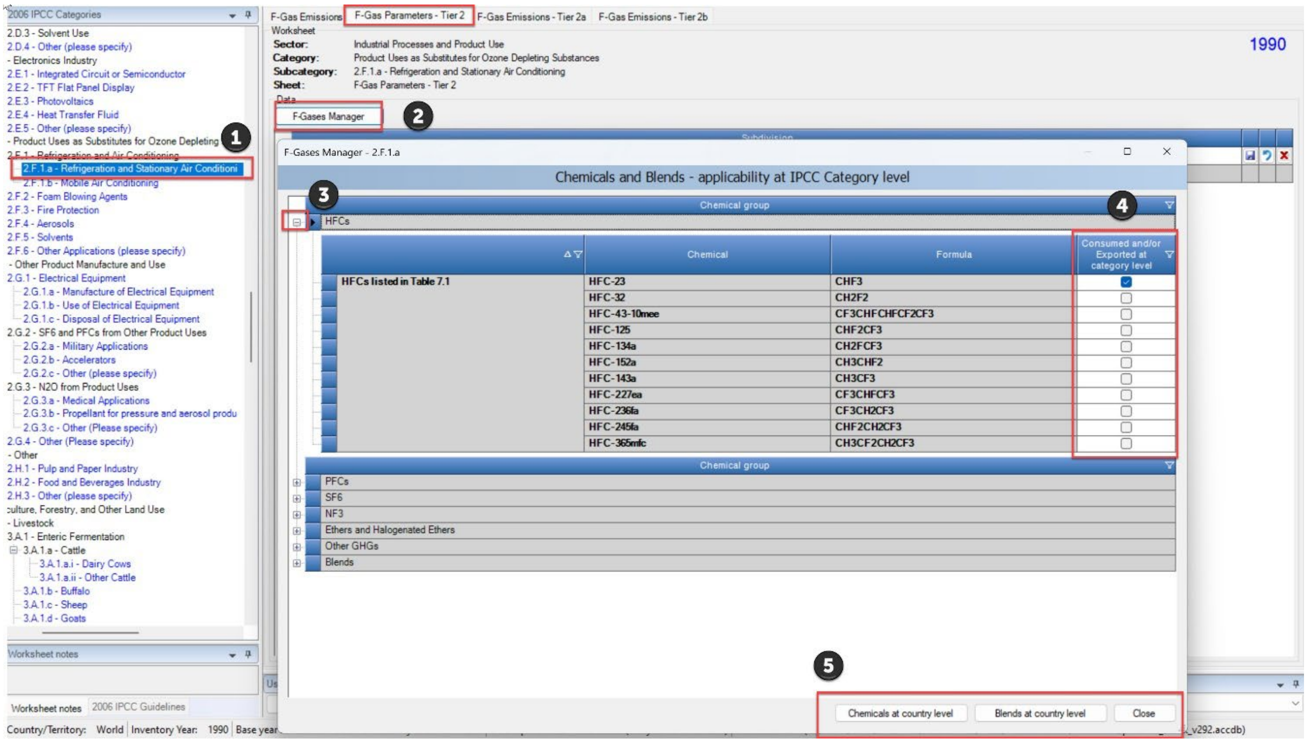
Example: **Identifying category level F gas and blend consumption: 2.F.1.and 2.F.2 (Tier 1 only) and 2.F.3**



<u>To identify the list of F-gases blends for Tier 1 in 2.F.1 and 2.F.2, and all of 2.F.3</u>

1. Navigate to the relevant worksheet
2. The user will not see any available options for F-gases initial by selecting the drop-down menu
3. To identify the relevant F-gases /blends consumed, select **Chemical's Data**
4. In the **Gas** field, select the drop-down
5. The user will be presented with a list of all Chemicals and Blends identified at the country level. To view the list, select the [+] plus symbol. The user shall select, by checking the box, those F-gases and blends that are consumed in that category (in the figure above, for refrigeration and air conditioning – Tier 1)
6. For users intending to use the GHG inventory information for purposes of reporting under the ETF of the Paris Agreement, and thus transmit information to the UNFCCC, they may indicate here if the consumption of gas in this application is considered Confidential. If designated as confidential, the AD on consumption will not be included in the JSON file submitted to the UNFCCC; and emissions will be transferred, along with any other confidential emissions of F-gases, in category 2.H. For more information, see Annex I.
7. The user may return to the main F-gases Manager by selecting "Chemicals at country level" or "Blends at country level" to add additional F-gases/blends for selection, other, **Close** the F-gases Manager here.

Example: **Identifying category level F-gas and blend consumption: all other categories**



<u>To identify the list of F-gases blends for all other categories:</u>

1. Navigate to the relevant worksheet
2. Select **F-gases Manager**
3. The user will be presented with a list of all Chemicals and Blends identified at the country level. To view the list, select the [+] plus symbol.
4. The user shall select, by checking the box, those F-gases and blends that are consumed in that category (in the figure above, for refrigeration and air conditioning – Tier 2).
5. The user may return to the main F-gases Manager by selecting "Chemicals at country level" or "Blends at country level" to add additional F-gases/blends for selection, other, **Close** the F-gases Manager here.

<u>Note that</u>, unlike the case where the F-gases Manager was accessed through Chemical's Data, the user does not have the ability to indicate in this table if the F-gas/blend used in the application is confidential. This is because for the Tier 2 approach for Refrigeration and Air Conditioning (2.F1), and for Foams (category 2.F.2) further consumption is further broken down by application (e.g. domestic refrigeration or Polyurethane – Continuous panel). Confidentiality will be designated for these categories at the sub-application level (see sections 2.F.1 and 2.F.3 Refrigeration and Air Conditioning *and 2.F.2 Foams (to be completed) for more information).*

1.1.3 Use of multiple Tiers for reporting

The *2006 IPCC Guidelines* provide methodological guidance to estimate anthropogenic GHG emission and removals according to three tier levels: Tier 1, Tier 2, Tier 3, where Tier 1 is the common default methodological approach that the IPCC Guidelines provide for all inventory compilers, while higher tiers are based on country-specific data on activity-dependant rates of GHG emissions and removals and likely have a higher spatial and temporal resolution of AD. Tier 2 may apply a different methodological approach[1], or the Tier 1 methodology approach with user-specific values for parameters and EFs and may further disaggregate the population of AD to apply condition-specific values of parameters and EFs. Tier 3 is generally[2] a country-specific methodological approach that, although consistent with IPCC good practice, has been designed specifically to better cope with the country-specific statistical population for which GHG emissions/removals are estimated or may be based on the direct monitoring of the source of GHG emissions.

[1] E.g. cement production or iron and steel production.

[2] In some cases, IPCC also provides a Tier 3 methodology, as for instance for HFC-23 emissions from HCFC-22 production.

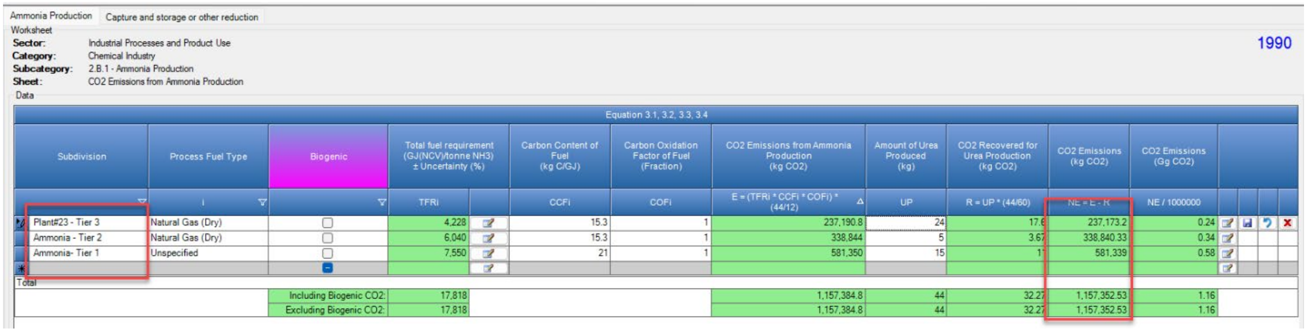
Where a user-specific Tier 3 method, which cannot be calculated by the *Software*, is used to prepare estimates of GHG emissions that need to be included in the NGHGI for completeness, the user can use the relevant calculation worksheet(s) to report it as it follows:

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

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*, 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.

Example: **Applying three different tiers**[1]



While the user may use a combination of Tiers within a single source/sink category, it may 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 double counting GHG emissions from a source category.

1.1.4 Reporting of Subdivisions

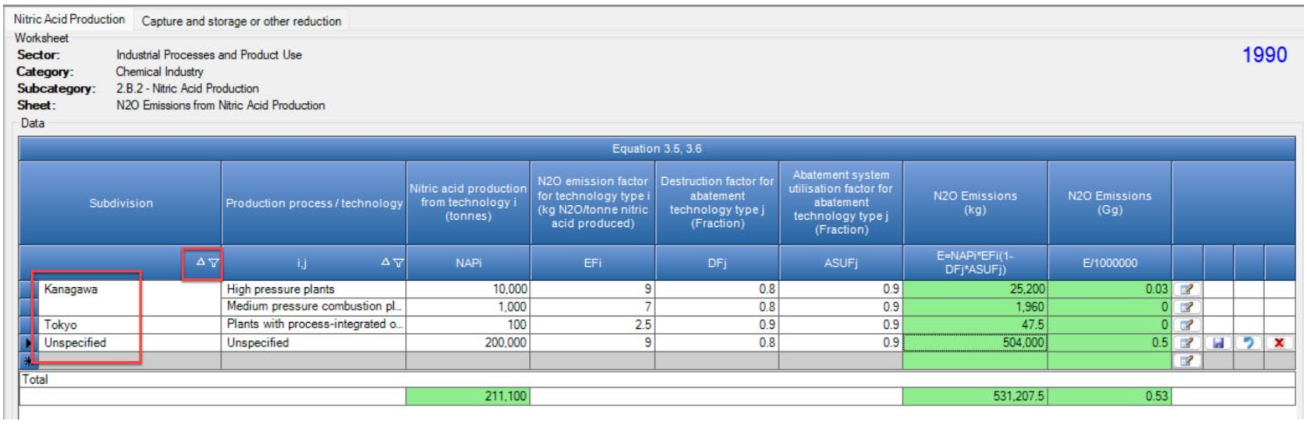
GHG inventories may be calculated at multiple levels of aggregation (e.g. facility, corporate, regional, national) to meet various domestic and international needs. Thus, *Subdivisions* can be entered for all source categories in the IPPU sector.

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 drop-down 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.

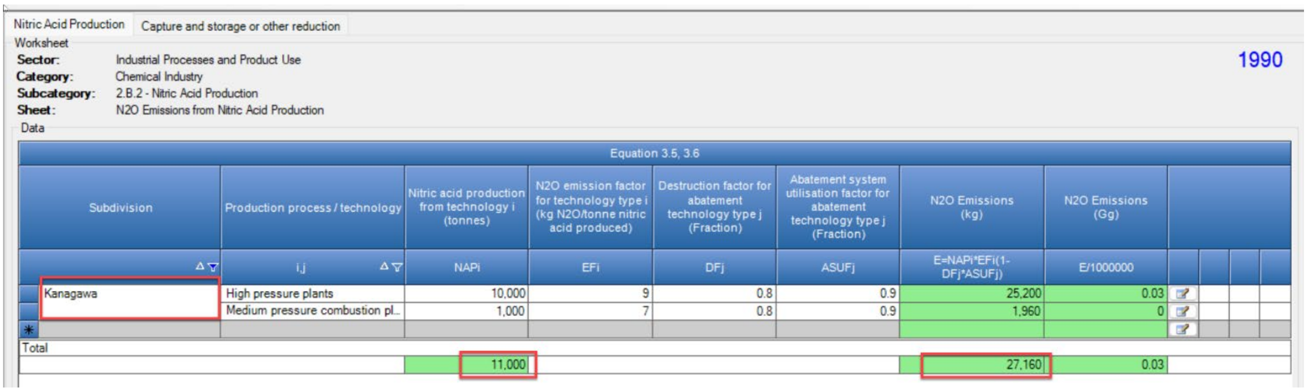
Every calculation worksheet[2] includes filters to enable the user to view data entry, by subdivision.

[1] In this example, Tier 1 – estimating fuel requirement based on ammonia production, Tier 2 – total fuel requirement for each fuel type, Tier 3 – fuel requirement for each fuel type at a specific plant.
[2] Those can also be referred as TABs of the *Software*

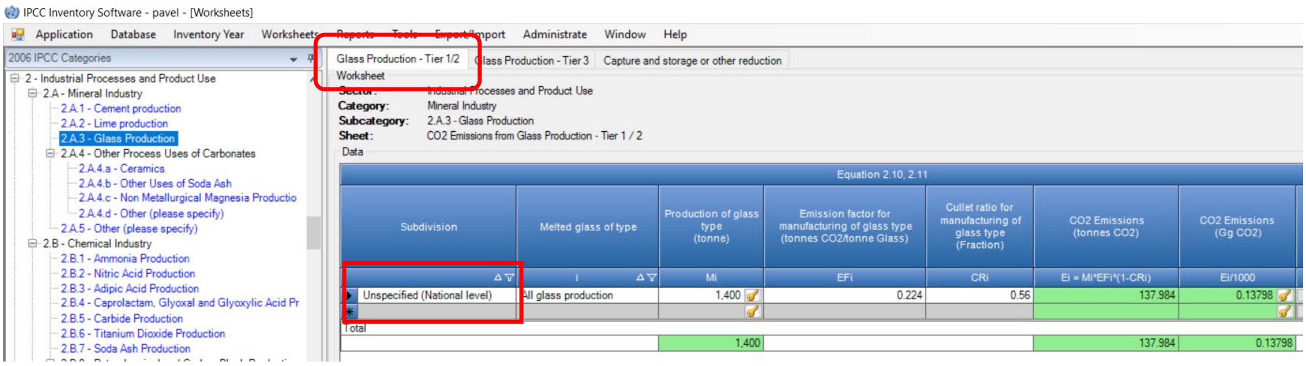
Example: **subdivisions and applying filter**



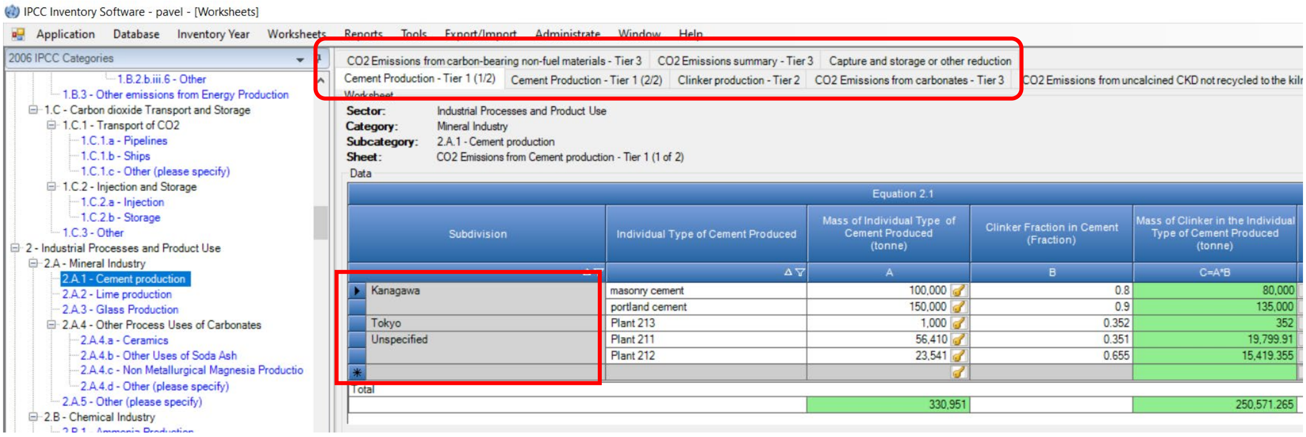
Example: **viewing filtered results**



Example: **Tiers and Subdivisions – Combination** (Several Tiers in One Worksheet Table)



Example: **Tiers and subdivisions – multiple** (several tiers in different worksheet tables)

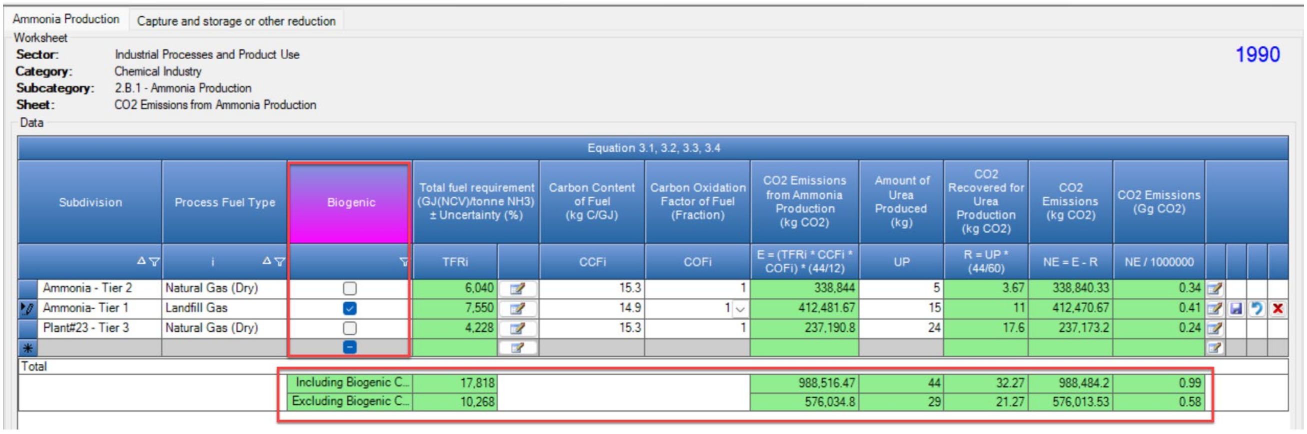


1.1.5 Biogenic fuels, feedstocks and reductants

Biogenic fuels may be used in the IPPU sector as a feedstock or a reductant (e.g. biochar), particularly in the chemical and metal industry. CO_2 emissions from use of biogenic fuels in the IPPU sector are not included in reporting tables of national GHG inventories, however, there may nevertheless be interest in tracking the use of these biogenic fuels.

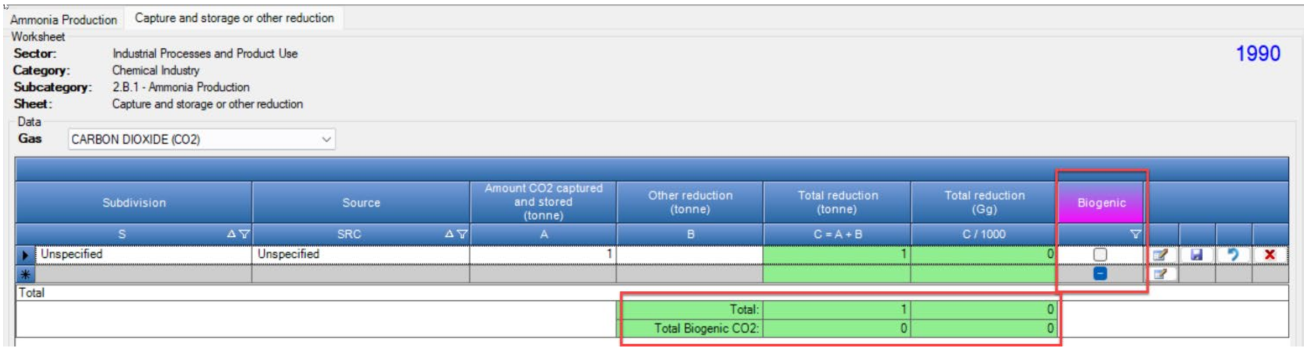
All source categories in the IPPU sector in which use of biogenic fuels is possible include a separate column(s), in magenta, to allow the user to indicate that the fuel input used in the process is of biogenic origin. In addition, for these categories, totals are provided including and excluding biogenic CO_2. Note that emissions of CO_2 from biogenic origin in the IPPU sector will not be included in any JSON file generated for UNFCCC reporting.

Example: **designation of biogenic fuels in a source category**



For these same categories, the *Capture and storage or other reduction* worksheet provides a column to allow the user to indicate if the CO_2 captured is of biogenic origin. Unlike the case with emissions of CO_2 of biogenic origin, the capture of CO_2 of biogenic origin will be included in any JSON file generated for UNFCCC reporting.

Example: **Capture of biogenic CO_2**

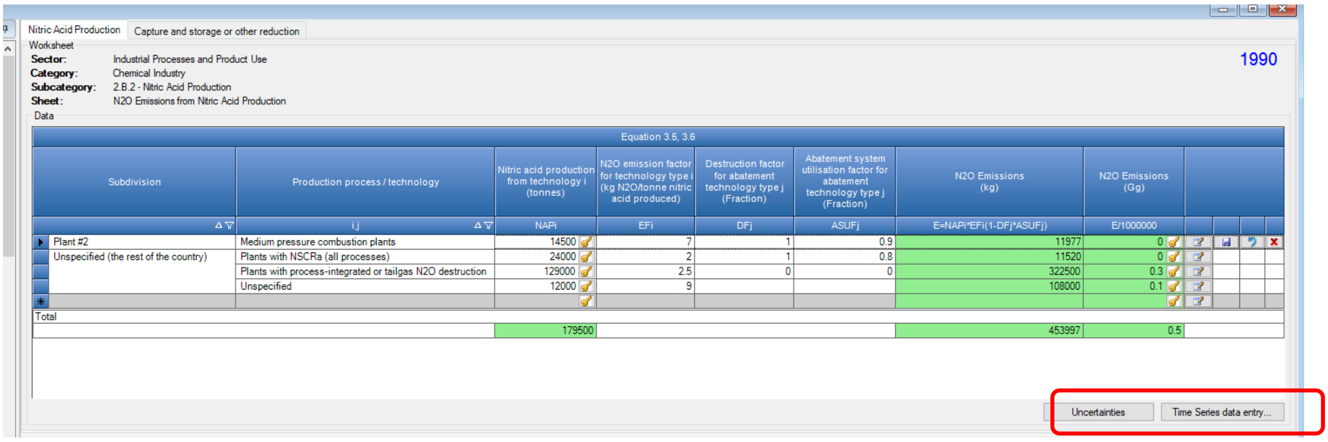


For more information on the reporting of emissions and removals of CO_2 of biogenic origin and reporting to the UNFCCC ETF Reporting Tool, see Annex I.

1.1.6 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 at the lower right-hand side of the worksheet. Users may learn more about how to use these functionalities in the general *User Manual* of the *Software* ("Help" tab).

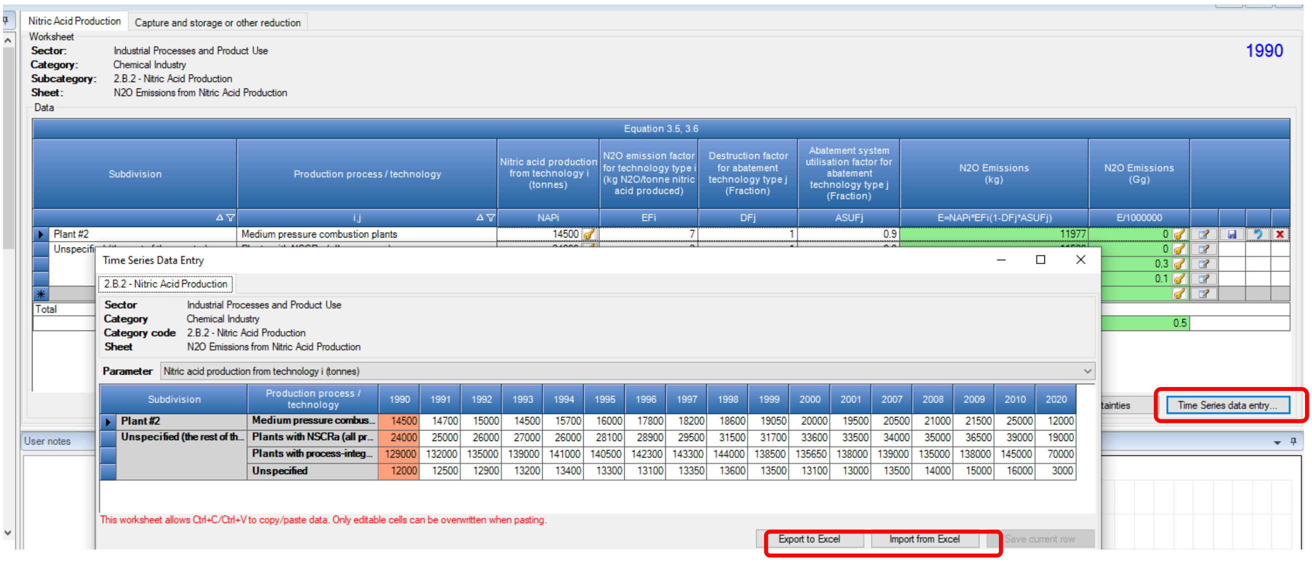
Example: **tabs for uncertainties and time series data entry**



Time series data entry

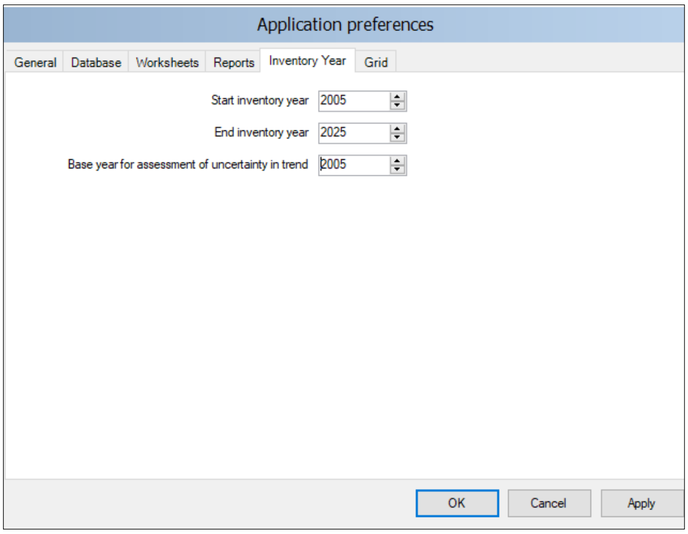
In each worksheet, there is a button *Time Series data entry* as shown in the screenshot below. After clicking on the tab *Time Series data entry* users can select the necessary parameters from the Parameters bar that can be exported/imported, depending on the information contained in each specific worksheet. To use this functionality, user must have the *Software* configured to include all inventory years in the time series, and each year must be populated with minimum identifying information (e.g. subdivision name and process technology/fuel, etc).

Example: **Time series export/import**



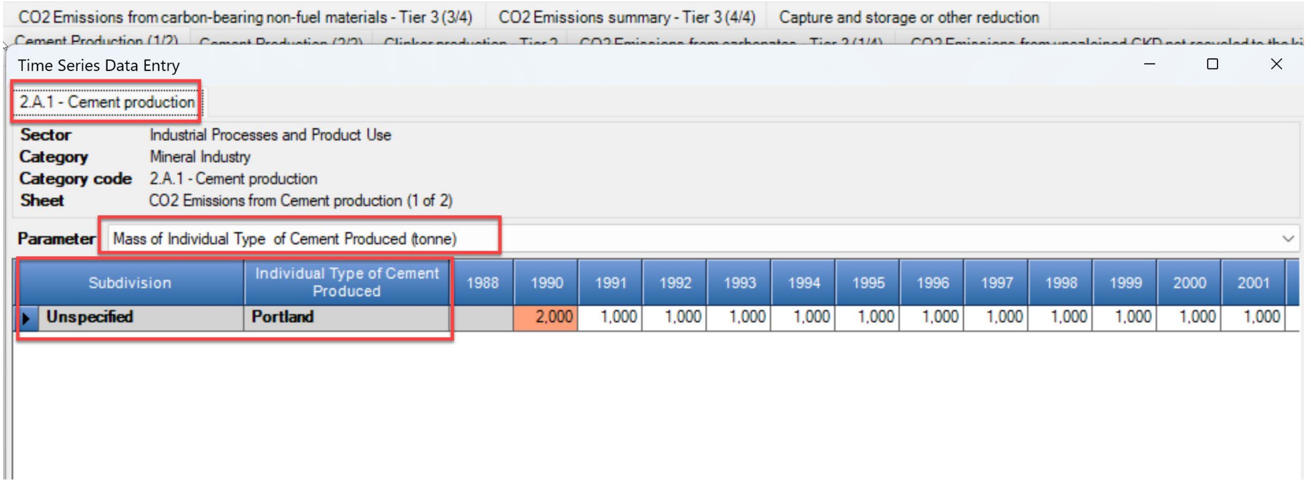
To use this functionality users:

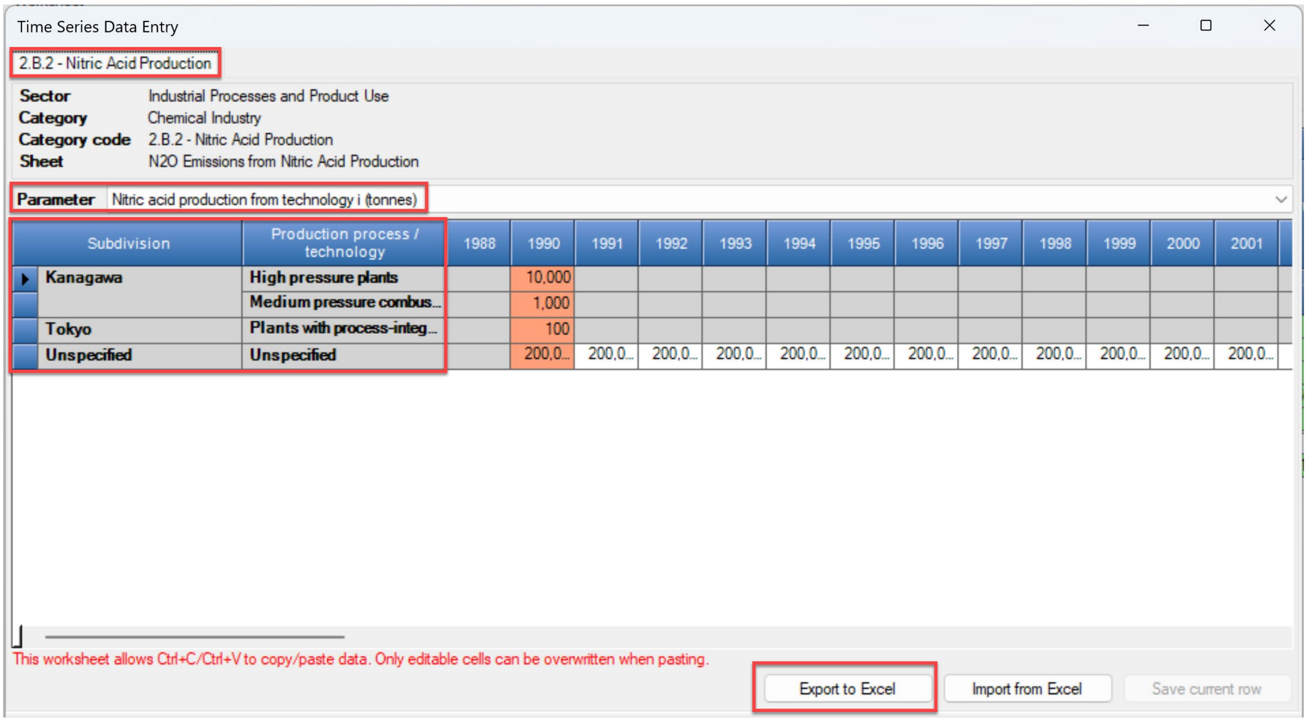
1. Select in TAB **Application**, sub-TAB **Inventory Year**, the time-period of the inventory and click on *Apply* to save it.



2. Ensure relevant identifying information is populated for each inventory year. The minimum information can be identified by selecting *Export to Excel* and noting the column headers. For example, for cement production, information on *Subdivision* and *Individual Type of Cement Produced* must be completed for each inventory year, while for nitric acid production, Subdivision and Production process/technology must be provided in order to be able to copy and paste underlying data into the exported data entry grids.

Example: **Preparing for time series export/import**





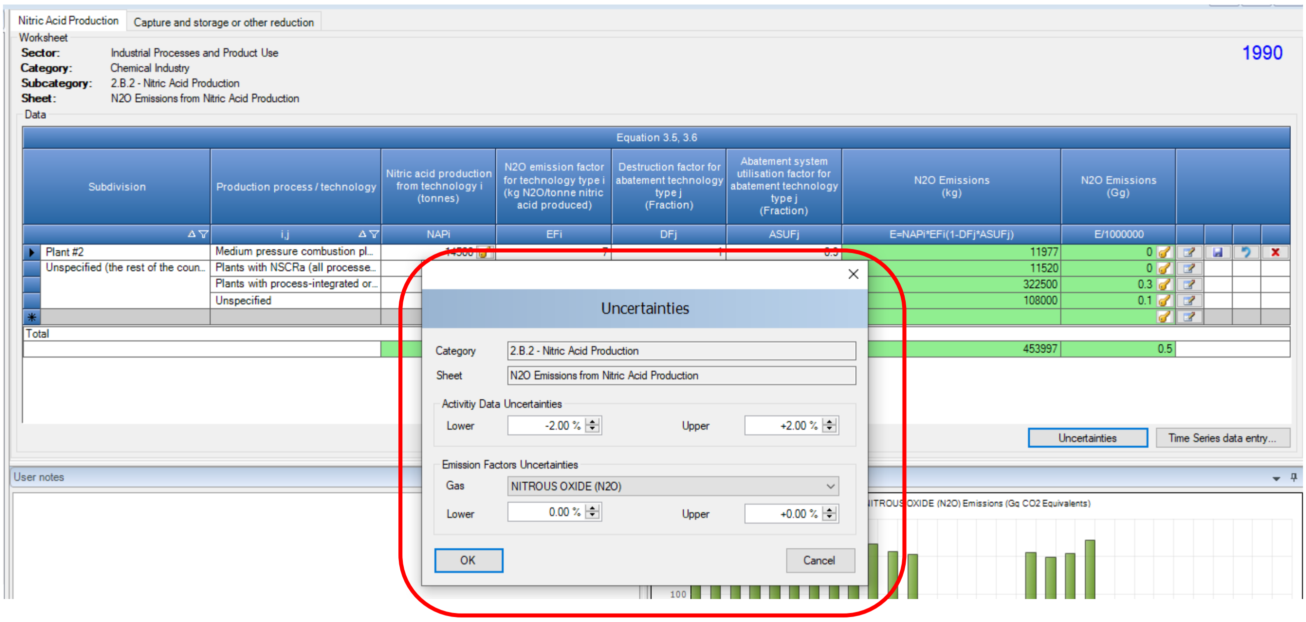
3. Select the *Export to Excel* button, name and save the file.
4. Users can open this exported file and make changes directly there for various years. Users can make changes in all white cells.
5. Once changes are made, then users can import the modified file into the *Software* (by clicking the *Import from Excel* button).

Uncertainty

In some categories of the *Software* IPCC default uncertainty information for AD are automatically filled. For IPPU, further information on the underlying sources of uncertainty and the default uncertainty values that may be used when country-specific information is not available, can be found in the section titled "Uncertainty Assessment" of the 2006 IPCC Guidelines for each source category.

Please note that the Uncertainty Analysis has not yet been enhanced in this version, so this section will be revised in the next future.

Example: **uncertainty data entry for AD and EFs**



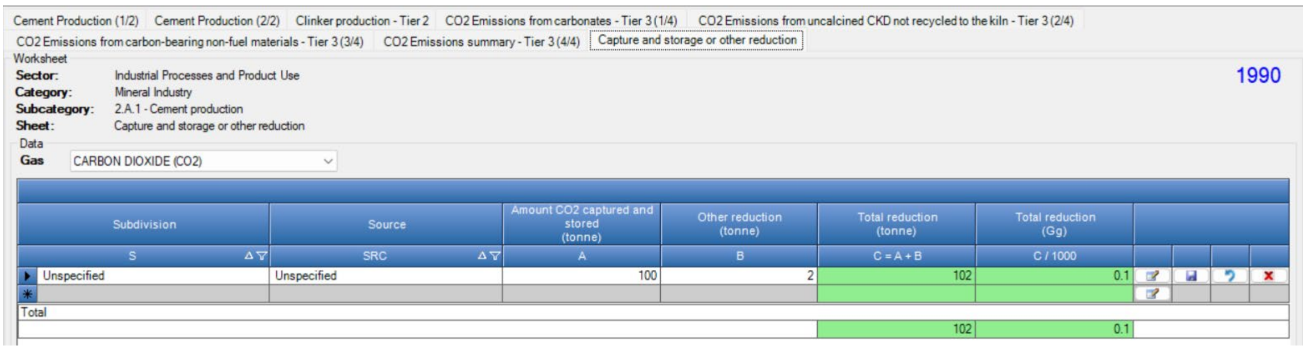
1.1.7 Capture and storage or other reduction

In the IPPU sector all categories include the worksheet *Capture and storage or other reduction*. It contains information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) or other GHG (e.g. recovery or destruction). The default assumption is that there is no CO_2 capture and storage taking place.

Three notes of importance regarding information included in this worksheet:

1. This worksheet is only to include the amount not accounted previously in other worksheets for the category (e.g. Tier 2 and Tier 3 may contain EFs or methodology which imply reduction/control technologies).
2. The amount of CO_2 or other GHGs included in this worksheet must be either permanently stored, or if not, either excluded from this worksheet, or the user must ensure that subsequent emissions are included elsewhere in the GHG inventory.
3. Care is to be taken to avoid double counting capture of CO_2 between the IPPU and Energy sectors. Any methodology taking into account CO_2 capture should consider that CO_2 emissions captured in the process may be both combustion and process-related. In cases where combustion and process emissions are to be reported separately, e.g. for cement production, inventory compilers should ensure that the same quantities of CO_2 are not double counted.

Example: **Capture and storage or other reduction**



2. IPPU Sector – Categories Guidance

2.A Mineral Industry

2.A.1 Cement Production

Information

Section 2.2 of the *2006 IPCC Guidelines* provides three Tiers to estimate CO_2 emissions from Cement Production. Countries may gather AD based on cement production data and an assumed clinker fraction of cement (Tier 1), clinker production data (Tier 2) or carbonates used for cement production (Tier 3).

GHGs

The *Software* includes the following GHG for the Cement Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

- ✓ Tier 1: Equations 2.1 and 2.4
- ✓ Tier 2: Equations 2.2 and 2.5
- ✓ Tier 3: Equation 2.3

As explained in section **1.1.3 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 CO_2 from Cement Production using worksheets:

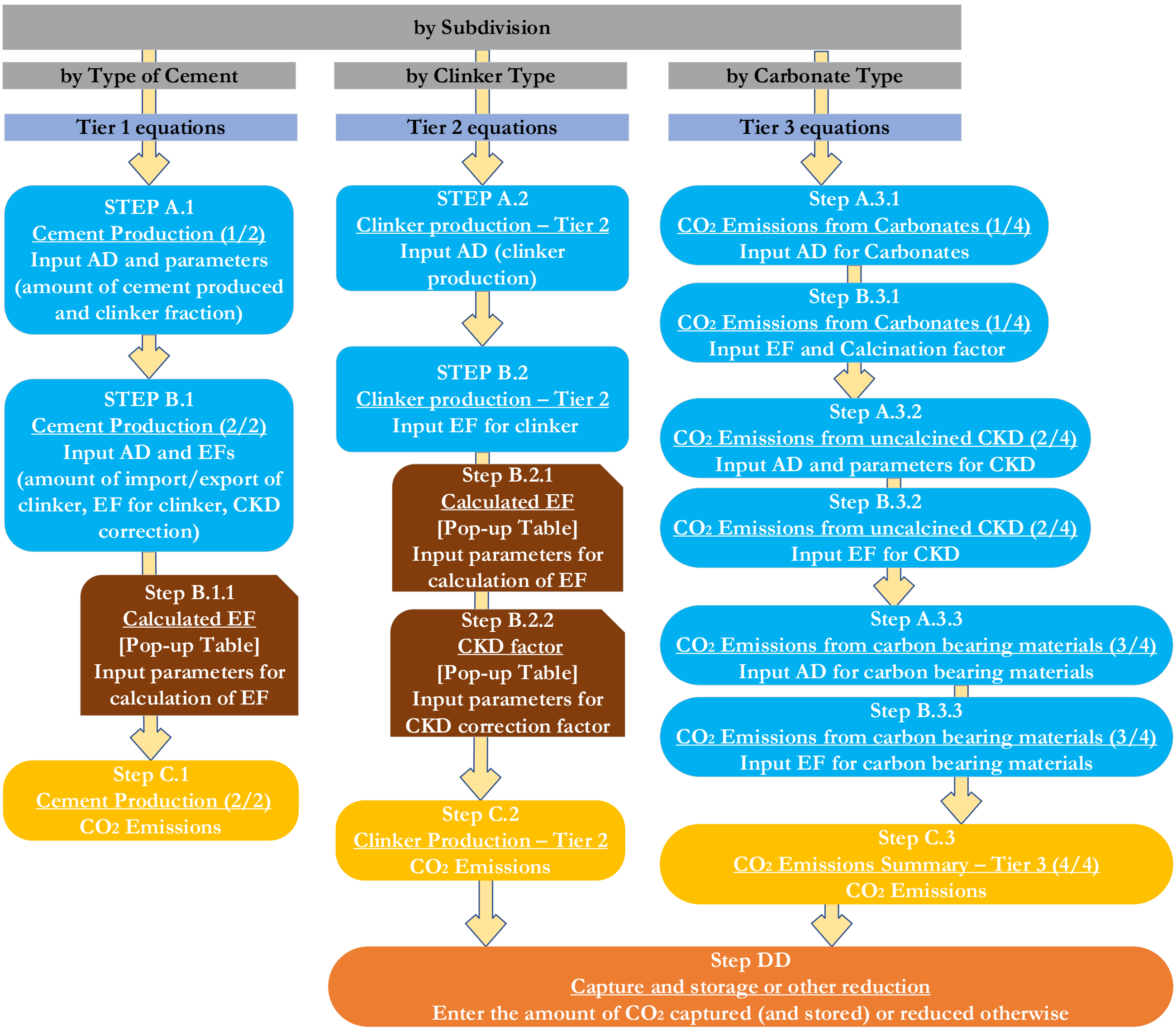
- ✓ **Cement Production (1/2):** contains for each subdivision and individual type of cement produced, information on the amount of cement produced and clinker fraction to estimate mass of clinker produced.
- ✓ **Cement Production (2/2):** contains for each subdivision information on import and export of clinker and the clinker CO_2 EF. The worksheet calculates the associated CO_2 emissions.
- ✓ **Clinker Production – Tier 2:** contains for each subdivision information on the amount of clinker production, the clinker CO_2 EF and the correction factor for cement kiln dust (CKD), the latter which can be entered manually or calculated in the pop-window. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Carbonates – Tier 3 (1/4):** contains for each subdivision information on types of carbonates used: amount, CO_2 EF and fraction of calcination. The worksheet calculates the associated CO_2 emissions
- ✓ **CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4):** contains for each subdivision information on uncalcined carbonate in CKD not recycled to the kiln: amount of CKD and the weight fraction not recycled, calcination fraction and the CO_2 EF. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from carbon bearing materials – Tier 3 (3/4):** contains for each subdivision information on raw material types (additional carbon bearing materials): amount, carbon fraction and CO_2 EF. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions summary – Tier 3 (4/4):** this worksheet automatically sums up total emissions from the previous three worksheets of Tier 3
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Cement Production.

Cement Production – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Then, for each subdivision, if any:

When Tier 1 Equations are applied:

Step A.1, in the worksheets **Cement Production (1/2),** users collect and input in the *Software* information on the amount of each cement type produced and the clinker fraction of cement.

Step B.1, in the worksheet **Cement Production (2/2),** users enter in the amount of imported and exported clinker. The user then either calculates, using a pop-up table, or directly inputs the CO_2 EF for clinker and applies the CKD correction factor.

Step C.1, in the worksheet **Cement Production (2/2),** for each subdivision, CO_2 emissions are calculated in mass units (tonnes and Gg). In addition, total CO_2 emissions are calculated.

When Tier 2 Equations are applied:

Step A.2, in the worksheet **Clinker Production – Tier 2**, users collect and input in the *Software* information on the amount of each clinker type produced.

Step B.2, in the worksheet **Clinker Production – Tier 2,** users either calculate, using a pop-up table (**Step B.2.1**), or directly input the CO_2 EF for clinker. In **Tier 2** the information to estimate the correction factor for CKD not recycled to the kiln is also needed and is either calculated, using a pop-up table (**Step B.2.2**), or directly input.

Step C.2, in the worksheet **Clinker Production – Tier 2,** for each subdivision, CO_2 emissions are calculated in mass units (Gg). In addition, total CO_2 emissions are calculated.

When the Tier 3 Equation is applied:

Steps A.3 -A.3.3, in the three worksheets **CO_2 Emissions from Carbonates – Tier 3 (1/4), CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4),** and **CO_2 Emissions from carbon-bearing materials – Tier 3 (3/4),** users collect and input in the *Software* information on types of carbonates used (amount and fraction of calcination), on uncalcined carbonate in CKD not recycled to the kiln (amount of carbonates, calcination fraction), and on raw materials types (additional carbon bearing materials – amount and carbon fraction).

Steps B.3.1-B.3.3, in the three worksheets **CO_2 Emissions from Carbonates – Tier 3 (1/4), CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4),** and **CO_2 Emissions from carbon bearing materials – Tier 3 (3/4),** users input EFs based on carbonates used and for the uncalcined carbonate in CKD not recycled to the kiln.

Step C.3, in the worksheet **CO_2 Emissions summary – Tier 3 (4/4),** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonnes and Gg). In addition, total CO_2 emissions are calculated.

Then, for Tier 2 and Tier 3, as appropriate:

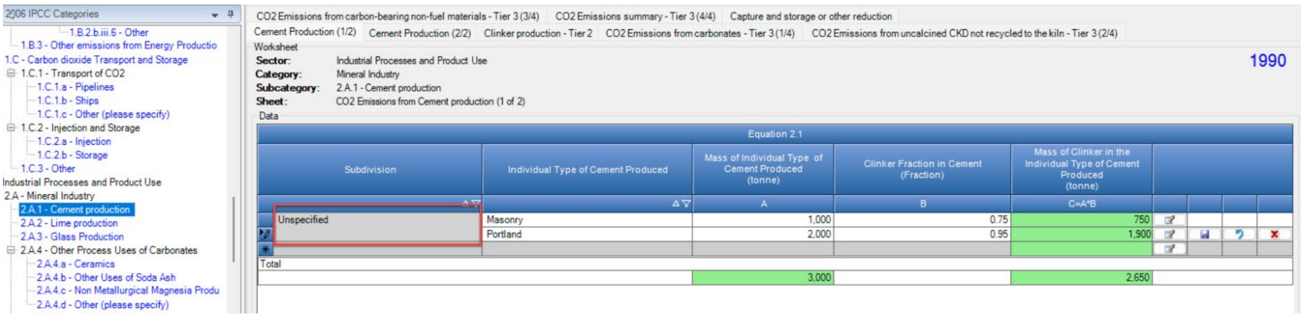
Step DD, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates).

Activity data input

Section 2.2.1.3, Chapter 2, Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for cement production.

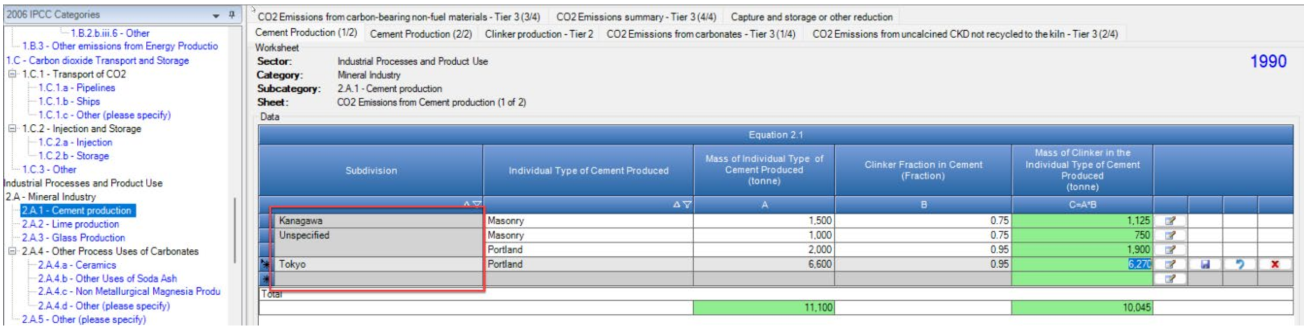
Input of AD for the Cement Production source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



When Tier 1 Equations are applied:

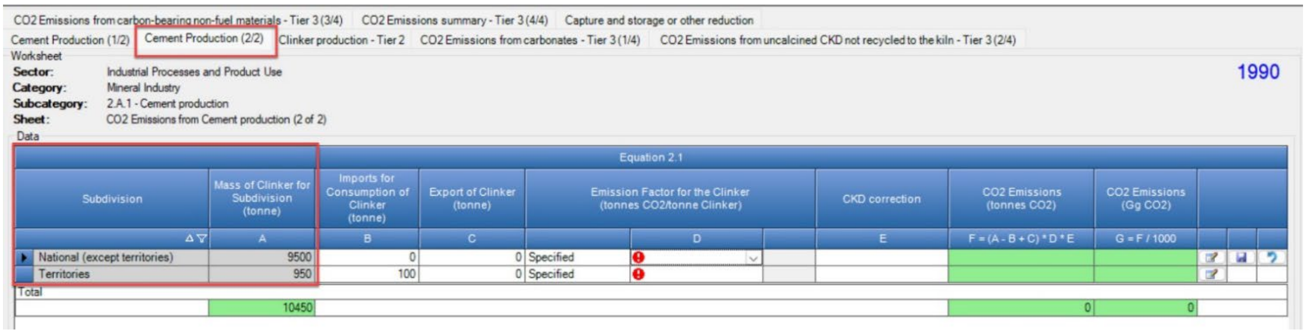
For each subdivision in Column |Subdivision|, data are entered in worksheet **Cement Production (1/2),** row by row, as follows:

1. Column |Individual type of Cement Produced|: select the type of cement produced from the drop-down menu, or, if unknown, select Unspecified (one row for each type of cement produced).
2. Column |A|: input the mass of individual type of cement produced, in tonnes.
3. Column |B|: select from the drop-down menu the clinker fraction in cement produced, fraction. If known, the user may directly enter an appropriate value. With this information, the worksheet calculates the clinker content of cement for each row.

Then, in worksheet **Cement Production (2/2)**, for each subdivision:

1. Column |A|: automatically calculates the total clinker content for each subdivision.

Example: **Automatic calculation of clinker content for each subdivision**



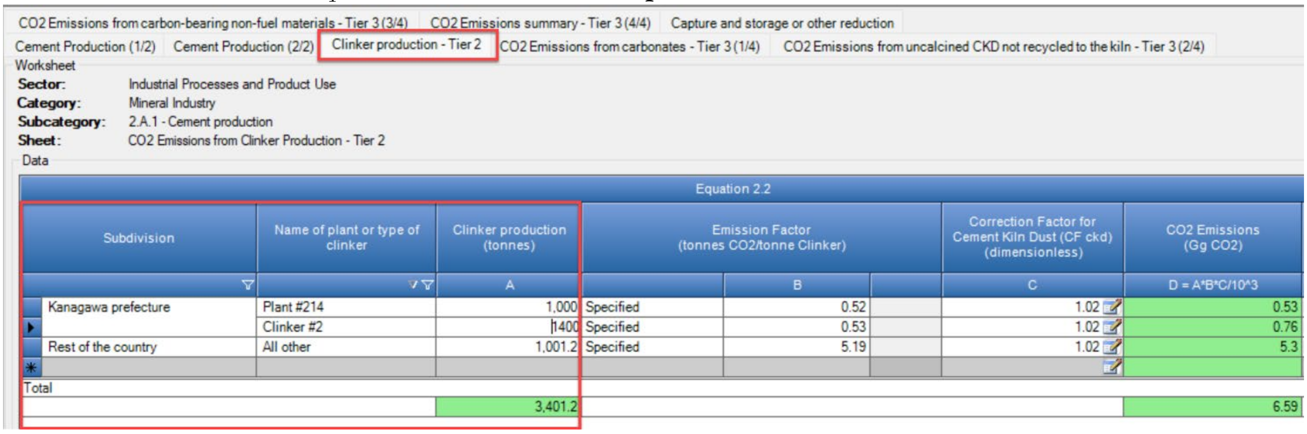
2. Column |B|: input the amount of imported clinker, in tonnes.
3. Column |C|: input the amount of exported clinker, in tonnes.

When Tier 2 Equations are applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **Clinker production – Tier 2,** row by row, as follows:

1. Column |Name of plant or type of clinker|: Enter a name for plant/facility and/or type of clinker produced.
2. Column |A|: enter the amount of clinker production, in tonnes.

Example: **AD for Tier 2 clinker production for each subdivision**



Subdivision	Name of plant or type of clinker	Clinker production (tonnes)	Emission Factor (tonnes CO2/tonne Clinker)			Correction Factor for Cement Kiln Dust (CF ckd) (dimensionless)	CO2 Emissions (Gg CO2)
		A		B		C	D = A*B*C/10^3
Kanagawa prefecture	Plant #214	1,000	Specified	0.52		1.02	0.53
	Clinker #2	1400	Specified	0.53		1.02	0.76
Rest of the country	All other	1,001.2	Specified	5.19		1.02	5.3
Total		3,401.2					6.59

When Tier 3 Equations are applied:

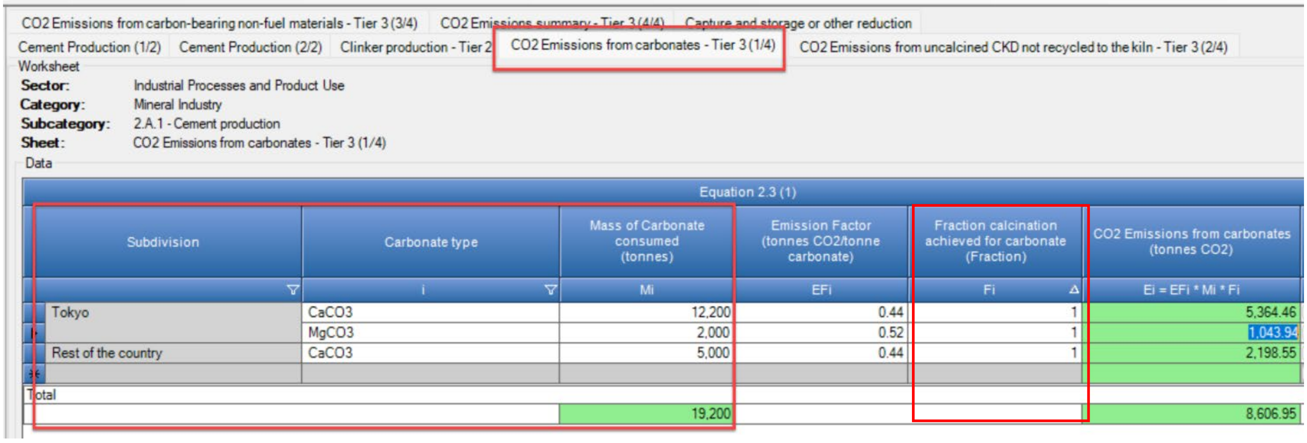
For Tier 3, for each subdivision in Column |Subdivision|, there are three worksheets to input AD as follows:

i. CO_2 Emissions from Carbonates – Tier 3 (1/4):

1. Column |i|: select from the drop-down menu the type of carbonate used or enter in directly any user-specific carbonate.
2. Column |Mi|: for each subdivision/ carbonate type, users enter information on the mass of carbonate consumed, in tonnes.
3. Column |Fi|: enter fraction of calcination achieved for carbonate.

   Note that in the absence of actual data, it may be assumed that, at the temperatures and residence times achieved in cement (clinker) kilns, the degree of calcination achieved for all material incorporated in the clinker is 100 percent (i.e., Fi = 1.00) or very close to it.

Example: **AD for Tier 3 – Amount of carbonates consumed**



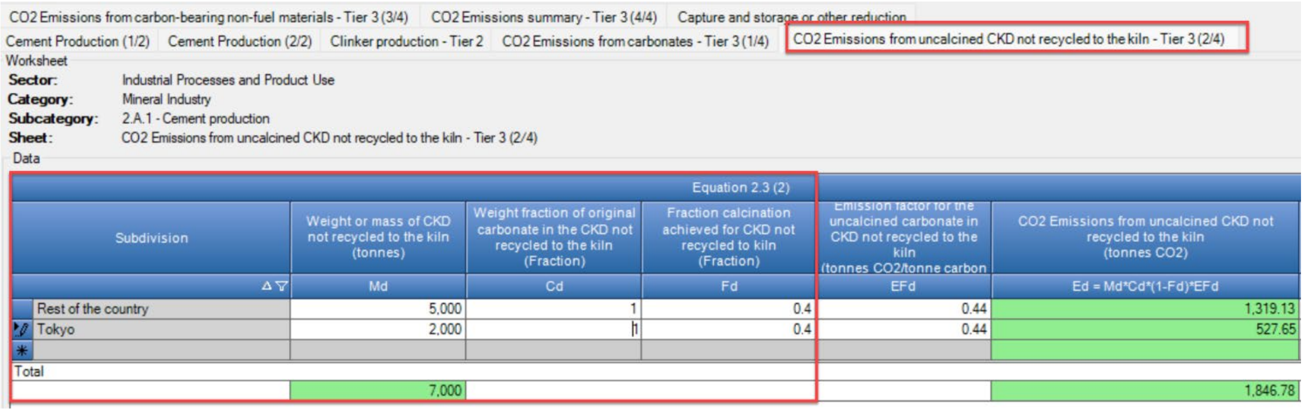
Subdivision	Carbonate type	Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)	Fraction calcination achieved for carbonate (Fraction)	CO2 Emissions from carbonates (tonnes CO2)
	i	Mi	EFi	Fi	Ei = EFi * Mi * Fi
Tokyo	CaCO3	12,200	0.44	1	5,364.46
	MgCO3	2,000	0.52	1	1,043.94
Rest of the country	CaCO3	5,000	0.44	1	2,198.55
Total		19,200			8,606.95

ii. CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4):

Note that this worksheet will have the same subdivisions entered in the previous worksheet (1/4) available for selection from the drop-down menu. For each subdivision users enter the following:

1. Column |Md|: input weight or mass of CKD not recycled to the kiln, in tonnes.
2. Column |Cd|: input the weight fraction of original carbonate in the CKD (i.e., before calcination) not recycled to the kiln, fraction.
   Note that because calcium carbonate is overwhelmingly the dominant carbonate in the raw materials, it may be assumed that it makes up 100 percent of the carbonate remaining in the CKD not recycled to the kiln. It is thus acceptable within good practice to set Cd as equal to the calcium carbonate ratio in the raw material feed to the kiln.
3. Column |Fd|: enter fraction of calcination achieved for CKD.
   Note that for CKD, a Fd of <1.00 is more likely but the data may show high variability and relatively low reliability. In the absence of reliable data for CKD, an assumption of Fd = 1.00 will result in the correction for CKD to equal zero.

Example: **AD for Tier 3 – amount of uncalcined CKD not recycled to the kiln**


CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction
Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)
Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.1 - Cement production
Sheet: CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)
Data

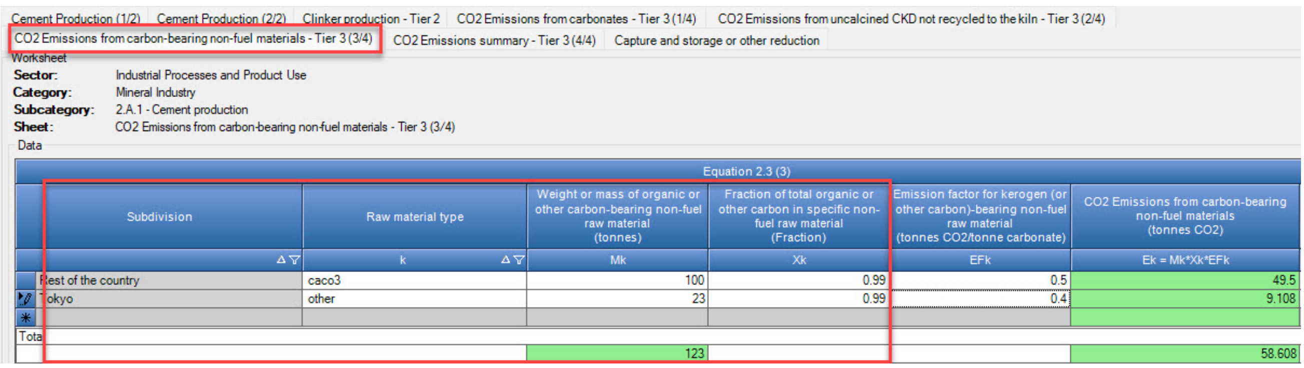
Equation 2.3 (2)					
Subdivision	Weight or mass of CKD not recycled to the kiln (tonnes)	Weight fraction of original carbonate in the CKD not recycled to the kiln (Fraction)	Fraction calcination achieved for CKD not recycled to kiln (Fraction)	Emission factor for the uncalcined carbonate in CKD not recycled to the kiln (tonnes CO2/tonne carbon	CO2 Emissions from uncalcined CKD not recycled to the kiln (tonnes CO2)
	Md	Cd	Fd	EFd	Ed = Md*Cd*(1-Fd)*EFd
Rest of the country	5,000	1	0.4	0.44	1,319.13
Tokyo	2,000	1	0.4	0.44	527.65
Total	7,000				1,846.78

iii. CO_2 Emissions from carbon-bearing materials – Tier 3 (3/4):

Note that this worksheet will have the same subdivisions entered in worksheet (1/4) available for selection from the drop-down menu. For each subdivision users enter the following:

1. Column |k|: input the type of carbon-bearing non-fuel materials.
2. Column |Mk|: input the weight or mass of organic or other carbon-bearing non-fuel raw materials, in tonnes.
3. Column |Xk|: input the fraction of total organic or other carbon in specific non-fuel raw material, fraction.
   Note that the CO_2 emissions from non-carbonate carbon (e.g., carbon in kerogen, carbon in fly ash) in the non-fuel raw materials can be ignored (set $M_k \cdot X_k \cdot EF_k = 0$), if the heat contribution from kerogen or other carbon is < 5 percent of total heat (from fuels).

Example: **AD for Tier 3 – amount of carbon-bearing materials**


Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)
CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction
Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.1 - Cement production
Sheet: CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4)
Data

Equation 2.3 (3)					
Subdivision	Raw material type	Weight or mass of organic or other carbon-bearing non-fuel raw material (tonnes)	Fraction of total organic or other carbon in specific non-fuel raw material (Fraction)	Emission factor for kerogen (or other carbon)-bearing non-fuel raw material (tonnes CO2/tonne carbonate)	CO2 Emissions from carbon-bearing non-fuel materials (tonnes CO2)
	k	Mk	Xk	EFk	Ek = Mk*Xk*EFk
Rest of the country	caco3	100	0.99	0.5	49.5
Tokyo	other	23	0.99	0.4	9.108
Total		123			58.608

Emission factor input

In the category 2.A.1 Cement Production there are two main factors used across Tiers (1, 2 and 3) to define the CO_2 EF: i) CO_2 EF for clinker in tonnes of CO_2 per tonne of clinker (Section 2.2.1.2 and Equation 2.4 in Chapter

2 Volume 3 of the *2006 IPCC Guidelines*) and ii) carbon content or CO_2 content of carbonates used, tonnes of CO_2 per tonne carbonate (Table 2.1 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines*).

The first one – CO_2 EF for clinker – is used in the following worksheets and based on country-specific or default assumptions, as further elaborated below for each tier:

- ✓ **Cement Production – Tier 1 (2/2)**
- ✓ **Clinker Production – Tier 2**

The second EF - CO_2 EF for carbonates – is used in the following worksheets and based on stoichiometry or formula weights and CO_2 ratios in common carbonate species (e.g. calcite - $CaCO_3$)

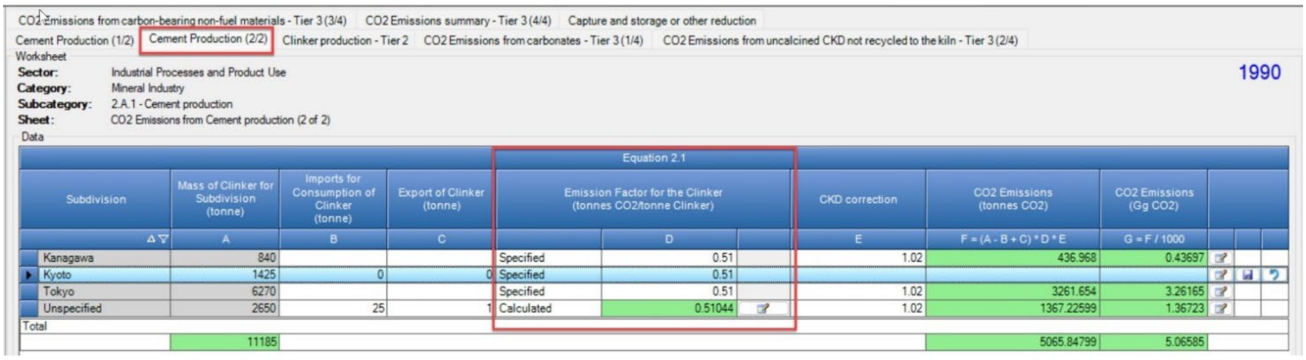
- ✓ **Clinker Production – Tier 2** (for CKD)
- ✓ **CO_2 Emissions from Carbonates – Tier 3 (1/4)**
- ✓ **CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4)**
- ✓ **CO_2 Emissions from carbon-bearing materials – Tier 3 (3/4)**

When Tier 1 Equations are applied:

The **Cement Production (2/2)** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of unique subdivisions in worksheet **Cement Production (1/2)** and the total mass of clinker in that subdivision. Then:

1. Column |D|: Select either *Specified* or *Calculated* for the CO_2 EF.
   - ✓ If specified, directly enter the default CO_2 EF for clinker of **0.51 tonne CO_2 per tonne of clinker** (uncorrected for CKD)**,** or instead enter a user-specific CO_2 EF.
     Note that the Tier 1 default CO_2 EF assumes a default CaO content for clinker of 65 percent and 100 percent of the CaO comes from calcium carbonate material.

Example: **Tier 1 EF for clinker**


CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction
Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.1 - Cement production
Sheet: CO2 Emissions from Cement production (2 of 2)

1990

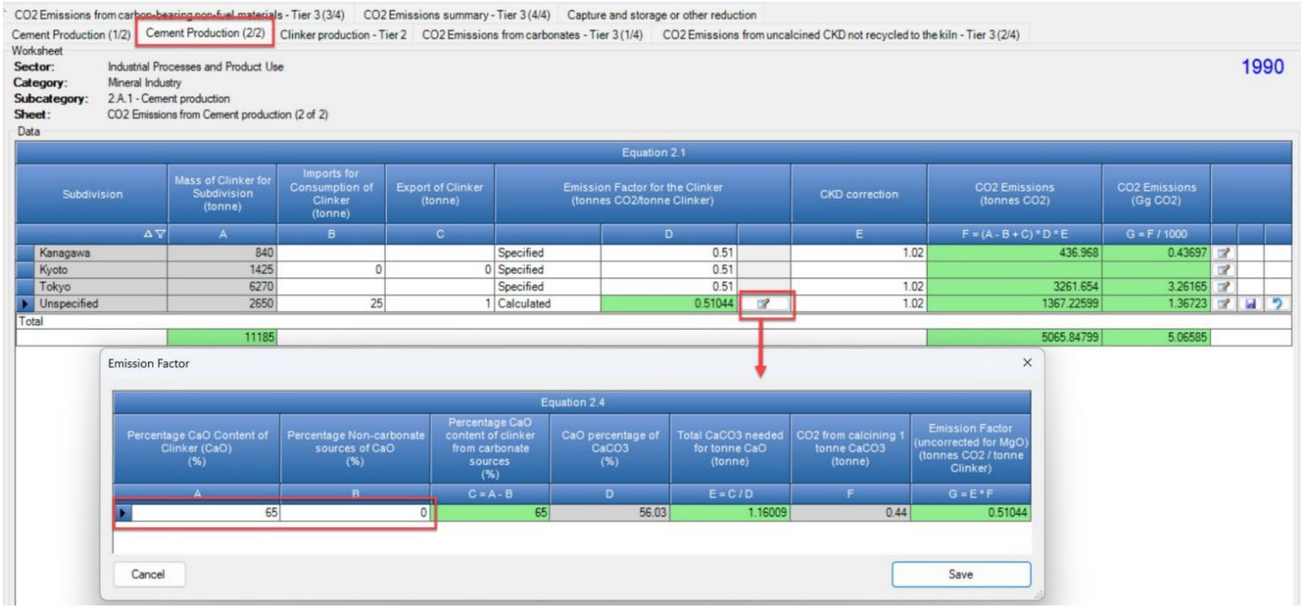
Data

				Equation 2.1					
Subdivision	Mass of Clinker for Subdivision (tonne)	Imports for Consumption of Clinker (tonne)	Export of Clinker (tonne)	Emission Factor for the Clinker (tonnes CO2/tonne Clinker)			CKD correction	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	A	B	C		D		E	F = (A - B + C) * D * E	G = F / 1000
Kanagawa	840			Specified	0.51		1.02	436.968	0.43697
Kyoto	1425	0	0	Specified	0.51				
Tokyo	6270			Specified	0.51		1.02	3261.654	3.26165
Unspecified	2650	25	1	Calculated	0.51044		1.02	1367.22599	1.36723
Total									
	11185							5065.84799	5.06585

   - ✓ If calculated, the user may calculate the CO_2 EF based on user-specific information on percentages of CaO content of clinker and non-carbonate sources of CaO. To do this, select the edit box and enter in the user-specific information.
     *Note that for the default CaO composition: 1 tonne of clinker contains 0.65 tonnes CaO from $CaCO_3$. This carbonate is 56.03 percent CaO and 43.97 percent CO_2 by weight. The amount of $CaCO_3$ needed to yield 0.65 tonnes CaO is 0.65/0.5603 = 1.1601 tonnes $CaCO_3$ (unrounded). The amount of CO_2 released by calcining this $CaCO_3$ = 1.1601 • 0.4397 = **0.5101** tonnes CO_2 (unrounded). The Tier 1 is not corrected for MgO content. Assuming no correction for CKD, the rounded default EF for clinker is 0.51tonnes CO_2 / tonne clinker.*

2. Column |E|: Select from the drop-down menu the default correction factor for CKD, or enter a user-specific value, dimensionless.

Example: **Calculating a Tier 1 EF for clinker**

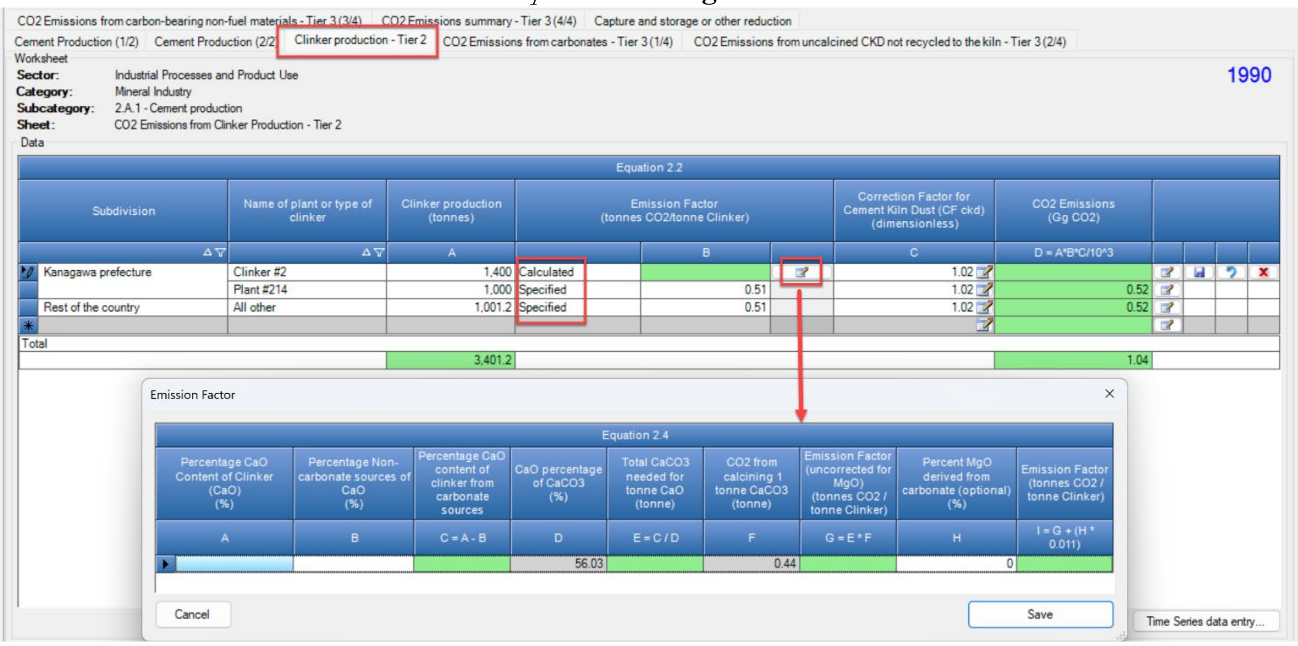


When Tier 2 Equations are applied:

For each subdivision/plant in worksheet **Clinker production – Tier 2**, then:

1. Column |B|: Select either *Specified* or *Calculated* for the CO_2 EF.
   - ✓ If specified, directly enter the default CO_2 EF for clinker of **0.51 tonne CO_2 per tonne of clinker**, uncorrected for CKD, or instead enter a user-specific CO_2 EF.
   - ✓ If calculated, the user may calculate the CO_2 EF based on user-specific information on percentages of CaO content of clinker and non-carbonate sources of CaO and, optionally, the percent of MgO derived from carbonate. To do this, select the edit box and enter in the user-specific information.

Example: **Calculating a Tier 2 EF for clinker**

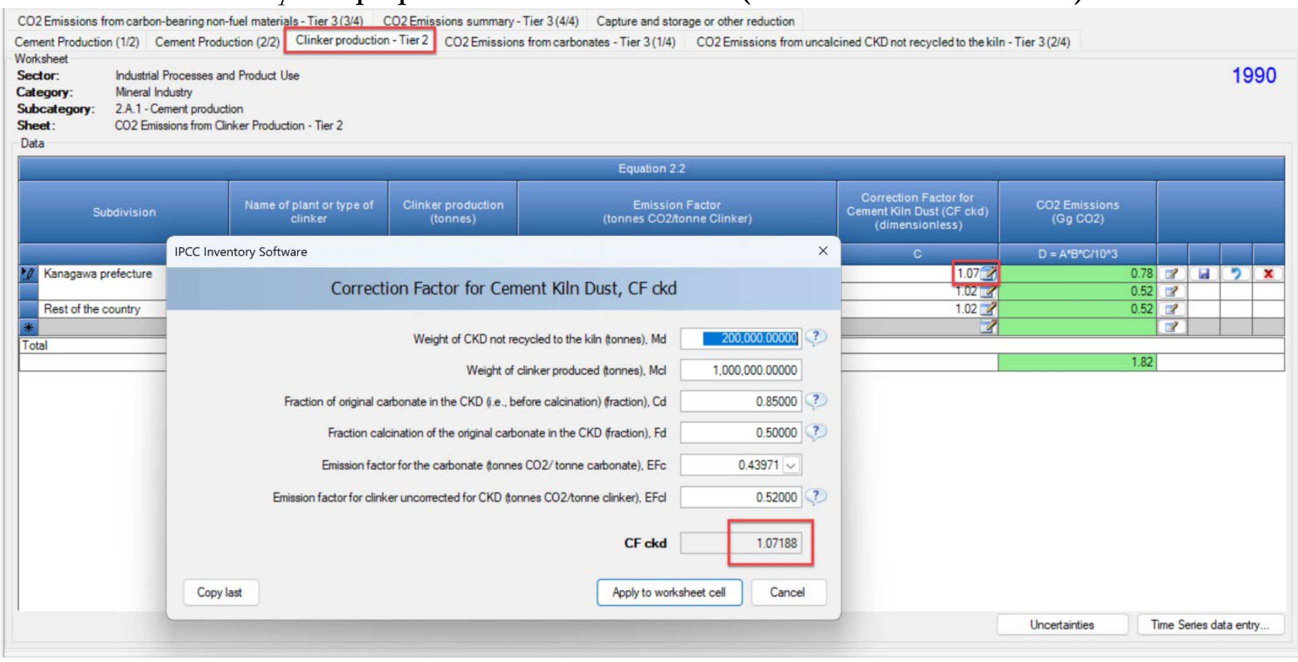


- ✓ Column |C|: Additional information is needed to estimate the correction factor for CKD not recycled into the kiln. The factor can be entered manually (the default is **1.02** (dimensionless)) or can be estimated based on several input data and parameters (a pop-up table). To estimate the CKD factor for each subdivision and plant or type of clinker, select the edit box and enter the following information:

- ✓ Weight of CKD not recycled to the kiln (Md), tonnes.
  Note that it is assumed that 100 percent of the CKD is first captured. If any CKD vents to the atmosphere, an estimate of this quantity must be made and included in the Md.
- ✓ Weight of clinker produced (Mcl), tonnes.
- ✓ Fraction of original carbonate in the CKD (i.e., before calcination) (Cd), fraction
  Note that it is acceptable to assume that the original carbonate is all $CaCO_3$ and that the proportion of original carbonate in the CKD is essentially the same as that in the raw mix kiln feed.
- ✓ Fraction calcination of the original carbonate in the CKD, fraction (Fd)
- ✓ Emission factor for the carbonate (Table 2.1) (EFc), tonnes CO_2/tonne carbonate may be selected from the drop-down menu or manually entered.
- ✓ Emission factor for clinker uncorrected for CKD (EFcl), tonnes CO_2/tonne clinker
  Note that the EF should be equal to the EF specified/calculated in Column |B|

For example, in illustration below, for Md/Mcl = 0.2, Cd = 0.85, Fd = 0.5, original carbonate all $CaCO_3$ (hence EFc = 0.4397 tonne CO_2/tonne carbonate), and EFcl = user value of 0.52 tonne CO_2/tonne clinker, the CFckd = 1.072 (unrounded) - that is, this represents about a 7 percent addition to the CO_2 calculated for the clinker alone

Example: **Pop-up table for CKD estimation (Tier 2 Cement Production)**



When Tier 3 Equations are applied:

For each subdivision/carbonate type in worksheet **CO_2 emissions from carbonates -Tier 3 (1/4)**:

1. Column |EFi|: the CO_2 EF is automatically populated in tonne of CO_2 per tonne of carbonate, based on the carbonate selected from the drop-down menu in column i. If a user-specific carbonate was entered in column i, enter the stoichiometric based EF for that carbonate in Column |EFi|.

Then, in worksheet **CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4)**:

1. Column |EFd|: enter EF for the uncalcined carbonate in CKD, in tonnes CO_2/tonne carbonate.
   Note that because calcium carbonate is overwhelmingly the dominant carbonate in the raw materials, it may be assumed that it makes up 100 percent of the carbonate remaining in the CKD not recycled to the kiln. It is thus acceptable within good practice to set Cd as equal to the calcium carbonate ratio in the raw material feed to the kiln. Likewise, it is acceptable to use the emission factor for calcium carbonate for EFd.

Then, in worksheet **CO_2 Emissions from carbon-bearing non-fuel materials – Tier 3 (3/4):**

1. Column |EFk|: enter the EF for kerogen or other non-bearing non-fuel raw material, in tonnes CO_2/tonne carbonate.
   Note that the CO_2 emissions from non-carbonate carbon (e.g., carbon in kerogen, carbon in fly ash) in the non-fuel raw materials can be ignored (set Mk • Xk • EFk = 0) if the heat contribution from kerogen or other carbon is < 5 percent of total heat (from fuels).

Results

CO_2 emissions from Cement Production are estimated in mass units (tonnes and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets:

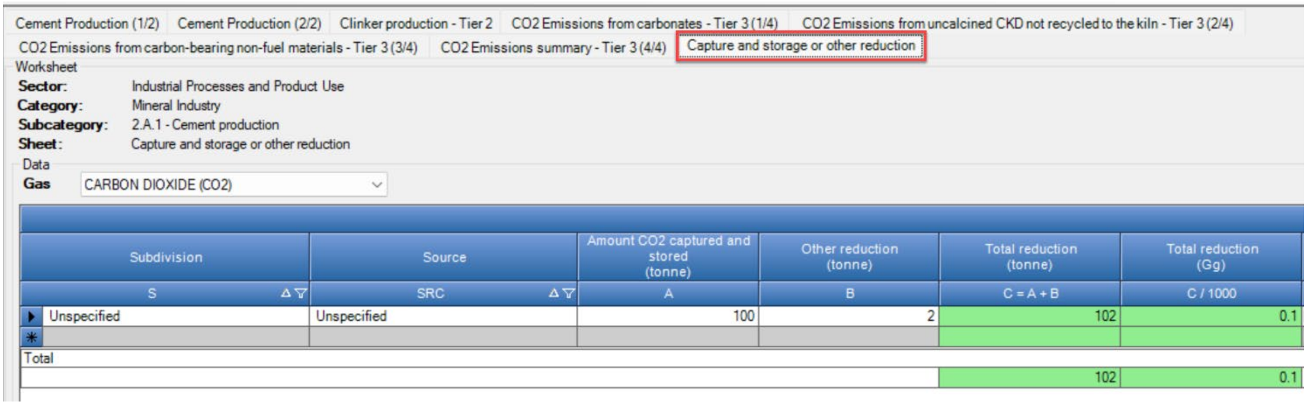
- ✓ **For Tier 1: Cement Production – Tier 1 (2/2)**
- ✓ **For Tier 2: Clinker Production – Tier 2**
- ✓ **For Tier 3: CO_2 Emissions summary – Tier 3 (4/4)**

Total CO_2 emissions from cement production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A| users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on other long-term reduction of CO_2 (e.g., re-conversion to carbonates),in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



2.A.2 Lime Production

Information

Section 2.3 of the *2006 IPCC Guidelines* provides three basic methodologies to estimate CO_2 emissions from Lime Production: an output-based approach using default values (Tier 1), an output-based approach that estimates emissions from CaO and CaO·MgO production and country-specific information for correction factors (Tier 2) and an input-based carbonate approach (Tier 3). Unlike the Tier 3 method which requires a plant-specific assessment, the Tier 1 and Tier 2 methods can be applied either to national, or where possible, plant statistics.

GHGs

The *Software* includes the following GHG for the Lime Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

- ✓ Tier 1:Equation 2.8
- ✓ Tier 2: Equations 2.6 and 2.9
- ✓ Tier 3:Equation 2.7

As explained in section **1.1.3 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 CO_2 from Lime Production using worksheets:

- ✓ **Lime Production – Tier 1:** contains for each subdivision and type of lime produced: information on the amount of lime produced and the lime EF. The worksheet calculates the associated CO_2 emissions.
- ✓ **Lime Production – Tier 2:** contains for each subdivision, name of plant and type of lime produced information on the amount of lime produced, the stoichiometric ratio of CO_2 from CaO (or CaO·MgO), CaO (or CaO·MgO) content, correction factor for lime kiln dust (LKD), and the correction factor for hydrated lime. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Carbonates – Tier 3 (1/3):** contains for each subdivision information on types and amounts of carbonates used, the CO_2 EF and fraction of calcination achieved. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from uncalcined LKD not recycled to the kiln – Tier 3 (2/3):** contains for each subdivision information on the amount of uncalcined carbonate in LKD not recycled to the kiln, the weight fraction of original carbonate in the LKD, the calcination fraction achieved and the CO_2 EF. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions summary – Tier 3 (3/3):** this worksheet automatically sums up total emissions from the previous two worksheets of Tier 3.
- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

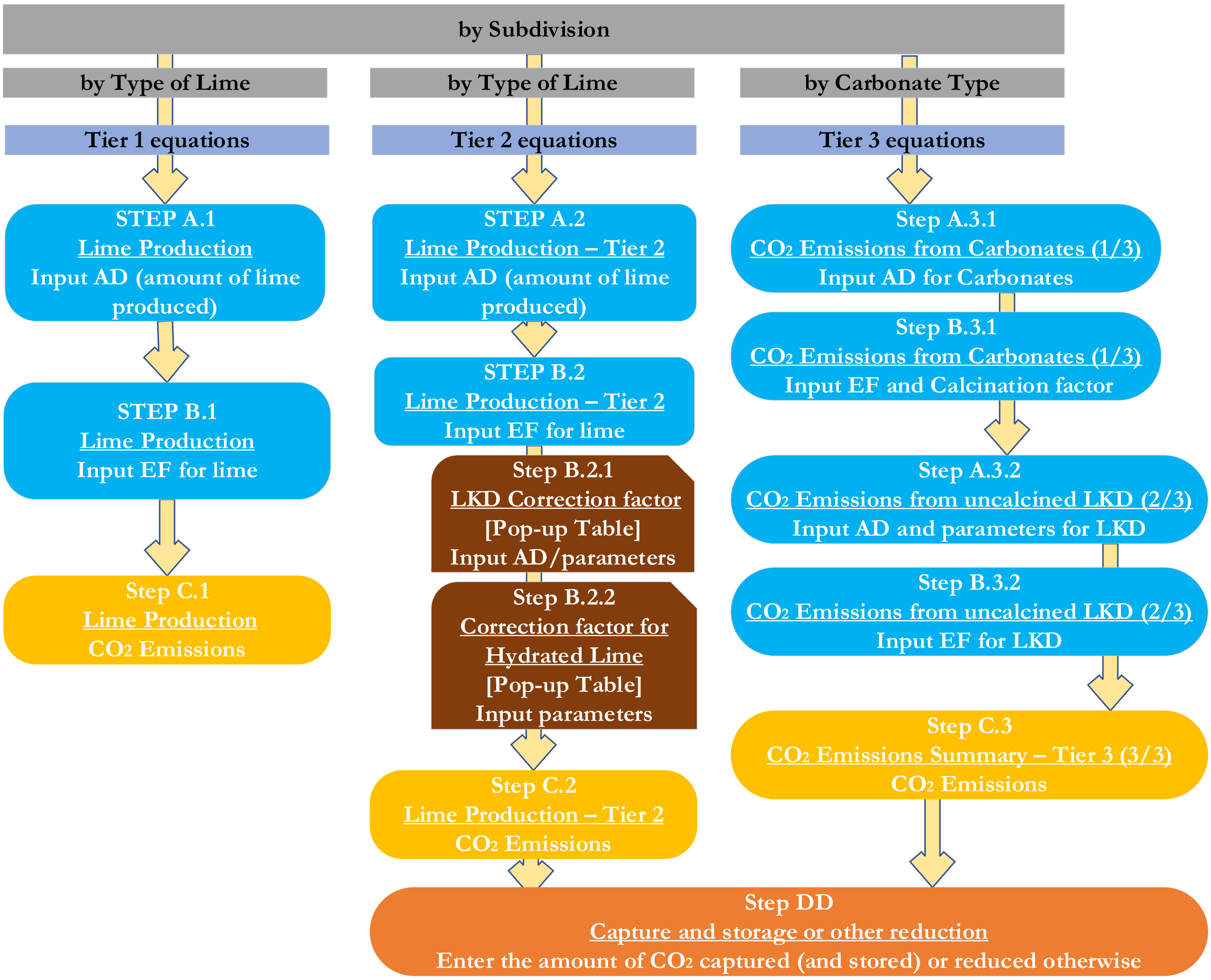
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 2.2 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[1] EFs or direct measurements.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

To ease the use of the *Software* as well as to avoid its misuse the user follows the following flowchart for Lime Production.

Lime Production – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step A.1, in the worksheet **Lime Production – Tier 1,** users collect and input in the *Software* information on the amount of each lime type produced.

Step B.1, in the worksheet **Lime Production – Tier 1,** users input an EF based on type of lime produced.

Step C.1, in the worksheet **Lime Production – Tier 1,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonnes and Gg). In addition, the total emissions are calculated.

When Tier 2 Equations are applied:

Step A.2, in the worksheet **Lime Production – Tier 2**, users collect and input in the *Software* information on the amount of each lime type produced, for each plant (if known).

Step B.2, in the worksheet **Lime Production – Tier 2,** users input EFs either based on type of lime produced. Information to estimate the correction factor for LKD not recycled to the kiln is needed (**Step B.2.0**) and for hydrated lime (**Step B.2.1**).

Step C.2, in the worksheet **Lime Production – Tier 2,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonnes and Gg). In addition, total emissions are calculated.

When the Tier 3 Equation is applied:

Step A.3.1, in the worksheets **CO_2 Emissions from Carbonates – Tier 3 (1/3)** users collect and input in the *Software* information on the types of carbonates used (amount and fraction of calcination) and in **Step B.3.1**, in the same worksheet**,** EFs based on carbonates used.

Step A.3.2, in the worksheet **CO_2 Emissions from uncalcined LKD not recycled to the kiln – Tier 3 (2/3),** users collect and input information on the amount of LKD not recycled to the kiln, the weight fraction of carbonates in the LKD and the calcination fraction achieved, and in **Step B.3.2,** in the same worksheet, information to estimate the correction factor for LKD not recycled to the kiln is entered.

Step C.3, in the worksheet **CO_2 Emissions summary – Tier 3 (3/3),** the *Software* calculates the associated CO_2 emissions in mass units (tonnes and Gg). In addition, the total emissions are calculated.

Then, for each tier, as appropriate:

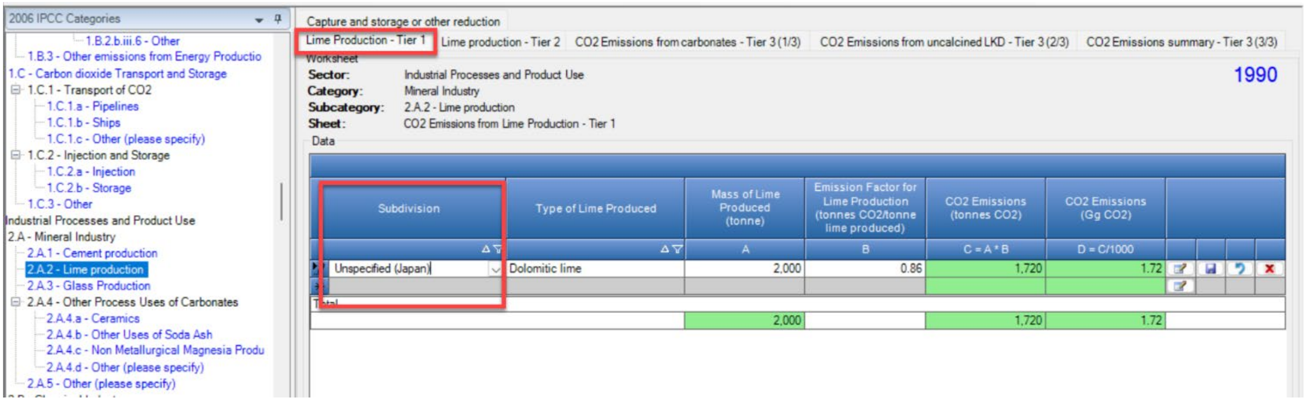
Step DD, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates), not otherwise captured in the worksheets above.

Activity data input

Section 2.3.1.3, in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for lime production.

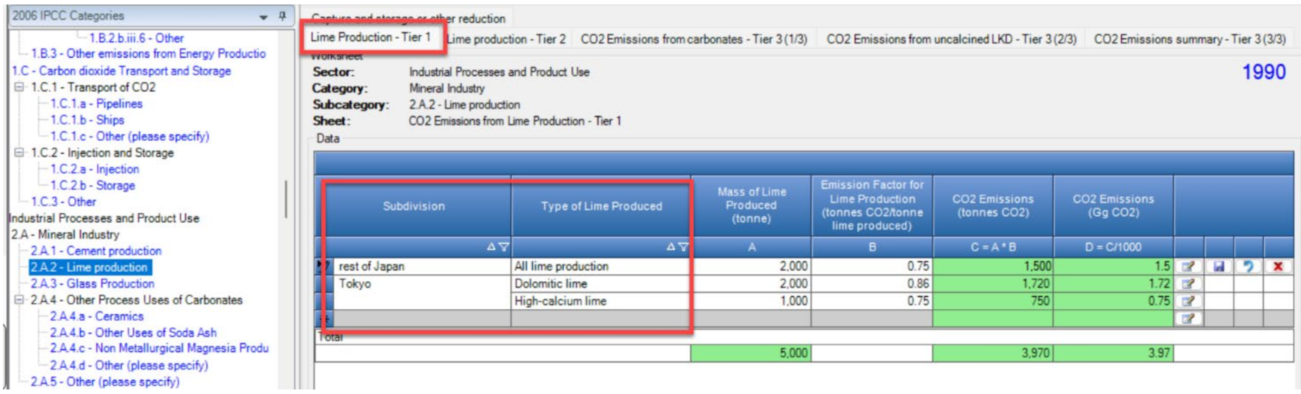
Input of AD for the Lime Production source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



Subdivision	Type of Lime Produced	Mass of Lime Produced (tonne)	Emission Factor for Lime Production (tonnes CO2/tonne lime produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		A	B	C = A * B	D = C/1000
rest of Japan	All lime production	2,000	0.75	1,500	1.5
Tokyo	Dolomitic lime	2,000	0.86	1,720	1.72
	High-calcium lime	1,000	0.75	750	0.75
Total		5,000		3,970	3.97

When the Tier 1 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **Lime Production- Tier 1,** row by row, as follows:

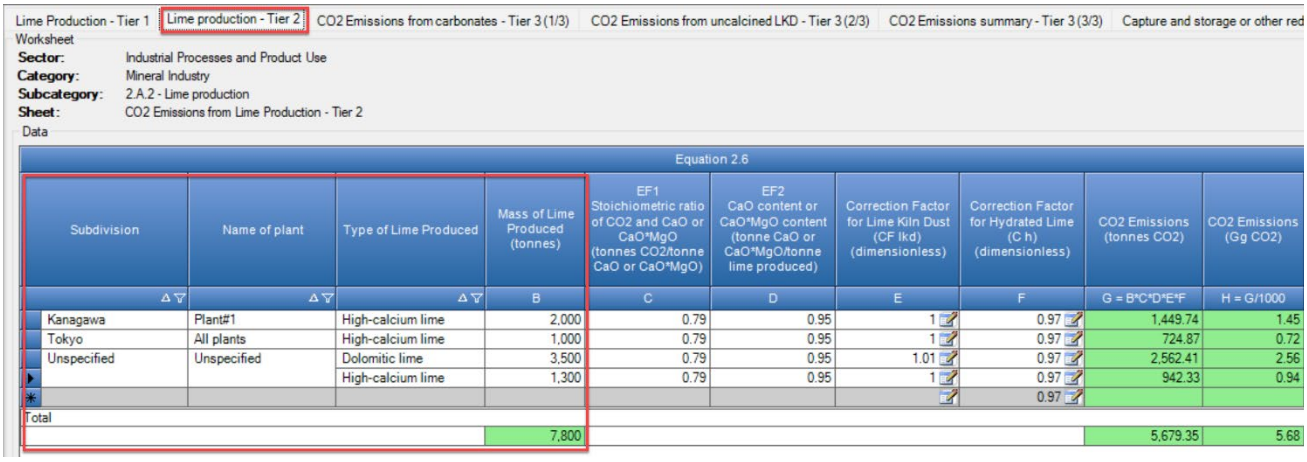
1. <u>Column |Type of Lime Produced|</u>: select from the drop-down menu the type of lime produced. If the type of lime is unknown, select *All lime production.*
   <u>Note that</u>, if type of lime is unknown, the 2006 IPCC Guidelines assume a breakdown of 85 percent high calcium lime / 15 percent dolomitic lime.
2. <u>Column |A|</u>: input the mass of each type of lime produced, in tonnes.

When Tier 2 Equations are applied:

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **Lime Production- Tier 2,** row by row, as follows:

1. <u>Column |Name of plant|:</u> enter the name of a plant/facility. If unknown, select *Unspecified* from the drop-down menu.
2. <u>Column |Type of Lime Produced|:</u> select the type of lime produced from the drop-down menu or enter in a user-specific type of lime produced.
3. <u>Column |B|</u>: enter the amount of lime produced, in tonnes.

Example: **AD for Tier 2 lime production for each subdivision**



Subdivision	Name of plant	Type of Lime Produced	Mass of Lime Produced (tonnes)	EF1 Stoichiometric ratio of CO2 and CaO or CaO*MgO (tonnes CO2/tonne CaO or CaO*MgO)	EF2 CaO content or CaO*MgO content (tonne CaO or CaO*MgO/tonne lime produced)	Correction Factor for Lime Kiln Dust (CF lkd) (dimensionless)	Correction Factor for Hydrated Lime (C h) (dimensionless)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
			B	C	D	E	F	G = B*C*D*E*F	H = G/1000
Kanagawa	Plant#1	High-calcium lime	2,000	0.79	0.95	1	0.97	1,449.74	1.45
Tokyo	All plants	High-calcium lime	1,000	0.79	0.95	1	0.97	724.87	0.72
Unspecified	Unspecified	Dolomitic lime	3,500	0.79	0.95	1.01	0.97	2,562.41	2.56
		High-calcium lime	1,300	0.79	0.95	1	0.97	942.33	0.94
							0.97		
Total			7,800					5,679.35	5.68

When the Tier 3 Equation is applied:

For Tier 3, for each subdivision in Column |Subdivision|, there are two worksheets to input AD as follows:

i. **CO_2 Emissions from Carbonates – Tier 3 (1/3):**

1. Column |i|: select from the drop-down menu the type of carbonate used or enter in directly any user-specific carbonate.
2. Column |Mi|: for each subdivision/ carbonate type, users enter the mass of carbonate consumed, in tonnes.

Example: **AD for Tier 3 – amount of carbonates consumed**

Lime Production - Tier 1 | Lime production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/3) | CO2 Emissions from uncalcined LKD - Tier 3 (2/3) | CO2 Emissions summary - Tier 3 (3/3) | Capture and storage

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.2 - Lime production
Sheet: CO2 Emissions from carbonates - Tier 3 (1/3)
Data

Equation 2.7 (1)					
Subdivision	Carbonate type	Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)	Fraction calcination achieved for carbonate (Fraction)	CO2 Emissions from carbonates (tonnes CO2)
	i	Mi	EFi	Fi	Ei = EFi * Mi * Fi
Plant #1	CaCO3	250	0.44	1	109.93
	MgCO3	200	0.52	1	104.39
Plant#2	CaCO3	100	0.44	1	43.97
Tokyo	MgCO3	120	0.52	1	62.64
Total					
		670			320.93

ii. **CO_2 Emissions from uncalcined LKD not recycled to the kiln – Tier 3 (2/3):**

Note that this worksheet will have the same subdivisions entered in the previous worksheet (1/3) available for selection from the drop-down menu. For each subdivision users enter the following:

1. Column |Md|: input weight or mass of LKD not recycled to the kiln, in tonnes
2. Column |Cd|: input the weight fraction of original carbonate in the LKD (i.e., before calcination) not recycled to the kiln, fraction

   Note that because calcium carbonate is overwhelmingly the dominant carbonate in the raw materials, it may be assumed that it makes up 100 percent of the carbonate remaining in the CKD not recycled to the kiln. It is thus acceptable within good practice to set Cd as equal to the calcium carbonate ratio in the raw material feed to the kiln.

Example: **AD for Tier 3 – Amount of uncalcined LKD not recycled to the kiln**

Lime Production - Tier 1 | Lime production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/3) | CO2 Emissions from uncalcined LKD - Tier 3 (2/3) | CO2 Emissions summary - Tier 3 (3/3) | Capture and storage

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.2 - Lime production
Sheet: CO2 Emissions from uncalcined LKD - Tier 3 (2/3)
Data

Equation 2.7 (2)					
Subdivision	Weight or mass of LKD (tonnes)	Weight fraction of original carbonate in the LKD (Fraction)	Fraction calcination achieved for LKD (Fraction)	Emission factor for the uncalcined carbonate in LKD (tonnes CO2/tonne carbonate)	CO2 Emissions from uncalcined LKD (tonnes CO2)
	Md	Cd	Fd	EFd	Ed = Md*Cd*(1-Fd)*EFd
Plant #1	1,000	1	0.95	0.44	21.99
Plant#2	200	0.9	0.97	0.44	2.37
Tokyo	200	0.9	1	0.43971	0
Total					
	1,400				24.36

Emission factor input

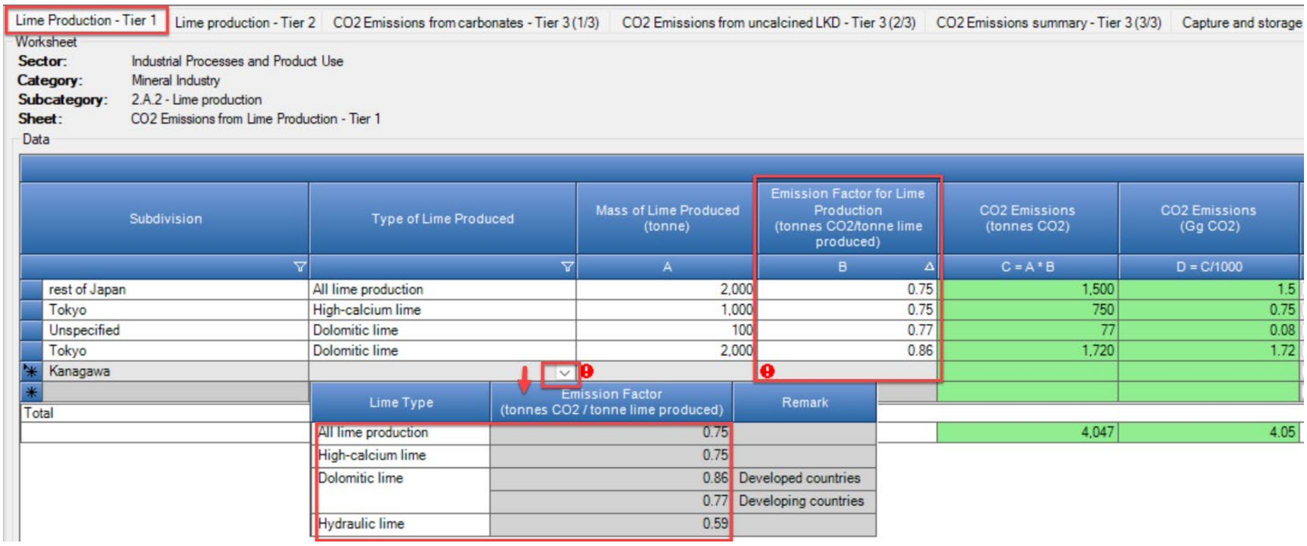
Section 2.3.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EF for Lime Production. IPCC default values for the Tier 1 and Tier 2 methods are contained in Equation 2.8 and Table 2.4, while the stoichiometric EF for use of each type of carbonates is found in Table 2.1. Then,

When the Tier 1 Equation is applied:

For each subdivision in worksheet **Lime Production- Tier 1:**

1. <u>Column |B|:</u> the default CO_2 EF is automatically populated, in tonnes CO_2/tonne lime produced, depending on the type of lime produced in <u>Column |Type of Lime Produced|.</u> The user may overwrite this value with user-specific information.
   <u>Note that</u> the Tier 1 EF is based on stoichiometric ratios, which varies depending on the type of lime produced. The stoichiometric ratio is the amount of CO_2 released by the carbonate precursor to the lime, assuming that the degree of calcination was 100 percent and assuming no LKD. In the absence of country-specific data, the selection of All Lime Production as the type of lime produced assumes 85 percent production of high calcium lime and 15 percent production of dolomitic lime, which results in a default EF = 0.75tonnes CO_2 / tonne lime produced.

Example: **Tier 1 EF for lime – different types of limes**



Lime Production - Tier 1 | Lime production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/3) | CO2 Emissions from uncalcined LKD - Tier 3 (2/3) | CO2 Emissions summary - Tier 3 (3/3) | Capture and storage

Worksheet

Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.2 - Lime production
Sheet: CO2 Emissions from Lime Production - Tier 1

Data

Subdivision	Type of Lime Produced	Mass of Lime Produced (tonne)	Emission Factor for Lime Production (tonnes CO2/tonne lime produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		A	B	C = A * B	D = C/1000
rest of Japan	All lime production	2,000	0.75	1,500	1.5
Tokyo	High-calcium lime	1,000	0.75	750	0.75
Unspecified	Dolomitic lime	100	0.77	77	0.08
Tokyo	Dolomitic lime	2,000	0.86	1,720	1.72
Kanagawa					
Total				4,047	4.05

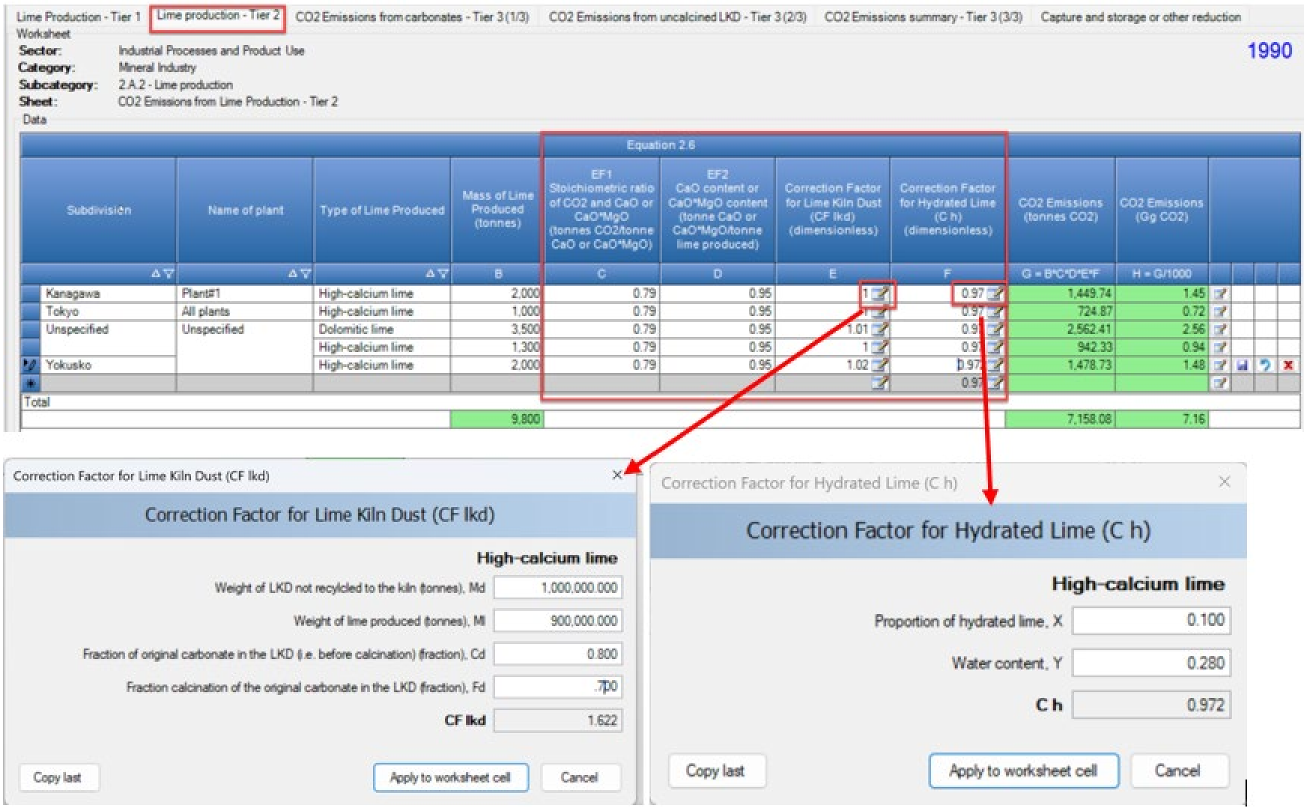
Lime Type	Emission Factor (tonnes CO2 / tonne lime produced)	Remark
All lime production	0.75	
High-calcium lime	0.75	
Dolomitic lime	0.86	Developed countries
	0.77	Developing countries
Hydraulic lime	0.59	

When Tier 2 Equations are applied:

For each subdivision/name of plant/type of lime produced in worksheet **Lime Production – Tier 2,** then:

1. <u>Column |C|</u>: select from the drop-down menu the relevant stoichiometric ratio for the type of lime produced, tonnes CO_2/tonne CaO or tonnes CO_2/tonne CaO·MgO.
2. <u>Column |D|</u>: select from the drop-down menu the relevant CaO Content or CaO·MgO content, tonnes CaO/tonne lime or tonnes CaO·MgO/tonne lime.
3. <u>Column |E|</u>: Additional information is needed to estimate the correction factor for LKD not recycled into the kiln. The factor can be entered manually (the default is 1.02 (dimensionless)) or can be estimated based on several input data and parameters (a pop-up table). To estimate the LKD factor for each subdivision and plant and type of lime produced, select the edit box and enter the following information:
   - ✓ Weight of LKD not recycled to the kiln (Md), tonnes.
   - ✓ Weight of lime produced (Ml), tonnes.
   - ✓ Fraction of original carbonate in the LKD (i.e., before calcination) (Cd), fraction
     <u>Note that</u> it is acceptable to assume that the original carbonate is all $CaCO_3$ and that the proportion of original carbonate in the LKD is essentially the same as that in the raw mix kiln feed.
   - ✓ Fraction calcination of the original carbonate in the LKD (Fd), fraction
4. <u>Column |F|</u>: Additional information is needed to estimate the correction factor for hydrated lime (see discussion under <u>Section 2.3.1.3</u> Chapter 2 Volume 3 of the *2006 IPCC Guidelines*). The factor can be entered manually (the default is 0.97 (dimensionless)) or can be estimated based on the following input data and parameters (a pop-up table).
   - ✓ Proportion of hydrated lime (X), fraction
   - ✓ Water content (Y), fraction

Example: **Tier 2 EF for lime production**

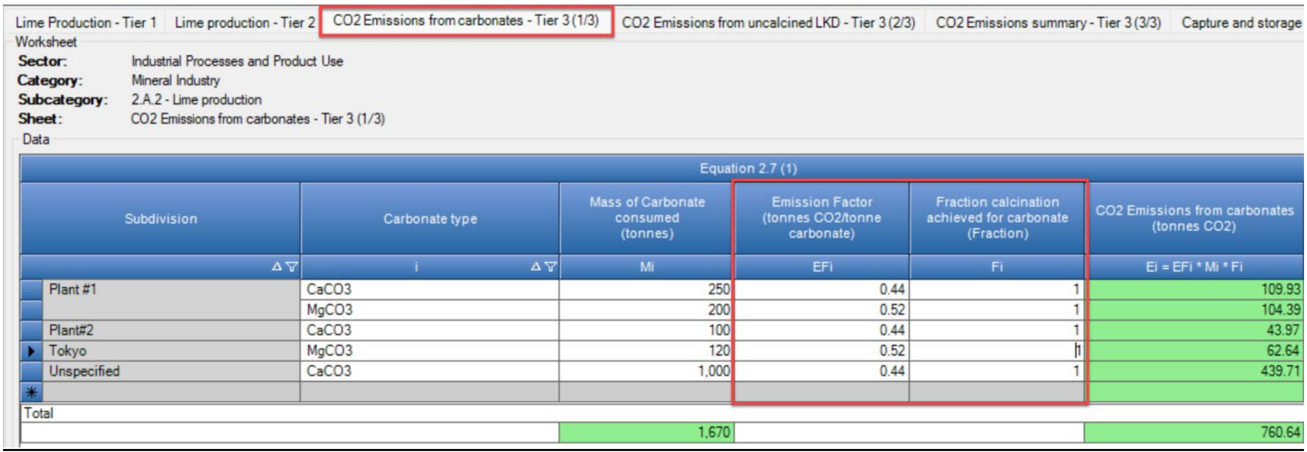


When the Tier 3 Equation is applied:

For each subdivision/carbonate type in worksheet **CO_2 Emissions from Carbonates – Tier 3 (1/3):**

1. <u>Column |EFi|:</u> the EF is automatically populated in tonne of CO_2 per tonne of carbonate, based on the carbonate selected from the drop-down menu in column i. If a user-specific carbonate was entered in column i, enter the stoichiometric based EF for that carbonate in Column |EFi|.
2. <u>Column |Fi|:</u> enter fraction of calcination achieved for carbonate.
   <u>Note that</u> in the absence of actual data, it is consistent with good practice to assume that the degree of calcination achieved is 100 percent (i.e., Fi = 1.00) or very close to it.

Example: **Tier 3 EF for lime production**



Then, in worksheet **CO_2 Emissions from uncalcined LKD not recycled to the kiln – Tier 3 (2/3):**

1. <u>Column |Cd|</u>: enter the weight fraction of original carbonate in the LKD.
2. <u>Column |Fd|</u>: enter fraction calcination achieved for LKD.
   <u>Note that</u> in the absence of actual data, it is consistent with good practice to assume that the degree of calcination achieved is 100 percent (i.e., Fi = 1.00) or very close to it. For LKD, a Fd of <1.00 is more likely but the data may show high variability and relatively low reliability. In the absence of reliable data for LKD, an assumption of Fd = 1.00 will zero out the subtraction correction for uncalcined carbonate remaining in LKD.
3. <u>Column |EFd|</u>: enter the EF for the uncalcined carbonate in LKD, tonnes CO_2/tonne carbonate
   <u>Note that</u> because calcium carbonate is overwhelmingly the dominant carbonate in the raw materials, in the absence of better data it may be assumed that it makes up 100 percent of the carbonate remaining in the LKD. It is thus consistent with good practice to set Cd equal to the calcium carbonate ratio in the raw material feed to the kiln. Likewise, in the absence of better data it is consistent with good practice to use the emission factor for calcium carbonate for EFd.

Example: **Tier 3 EF for lime production - LKD**

Lime Production - Tier 1 | Lime production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/3) | CO2 Emissions from uncalcined LKD - Tier 3 (2/3) | CO2 Emissions summary - Tier 3 (3/3) | Capture and storage

Worksheet

Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.2 - Lime production
Sheet: CO2 Emissions from uncalcined LKD - Tier 3 (2/3)

Data

Equation 2.7 (2)					
Subdivision	Weight or mass of LKD (tonnes)	Weight fraction of original carbonate in the LKD (Fraction)	Fraction calcination achieved for LKD (Fraction)	Emission factor for the uncalcined carbonate in LKD (tonnes CO2/tonne carbonate)	CO2 Emissions from uncalcined LKD (tonnes CO2)
	Md	Cd	Fd	EFd	Ed = Md*Cd*(1-Fd)*EFd
Plant #1	1,000	1	0.95	0.44	21.99
Plant#2	200	0.9	0.97	0.44	2.37
Tokyo	200	0.9	1	0.44	0
*					
Total	1,400				24.36

Results

CO_2 emissions from Lime Production are estimated in mass units (tonnes and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets:

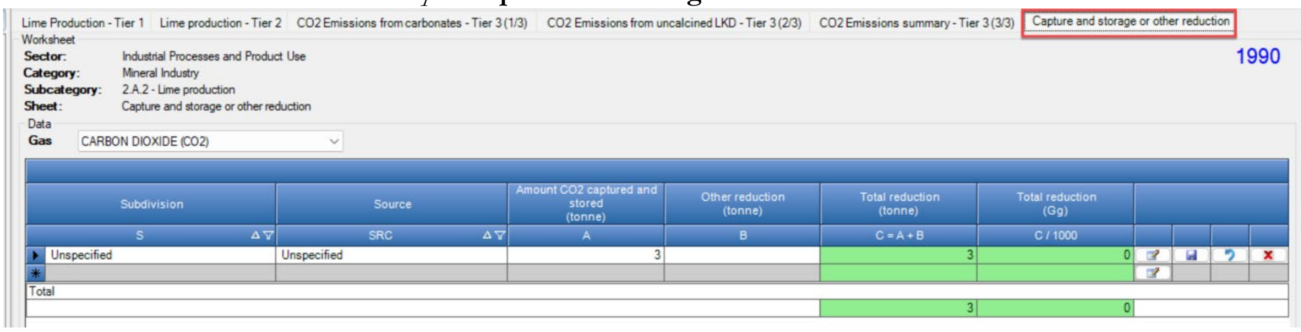
- ✓ **For Tier 1: Lime Production – Tier 1**
- ✓ **For Tier 2: Lime Production – Tier 2**
- ✓ **For Tier 3: CO_2 Emissions summary – Tier 3 (3/3)**

Total CO_2 emissions from lime production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A| users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on other long-term reduction of CO_2 (e.g., re-conversion to carbonates), in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



2.A.3 Glass Production

Information

Section 2.4 of the *2006 IPCC Guidelines* provides three Tiers to estimate CO_2 emissions from Glass Production. Tier 1 method should be used where data are not available on glass manufactured by process or on the carbonates used in glass manufacturing. Tier 1 applies a default EF and cullet ratio to national-level glass production statistics.

Tier 2 is a refinement of Tier 1. Instead of collecting national statistics on total glass production, emissions are estimated based on the different glass manufacturing processes undertaken in the country (e.g., float glass, container glass, fibre glass, etc). Different manufacturing processes typically use different types and ratios of raw materials. Tier 2 method applies default EFs to each glass manufacturing process. The emission estimate must be corrected for the portion of recycled glass (cullet).

The Tier 3 methodology is based on accounting for the carbonate input to the glass melting furnace (similar to the methodology for Cement and Lime Production).

GHGs

The *Software* includes the following GHG for the Glass Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

- ✓ Tier 1:Equations 2.10 and 2.13
- ✓ Tier 2: Equation 2.11
- ✓ Tier 3: Equation 2.12

As explained in section **1.1.3 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 CO_2 from Glass Production using worksheets:

- ✓ **Glass Production – Tier 1/2:** contains for each subdivision information on the amount of glass produced either at the national level (Tier 1, undifferentiated by type of glass) or by individual type of glass (Tier 2), the CO_2 EF and cullet ratio factor. The worksheet calculates the associated CO_2 emissions.
- ✓ **Glass Production – Tier 3:** contains for each subdivision information on the type and amount of carbonate consumed, the CO_2 EF and the calcination fraction. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

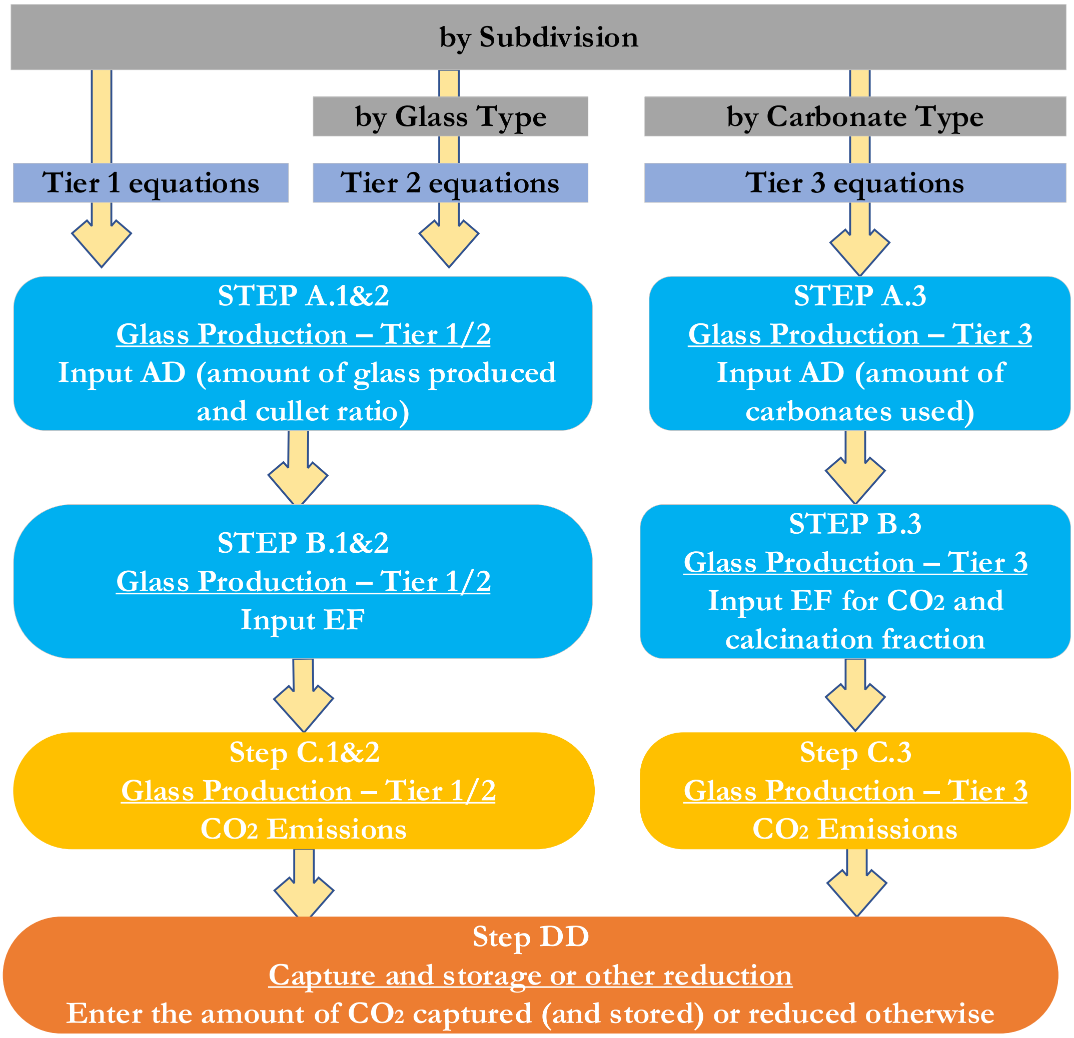
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 2.3 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[1] and/or plant-specific EFs, or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Glass Production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Glass Production - flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When Tier 1 or Tier 2 Equations are applied:

Step A.1&2, in the worksheet **Glass Production – Tier 1/2,** users collect and input in the *Software* information on the total amount of glass produced and cullet ratio (Tier 1) or by each type of glass produced (Tier 2), e.g., float glass, container glass, fibre glass, etc.

Step B.1&2, in worksheet **Glass Production – Tier 1/2,** users input associated CO_2 EFs based on glass produced (either total glass production (Tier 1) or by each type of glass produced (Tier 2).

Step C.1&2, in the worksheet **Glass Production – Tier 1/2,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonnes and Gg) for Tier 1 and 2. In addition, total CO_2 emissions are calculated.

When the Tier 3 Equation is applied:

Step A.3, in the worksheet **Glass Production – Tier 3**, users collect and input in the *Software* information on the type and amount of carbonates consumed.

Step B. 3, in worksheet **Glass Production – Tier 3,** users input associated CO_2 EFs based on carbonates used and calcination fraction.

Step C.3, in the worksheet **Glass Production – Tier 3,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonnes and Gg) for Tier 3. In addition, total CO_2 emissions are calculated.

Then, for each tier, as appropriate:

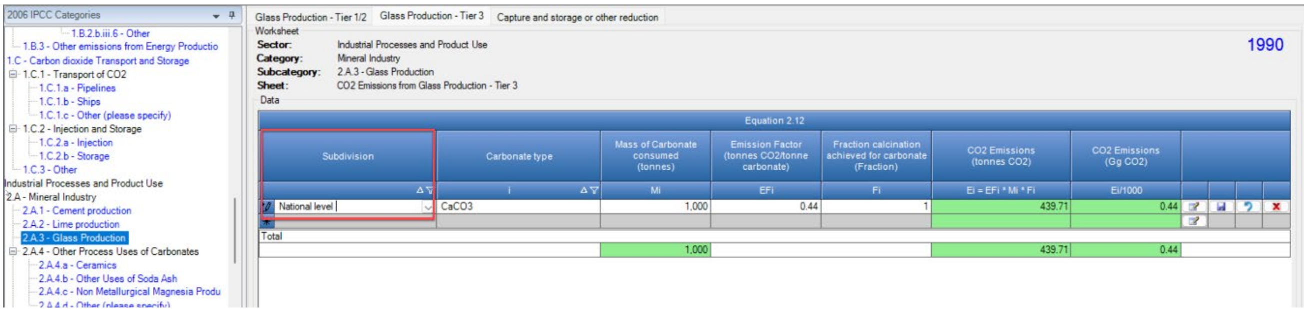
Step DD, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates), not otherwise captured in the worksheets above.

Activity data input

Section 2.4.1.3, Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for glass production.

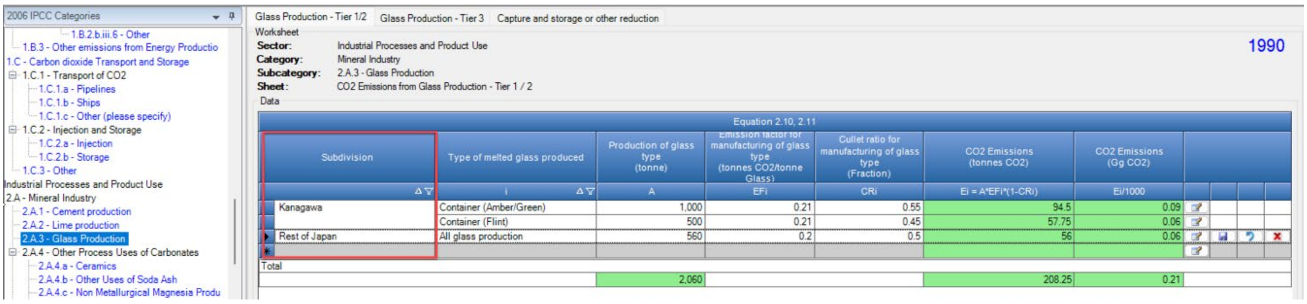
Input of AD for the Glass Production source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



When Tier 1 and Tier 2 Equations are applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **Glass Production – Tier 1/2,** row by row, as follows:

1. Column |i|: select from the drop-down menu the type of melted glass produced, if known, or overwrite with a user-specific type of melted glass (Tier 2). If the type of melted glass is unknown, select from the drop-down menu *All glass production* (Tier 1).
2. Column |A|: input the mass of type of glass produced, in tonnes.
3. Column |CRi|: the cullet ratio for each type of glass produced will automatically be populated based on the type of glass produced, fraction. The user may overwrite with a user-specific cullet ratio.

Note that Tier 1 assumes a default cullet ratio of 50 percent. If country specific information is available for the average annual cullet ratio, countries are encouraged to modify the emission factor accordingly. Although the Tier 2 method provides typical default ranges for the cullet ratio (Table 2.6 Chapter 2 Volume 3 of the 2006 IPCC Guidelines), if country-specific or plant-specific data are available countries are encouraged to collect these data. The midpoint of the range has been taken as the default.

Example: **AD for Tier 1/2 – default cullet ratio (ranges) by type of glass**

Glass Production - Tier 1/2 | Glass Production - Tier 3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.3 - Glass Production
Sheet: CO2 Emissions from Glass Production - Tier 1 / 2

1990

Data

Equation 2.10, 2.11						
Subdivision	Type of melted glass produced	Production of glass type (tonne)	Emission factor for manufacturing of glass type (tonnes CO2/tonne Glass)	Cullet ratio for manufacturing of glass type (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	i	A	EFi	CRi	Ei = A*EFi*(1-CRi)	Ei/1000
Kanagawa	Container (Amber/Green	1,000	0.21	0.55	94.5	0.09
	Container (Flint)	500	0.21	0.45	57.75	0.06
rest	Float	750	0.21	0.18	129.94	0.13
Rest of Japan	All glass production	560	0.2	0.5	56	0.06
Unspecified	All glass production	200	0.2	0.5	20	0.02
Total						

Type of melted glass produced	Emission factor for manufacturing of glass type (tonnes CO2/tonne Glass)	Cullet ratio for manufacturing of glass type (Fraction)	Remark
All glass production	0.2	0.5	Tier 1
Float	0.21	10% - 25%	
Container (Flint)	0.21	30% - 60%	
Container (Amber/Green)	0.21	30% - 80%	
Fiberglass (E-glass)	0.19	0% - 15%	
Fiberglass (Insulation)	0.25	10% - 50%	
Specialty (TV Panel)	0.18	20% - 75%	
Specialty (TV Funnel)	0.13	20% - 70%	

When the Tier 3 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **Glass production – Tier 3,** row by row, as follows:

1. Column |i|: select from the drop-down menu the type of carbonate used or overwrite with user-specific carbonate.
2. Column |Mi|: for each subdivision/ carbonate type, users enter the mass of carbonate consumed, in tonnes.

Example: **AD for Tier 3 – amount of carbonates consumed**

Glass Production - Tier 1/2 | Glass Production - Tier 3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.3 - Glass Production
Sheet: CO2 Emissions from Glass Production - Tier 3

Data

Equation 2.12						
Subdivision	Carbonate type	Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)	Fraction calcination achieved for carbonate (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	i	Mi	EFi	Fi	Ei = EFi * Mi * Fi	Ei/1000
Plant#1	CaCO3	1,000	0.44	1	439.71	0.44
Plant#2	MgCO3	2,000	0.52	1	1,043.94	1.04
Plant#3	CaCO3	1,500	0.44	1	659.57	0.66
Plant#3	FeCO3	1,500	0.38	1	569.81	0.57
Total						
		6,000			2,713.02	2.71

Emission factor input

Section 2.4.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EF for Glass Production.

There are two types of default EFs:

i) CO_2 EF for glass produced in tonne CO_2 per tonne of glass produced – Tier 1&2 (Table 2.6 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines*)

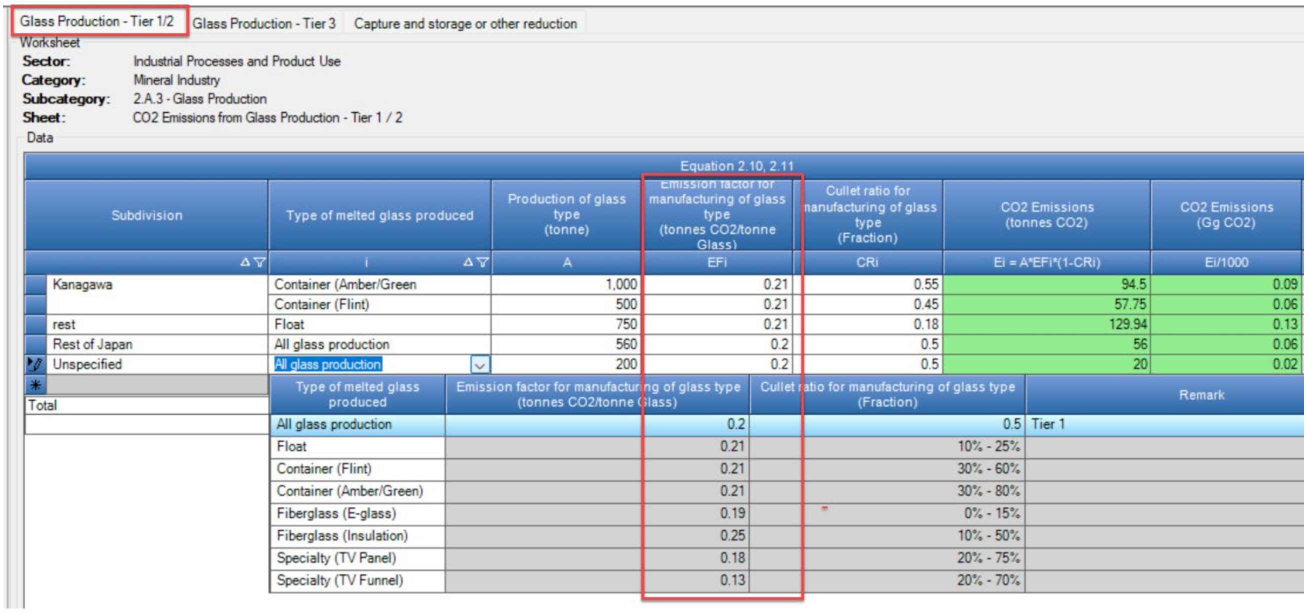
ii) CO_2 EF for carbonates consumed (based on stoichiometry of carbonates) in tonnes of CO_2 per tonne of carbonate used – Tier 3 (Table 2.1 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines*). Additionally, calcination fraction of carbonates is needed to make emission estimates.

When Tier 1 and Tier 2 Equations are applied:

For each combination of subdivision/type of melted glass produced in worksheet **Glass Production – Tier 1/2**:

1. Column |EFi|: the default CO_2 EF is automatically populated, in tonnes CO_2/tonne glass produced, depending on the type of melted glass produced in Column |Type of melted glass produced|. The user may overwrite this value with user-specific information.

Example: **Tier 1&2 EF for Glass Production**



Glass Production - Tier 1/2 | Glass Production - Tier 3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.3 - Glass Production
Sheet: CO2 Emissions from Glass Production - Tier 1 / 2

Data

Subdivision	Type of melted glass produced	Production of glass type (tonne)	Emission factor for manufacturing of glass type (tonnes CO2/tonne Glass)	Cullet ratio for manufacturing of glass type (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	i	A	EFi	CRi	Ei = A*EFi*(1-CRi)	Ei/1000
Kanagawa	Container (Amber/Green	1,000	0.21	0.55	94.5	0.09
	Container (Flint)	500	0.21	0.45	57.75	0.06
rest	Float	750	0.21	0.18	129.94	0.13
Rest of Japan	All glass production	560	0.2	0.5	56	0.06
Unspecified	All glass production	200	0.2	0.5	20	0.02
Total						

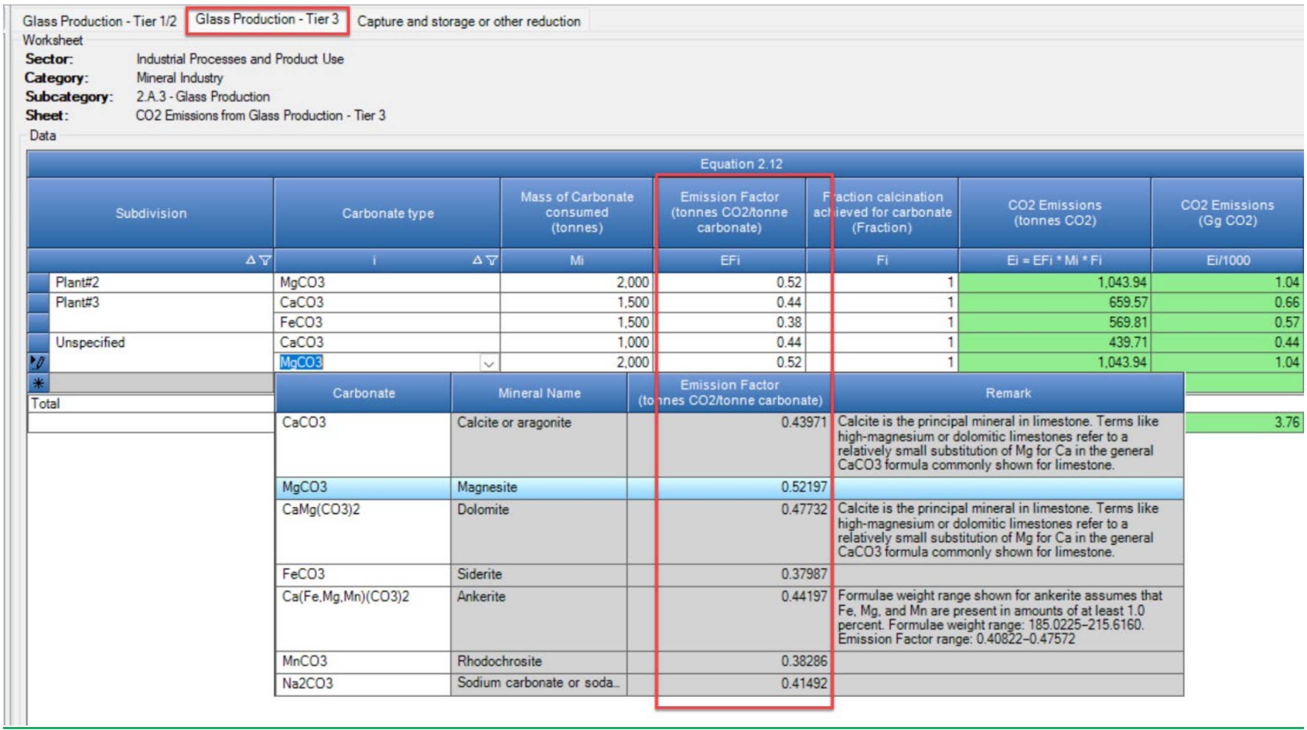
Type of melted glass produced	Emission factor for manufacturing of glass type (tonnes CO2/tonne Glass)	Cullet ratio for manufacturing of glass type (Fraction)	Remark
All glass production	0.2	0.5	Tier 1
Float	0.21	10% - 25%	
Container (Flint)	0.21	30% - 60%	
Container (Amber/Green)	0.21	30% - 80%	
Fiberglass (E-glass)	0.19	0% - 15%	
Fiberglass (Insulation)	0.25	10% - 50%	
Specialty (TV Panel)	0.18	20% - 75%	
Specialty (TV Funnel)	0.13	20% - 70%	

When the Tier 3 Equation is applied:

For each subdivision / carbonate type in worksheet **Glass Production – Tier 3:**

1. Column |EFi|: the EF is automatically populated in tonne of CO_2 per tonne of carbonate, based on the carbonate selected from the drop-down menu in column i. If a user-specific carbonate was entered in column i, enter the stoichiometric based EF for that carbonate in Column |EFi|.
2. Column |Fi|: enter fraction of calcination achieved for carbonate.
   Note that where the fraction calcination achieved for the particulate carbonate is not known, it can be assumed that the fraction calcination is equal to 1.00.

Example: **Tier 3 EF for glass production**



Glass Production - Tier 1/2 | Glass Production - Tier 3 | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.3 - Glass Production
Sheet: CO2 Emissions from Glass Production - Tier 3

Data

		Equation 2.12				
Subdivision	Carbonate type	Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)	Fraction calcination achieved for carbonate (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	i	Mi	EFi	Fi	Ei = EFi * Mi * Fi	Ei/1000
Plant#2	MgCO3	2,000	0.52	1	1,043.94	1.04
Plant#3	CaCO3	1,500	0.44	1	659.57	0.66
	FeCO3	1,500	0.38	1	569.81	0.57
Unspecified	CaCO3	1,000	0.44	1	439.71	0.44
	MgCO3	2,000	0.52	1	1,043.94	1.04
Total						3.76

Carbonate	Mineral Name	Emission Factor (tonnes CO2/tonne carbonate)	Remark
CaCO3	Calcite or aragonite	0.43971	Calcite is the principal mineral in limestone. Terms like high-magnesium or dolomitic limestones refer to a relatively small substitution of Mg for Ca in the general CaCO3 formula commonly shown for limestone.
MgCO3	Magnesite	0.52197	
CaMg(CO3)2	Dolomite	0.47732	Calcite is the principal mineral in limestone. Terms like high-magnesium or dolomitic limestones refer to a relatively small substitution of Mg for Ca in the general CaCO3 formula commonly shown for limestone.
FeCO3	Siderite	0.37987	
Ca(Fe,Mg,Mn)(CO3)2	Ankerite	0.44197	Formulae weight range shown for ankerite assumes that Fe, Mg, and Mn are present in amounts of at least 1.0 percent. Formulae weight range: 185.0225–215.6160. Emission Factor range: 0.40822–0.47572
MnCO3	Rhodochrosite	0.38286	
Na2CO3	Sodium carbonate or soda..	0.41492	

Results

CO_2 emissions from Glass Production are estimated in mass units (tonnes and Gg) by the *Software* in the following worksheets:

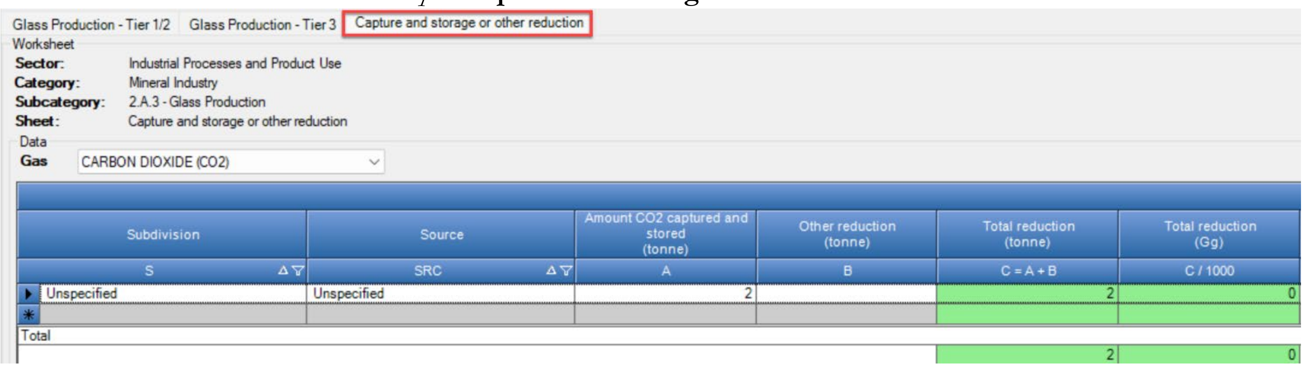
- ✓ **For Tier 1 and Tier 2: Glass Production – Tier 1/2**
- ✓ **For Tier 3: Glass Production – Tier 3**

Total CO_2 emissions from glass production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A| users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on other long-term reduction of CO_2 (e.g., re-conversion to carbonates), in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



Subdivision	Source	Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
S	SRC	A	B	C = A + B	C / 1000
Unspecified	Unspecified	2		2	0
Total				2	0

2.A.4 Other Process Uses of Carbonates

Information

Section 2.5 of the *2006 IPCC Guidelines* provides common methodological guidance for the following sub-categories:

2.A.4.a Ceramics

2.A.4.b Other Uses of Soda Ash

2.A.4.c Non-Metallurgical Magnesia Production

2.A.4.d Other

Consistent with *good practice*, where carbonates are consumed in these industries, they are considered in the calculation worksheets of 2.A.4. Carbonates used in cement, lime and glass production have already been considered in previous sections of this Users' Guidebook. As discussed in Section 2.3.1.1 Chapter 2 Volume 3 of the *2006 IPCC Guidelines*, all marketed and non-marketed production of lime should be reported under Lime Production. Where limestone is used for the liming of soils, the corresponding amount of carbonates should be excluded from the calculation worksheets in category 2.A.4, and rather included in the respective source category of the AFOLU sector. Where carbonates are used as fluxes or slagging agents (e.g., in iron and steel production, chemical production, or for environmental pollution control etc.), AD for that carbonate consumption should be included in those respective source categories.

The general methodological approach to estimate emissions from use of carbonates is to multiply the amount of carbonates consumed by the CO_2 EF and the fraction of calcination achieved.

GHGs

The *Software* includes the following GHG for the Other Process Uses of Carbonates source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

- ✓ Tier 1: Equation 2.14
- ✓ Tier 2: Equation 2.15
- ✓ Tier 3: Equation 2.16

As explained in section **1.1.3 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 CO_2 from Other Process Uses of Carbonates using worksheets:

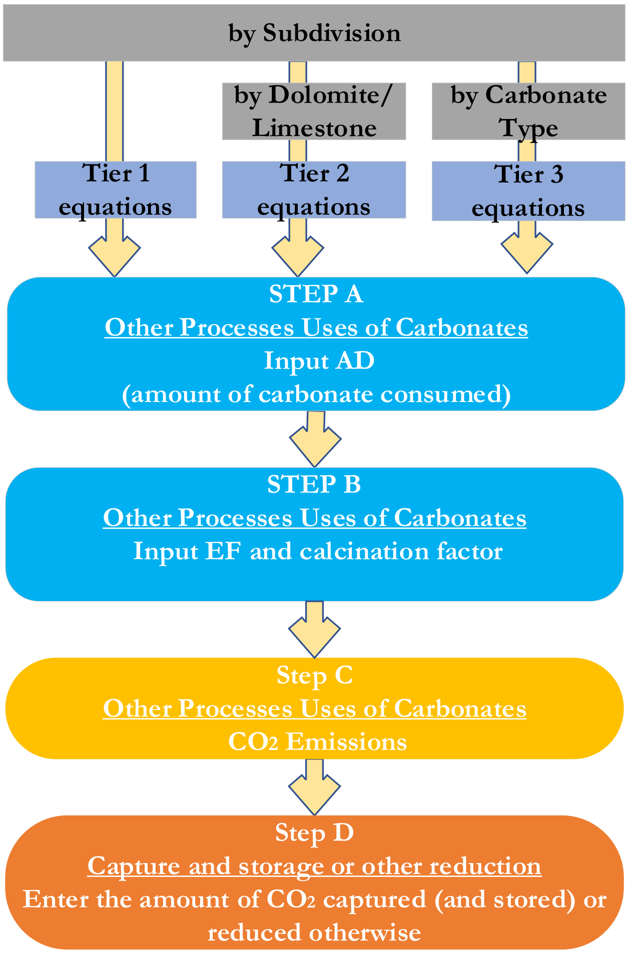
- ✓ **Other Process Uses of Carbonates – Tier 1/2/3:** contains for each subdivision information on the amount of carbonate consumed either at the national level (Tier 1, undifferentiated by type of carbonate, total) or by specifying the amount of dolomite and limestone used (Tier 2) or by individual type of carbonate used (Tier 3), and the calcination fraction achieved. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

User’s work Flowchart

Consistent with the key category analysis and the decision tree in Figure 2.4 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Other Process Uses of Carbonates.

Other Process Uses of Carbonates - flowchart



Thus, for the relevant source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step A, in the worksheet **Other Process Uses of Carbonates – Tier 1/2/3,** users collect and input in the *Software* information on the amount of carbonate(s) consumed either at the national level (Tier 1, undifferentiated by type of carbonate, total) or by specifying the amount of dolomite and limestone used (Tier 2) or by individual type of carbonate used (Tier 3), as well as the calcination fraction achieved.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Step B, in the worksheet **Other Process Uses of Carbonates – Tier 1/2/3,** users collect and input associated CO_2 EFs based on type of carbonates used.

Step C, in the worksheet **Other Process Uses of Carbonates – Tier 1/2/3,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonnes and Gg). In addition, total CO_2 emissions are calculated.

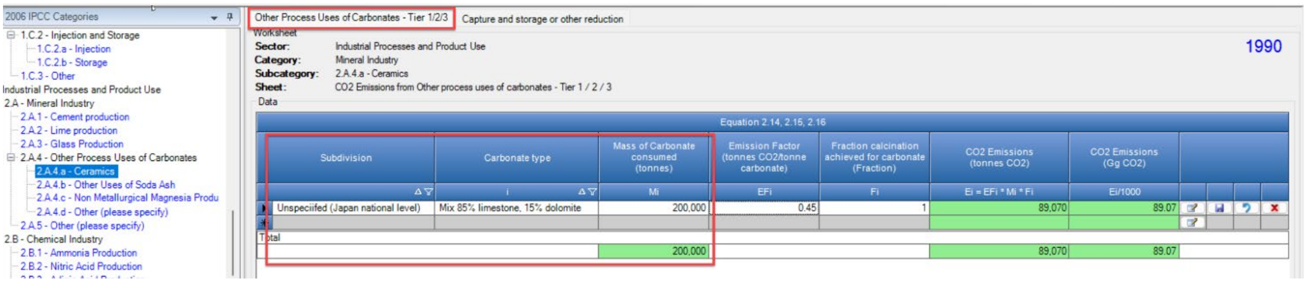
Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates).

Activity data input

Section 2.5.1.3, Chapter 2 Volume 3 of the *2006 IPCC* Guidelines contains information on the choice of AD for Other Process Uses of Carbonates.

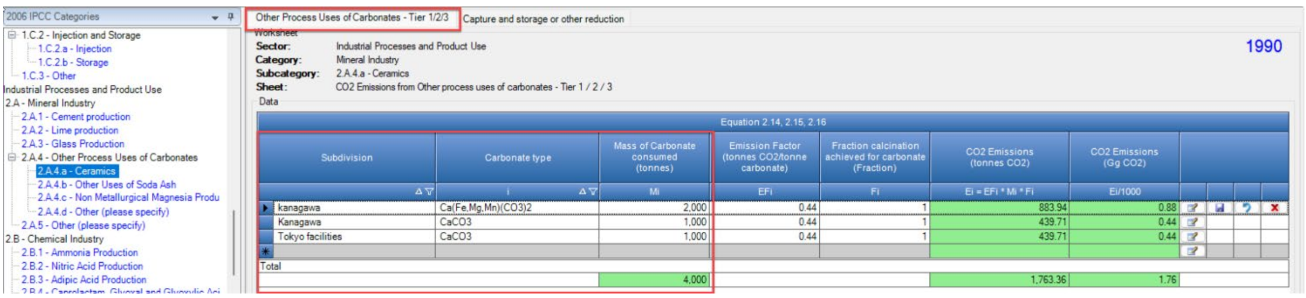
Input of AD for the Other Process Uses of Carbonates source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified) and AD – Tier 1**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions – AD Tier 2 and Tier 3**



Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **Other Process Uses of Carbonates- Tier 1/2/3,** row by row, as follows:

1. Column |i|: select the type of carbonate from the drop-down menu or enter in a user-specific type.
2. Column |Mi|: input the mass of individual carbonate consumed, in tonnes.
   Note that in the Tier 1 method, the inventory compiler should collect AD for total carbonate consumption for emissive uses (see Table 2.7 in Chapter 2 Volume 3 of the 2006 IPCC Guidelines). In the absence of better data, it is consistent with good practice for inventory compilers to assume that 85 percent carbonates consumed are limestone and 15 percent of carbonates consumed are dolomite. Tier 2 requires national level information only on total limestone and dolomite consumed.

Emission factor input

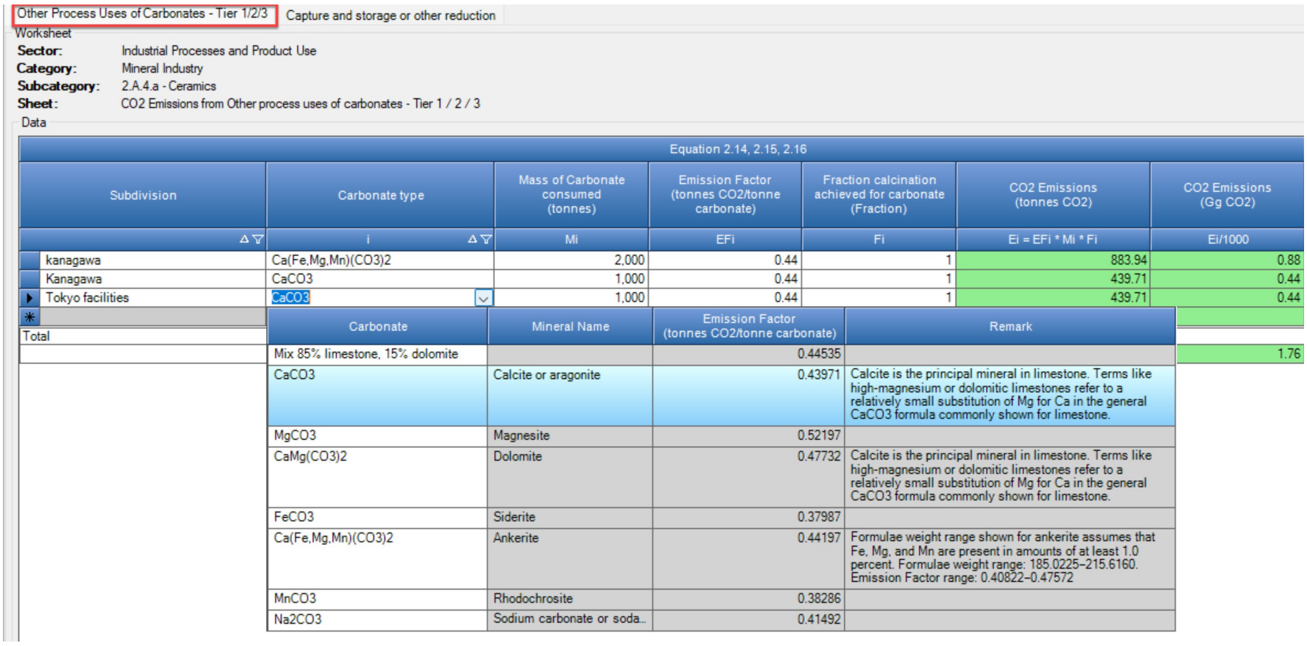
Section 2.5.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EF for Other Process Uses of Carbonates.

Both Tier 1 and Tier 2 assume only limestone and dolomite are consumed; use of limestone results in 0.43971 tonne of CO_2 per tonne of limestone and dolomite, 0.47732 tonne of CO_2 per tonne of dolomite. For Tier 1, a ratio of 85 (limestone)/15 (dolomite) is assumed, resulting in an EF of 0.44535 tonne of CO_2 per tonne of carbonate. Tier 3 also applies stoichiometric EFs for CO_2 from carbonates which are provided in Table 2.1 Chapter 2 Volume 3 of the 2006 IPCC Guidelines.

For each combination of subdivision/carbonate type in worksheet **Other Process Uses of Carbonates – Tier 1/2/3:**

1. Column |EFi|: the EF is automatically populated in tonne of CO_2 per tonne of carbonate, based on the carbonate selected from the drop-down menu in column i. If a user-specific carbonate was entered in column i, enter the stoichiometric based EF for that carbonate in Column |EFi|.
2. Column |Fi|: input the calcination fraction for each carbonate, fraction.
   Note that where the fraction of calcination achieved is unknown, it is consistent with good practice for the inventory compiler to assume that 100 percent calcination is achieved (i.e. enter 1.00 for Column |Fi|.

Example: **Tier 1/2/3 EFs for other process uses of carbonates**



Results

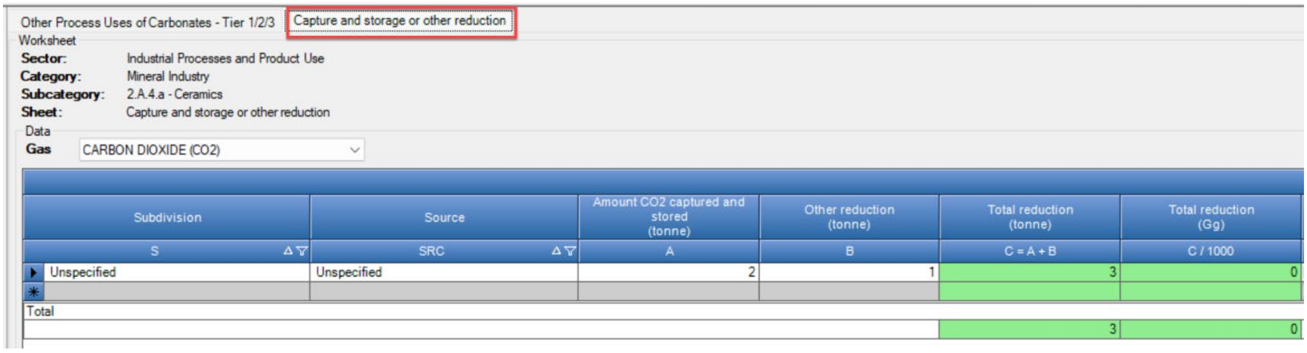
CO_2 emissions from Other Process Uses of Carbonates are estimated in mass units (tonnes and Gg) by the *Software* in the worksheet **Other Process Uses of Carbonates – Tier 1/2/3**.

Total CO_2 emissions from other process uses of carbonates is the sum of all emissions of all subdivisions, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A| users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on other long-term reduction of CO_2 (e.g., re-conversion to carbonates), in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**


Other Process Uses of Carbonates - Tier 1/2/3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.4.a - Ceramics
Sheet: Capture and storage or other reduction

Data
Gas CARBON DIOXIDE (CO2)

Subdivision	Source	Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
S	SRC	A	B	C = A + B	C / 1000
Unspecified	Unspecified	2	1	3	0
Total				3	0

.

2.A.5 Other

Information

There is no specific methodological guidance or worksheets for this source category in the *2006 IPCC Guidelines*.

According to Section 2.4.1 of the *2006 IPCC Guidelines,* the source category 2.A.3 Glass Production includes emissions from the production of glass wool, a category of mineral wool, where the production process is similar to glass making. But, the term mineral wool may also be used to refer to natural rock- and slag-based wool. Where the production of rock wool is emissive these emissions should be reported under this source category 2.A.5.

Emissions related to slag production should be reported in the relevant metallurgical source category. The re-melting of slag to make mineral wool does not involve significant process-related emissions and does not need to be reported.

GHGs

The *Software* includes the following GHGs for the Other source category:

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 emissions from mineral industry.

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 **1.1.3 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 2 basic equation.

Software Worksheets

The *Software* calculates emissions from Other (Mineral Industry) source category using worksheets:

- ✓ **Other:** contains for each subdivision and source of emissions, information on the activity type, data and unit, and corresponding EFs. The worksheet calculates the associated CO_2, CH_4 and N_2O emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of GHG emissions, not accounted previously.

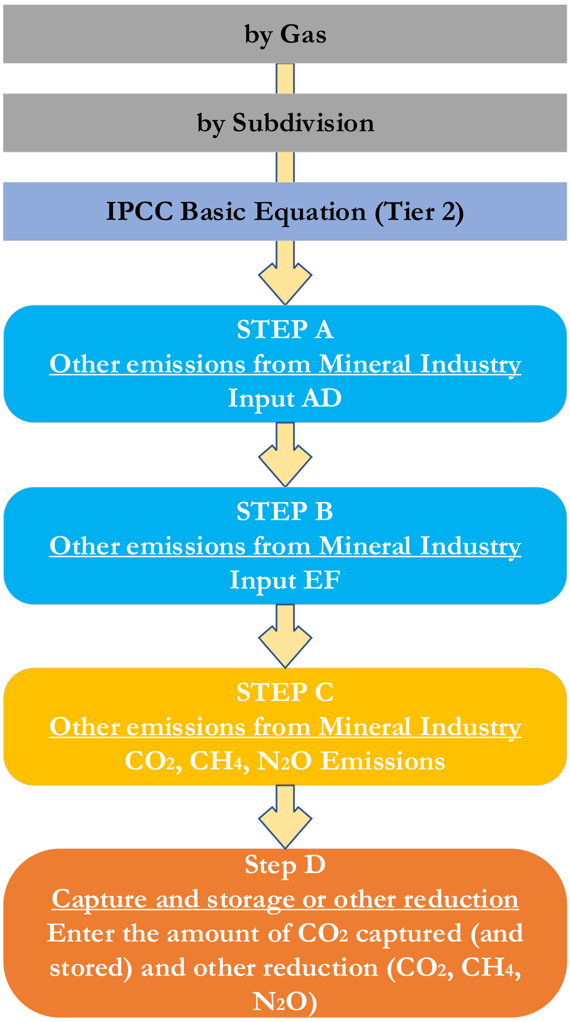
User's work Flowchart

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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Other Process Uses of Carbonates.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Other (Mineral industry) – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step A, in **Other** worksheet, users collect and enter data on the source and AD.

Step B, in **Other** worksheet, users collect and enter in each row the associated EF.

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

Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and/or other reduction of CO_2 (e.g., re-conversion to carbonates) or other GHG.

Activity data input

Input of AD for the Other source category requires the user first to enter information on the subdivisions in the country. 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 drop-down 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,** row by row, as follows:

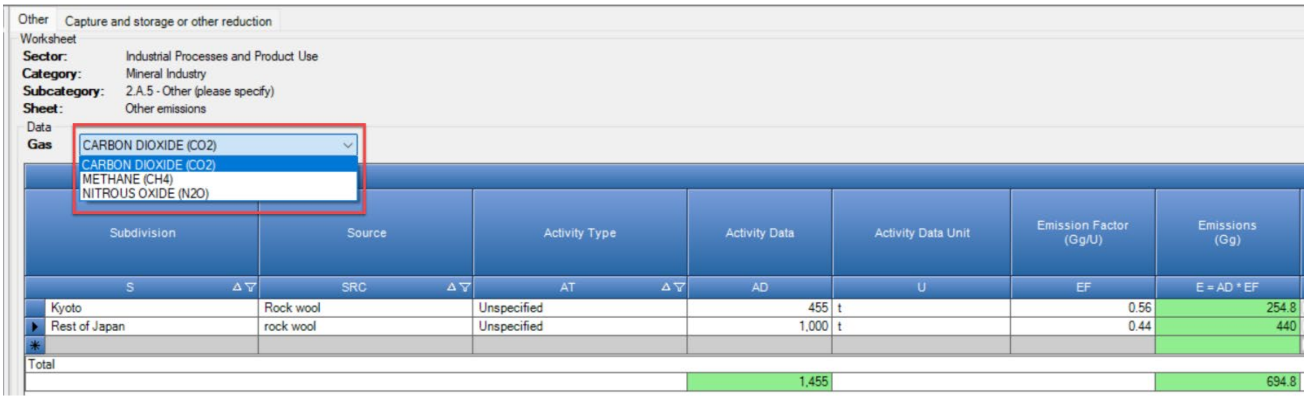
1. Column |SRC|: describe the type of activity emitting GHG emissions from this category (e.g. rock wool production).
2. Column |AT|: enter the activity type corresponding to the source selected.
3. Column |AD|: enter AD (quantity).
4. Column |U|: enter unit of the AD.

Emission factor input

For each row of data entered in worksheet **Other**, 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: **multiple subdivisions, by gas**


Other | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.5 - Other (please specify)
Sheet: Other emissions

Data
Gas CARBON DIOXIDE (CO2)
CARBON DIOXIDE (CO2)
METHANE (CH4)
NITROUS OXIDE (N2O)

Subdivision	Source	Activity Type	Activity Data	Activity Data Unit	Emission Factor (Gg/U)	Emissions (Gg)
S	SRC	AT	AD	U	EF	E = AD * EF
Kyoto	Rock wool	Unspecified	455	t	0.56	254.8
Rest of Japan	rock wool	Unspecified	1,000	t	0.44	440
Total			1,455			694.8

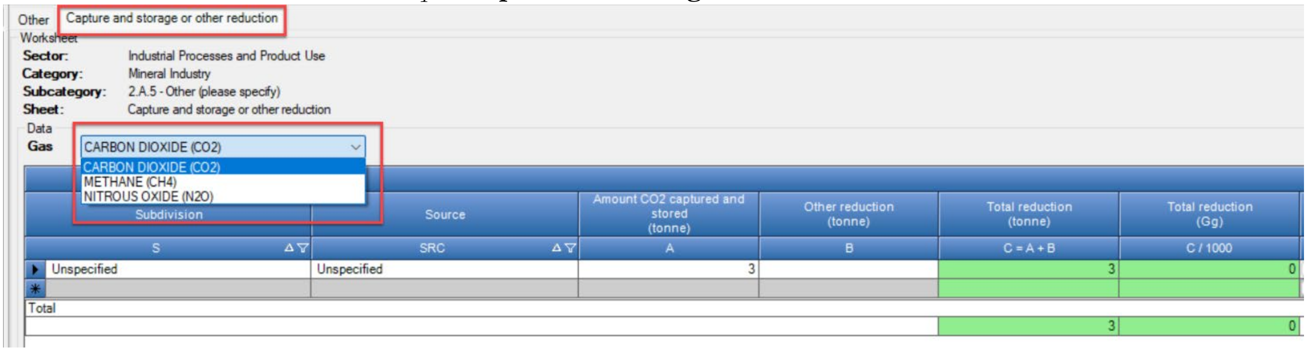
Results

Total CO_2, CH_4 and N_2O emissions from Other is the sum of all subdivisions in the above worksheet, taking into account any CO_2 capture with subsequent storage or other GHG reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage and other GHG reduction.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other reduction of GHGs, in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



2.B Chemical Industry

2.B.1 Ammonia Production

Information

The *2006 IPCC Guidelines* provide three Tiers to estimate CO_2 emissions from Ammonia Production. Generally, all three Tiers require fuel consumption as AD: in the Tier 1 method - data are based on total ammonia production in the country multiplied by fuel requirement (gas, coal, oil) utilizing default EFs; Tier 2 – data are differentiated by process type and by fuel type (country-specific EFs) and Tier 3 – data should be obtained from producers of ammonia (plant-specific EFs).

GHGs

The *Software* includes the following GHG for the Ammonia Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

The *2006 IPCC Guidelines* do not contain methods for estimating CH_4 and N_2O emissions from ammonia production, however for interoperability with the UNFCCC ETF Reporting Tool, the *Software* allows these emissions to be calculated in category **2.B.11 Other**. The source "CH_4 and N_2O emissions from ammonia production" is provided as a default dropdown in Column |SRC|. For further information, see description under section **2.B.11 Other**.

IPCC Equations

- ✓ Tier 1: Equation 3.1
- ✓ Tier 2: Equations 3.2 and 3.3
- ✓ Tier 3: Equations 3.3 and 3.4

As explained in section **1.1.3 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 CO_2 from Ammonia Production using worksheets:

- ✓ **1.1.1 Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Ammonia Production:** contains for each subdivision (and for each process fuel type) information on the amount of ammonia produced and fuel requirement (Tier 1 and Tier 2) or only total fuel requirement (Tier 3), carbon content of fuels, oxidation factor and amount of urea produced from produced CO_2. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheet for different Tiers.

User's work Flowchart

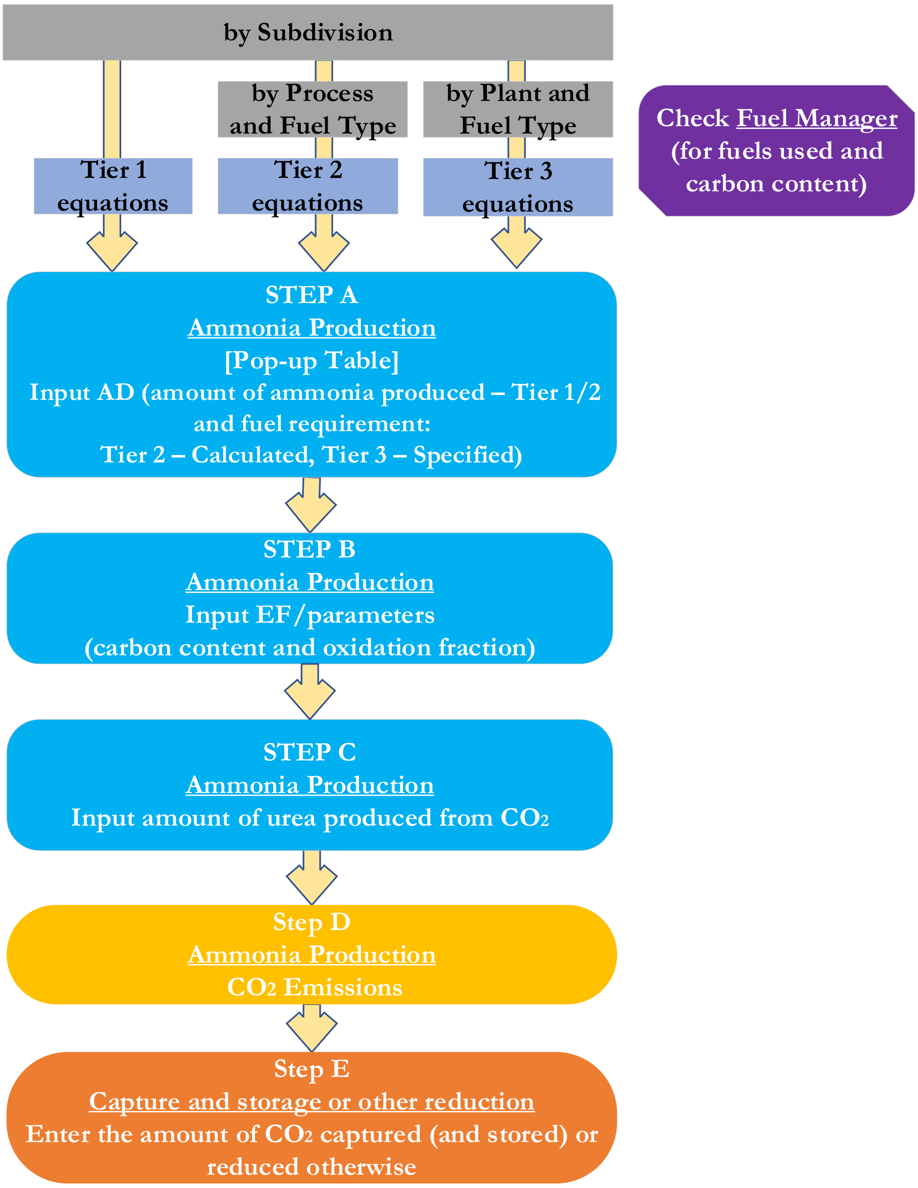
Consistent with the key category analysis and the decision tree in Figure 3.1 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Prior to following the flowchart below, the user shall collect and enter data in the **1.1.1 Fuel Manager** on each fuel used in ammonia production: 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.

Ammonia Production - flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step A, in the worksheet **Ammonia Production,** users collect and input in the *Software* information on the amount of ammonia produced (Tier 1 and Tier 2 only) and fuel requirement (specified directly in Tier 3). Information is entered via a pop-up table.

Step B, in the same worksheet **Ammonia Production,** users collect and input information on the carbon content and oxidation fraction of fuels.

Step C, in the same worksheet **Ammonia Production,** users collect and input information on the amount of urea produced from the CO_2 generated from ammonia production (this will be deducted from total CO_2 emissions).

Step D, in the same worksheet **Ammonia Production**, the *Software* calculates the associated CO_2 emissions for each subdivision (and each fuel type) in mass units (kg and Gg). In addition, the total emissions are calculated.

Step E, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) not accounted in Step **C**.

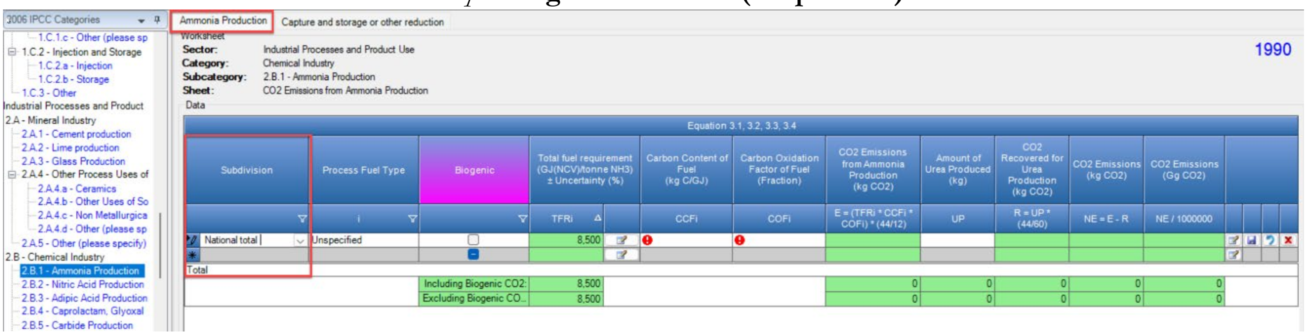
Activity data input

Section 3.2.2.3 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for ammonia production.

As a **Starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for ammonia production; 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 drop-down menu.

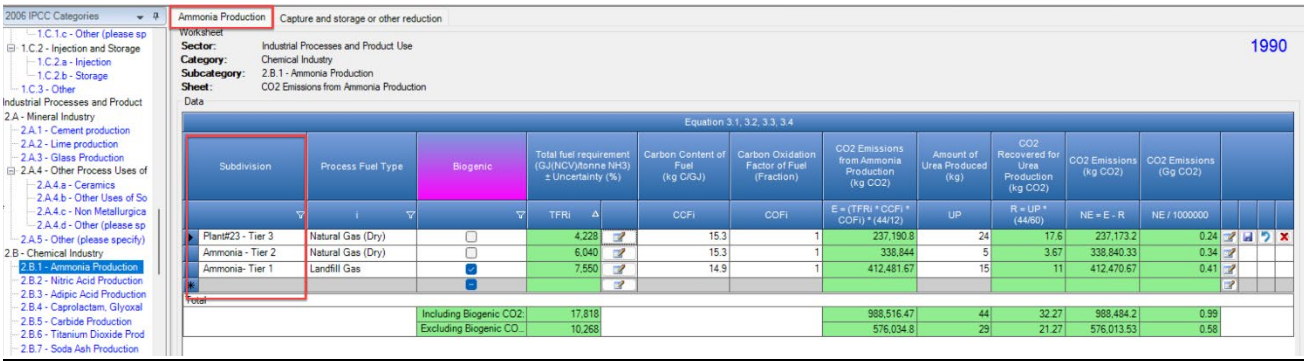
Second, input of AD for the Ammonia Production source category requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



For each subdivision in Column |Subdivision|, data are entered in worksheet **Ammonia Production,** row by row, as follows:

1. Column |i|: select each process fuel used from the drop-down menu (one row for each fuel). If unknown select Unspecified.

Note that fuels shown in the drop-down menu are those listed in the Fuel Manager.

2. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.
3. Column |TFRi |: select the icon and input information in the pop-up table to estimate total fuel requirement.

In the pop-up table indicate if TFRj will be *Calculated* or *Specified*:

i. If *Calculated* is selected (Tier 1 and Tier 2)

4. Column |j|: For Tier 1 – select *Unspecified* or select a particular process from the default drop-down menu, for Tier 2 –specify production process type j either from the drop-down menu or manually input a user-specific process(es).
5. Column |APj|: input the mass of ammonia produced, in tonnes, either national total (Tier 1) or by process type (Tier 2).
6. Column |FRj|: the feedstock fuel requirement for ammonia production will be automatically populated based on the production process selected in Column |j|, in GJ/tonne NH_3 produced, or the user may overwrite.

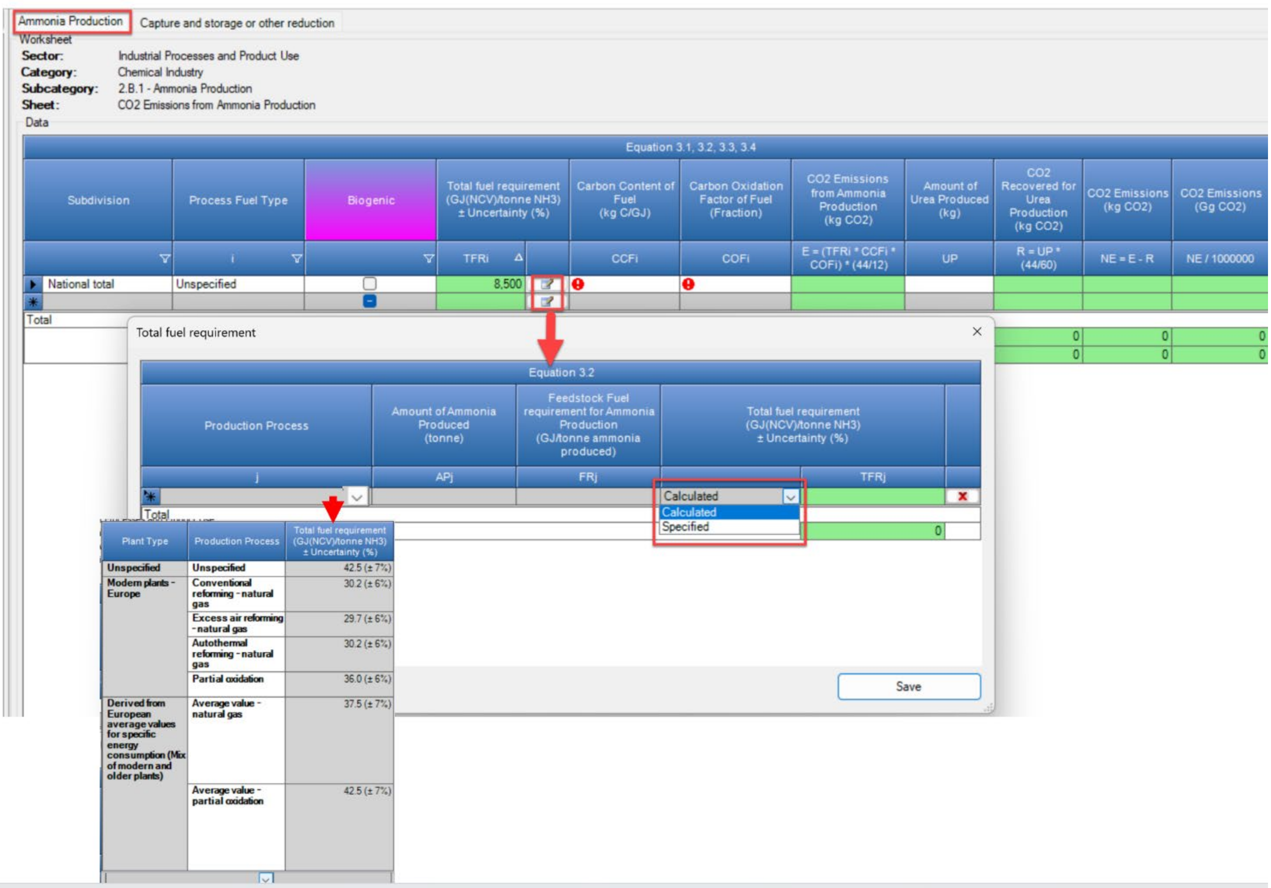
   Note that the Software automatically calculates the fuel requirement in the pop-up table and transfers the value into the main worksheet.

ii. If *Specified* is selected (Tier 3)

4. Column |TFRj|: input the total fuel requirement for ammonia production for that subdivision (i.e. plant)/process fuel/production process.

   Note that total fuel requirement includes fuel used for fuel plus feedstock. To avoid double counting, the amount of fuel used for ammonia production should be subtracted from fuel use included in the Energy Sector.

Example: **entering AD for ammonia production -Tier 1/2/3**



Emission factor input

Section 3.2.2.2 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Ammonia Production.

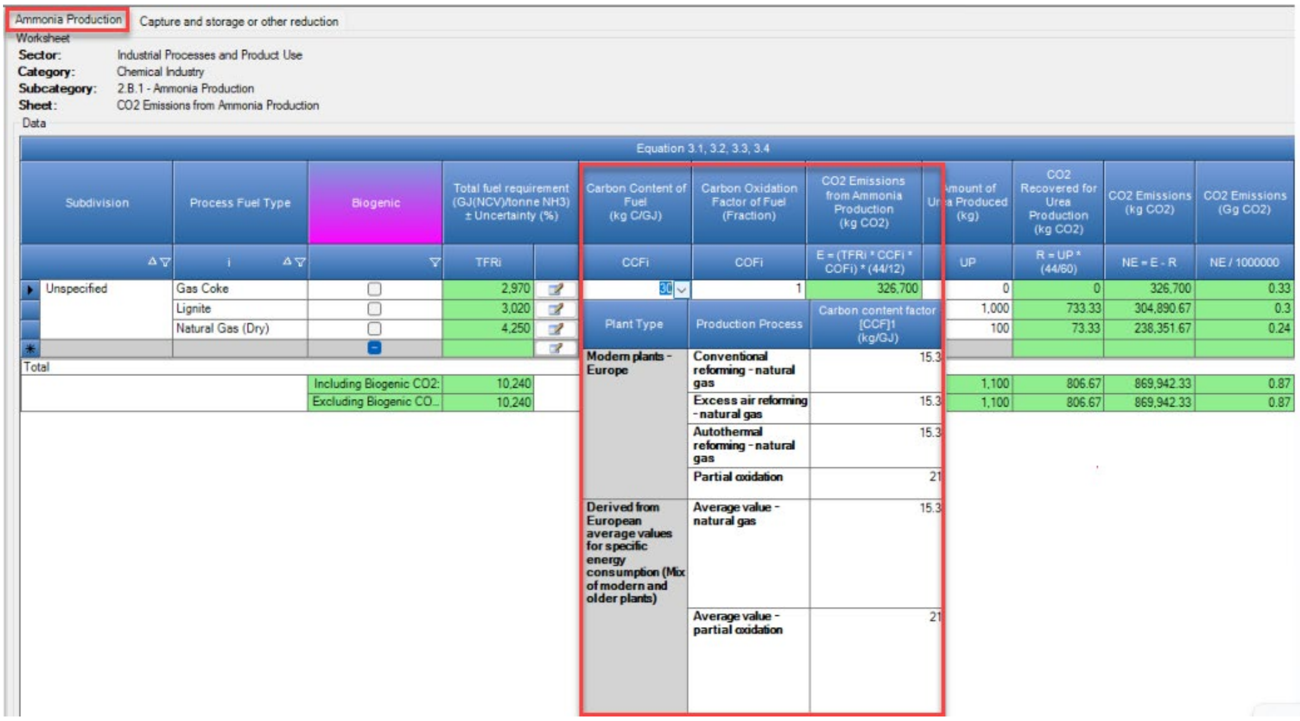
There are two types of EFs/parameters, with IPCC default values included in Table 3.1 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines:*

i) Carbon content of fuel, in kgC/GJ of fuel
ii) Oxidation fraction of fuel, fraction

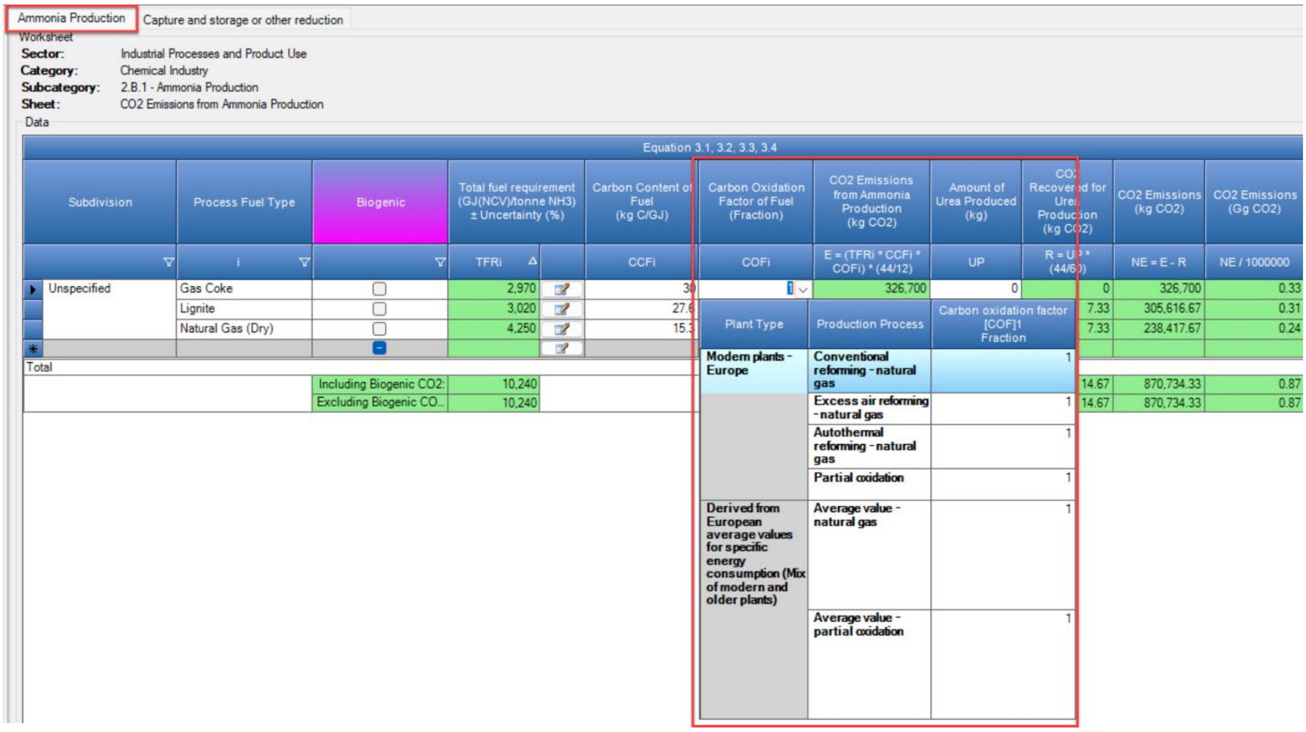
For each combination of subdivision/process fuel type/production process in worksheet **Ammonia Production**:

1. Column |CCFi| - the default carbon content of fuel from the **1.1.1 Fuel Manager** is automatically populated, in kgC/GJ, depending on the process fuel selected in Column |i|. The user may overwrite this value with user-specific information.
   Note that: if Unspecified is selected in Column |i|, in accordance with good practice the value for partial oxidation shall be selected from the drop-down menu in column CCFi.
   Note that the default carbon contents available in the drop-down menu assume either that the process fuel type is Unspecified (and thus partial oxidation is selected) or natural gas.
2. Column |COFi| - select from the drop-down menu the default carbon oxidation factor or enter a user-carbon oxidation factor.

Example: **Tier 1 default EFs for ammonia production – carbon content**



Example: **Tier 1 default EFs for ammonia production – oxidation factor**

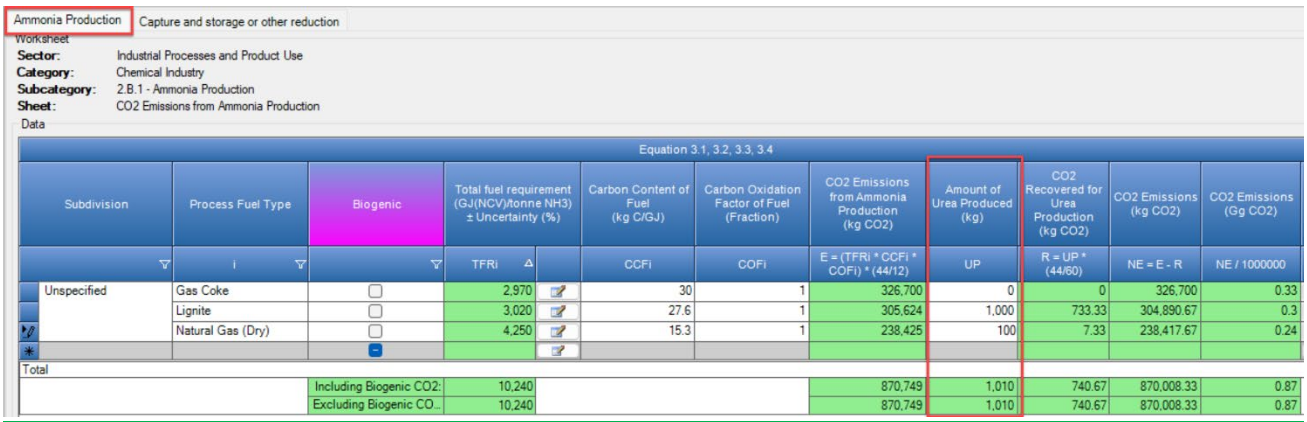


Urea Production

Additionally, for reach subdivision/process fuel type, if data are available, then

1. Column |UP|: if applicable, enter the amount of urea produced (in kg) from CO_2 generated from ammonia production. When a deduction is made for CO_2 used in urea production, it is *good practice* to ensure that emissions from urea use are included elsewhere in the inventory. If data are not available on urea production, or final end use, it is good practice to assume that CO_2 recovered is zero.
   Note that the quantity of urea produced can be estimated from CO_2 by multiplying urea production by 44/60, which is the stoichiometric ratio of CO_2 to urea ($CO(NH_2)_2$).

Example: **Input of urea production – deduction of CO_2 from total emissions**



Subdivision	Process Fuel Type	Biogenic	Total fuel requirement (GJ(NCV)/tonne NH3) ± Uncertainty (%)	Carbon Content of Fuel (kg C/GJ)	Carbon Oxidation Factor of Fuel (Fraction)	CO2 Emissions from Ammonia Production (kg CO2)	Amount of Urea Produced (kg)	CO2 Recovered for Urea Production (kg CO2)	CO2 Emissions (kg CO2)	CO2 Emissions (Gg CO2)
	i		TFRi	CCFi	COFi	E = (TFRi * CCFi * COFi) * (44/12)	UP	R = UP * (44/60)	NE = E - R	NE / 1000000
Unspecified	Gas Coke		2,970	30	1	326,700	0	0	326,700	0.33
	Lignite		3,020	27.6	1	305,624	1,000	733.33	304,890.67	0.3
	Natural Gas (Dry)		4,250	15.3	1	238,425	100	7.33	238,417.67	0.24
Total										
		Including Biogenic CO2:	10,240			870,749	1,010	740.67	870,008.33	0.87
		Excluding Biogenic CO...	10,240			870,749	1,010	740.67	870,008.33	0.87

Results

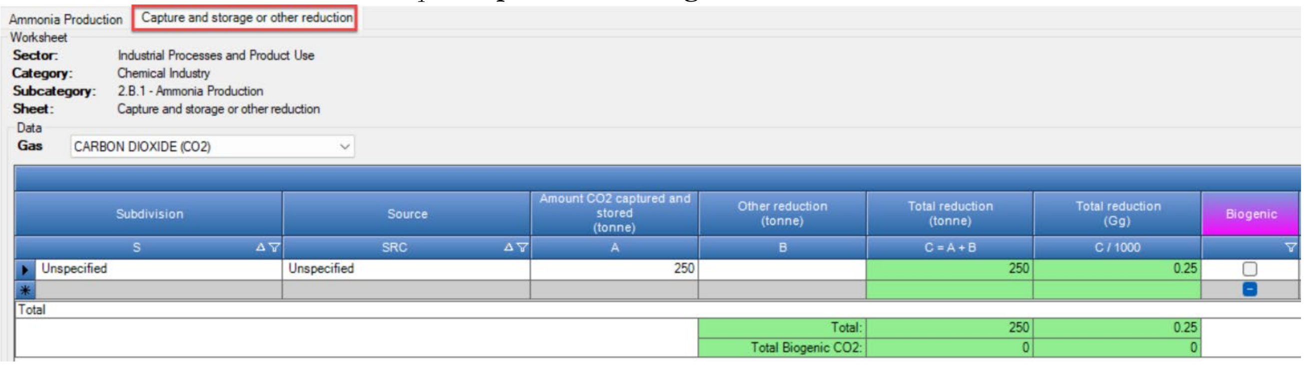
CO_2 emissions from Ammonia Production are estimated in mass units (kg and Gg) by the *Software* in the worksheet **Ammonia Production.**

Total CO_2 emissions from ammonia production is the sum of all subdivisions in the above worksheet, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage that is not otherwise included in the worksheet **Ammonia production** (i.e. do not include in the **Capture and storage or other reduction** worksheet a reduction for the CO_2 used for urea production as that was already accounted for in the calculation worksheet).

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2, in tonnes.
   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.
4. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.
   Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.

Example: **Capture and storage or other reduction**



2.B.2, 2.B.3 and 2.B.4 Nitric Acid, Adipic Acid, and Caprolactam, Glyoxal and Glyoxylic Acid Production

Information

This section groups guidance for the following source categories according to their common methodological approaches applied in the *Software*:

- ✓ **2.B.2 Nitric Acid Production**
- ✓ **2.B.3 Adipic Acid Production**
- ✓ **2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production**

The *2006 IPCC Guidelines* provide three Tiers to estimate N_2O emissions for these source categories. Tier 1 is a default method, where AD are multiplied by default EFs provided in the Guidelines. The Tier 2 method requires plant-level data and includes a correction for abatement (Tier 1 assumes no control/abatement technologies in place). Tier 3 uses plant-level data derived from direct measurements to estimate N_2O emissions.

GHGs

The *Software* includes the following GHG for the Nitric Acid Production, Adipic Acid Production and Caprolactam, Glyoxal and Glyoxylic Acid Production source categories:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X		X				

The *2006 IPCC Guidelines* do not contain methods for estimating CO_2 emissions from adipic acid production or the caprolactam, glyoxal and glyoxylic acid production source categories, however for interoperability with the UNFCCC ETF Reporting Tool, the *Software* allows these emissions to be calculated in category **2.B.11 Other**. CO_2 emissions from the individual source categories are provided as a default dropdown in Column |SRC|. For further information, see description under section **2.B.11 Other**. CO_2 emissions from nitric acid production are not included in the *Software* or the CRT.

IPCC Equations

- ✓ Tier 1: Equation 3.5 (Nitric Acid), Equation 3.7 (Adipic Acid), Equation 3.9 (Caprolactam, Glyoxal and Glyoxylic Acid)
- ✓ Tier 2: Equation 3.6 (Nitric Acid), Equation 3.8 (Adipic Acid), Equation 3.10 (Caprolactam, Glyoxal and Glyoxylic Acid)
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines* for these source categories.

As explained in section **1.1.3 Use of multiple Tiers for reporting**, GHG estimates prepared with user-specific Tier 3 methods, including direct measurement, can be reported in the *Software* worksheets that implement IPCC Tier 1 equations.

Software Worksheets

GHG emissions from each source category are estimated using the following worksheets:

- ✓ **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production:** contains for each subdivision (and for each production process/technology, and in the case of caprolactam, glyoxal and glyoxylic acid production, chemical) information on the amount of product produced, EFs, and abatement parameters (destruction factor and utilization factor – Tier 2). These worksheets calculate the associated N_2O emissions for the source category.
- ✓ **Capture and storage or other reduction:** contains information on other reduction of N_2O, not accounted previously in the worksheet for different Tiers.

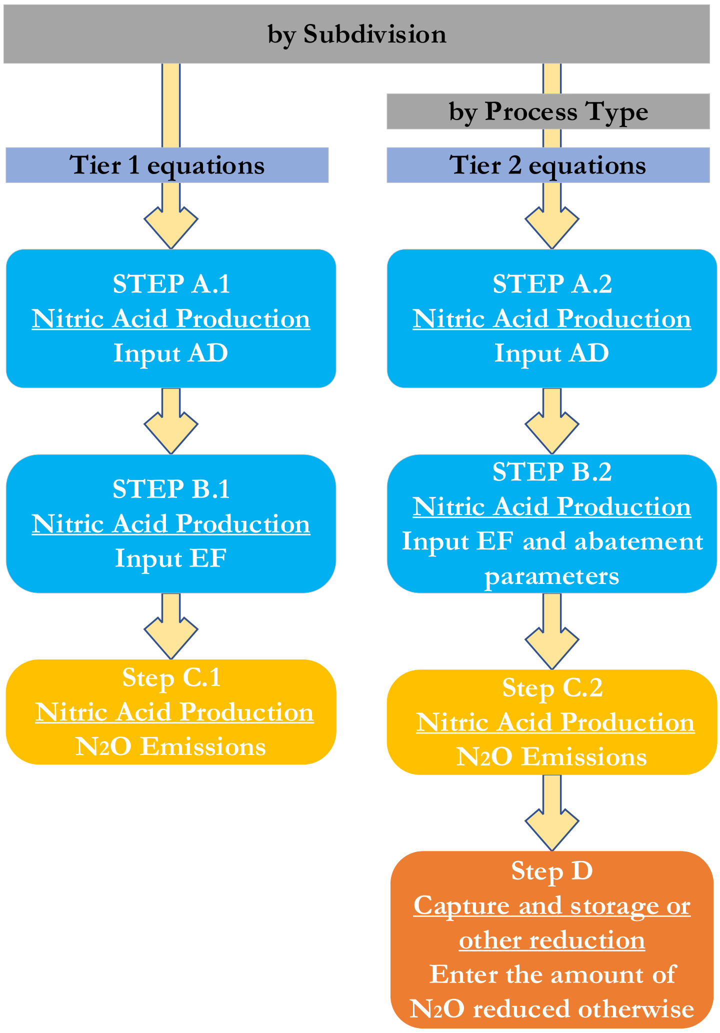
User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 3.2 (Nitric Acid Production), Figure 3.3 (Adipic Acid Production) and Figure 3.4 (Caprolactam, Glyoxal and Glyoxylic Acid Production) of the *2006 IPCC*

Guidelines, GHG estimates are calculated using a single methodological tier for each source category, or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements for that source category.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Nitric Acid Production.

Nitric Acid and **Adipic Acid** and **Caprolactam, Glyoxal and Glyoxylic Acid Production – flowchart**



Thus, for the relevant source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step A.1, in the worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** users collect and input in the *Software* information on the total amount of the product

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

produced.
*Note that: in worksheet **Caprolactam, Glyoxal and Glyoxylic Acid Production** information is entered separately for each chemical.*

Step B.1, in the same worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** users input the associated N_2O EF (N_2O emissions/ tonne of product produced) (default or user-specific).
*Note that: in worksheet **Caprolactam, Glyoxal and Glyoxylic Acid Production** information is entered separately for each chemical.*

Step C.1, in the same worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** the *Software* calculates the associated N_2O emissions for each subdivision/process type, and in the case of caprolactam, glyoxal and glyoxylic acid production, chemical, in mass units (kg and Gg).

When the Tier 2 Equation is applied:

Step A.2, in the worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** users collect and input information at the plant level on the amount of product produced by technology/process type.
*Note that: in worksheet **Caprolactam, Glyoxal and Glyoxylic Acid Production** information is also stratified by each chemical.*

Step B.2, in the same worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** users collect and input user-specific EFs (by each technology/process), N_2O EF, destruction factor for abatement technology and abatement system utilisation factor.
*Note that: in worksheet **Caprolactam, Glyoxal and Glyoxylic Acid Production** information is also stratified by each chemical.*

Step C.2, in the same worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** the *Software* calculates the associated N_2O emissions for each subdivision/process type, and in the case of caprolactam, glyoxal and glyoxylic acid production, chemical, in mass units (kg and Gg).

Step D, in the worksheet **Capture and storage or other reduction**, users collect and input information on the amount of other reduction of N_2O not accounted in Step **C.2**.

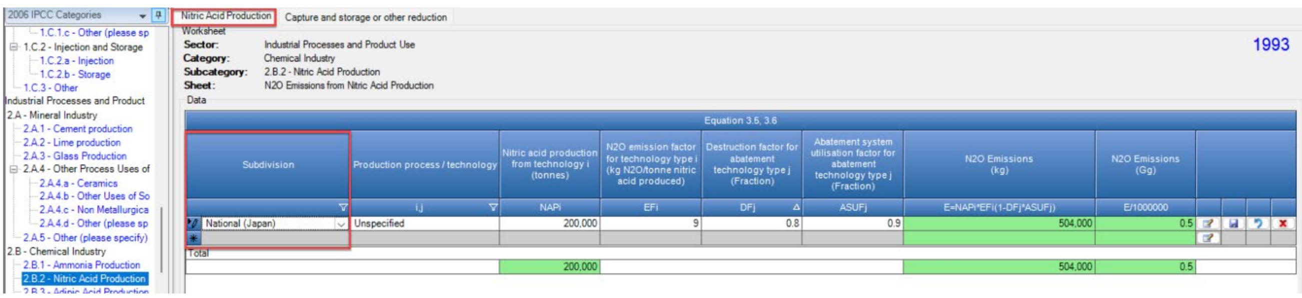
Activity data input

The following sections in Chapter 3, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of AD:

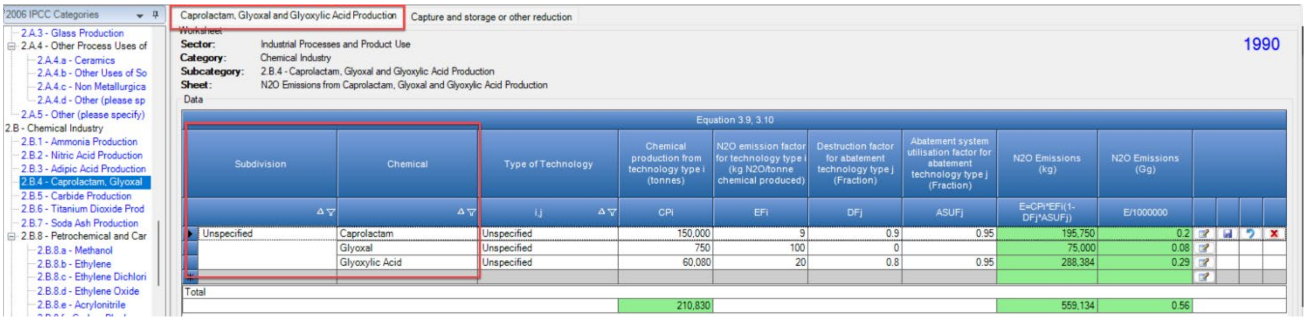
- ✓ Section 3.3.2.3 contains information on the choice of AD for Nitric Acid Production.
- ✓ Section 3.4.2.3 contains information on the choice of AD for Adipic Acid Production.
- ✓ Section 3.5.2.1 contains information on the choice of AD for Caprolactam Production.
  Note that, although the 2006 IPCC Guidelines do not include a section for Choice of Activity Data for glyoxal and glyoxylic acid production the decision tree in Figure 3.4 indicates the same type of AD as for caprolactam production is required.

Input of AD for each source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified) – nitric acid production**

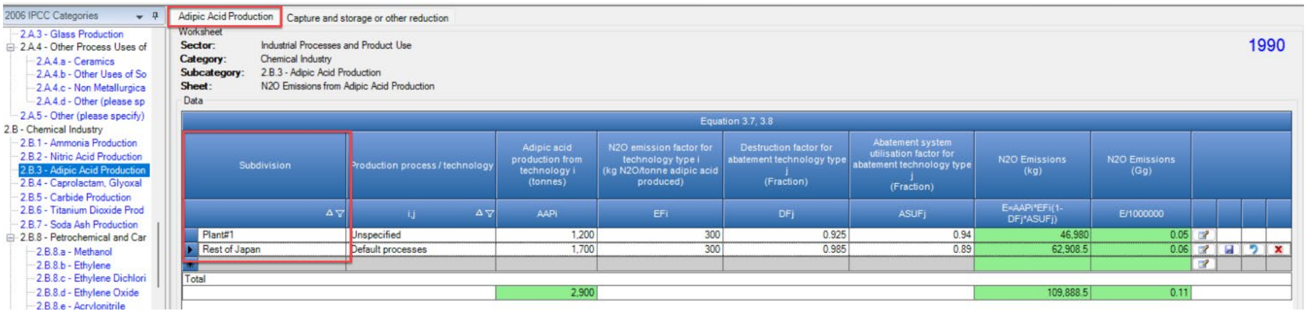


Example: **single subdivision/multiple chemicals - caprolactam, glyoxal and glyoxylic acid production**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions – adipic acid production**



For each subdivision in Column |Subdivision|, data are entered in worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production,** row by row, as follows:

For worksheet **Caprolactam, Glyoxal and Glyoxylic Acid Production** only:

1. Column |Chemical|: select from the drop-down menu the name of the chemical produced (caprolactam, glyoxal, or glyoxylic acid).

Then, for all three worksheets:

2. Column |i,j|: select from the drop-down menu the name of production process type, i, and abatement type technology, j (if unknown select *Unspecified*), or the user may overwrite.
3. Column |NAPi|: input the mass of product produced, by subdivision/production process/technology, in tonnes.

Emission factor input

The following sections in Chapter 3, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of EFs:

- ✓ Section 3.3.2.2 contains information on the choice of EFs for **Nitric Acid Production**. IPCC default EFs are included in Table 3.3
- ✓ Section 3.4.2.2 contains information on the choice of EFs for **Adipic Acid Production**. IPCC default EFs are included in Table 3.4.
- ✓ Sections 3.5.2.1 and 3.5.3 contain information on the choice of EFs for **Caprolactam, Glyoxal and Glyoxylic Acid Production**. IPCC default EFs are included in Tables 3.5 and 3.6

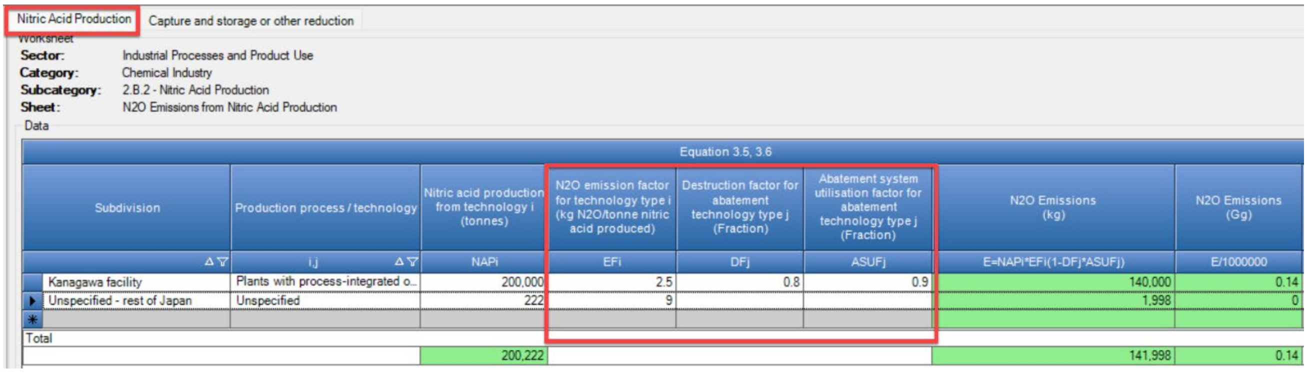
There are three types of EFs/parameters for all three source categories in the *2006 IPCC Guidelines*:

i. N_2O emissions/ tonne of product produced.
ii. destruction factor for abatement technology, fraction.
iii. abatement system utilisation factor for abatement technology, fraction.

For each combination of subdivision/ production process /technology/chemical (if applicable) in worksheet **Nitric Acid Production** or **Adipic Acid Production** or **Caprolactam, Glyoxal and Glyoxylic Acid Production**:

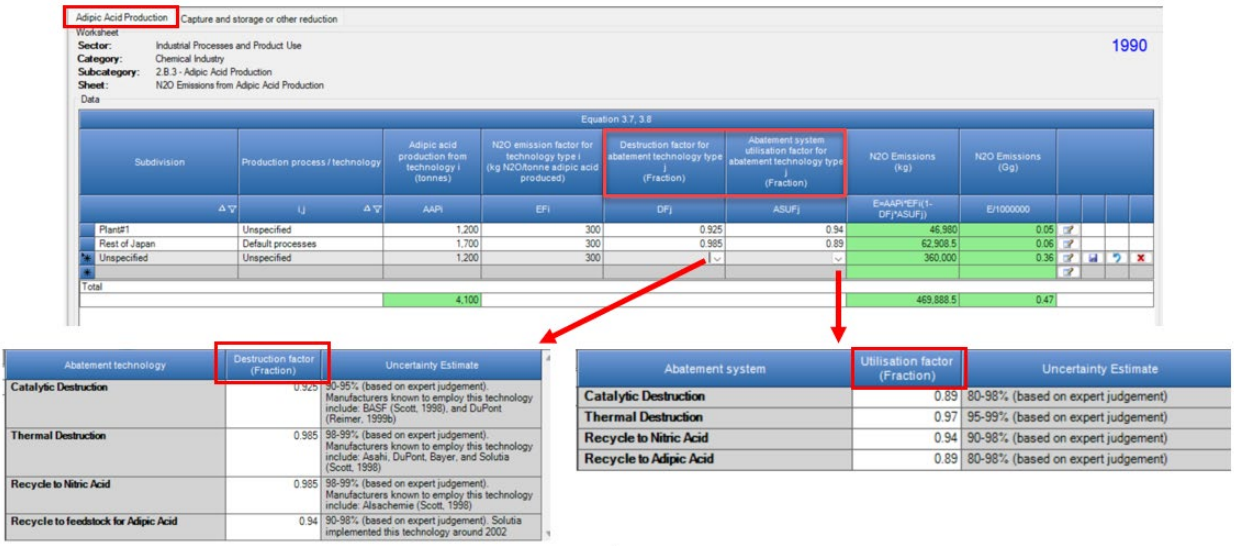
1. Column |EFi|: select from the drop-down menu the default N_2O EF or overwrite this value with user-specific information.
   *Note that in the case of worksheets **Nitric Acid Production** and **Caprolactam, Glyoxal and Glyoxylic Acid Production**, the default N_2O EF for the technology type, i, and abatement technology, j, is automatically populated in Column |EFi|, in kg N_2O/tonne product produced, depending on the production process/technology selected in Column |i,j|.*
   Note that the Tier 1 method does not disaggregate estimates by production process/technology. Thus, where the Tier 1 method is applied, select "Unspecified" in the drop-down menu of Column |i,j| and leave blank cells for abatement in Column |DFj| and Column |ASUFj|.
2. Column |DFj|: enter the destruction factor for abatement technology type j, fraction. For adipic acid production, the user may instead select an appropriate destruction factor from the drop-down menu.
   Note that, at Tier 2, destruction and/or abatement of N_2O emissions are estimated in this worksheet to calculate total emissions. Double counting of those reductions in the worksheet "Capture and Storage and Other reduction" shall be avoided.
3. Column |ASUFj|: enter the abatement system utilisation factor for abatement technology type j, fraction. For adipic acid production, the user may instead select an appropriate utilisation factor from the drop-down menu.

Example: **Tier 1 and 2 EFs for nitric acid production**



Equation 3.5, 3.6							
Subdivision	Production process / technology	Nitric acid production from technology i (tonnes)	N2O emission factor for technology type i (kg N2O/tonne nitric acid produced)	Destruction factor for abatement technology type j (Fraction)	Abatement system utilisation factor for abatement technology type j (Fraction)	N2O Emissions (kg)	N2O Emissions (Gg)
	i,j	NAPi	EFi	DFj	ASUFj	E=NAPi*EFi(1-DFj*ASUFj)	E/1000000
Kanagawa facility	Plants with process-integrated o...	200,000	2.5	0.8	0.9	140,000	0.14
Unspecified - rest of Japan	Unspecified	222	9			1,998	0
Total		200,222				141,998	0.14

Example: **destruction and abatement utilisation EF for adipic acid production**

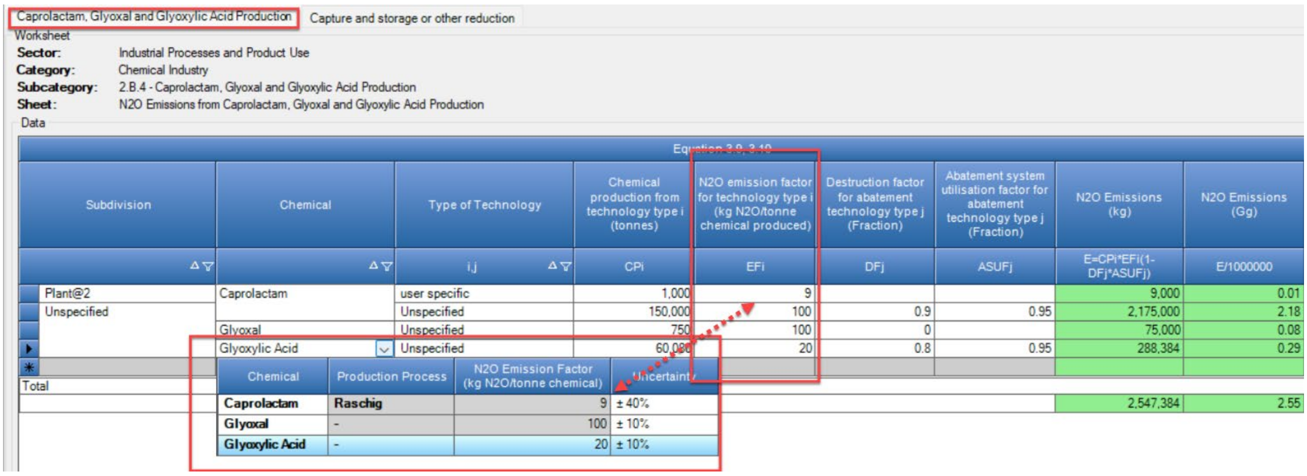


Equation 3.7, 3.8							
Subdivision	Production process / technology	Adipic acid production from technology i (tonnes)	N2O emission factor for technology type i (kg N2O/tonne adipic acid produced)	Destruction factor for abatement technology type j (Fraction)	Abatement system utilisation factor for abatement technology type j (Fraction)	N2O Emissions (kg)	N2O Emissions (Gg)
	i,j	AAPi	EFi	DFj	ASUFj	E=AAPi*EFi(1-DFj*ASUFj)	E/1000000
Plant#1	Unspecified	1,200	300	0.925	0.94	46,980	0.05
Rest of Japan	Default processes	1,700	300	0.985	0.89	62,908.5	0.06
Unspecified	Unspecified	1,200	300			360,000	0.36
Total		4,100				469,888.5	0.47

Abatement technology	Destruction factor (Fraction)	Uncertainty Estimate
Catalytic Destruction	0.925	90-95% (based on expert judgement). Manufacturers known to employ this technology include: BASF (Scott, 1998), and DuPont (Reimer, 1999b)
Thermal Destruction	0.985	98-99% (based on expert judgement). Manufacturers known to employ this technology include: Asahi, DuPont, Bayer, and Solutia (Scott, 1998)
Recycle to Nitric Acid	0.985	98-99% (based on expert judgement). Manufacturers known to employ this technology include: Alsachemie (Scott, 1998)
Recycle to feedstock for Adipic Acid	0.94	90-98% (based on expert judgement). Solutia implemented this technology around 2002

Abatement system	Utilisation factor (Fraction)	Uncertainty Estimate
Catalytic Destruction	0.89	80-98% (based on expert judgement)
Thermal Destruction	0.97	95-99% (based on expert judgement)
Recycle to Nitric Acid	0.94	90-98% (based on expert judgement)
Recycle to Adipic Acid	0.89	80-98% (based on expert judgement)

Example: **IPCC default N_2O EFs for caprolactam, glyoxal and glyoxylic acid production**



Results

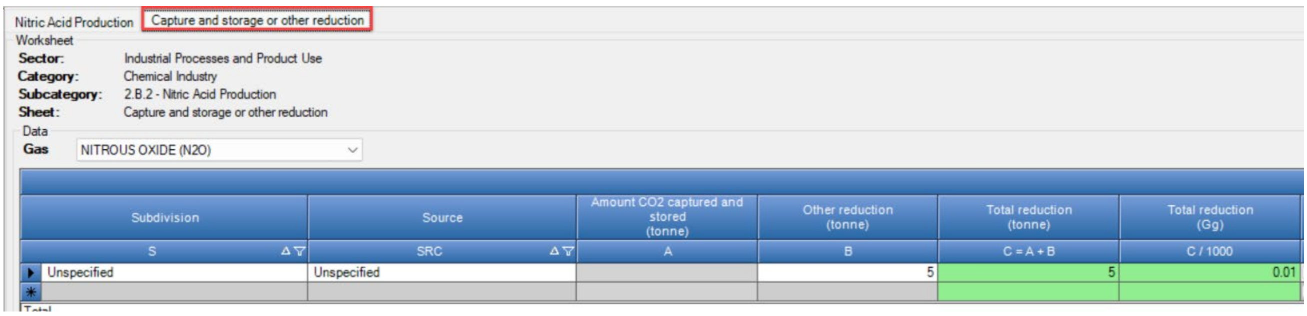
N_2O emissions are estimated in mass units (kg and Gg) by the *Software* in the worksheet **Nitric Acid Production** and **Adipic Acid Production** and **Caprolactam, Glyoxal and Glyoxylic Acid Production:**

Total N_2O emissions from each source category is the sum of all subdivisions in the relevant worksheet above, taking into account any further N_2O capture, abatement or destruction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate any further N_2O reductions. But, recall, that at Tier 2 destruction and/or abatement of N_2O emissions are estimated in the relevant source category worksheet to calculate total emissions; double counting of those reductions in the worksheet **Capture and storage or other reduction** shall be avoided.

In the worksheet **Capture and storage or other reduction,** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the other reduction of N_2O occurs (e.g. the facility, stream, or other identifying information).
2. Column |B|: users collect and input information on any other long-term reduction of N_2,O in tonnes..

Example: **Capture and storage or other reduction**



2.B.5 Carbide Production

Information

GHG emissions are associated with production of two types of carbides – silicon carbide (SiC) and calcium carbide (CaC_2). The production of carbides can result in emissions of CO_2 and CH_4. SiC is produced from silica sand or quartz and petroleum coke. CaC_2 is made from two carbon containing raw materials: calcium carbonate (limestone) and petroleum coke.

The *2006 IPCC Guidelines* provide three Tiers to estimate CO_2 and CH_4 emissions from carbide production. Tier 1 uses national aggregate input data, national production data or production capacity data and default EFs to calculate emissions. The Tier 2 method calculates emissions using plant-level data on production of carbide and plant-specific EFs. For the plants, where plant-specific EFs are not available, Tier 2 allows use of default EFs with plant-specific AD. Tier 3 uses the plant-specific coke consumption data including C content and percent oxidised, along with a plant-specific CH_4 EF.

GHGs

The *Software* includes the following GHG for the Carbide Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X (silicon carbide only)	--	--	--	--	--

IPCC Equations

- ✓ Tier 1: Equation 3.11
- ✓ Tier 2: Same equation as Tier 1, although with plant-specific production data, data on the use of CaC_2 for the production of acetylene used in welding applications, and user-specific or default EFs
- ✓ Tier 3: Same equation as Tier 1, although with plant-specific coke consumption and CH_4 EF (SiC only)

As explained in section **1.1.3 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

GHG emissions from the Carbide Production source category are estimated using the following worksheets:

- ✓ **Carbide Production:** contains for each subdivision (and for each type of AD used – production or consumption) information on the amount of a carbide produced or raw materials used (e.g. petroleum coke) by each type of carbide (CaC_2 or SiC) and corresponding EFs (default, country-specific, plant-specific). The worksheet calculates the associated CO_2 and CH_4 emissions.
- ✓ **Carbide Use:** contains for each subdivision information on the amount of calcium carbide used for acetylene production and the EF. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) or other reductions, not accounted previously.

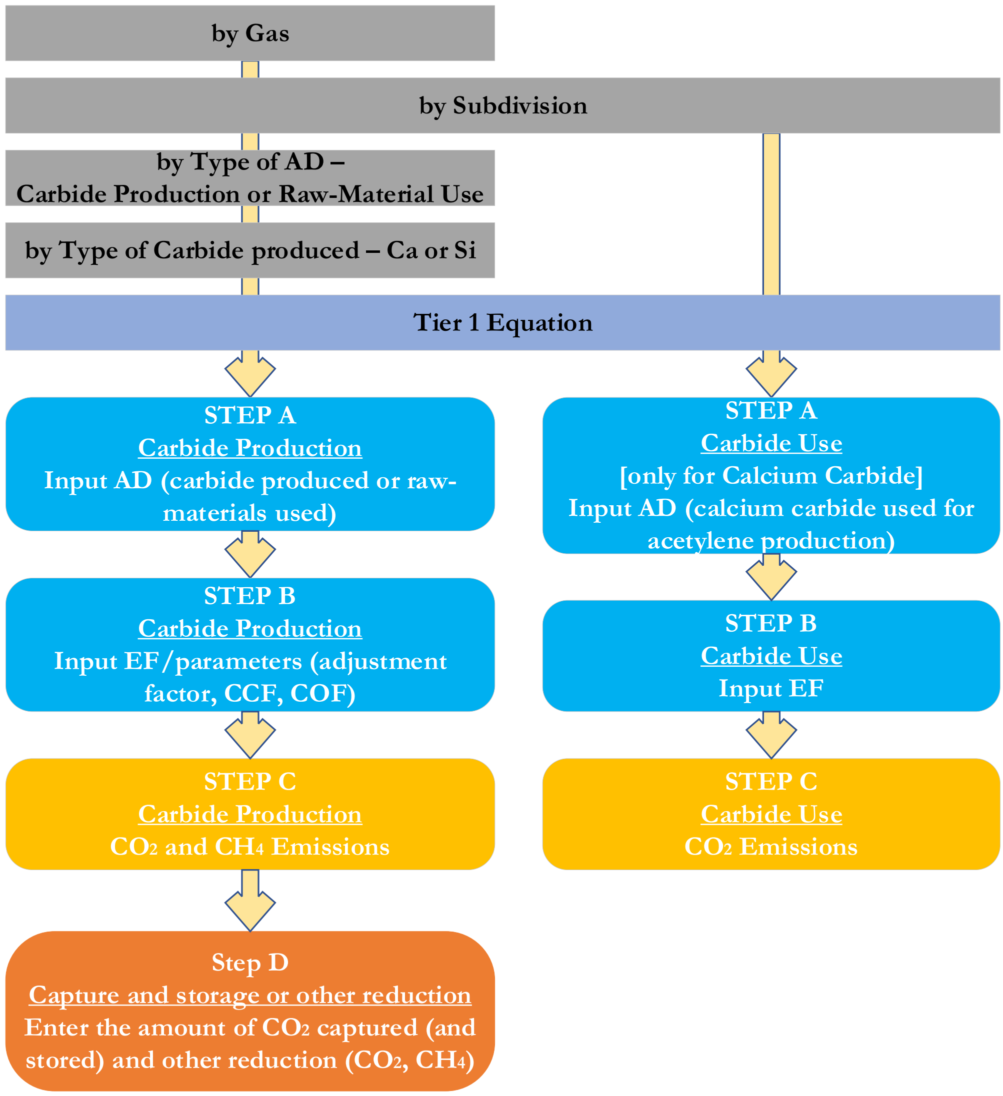
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.5 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Carbide Production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Carbide Production – flowchart



Thus, for the source-category:

The workflow is followed first for carbide production, then carbide use.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Carbide production

Step A, in the worksheet **Carbide Production,** users collect and input in the *Software* AD for each type of carbide (CaC_2 and SiC) produced. AD can be the amount of carbide produced or the amount of the raw materials used (petroleum coke) for carbide production.

Step B, in the worksheet **Carbide Production**, for each type of AD, users collect and input the associated CO_2 and CH_4 EFs either based on carbide produced or raw materials used (default or plant-specific).

Step C, in the worksheet **Carbide Production,** the *Software* calculates the associated emissions for each subdivision and each carbide type in mass units (tonne CO_2, kg CH_4, and Gg).

Step D, in the worksheet **Capture and storage or other reduction**, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of GHG.

Carbide Use

Step A, in worksheet **Carbide Use,** users collect and input information on the amount of CaC_2 used in acetylene production.

Step B, in the worksheet **Carbide Use,** users input the CO_2 EF.

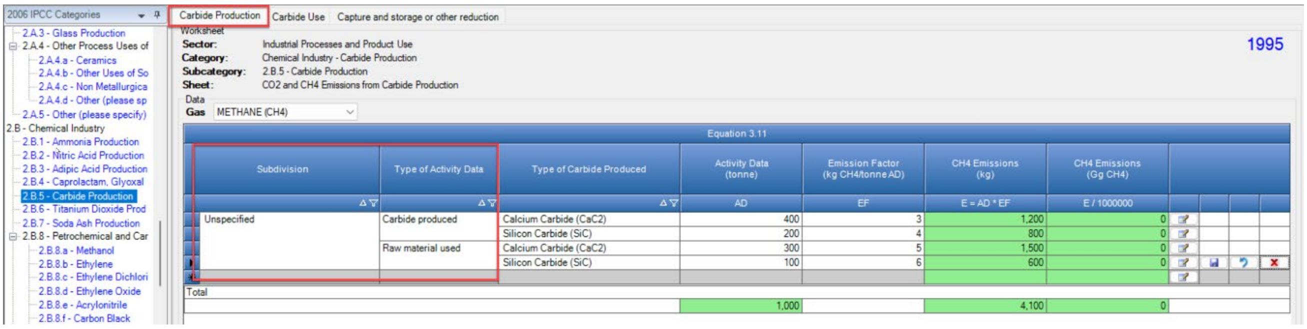
Step C, in the worksheet **Carbide Use,** the *Software* calculates the associated emissions for each subdivision for CaC_2 in mass units (tonne and Gg).

Activity data input

Section 3.6.2.3 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Carbide Production.

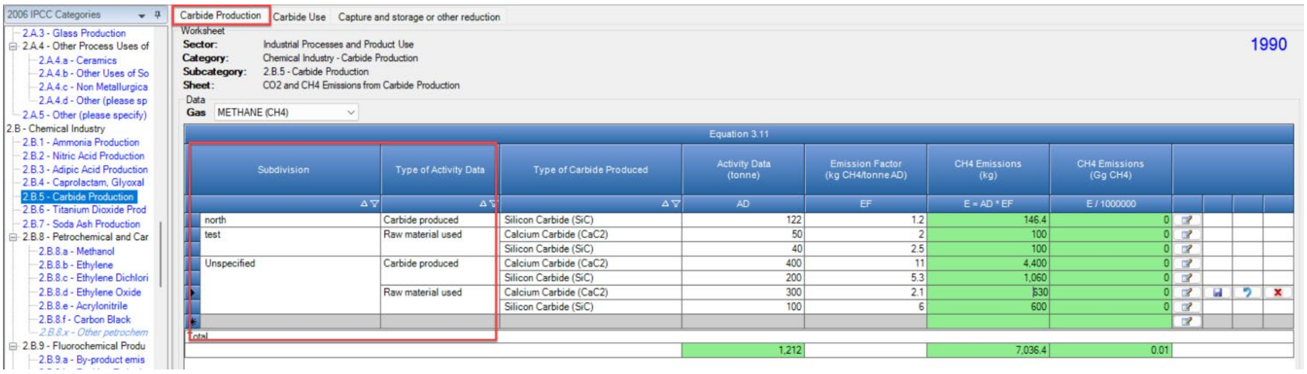
Input of AD for the Carbide Production source category requires the user first to enter information on the subdivisions in the country. Subdivisions are entered separately for Carbide Production and Carbide Use, they may be the same or differ. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



For each subdivision in Column |Subdivision|, data are entered in worksheet **Carbide Production,** row by row, as follows:

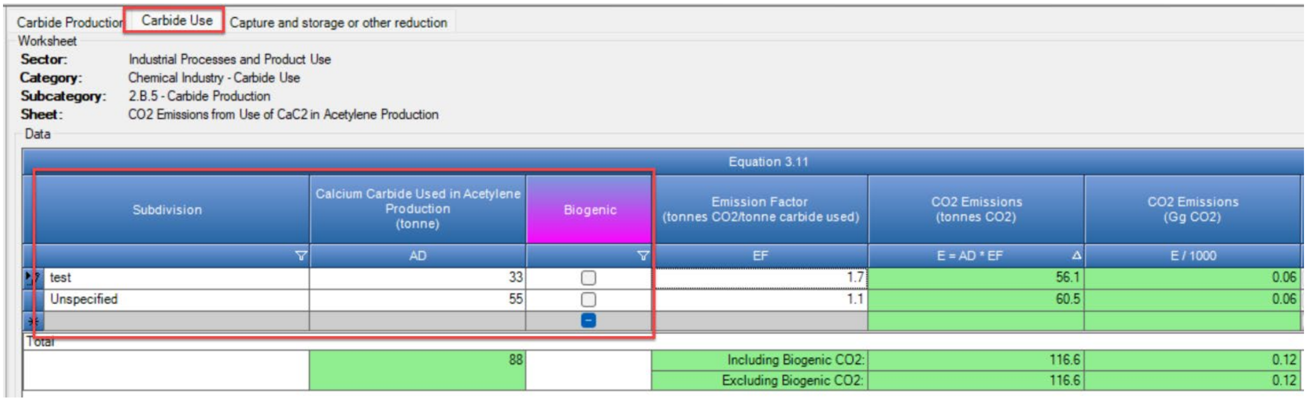
1. Column |Type of Activity Data|: select from the drop-down menu the type of AD to be used – carbide produced or raw materials used.

2. Column |Type of Carbide Produced|: select from the drop-down menu the type of carbide produced – SiC or CaC_2. The user may enter directly another type of carbide.
Note that users must enter a unique combination of subdivision/type of activity data/type of carbide produced. If the same combination is entered twice, an error will pop-up asking the user to re-enter a unique combination by changing either the subdivision or type of carbide produced.
3. Column |AD|: enter for each type of AD and for each type of carbide produced the amount of either raw materials used (e.g. petroleum coke) or carbide produced (CaC_2 or SiC), in tonnes.
4. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.

Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **Carbide Use,** row by row, as follows:

1. Column |AD|: enter information on the amount of CaC_2 used in acetylene production, in tonnes.
2. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.

Example: **AD for calcium carbide used in acetylene production**



Emission factor input

Section 3.6.2.2 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Carbide Production.

There are three types of default EFs, listed here and further described below:

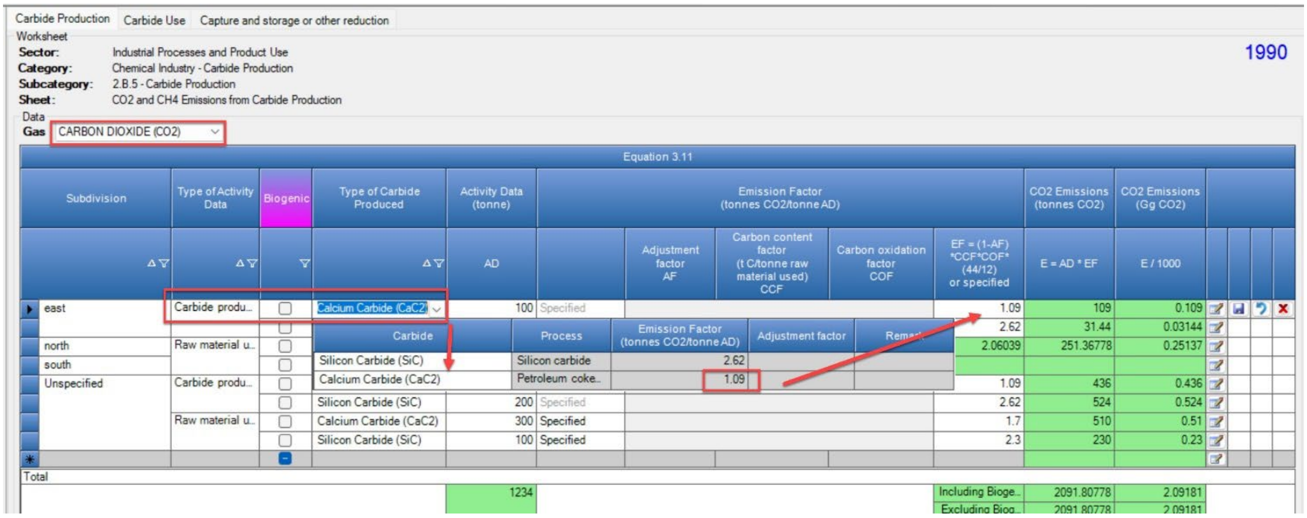
i) CO_2 and CH_4 EFs based on carbide production AD - in tonnes of CO_2 and kg of CH_4 per tonne of carbide produced (Tables 3.7 and 3.8 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines*)
ii) CO_2 and CH_4 EFs based on raw materials consumption (petroleum coke) - in tonne of CO_2 and kg of CH_4 per tonne of petroleum coke (Tables 3.7 and 3.8 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines*)
iii) CO_2 EF for CaC_2 used in acetylene production in tonne of CO_2 per tonne of CaC_2 used (Table 3.8 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines*).

CO_2 and CH_4 EFs based on carbide production

Where Carbide Produced is selected in Column |Type of Activity Data|, for each combination of subdivision/Type of Activity Data/ Type of Carbide Produced data are entered in worksheet **Carbide Production,** row by row, as follows:

1. Column |EF|: The default EF will automatically be populated based on the type of carbide produced, or the user may manually enter in user-specific EFs in tonne of CO_2 per tonne of carbide produced or kg of CH_4/tonne carbide produced.
Note that data entry for each gas is made through selection of the relevant gas in the drop-down menu for "Gas".

Example: **CO_2 and CH_4 EFs for carbide production – Tier 1**



<u>CO_2 and CH_4 EFs based on raw materials consumption (petroleum coke)</u>

Where Raw material used is selected in <u>Column |Type of Activity Data</u>|, for each combination of subdivision/Type of Activity Data/ Type of Carbide Produced data are entered in worksheet **Carbide Production,** row by row, as follows:

1. <u>Column |Emission Factor</u>|: Indicate in the first of five columns here if the EF will be specified or calculated.

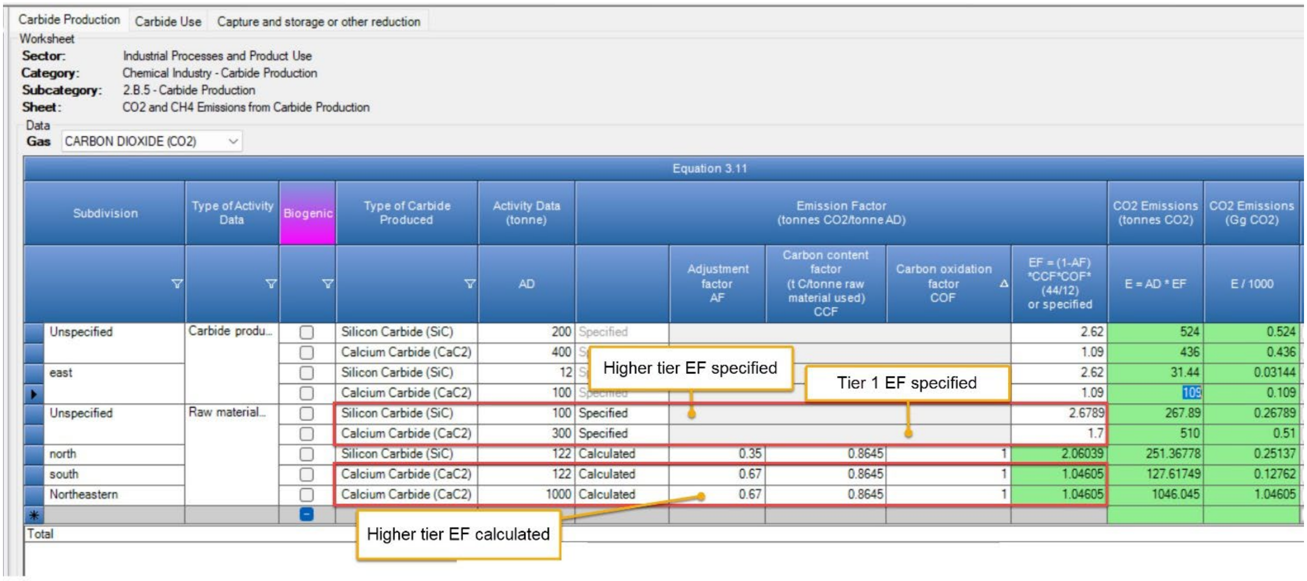
   i. If *Specified* (use for Tier 1 or for insertion of the results of a user-specific method (see section **1.1.3 Use of multiple Tiers for reporting**)

   2. <u>Column |EF|</u>: The default EF will automatically be populated based on the type of carbide produced, or the user may manually enter in user-specific EFs in tonne of CO_2 per tonne of carbide produced or kg of CH_4/tonne carbide produced.
   <u>Note that</u> data entry for each gas is made through selection of the relevant gas in the drop-down menu for "Gas".

   ii. If *Calculated* is selected (Tier 2 or Tier 3)

   2. <u>Column |AF|:</u> The adjustment factor will automatically be populated based on the type of carbide produced, or the user may manually enter in a user-specific AF, dimensionless.
   3. <u>Column |CCF|:</u> Select from the drop-down menu the CCF for the raw material used, or the user may overwrite this value with use-specific information.
   4. <u>Column |COF|:</u> A COF of 1 will automatically populate, or the user may overwrite this value with user-specific information.

Example: **CO_2 and CH_4 EFs for raw materials used – all tiers**



Carbide Production | Carbide Use | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry - Carbide Production
Subcategory: 2.B.5 - Carbide Production
Sheet: CO2 and CH4 Emissions from Carbide Production

Data

Gas CARBON DIOXIDE (CO2)

Equation 3.11

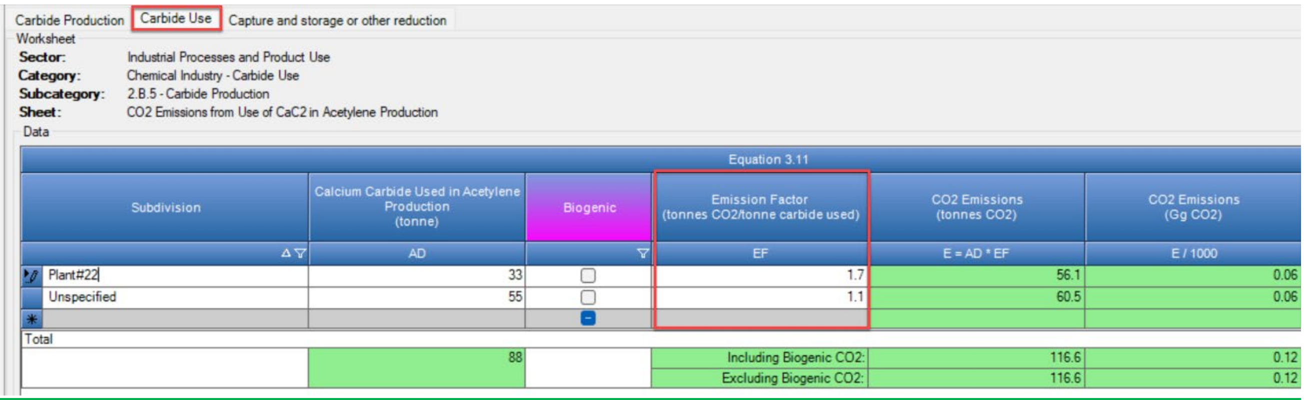
Subdivision	Type of Activity Data	Biogenic	Type of Carbide Produced	Activity Data (tonne)	Emission Factor (tonnes CO2/tonne AD)					CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
				AD		Adjustment factor AF	Carbon content factor (t C/tonne raw material used) CCF	Carbon oxidation factor COF	EF = (1-AF) *CCF*COF* (44/12) or specified	E = AD * EF	E / 1000
Unspecified	Carbide produ...	☐	Silicon Carbide (SiC)	200	Specified				2.62	524	0.524
		☐	Calcium Carbide (CaC2)	400					1.09	436	0.436
east		☐	Silicon Carbide (SiC)	12					2.62	31.44	0.03144
		☐	Calcium Carbide (CaC2)	100	Specified				1.09	109	0.109
Unspecified	Raw material...	☐	Silicon Carbide (SiC)	100	Specified				2.6789	267.89	0.26789
		☐	Calcium Carbide (CaC2)	300	Specified				1.7	510	0.51
north		☐	Silicon Carbide (SiC)	122	Calculated	0.35	0.8645	1	2.06039	251.36778	0.25137
south		☐	Calcium Carbide (CaC2)	122	Calculated	0.67	0.8645	1	1.04605	127.61749	0.12762
Northeastern		☐	Calcium Carbide (CaC2)	1000	Calculated	0.67	0.8645	1	1.04605	1046.045	1.04605
Total											

<u>CO_2 EF for CaC_2 used in acetylene production</u>

For each subdivision, for CO_2 emissions from the use of CaC_2 in acetylene production, in worksheet **Carbide Use**:

1. <u>Column |EF|</u>: input the EF for CaC_2 used for acetylene production in tonne of CO_2/tonne of CaC_2 used.

Example: **EF for calcium carbide used in acetylene production**



Carbide Production | Carbide Use | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry - Carbide Use
Subcategory: 2.B.5 - Carbide Production
Sheet: CO2 Emissions from Use of CaC2 in Acetylene Production

Data

Equation 3.11

Subdivision	Calcium Carbide Used in Acetylene Production (tonne)	Biogenic	Emission Factor (tonnes CO2/tonne carbide used)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	AD		EF	E = AD * EF	E / 1000
Plant#22	33	☐	1.7	56.1	0.06
Unspecified	55	☐	1.1	60.5	0.06
Total	88		Including Biogenic CO2:	116.6	0.12
			Excluding Biogenic CO2:	116.6	0.12

Results

CO_2 and CH_4 emissions from Carbide Production are estimated in mass units (tonnes and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets:

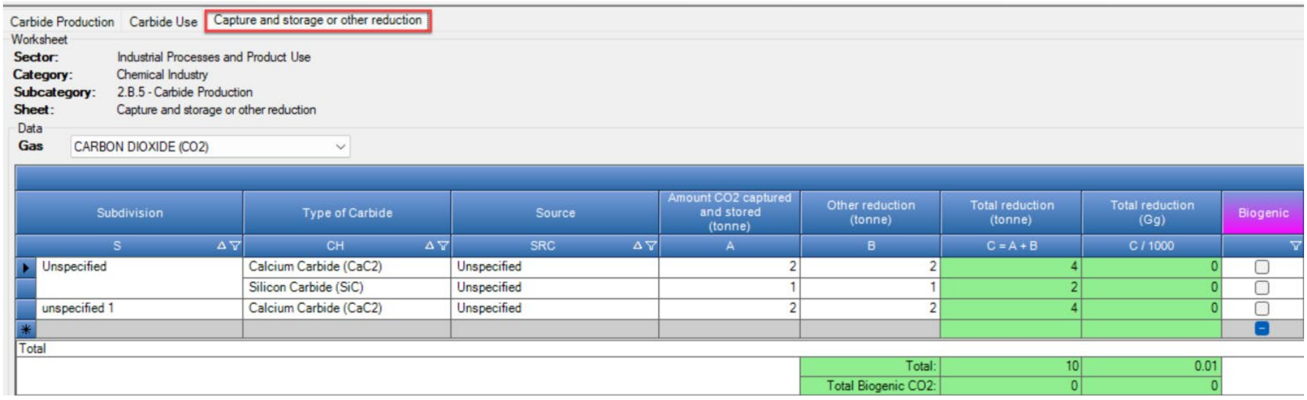
- ✓ **Carbide Production**
- ✓ **Carbide Use**

Total CO_2 and CH_4 emissions from carbide production is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision, each gas and each type of carbide produced:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where CO_2 capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2 or CH_4, in tonnes.
   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.
4. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.
   Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.

Example: **Capture and storage or other reduction**


Carbide Production | Carbide Use | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.5 - Carbide Production
Sheet: Capture and storage or other reduction

Data

Gas CARBON DIOXIDE (CO2)

Subdivision	Type of Carbide	Source	Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	Biogenic
S	CH	SRC	A	B	C = A + B	C / 1000	
Unspecified	Calcium Carbide (CaC2)	Unspecified	2	2	4	0	☐
	Silicon Carbide (SiC)	Unspecified	1	1	2	0	☐
unspecified 1	Calcium Carbide (CaC2)	Unspecified	2	2	4	0	☐

Total

Total:	10	0.01
Total Biogenic CO2:	0	0

2.B.6 Titanium Dioxide Production

Information

There are three processes that are used in the production of titanium dioxide (TiO_2) that lead to process GHG emissions: titanium slag production in electric furnaces, synthetic rutile production using the Becher process, and rutile TiO_2 production via the chloride route. The sulphate route process does not give rise to process GHG emissions that are of significance.

The *2006 IPCC Guidelines* provide two Tiers to estimate CO_2 emissions from TiO_2 Production. The Tier 1 method calculates emissions using national aggregate data on production of titanium slag, synthetic rutile or rutile TiO_2 and default EFs. Tier 2 uses the plant-level AD on the quantities of reducing agent or carbothermal input and EFs (carbon content and carbon oxidation factors).

GHGs

The *Software* includes the following GHG for the Titanium Dioxide Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

- ✓ Tier 1: Equation 3.12
- ✓ Tier 2: Equation 3.13
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section **1.1.3 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 CO_2 from Titanium Dioxide Production using worksheets:

- ✓ **1.1.1 Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Titanium Dioxide Production:** contains for each subdivision information on the amount of TiO_2 produced by each type of production process (slag, synthetic rutile and rutile) and default CO_2 EFs. The worksheet calculates the associated CO_2 emissions.
- ✓ **Titanium Dioxide production – Tier 2:** contains for each subdivision information on the amount of reducing agent or carbothermal input by each type of production process (slag, synthetic rutile and rutile) and plant-specific EFs (carbon content and carbon oxidation factors). The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

User's work Flowchart

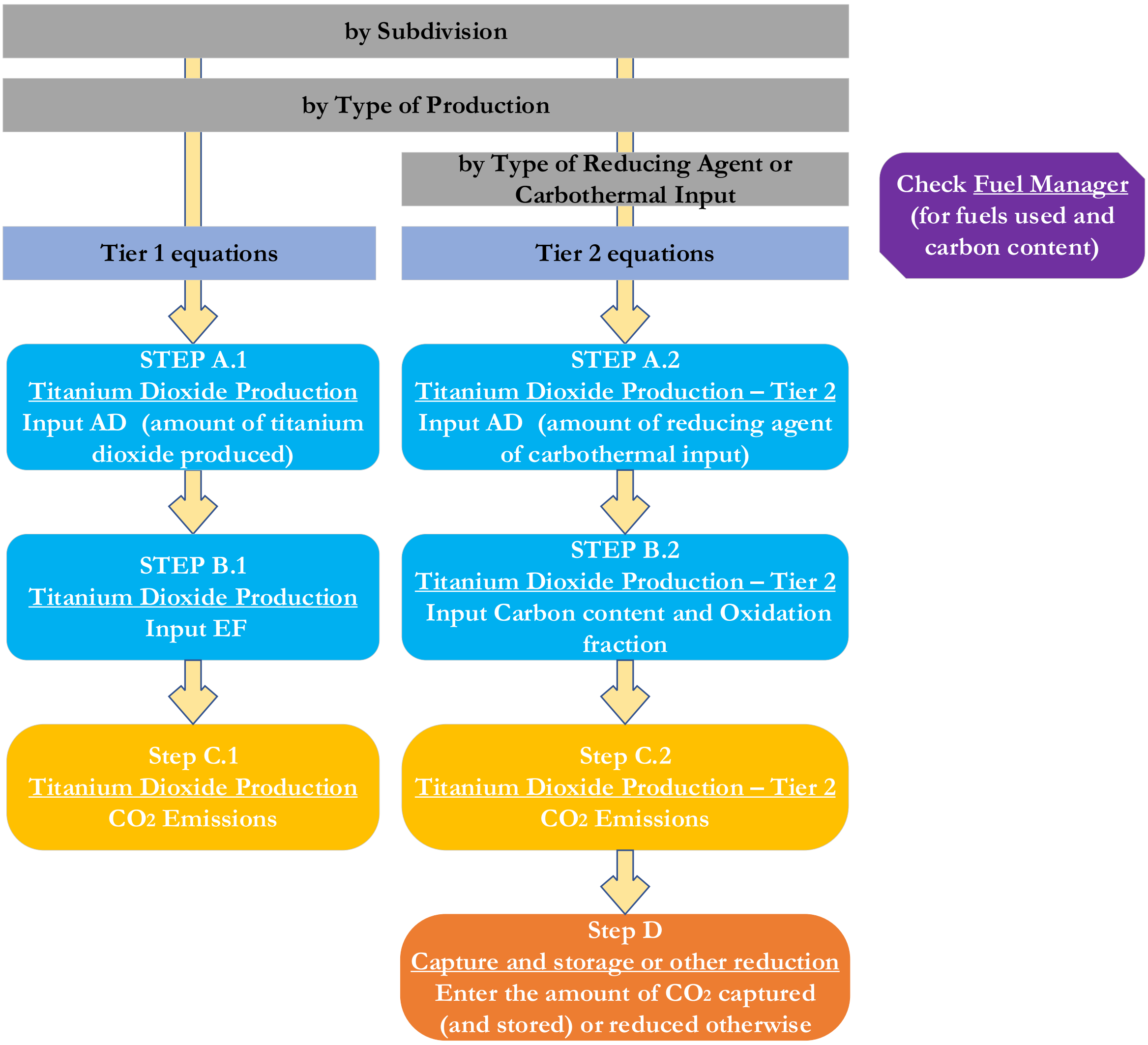
Consistent with the key category analysis and the decision tree in Figure 3.6 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Prior to following the flowchart below, the user shall collect and enter data in the **1.1.1 Fuel Manager** on each fuel used in TiO_2 production (necessary for Tier 2 only): 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.

Titanium Dioxide Production – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step A.1, in the worksheet **Titanium Dioxide Production,** users collect and input in the *Software* information on the amount of TiO_2 produced by each type (titanium slag, synthetic rutile or rutile TiO_2).

Step B.1, in worksheet **Titanium Dioxide Production,** users input CO_2 EFs per unit of production of titanium slag, synthetic rutile or rutile TiO_2.

Step C.1, in the worksheet **Titanium Dioxide Production,** for each subdivision and each production type, the *Software* calculates the associated CO_2 emissions in mass units (tonne and Gg). In addition, the total CO_2 emissions are calculated.

When the Tier 2 Equation is applied:

Step A.2, in worksheet **Titanium Dioxide Production – Tier 2,** users select the fuel type(s) or other carbothermal inputs and amounts used as reducing agents for TiO_2 production, by each type of production (titanium slag, synthetic rutile or rutile TiO_2).

Step B.2, in worksheet **Titanium Dioxide Production – Tier 2,** users collect and input the carbon content and carbon oxidation factors for the reducing agent or carbothermal input used, by each type of production (titanium slag, synthetic rutile or rutile TiO_2).

Step C.2, in the worksheets **Titanium Dioxide Production – Tier 2,** for each subdivision and each production type, the *Software* calculates the associated CO_2 emissions in mass units (kg and Gg). In addition, the total CO_2 emissions are calculated.

Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2.

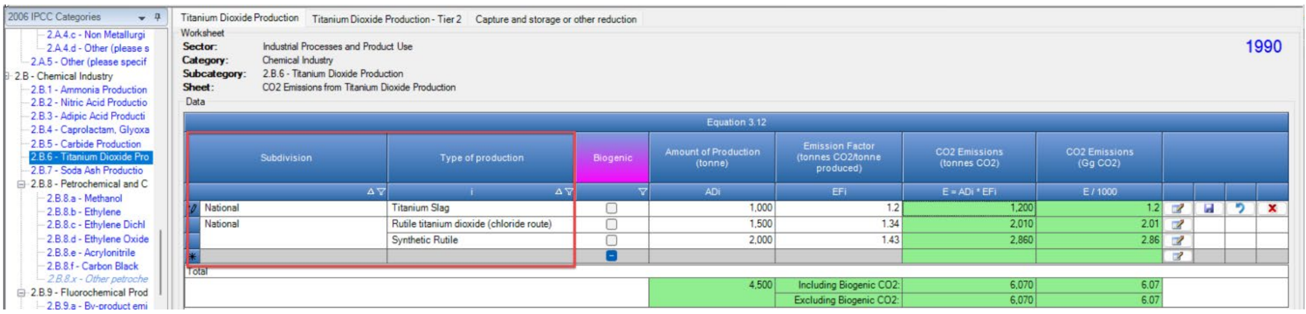
Activity data input

Section 3.7.2.3 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Titanium Dioxide Production.

As a **Starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for titanium dioxide production (Tier 2 only); 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 drop-down menu.

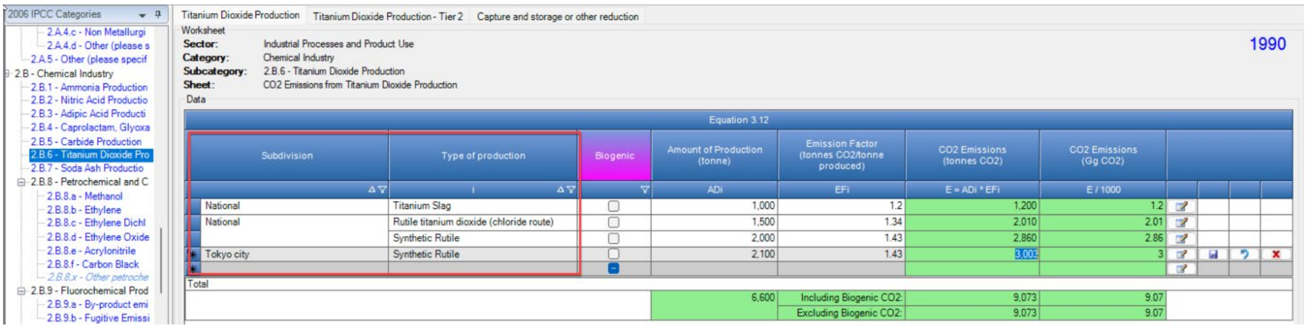
Second, input of AD for the Titanium Dioxide Production source category requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified/national)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **Titanium Dioxide Production,** row by row, as follows:

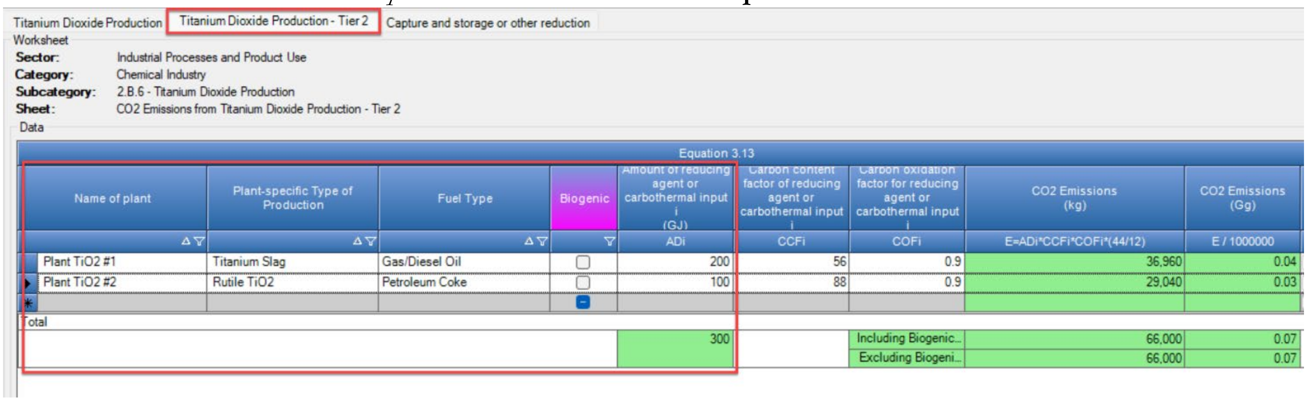
1. Column |i|: select the type of production process for titanium dioxide from the drop-down menu- titanium slag, synthetic rutile or rutile TiO_2, or the user may overwrite
2. Column |Biogenic |: indicate with a check if the process fuel is of biogenic origin.
   Note that as this is a Tier 1 the type of fuel is not required to be known. By default, the assumption is that the TiO_2 is using reducing agents of fossil origin, and therefore this column should remain unchecked.
3. Column |ADi|: input the mass of TiO_2 produced using each production process, in tonnes
   Note that fuel input is not used for the Tier 1 method. However, if known and to avoid double counting, the amount of reducing agent or carbothermal input used for titanium dioxide production should be subtracted from fuel use included in the Energy Sector.

When the Tier 2 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **Titanium Dioxide Production – Tier 2,** row by row, as follows:

1. Column |Name of plant|: enter the name of each plant; the Tier 2 requires plant level AD.
2. Column |Plant-specific Type of Production|: select the type of production process for titanium dioxide from the drop-down menu- titanium slag, synthetic rutile or rutile TiO_2, or the user may overwrite.
3. Column |Reducing agent/Carbothermal input|: select each reducing agent or carbothermal input used as a reducing agent from the drop-down menu (one row for each fuel type).
   Note that if a carbothermal input is used that is not included in the Fuel Manager, the user may either enter that input in the Fuel Manager, and thus make it available for selection from the drop-down menu, or alternatively, select "Unspecified" for the Fuel Type and describe in the User Notes or Remarks the carbothermal input used.
4. Column |Biogenic|: indicate with a check if the fuel is of biogenic origin.
5. Column |ADi|: enter the mass/amount of reducing agent or carbothermal input used for each plant, in GJ.
   Note that to avoid double counting, the amount of reducing agent or carbothermal input used for titanium dioxide production should be subtracted from fuel use included in the Energy Sector.

Example: **AD for titanium dioxide production – Tier 2**



Emission factor input

[Section 3.7.2.2](#) in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Titanium Dioxide Production.

There are two types of EFs:

i) Default CO_2 EF for Tier 1 - in tonne of CO_2 per tonne of product produced ([Table 3.9](#) in Chapter 3 Volume 3 of the *2006 IPCC Guidelines*)

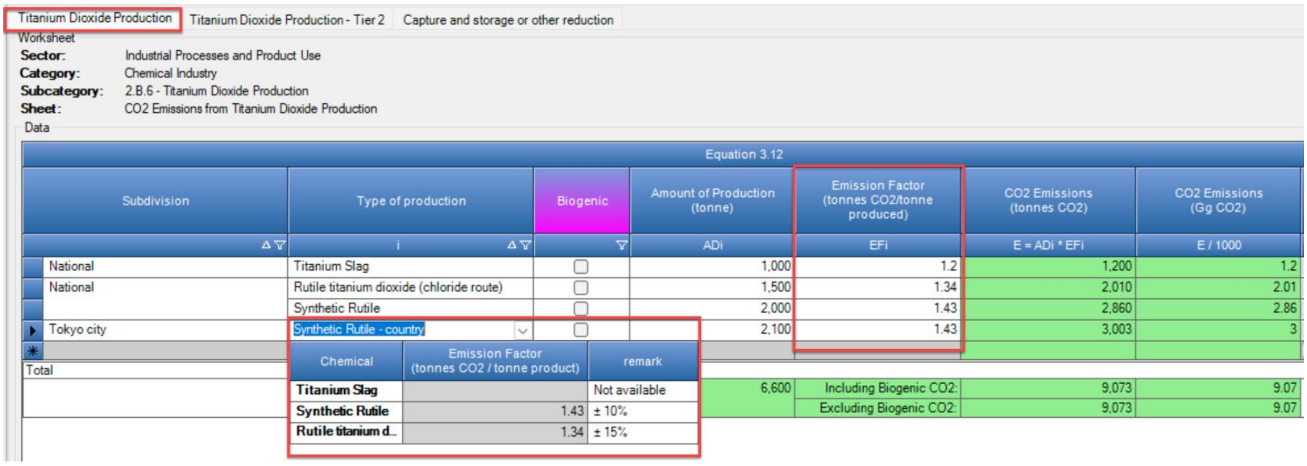
ii) Plant-specific CO_2 EFs for Tier 2 collected by users – the carbon content and carbon oxidation factors for reducing agent or carbothermal input (kg C/GJ and fraction, respectively).

When the Tier 1 Equation is applied:

For each combination of subdivision/type of production process in worksheet **Titanium Dioxide Production**:

1. Column |EFi|: the CO_2 EF is automatically populated in tonne of CO_2/tonne of product produced, when synthetic rutile or rutile titanium dioxide are selected in Column |i|. Users can overwrite these values with user-specific information, if available, and in the case of the TiO_2 produced via the titanium slag production process, must directly enter the CO_2 EF in this column.

Example: **EFs for Titanium Dioxide Production – Tier 1**

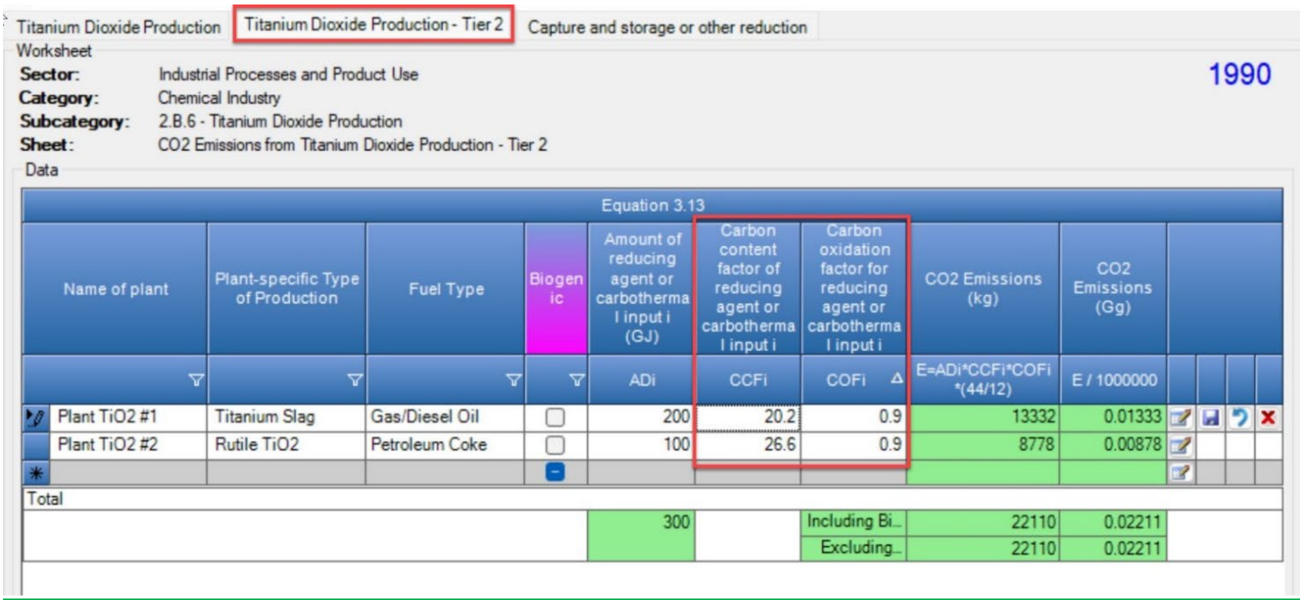


When the Tier 2 Equation is applied:

For each combination of subdivisions/individual plant/production process/fuel type, users need to input the following EFs/parameters:

1. Column |CCFi|: the carbon content factor for the corresponding fuel is automatically populated, in kgC/GJ, or the user may overwrite with user-specific information. Where a carbothermal input is used that is not in the Fuel Manager and thus Unspecified is selected in Column |Reducing agent/Carbothermal input, the user must insert a user-specifi cvalue for the carbothermal input.
2. Column |COFi|: input the carbon oxidation factor for the reducing agent or carbothermal input (fraction).

Example: **EFs for titanium dioxide production – Tier 2**



Results

CO_2 emissions from Titanium Dioxide Production are estimated in mass units (tonne/kg and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets:

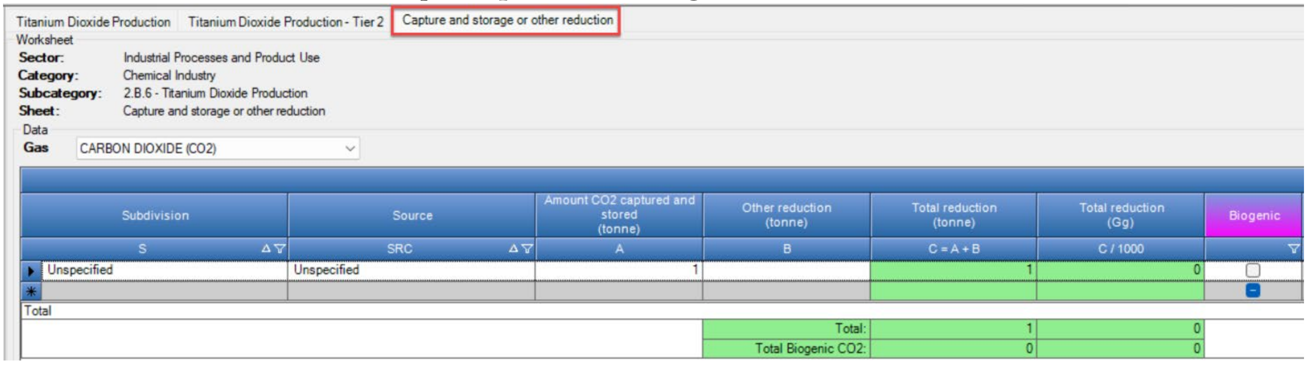
- ✓ **Titanium Dioxide Production**
- ✓ **Titanium Dioxide Production – Tier 2**

Total CO_2 emissions from titanium dioxide production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where CO_2 capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2, in tonnes.
   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.
4. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.
   Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.

Example: **Capture and storage or other reduction**



2.B.7 Soda Ash Production

Information

Soda ash can be produced by different processes - natural processes (monohydrate, sodium sesquicarbonate or trona and direct carbonation) and synthetic processes (Solvay process). CO_2 emitted during the natural production processes should be accounted for here in 2.B.7. CO_2 emitted during the use of soda ash should be accounted for under the source category of the relevant industry where the soda ash is used.

The *2006 IPCC Guidelines* provide three Tiers to estimate CO_2 emissions from natural Soda Ash Production. Tier 1 is a default method, with national AD (input/trona or output/soda ash) multiplied by default EFs. To use the Tier 2 method, it is necessary to gather complete data on trona consumption or natural soda ash production for each of the plants within the country along with plant-specific EFs for the trona input or soda ash output. Tier 3 uses plant-level data derived from direct measurements to estimate CO_2 emissions. In theory, the Solvay process does not lead to CO_2 emissions because the CO_2 generated as a by-product is recovered and recycled for use in the carbonation stage (i.e. CO_2 generation equals uptake).

GHGs

The *Software* includes the following GHG for the Soda Ash Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X						

IPCC Equations

- ✓ Tier 1: Equation 3.14
- ✓ Tier 2: IPCC Tier 1 equation, although with plant-specific AD, and if available EFs
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*, emissions based on direct measurement

As explained in section **1.1.3 Use of multiple Tiers for reporting**, GHG estimates prepared with user-specific Tier 3 methods, including emission from the soda ash produced via the Solvay process can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

GHG emissions from the Soda Ash Production source category are estimated using the following worksheets:

- ✓ **Soda Ash Production:** contains for each subdivision and each type of AD (e.g. trona used or soda ash produced) information on the amount of trona consumption or natural soda ash produced and EFs. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

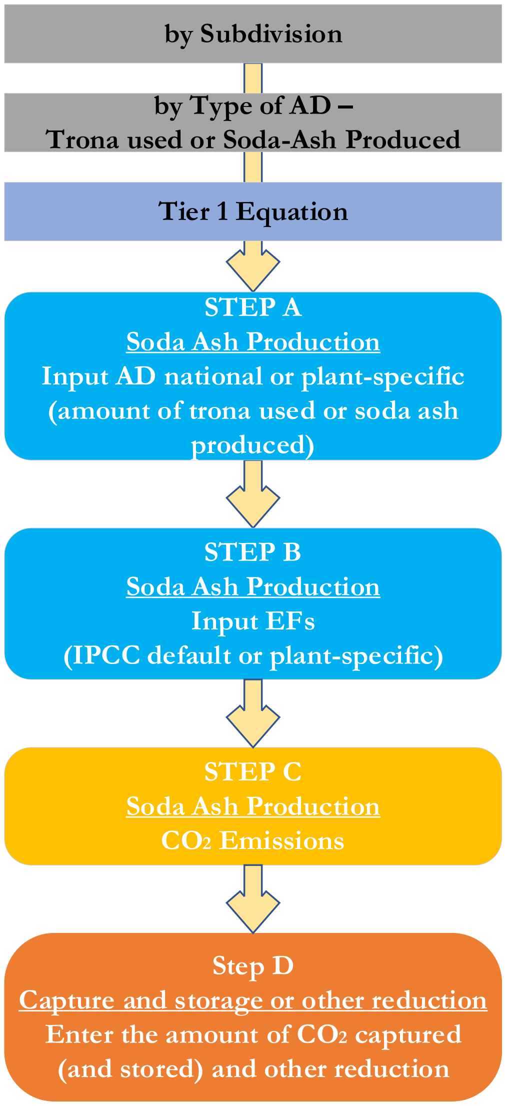
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.7 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Soda Ash Production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Soda Ash Production- flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step A, in the worksheet **Soda Ash Production,** users collect and input in the *Software* information on the amount of either trona consumption or natural soda ash production (Tier 1 – national level, Tier 2 – plant-specific).

Step B, in the same worksheet **Soda Ash Production,** users either collect or directly input the CO_2 EFs for each type of AD.

Step C, in the same worksheet **Soda Ash Production,** the *Software* calculates the associated CO_2 emissions for each subdivision (and each type of AD) in mass units (tonne and Gg). In addition, total CO_2 emissions are calculated

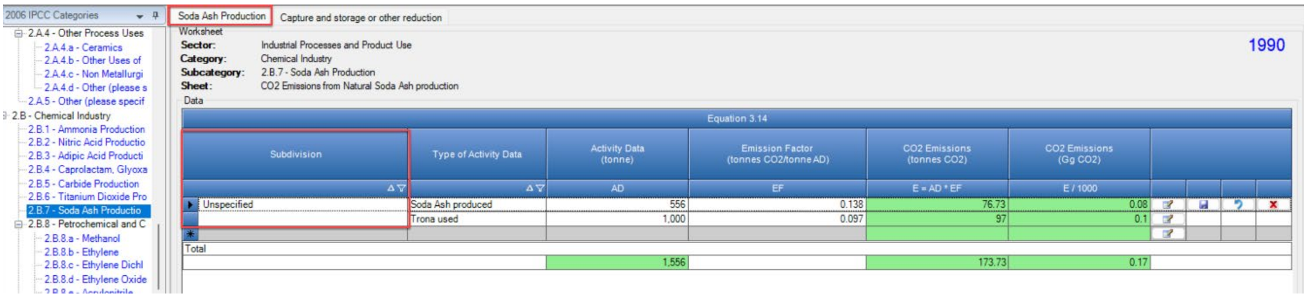
Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2.

Activity data input

Section 3.8.2.1 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Soda Ash Production.

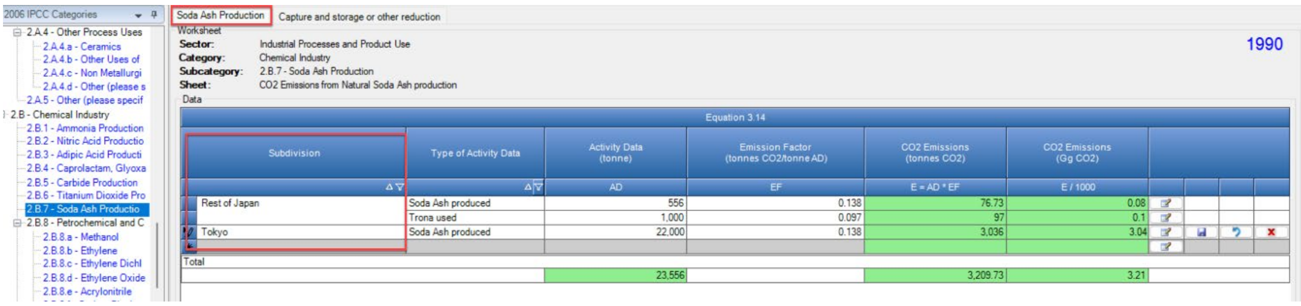
Input of AD for the Soda Ash Production source category requires the user to first enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



Then for each subdivision input information in worksheet **Soda Ash Production** in a single row, or in a number of rows, as follows:

1. Column |Type of Activity Data|: select from the drop-down menu the type of AD – input (trona used) or output (soda ash produced).
2. Column |AD|: input the mass of either trona consumption or soda ash production, in tonnes.

Emission factor input

Section 3.8.2.1 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Soda Ash Production.

For Tier 1, the following default CO_2 EFs are presented in the *2006 IPCC Guidelines*: CO_2 EF for Trona = 0.097 tonnes CO_2/tonne of trona, CO_2 EF for soda ash = 0.138 tonnes CO_2/tonnes natural soda ash produced.

Then, for each combination of subdivision/type of AD in worksheet **Soda Ash Production:**

1. Column |EF|: input or select the down-down the default CO_2 EFs (Tier 1) or input manually plant-specific CO_2 EFs (Tier 2) in tonnes of CO_2 per tonne of soda ash produced or trona used.

Example: **EFs for soda ash production – Tier 1&2**

Soda Ash Production | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.7 - Soda Ash Production
Sheet: CO2 Emissions from Natural Soda Ash production

Data

Equation 3.14					
Subdivision	Type of Activity Data	Activity Data (tonne)	Emission Factor (tonnes CO2/tonne AD)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		AD	EF	E = AD * EF	E / 1000
Rest of Japan	Soda Ash produced	556	0.138	76.73	0.08
	Trona used	1,000	0.097	97	0.1
Tokyo	Soda Ash produced	22,000	0.138	3,036	3.04
Total		23,556			3.21

Type of Activity Data	CO2 Emission Factor (tonnes CO2/tonne AD)
Soda Ash production	0.138

Results

CO_2 emissions from Soda Ash Production are estimated in mass units (tonne and Gg) by the *Software* in the same worksheet **Soda Ash Production.**

Total CO_2 emissions from soda ash production is the sum of all emissions in the above worksheet, taking into account any CO_2 capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where CO_2 capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A| users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on other long-term reduction of CO_2, in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**

Soda Ash Production | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.7 - Soda Ash Production
Sheet: Capture and storage or other reduction

Data

Gas CARBON DIOXIDE (CO2)

Subdivision	Source	Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
S	SRC	A	B	C = A + B	C / 1000
Plant#2	Unspecified	50		50	0.05
Total				50	0.05

2.B.8 Petrochemical and Carbon Black Production

GHG emissions from petrochemicals production include CO_2 and CH_4 emitted from fuel or process by-products combusted to provide heat or thermal energy to the production process, CO_2 and CH_4 emitted from process vents, and CO_2 and CH_4 emitted from flared waste gases. Section 3.9 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* provides common methodological guidance for estimating GHG emissions from category 2.B.8 Petrochemical and carbon black production, which specifically covers six sub-categories:

- ✓ **2.B.8.a Methanol**
- ✓ **2.B.8.b Ethylene**
- ✓ **2.B.8.c Ethylene Oxide**
- ✓ **2.B.8.d Ethylene Dichloride (EDC) and Vinyl Chloride Monomer (VCM)**
- ✓ **2.B.8.e Acrylonitrile**
- ✓ **2.B.8.f Carbon Black**

These petrochemicals and carbon black are addressed in detail because their global production volume and associated GHG emissions are relatively large. However, the chemicals included are not intended to represent the entire petrochemical process industry. There are a number of other petrochemical processes that emit small amounts of GHGs for which specific guidance is not provided in the *2006 IPCC Guidelines* (e.g., styrene production). A seventh category, **2.B.8.x Other petrochemical production** has been added to the *Software* to allow for reporting of these additional petrochemicals, and to enable interoperability with the UNFCCC ETF Reporting Tool.

In addition to the common methodological guidance, additional guidance is provided to estimate GHG emissions from production of secondary products for 2.B.8.b Ethylene and 2.B.8.e Acrylonitrile.

Guidance for how to use the *Software* to estimate GHG emissions from petrochemical and carbon black production is provided, together, below due to application of common methodologies. Any distinctions for use of the *Software* for a specific petrochemical, or group of petrochemicals, is highlighted, where relevant.

Three methodological tiers are provided in the *2006 IPCC Guidelines* for estimating GHG emissions from this source category. Tier 1 is a product-based EF method (default method) and applied to estimate CO_2 and CH_4 emissions. Tier 2 is a total feedstock carbon balance method (for CO_2 only). This approach is applicable in cases where AD for all carbon flows are available for both feedstock consumption and primary and secondary product production and disposition. Tier 3 requires plant-specific data and/or measurements.

GHGs

The *Software* includes the following GHGs for all subcategories of the petrochemical and carbon black source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X					

IPCC Equations

The following IPCC Equations apply to all subcategories of the petrochemicals and carbon black source category, as described: '

CO_2 emissions:

- ✓ Tier 1: Equation 3.15, if information on production of each petrochemical is known. Equations 3.15 and 3.16 if the amount of petrochemical produced is not known, but the user has information on feedstock consumption for petrochemical production.
- ✓ Tier 2: Equation 3.17. In addition, for production of **Ethylene** and **Acrylonitrile,** Equations 3.18 and 3.19, respectively.
- ✓ Tier 3: Equations 3.20 and 3.21 and 3.22

CH_4 emissions:

- ✓ Tier 1: Equations 3.23 and 3.24 and 3.25
- ✓ Tier 2: No Tier 2 Equations exist for CH_4 emissions in the *2006 IPCC Guidelines*

- ✓ Tier 3: Equation 3.26 or Equations 3.27 and 3.28 and 3.29
  Note that a plant would use either i) Equation 3.26 (atmospheric measurements) or ii) Equations 3.27, 3.28, and 3.29 (combustion, flaring and venting) to estimate CH_4 emissions following the Tier 3 method

As explained in section **1.1.3 Use of multiple Tiers for reporting**, for both CO_2 and CH_4, estimates prepared with user-specific Tier 3 methods can be reported in the *Software* worksheets that implement the IPCC Tier 1 equation.

Software Worksheets

GHG emissions from the Petrochemical and Carbon Black source category are estimated using the following worksheets. The set of worksheets available to the user for all subcategories have a common naming convention, except for the first worksheet for collection of AD, which has a unique name for each chemical, as follows:

- ✓ **1.1.1 Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **[Methanol][Ethylene][Ethylene Dichloride and Vinyl Chloride Monomer][Ethylene Oxide][Acrylonitrile][Carbon Black][Other petrochemical] Production – Tier 1/2** worksheet is an AD input worksheet for Tier 1 and Tier 2 for CO_2 and CH_4 emissions. It contains for each subdivision the choice of data input based on the chemical produced or feedstock consumed for each type of production process. In the worksheets for **Ethylene** and **Acrylonitrile** there is also a sub-table for inputting the AD associated with the carbon content of secondary products.
- ✓ **CO_2 Emissions – Tier 1:** contains for each subdivision/production process the amount of the specific chemical produced and the CO_2 EFs. The worksheet calculates the associated CO_2 emissions.
- ✓ **CH_4 Emissions – Tier 1:** contains for each subdivision/production process the amount of the specific chemical produced and the CH_4 EFs, by source (total, fugitive and venting). The worksheet calculates the associated CH_4 emissions through use of a sub-table.
- ✓ **CO_2 Emissions – Tier 2:** contains for each subdivision information on the carbon content of the chemical produced. The data on total carbon content of feedstock and chemical production (both primary product, and in the case of ethylene and acrylonitrile, secondary product) are automatically transferred from the relevant AD worksheet. The worksheet calculates the associated CO_2 emissions for Tier 2 (based on carbon/mass-balance).
- ✓ **CO_2 and CH_4 Emissions from Combustion – Tier 3 (1/3):** contains for each subdivision (plant-level) information on the type and amount of fuel used, conversion factor and EFs for CO_2 and CH_4. The worksheet calculates the associated plant-specific CO_2 and CH_4 emissions from combustion.
- ✓ **CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3):** contains for each subdivision (plant-level) information on the type and amount of flared gas (including whether the flared gas is of biogenic origin), conversion factor and EFs for CO_2 and CH_4. The worksheet calculates the associated plant-specific CO_2 and CH_4 emissions from flaring.
- ✓ **CO_2 and CH_4 Emissions Summary – Tier 3 (3/3):** contains for each subdivision (plant-level) information on the amount of emissions from venting (including whether the vented emissions are of biogenic origin). The combustion and flaring emissions are transferred automatically from the two previous worksheets. The worksheet calculates the total plant-specific CO_2 and CH_4 emissions from combustion, flaring and venting.
- ✓ **Atmospheric measurement data – CH_4 Emissions – Tier 3:** contains for each subdivision/plant (and each measurement campaign) the measured atmospheric concentrations of VOC/CH_4 and other parameters (fraction of CH_4 in VOC, background/reference concentrations, wind speed and plume area). The results of CH_4 emissions from measurements campaigns are summed over time to present annual CH_4 emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2 and CH_4, not accounted previously in the worksheets for different Tiers.

User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 3.8 (for CO_2 emissions) and Figure 3.9 (for CH_4 emissions) of the *2006 IPCC Guidelines,* as well as Figure 3.10 (illustrating the Tier 2 carbon balance flow diagram), GHG estimates are calculated using a single methodological tier for each chemical in the petrochemical and carbon black production source category, or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements for that source category.

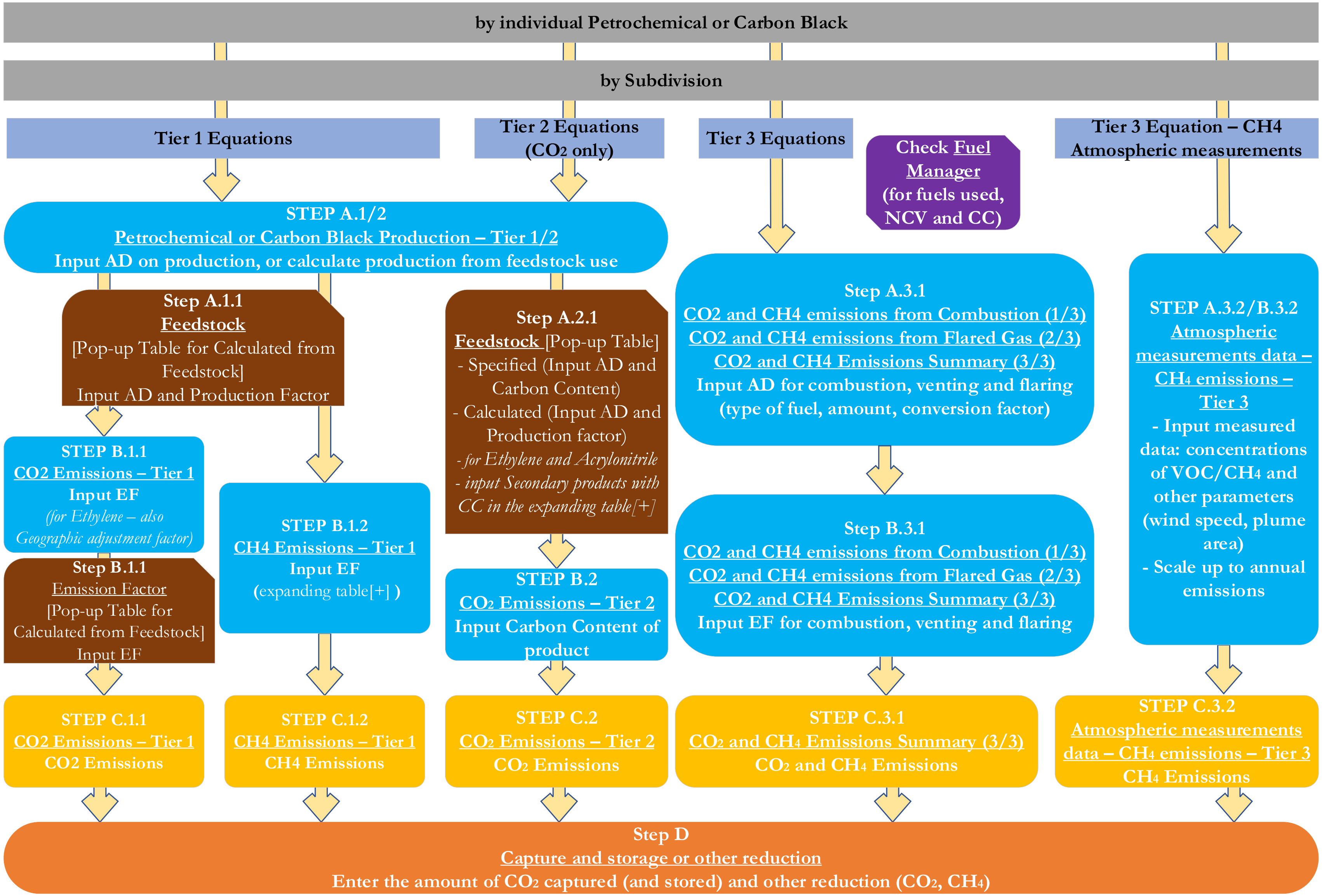
To ease the use of the *Software* as well as to avoid its misuse, for the Petrochemical and Carbon Black Production source category, users follow the following two flowcharts for CO_2 and CH_4 emissions. As the emissions from petrochemical and carbon black production vary both with the process used and the feedstock used, the choice of method shall be repeated for each product, process and feedstock used.

Prior to following the flowchart below, for users applying the Tier 3 method for CO_2 (Equations 3.27, 3.28 and 3.29) shall collect and enter data in the **1.1.1 Fuel Manager** on each fuel used for the petrochemical and carbon black production 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.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Petrochemical and Carbon Black Production – CO_2 and CH_4– flowchart

Note that this flowchart shall be followed for subcategories 2.B.8.a – 2.B.8.f and 2.B.8.x, as applicable



Thus, for the relevant petrochemical or carbon black subcategory:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 or Tier 2 Equations are applied:

Step A.1/A.2, in the worksheet **[Methanol][Ethylene][Ethylene Dichloride and Vinyl Chloride Monomer][Ethylene Oxide][Acrylonitrile][Carbon Black][Other petrochemical] Production – Tier 1/2 ,** users collect and input in the *Software* information either the amount of the respective chemical produced (specified input by users) or the amount of feedstock used (from which the amount of chemical produced is calculated) for each type of production process. Information on feedstock is entered in pop-up table (**Step A.1.1** and **Step A.2.1)**

For the **Ethylene and Acrylonitrile** subcategories (Tier 2), users specify or calculate (by applying a production factor from feedstock) the amount of each secondary product produced from feedstock (**Step A.2.1)**.

Then, for Tier 1:

Step B.1.1, in the worksheet **CO_2 Emissions – Tier 1,** users input CO_2 EFs for each type of production process, per tonne of chemical produced. For the **Ethylene Production** subcategory, users also enter in the geographic adjustment factor, if applicable. Where the CO_2 EF is based on feedstock consumption, the CO_2 EF is calculated in a pop-up table (**Step B.1.1).**

Step B.1.2, in the worksheet **CH_4 Emissions – Tier 1,** users input CH_4 EFs for each type of production process/source (total/fugitive/venting), per tonne of chemical produced.

Step C.1.1, in the worksheet **CO_2 Emissions – Tier 1,** the *Software* calculates the associated CO_2 emissions for each type of production process in mass units (tonne and Gg). In addition, total CO_2 emissions are calculated.

Step C.1.2, in the worksheet **CH_4 Emissions – Tier 1,** the *Software* calculates the associated CH_4 emissions for each type of production process/ source (total/fugitive/venting in mass units (tonne and Gg). In addition, total CH_4 emissions are calculated.

Then, for Tier 2:

Step B.2, in the worksheet **CO_2 Emissions – Tier 2,** users input the carbon content of the chemical produced for each type of production process, per tonne of chemical produced.

For the **Ethylene Production** and **Acrylonitrile Production** subcategories, in the sub-tables of the worksheets **Ethylene Production-Tier 1/2** and **Acrylonitrile Production-Tier 1/2,** users input the carbon content of each secondary product produced (**Step A.2.1)**.

Step C.2, in the worksheet **CO_2 Emissions – Tier 2,** the *Software* calculates the associated CO_2 emissions for each type of production process in mass units (tonne and Gg). In addition, total CO_2 emissions are calculated.

When the Tier 3 Equations are applied:

<u>For the Plant-specific Data Approach</u>

Step A.3.1, in the worksheets **CO_2 and CH_4 Emissions from Combustion – Tier 3 (1/3), CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3) and CO_2 and CH_4 Emissions Summary – Tier 3 (3/3),** users collect and input in the *Software* information on the amount of fuel used, gas flared and gas vented, and their units.

Step B.3.1, in the worksheets **CO_2 and CH_4 Emissions from Combustion – Tier 3 (1/3) and CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3),** users input the conversion factors and CO_2 and CH_4 EFs for the fuels combusted and gases flared.

Step C.3.1 in the worksheet **CO_2 and CH_4 Emissions Summary – Tier 3 (3/3),** the *Software* calculates the associated GHG emissions in mass units (tonne and Gg). In addition, total GHG emissions are calculated.

<u>For the Atmospheric Measurement Approach</u>

Step A.3.2, /B.3.2 in the worksheet **Atmospheric measurement data – CH_4 Emissions – Tier 3,** users collect and input in the *Software* for each plant and each measurement campaign, the atmospheric concentrations of VOC/CH_4 and other parameters (fraction of CH_4 in VOC, background/reference concentrations, wind speed and plume area, summing up measurement campaigns to cover the entire year.

Step C.3.2 in the worksheet **Atmospheric measurement data – CH_4 Emissions – Tier 3**, the *Software* calculates the associated CH_4 emissions for each plant in mass units (kg and Gg).

Then, for each tier, as appropriate:

Step D, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of GHG, not otherwise captured in the worksheets above.

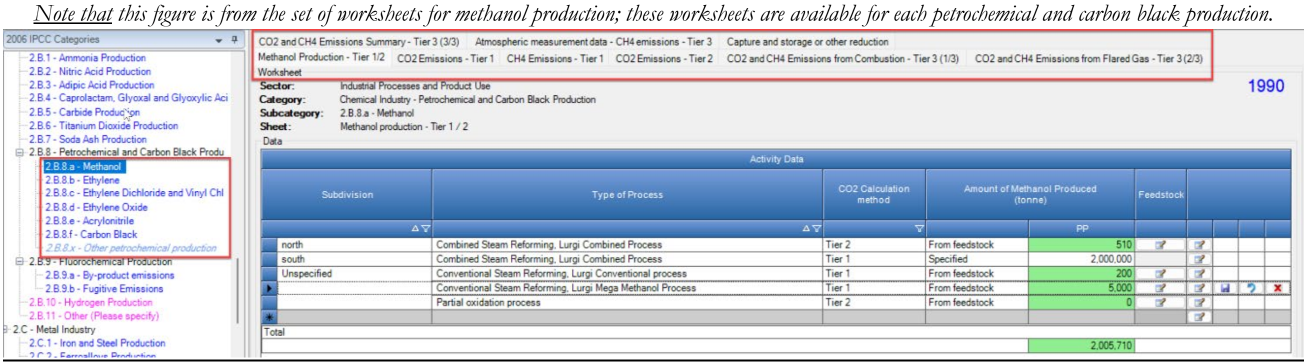
Activity data input

Section 3.9.2.3 Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for each chemical in the Petrochemical and carbon black production source category.

Input of AD for Petrochemical and carbon black production source category requires the user first to navigate to the relevant chemical in the navigation tree on the left-hand side of the screen, and then select the worksheet for AD entry. The AD entry worksheet is labelled as **[Name of chemical] Production-Tier 1/2**.

Example: **common set of worksheets for each chemical**

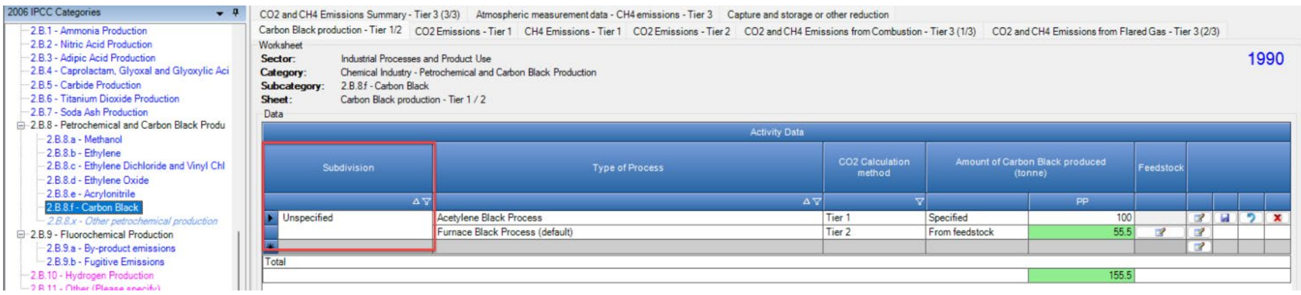
Note that this figure is from the set of worksheets for methanol production; these worksheets are available for each petrochemical and carbon black production.



Input of AD for the subcategories of the Petrochemical and Carbon Black Production source category requires the user to first enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**

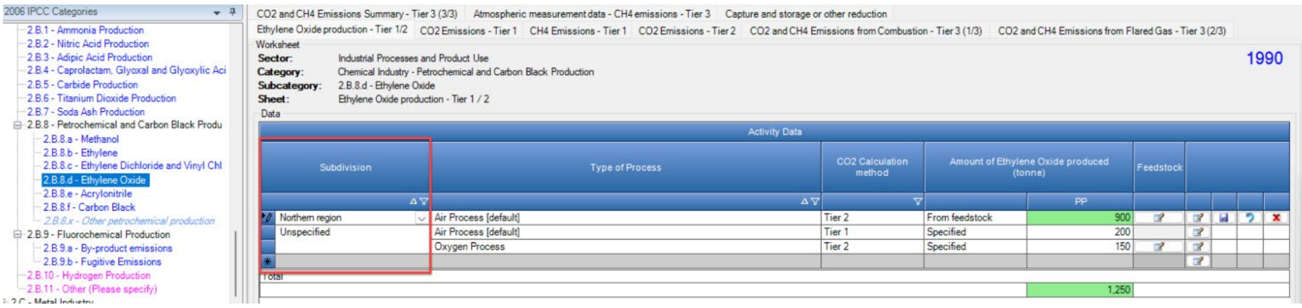
Note that this figure is from the set of worksheets for carbon black production; a unique subdivision could be identified for each chemical.



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**

Note that this figure is from the set of worksheets for ethylene oxide production; separate subdivisions could be identified for each chemical



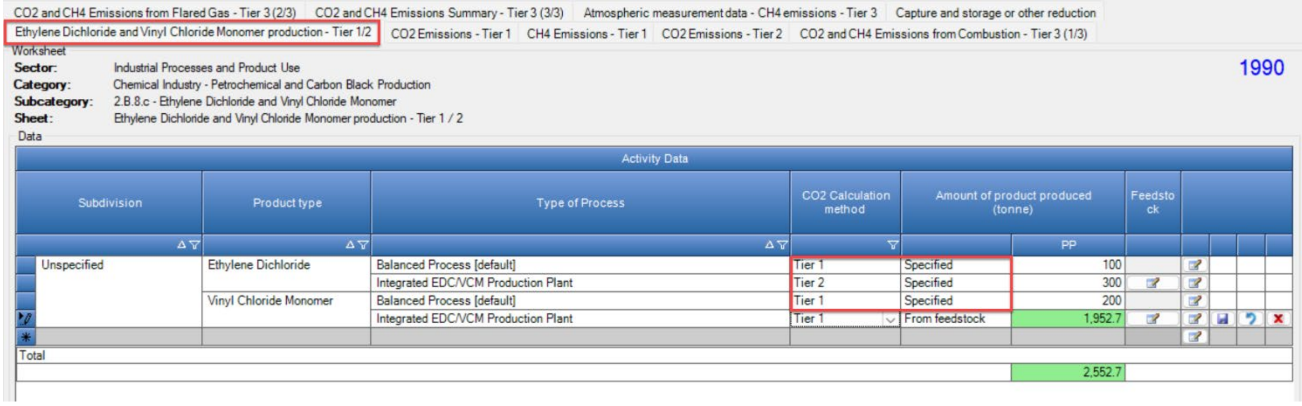
When the Tier 1 and Tier 2 Equations are applied:

For each chemical, and each subdivision for that chemical in worksheet **[Methanol][Ethylene][Ethylene Dichloride and Vinyl Chloride Monomer][Ethylene Oxide][Acrylonitrile][Carbon Black][Other petrochemical] Production – Tier 1/2**, the user will in Column |Subdivision| input information in a single row, or in a number of rows, as follows:

1. Column |Product Type| (applicable to subcategory 2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer Production subcategory only): select from the drop-down menu whether information in that row is for the production of ethylene dichloride or vinyl chloride monomer.
   Note that: Users should use either EDC production or VCM production (not both) as AD.
2. Column |Type of Process|: select the name of the type of production process for each chemical from the drop-down menu, or the user may overwrite.
   Note that, in the absence of country-specific information, the 2006 IPCC Guidelines provide a default process (and type of feedstock) in Table 3.11.
3. Column |CO_2 Calculation method|: select from the drop-down whether Tier 1 or Tier 2 is applied.
4. Column |Amount of [Chemical] Produced, PP|: select whether the AD for the amount of chemical produced is specified (i.e. entered) directly or calculated from the feedstock used (Tier 1 and Tier 2). For entry of AD, the following column headers are applicable when either Tier 1or Tier 2 methods are implemented:
   Note that:
   ***Specified**: when selected, the user inputs manually the amount of the chemical produced in Column |PP|.*
   ***From feedstock** –when selected, the user inputs in a sub-table (accessed by clicking on the icon in Column |Feedstock| the following:*
   Column |Type of Feedstock| Select the type of feedstock from the drop-down menu or enter a user-specific feedstock. In the absence of country-specific information, the 2006 IPCC Guidelines provide a default type of feedstock) in Table 3.11.
   Column |Biogenic| indicate with a check if the process fuel is of biogenic origin. Note that CO_2 emissions from flared gas of biogenic origin will not be included in national totals.
   Column |FA| enter the amount of feedstock consumed.
   Column |SPP|: slect the IPCC default for the tonnes of chemical produced per tonne of feedstock used, or overwrite with user-specific value. Once calculated, the amount of the chemical produced automatically appears in the main worksheet.
   Note that: for Tier 2, if the amount of chemical was specified in Column |PP|, Column |SPP| should not be filled, and in fact, any amount of petrochemical produced calculated in Column |PP| of the subtable, whill not tranfer back to the main table.
5. Column |Feedstock|: user shall select the icon in this column to enter information on feedstock consumed in two cases:
   - ✓ The user is calculating the amount of the chemical produced based on feedstock consumed (Tier 1 and Tier 2), as described in step 3 above.
   - ✓ The user has selected use of a Tier 2 method in Column |CO_2 Calculation method|**,** which requires information on the amount and carbon content of feedstock(s) consumed.

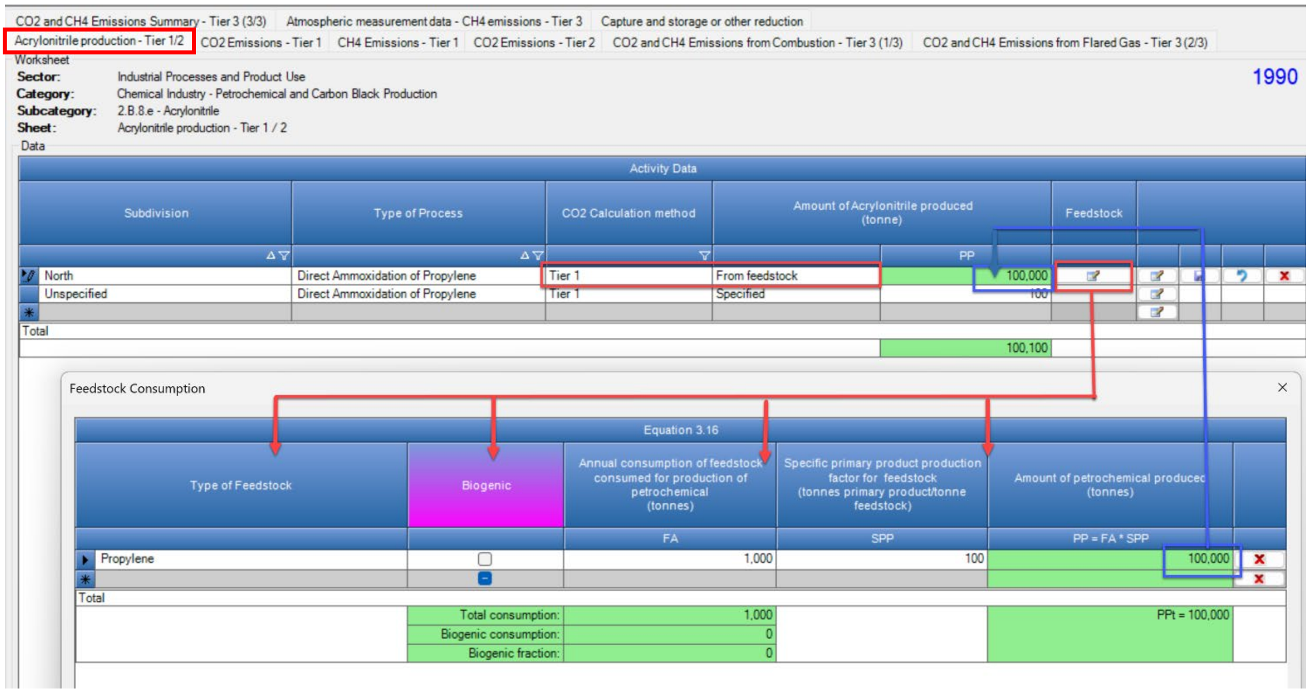
Example: **AD input Tier 1 and Tier 2–chemical produced is <u>specified</u> directly in <u>|Column PP|</u>**

<u>Note that</u> this figure is from the set of worksheets for EDC/VCM Production; this worksheet is available for each petrochemical and carbon black production.



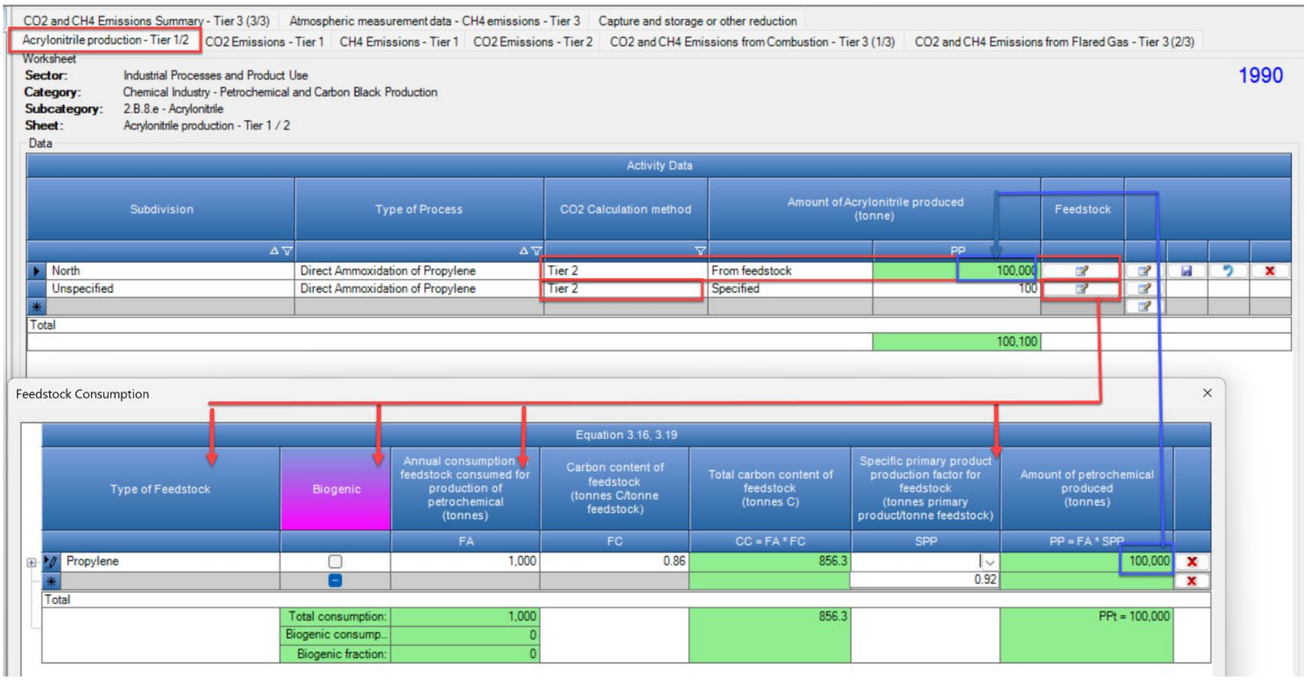
Example: **AD input Tier 1 –chemical produced calculated <u>from feedstock</u>**

<u>Note that</u> this figure is from the set of worksheets for Acrylonitrile Production; this sub-table is available for each petrochemical and carbon black production.



Example: **AD input Tier 2 –entering AD** **<u>from feedstock</u> use**

<u>Note that</u> this figure is from the set of worksheets for Acrylonitrile production; this sub-table is available for each petrochemical and carbon black production.



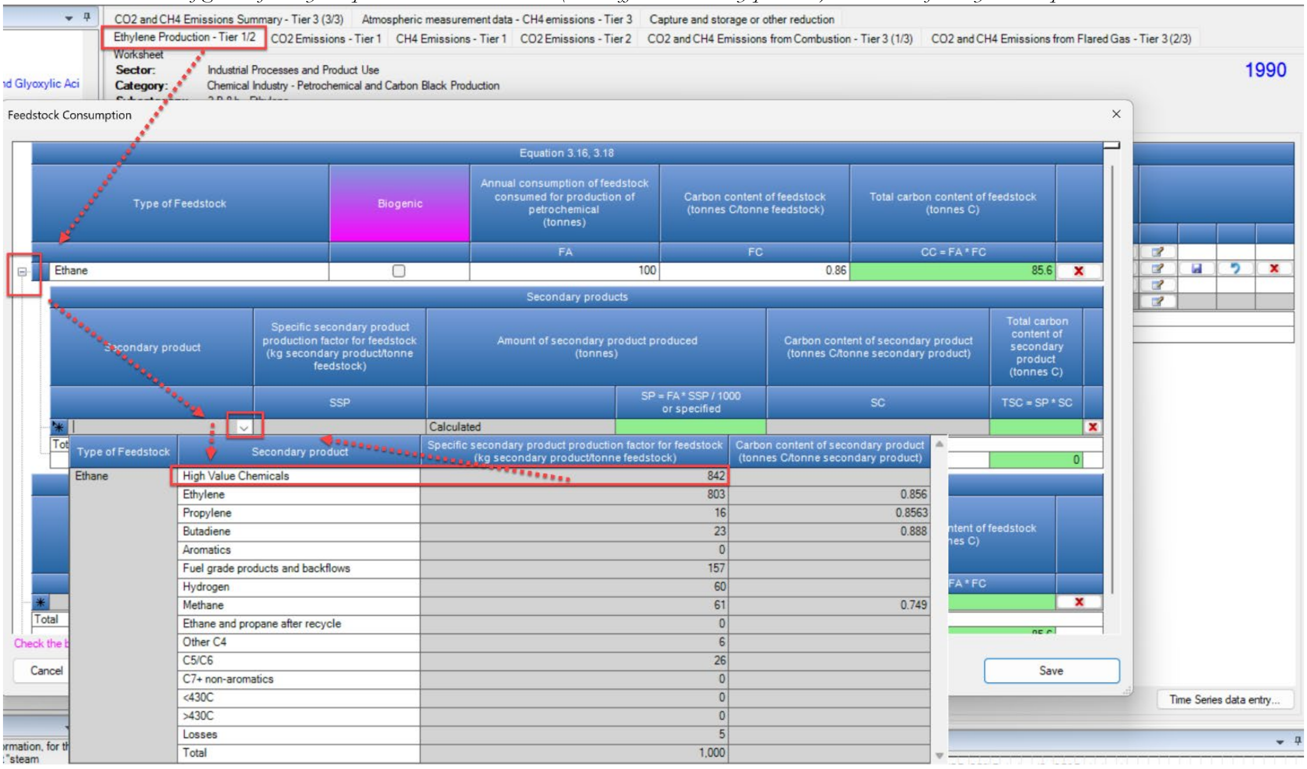
For the subcategories Ethylene Production (2.B.8.b) and Acrylonitrile Production (2.B.8.e) only:

In addition to entering information on the primary products above, when estimating GHG emissions for Ethylene Production and Acrylonitrile Production following a Tier 2 method (i.e. Tier 2 is selected in <u>Column |CO_2 Calculation method|</u>, AD on secondary products must also be entered in the feedstock sub-table by:

1. For each type of feedstock in the feedstock sub-table, click the symbol "⊞" on the left of the row to open a drop-down table where information on the secondary products are to be compiled. Then:
2. <u>Column |Secondary Product|</u>: select from the drop-down menu each secondary produced from the primary product for each type of feedstock, one row for each secondary product, or enter in user-specific secondary products.
<u>Note that:</u> In the absence of country specific information, the user shall enter one row for each and every secondary product available in the drop-down menu to ensure that the carbon content of these secondary products is considered in the mass balance at Tier 2.
3. <u>Column |SP|:</u> the user by default can *calculate* the amount of each secondary product produced, or may specify this information directly in <u>Column |SP|</u> by selecting "Specified"
   - ✓ If *Calculated:* by default, the *Software* automatically calculates the amount of secondary product produced in <u>Column |SP|</u>, in tonnes, for each type of secondary product selected from the drop-down menu in <u>Column |Secondary Product|</u>, based on default specific secondary product production factors automatically populated in <u>Column |SSP|</u> for the relevant feedstocks (in kg secondary product /tonne ethylene or acrylonitrile produced) taken from Table 3.25 (for ethylene) and Table 3.26 (for acrylonitrile) of the *2006 IPCC Guidelines*.
   - ✓ If *Specified:* <u>Column |SSP|</u> is greyed out and the user enters the amount of each secondary product directly in <u>Column |SP|</u>.

Example: **AD on secondary products input – Tier 2 – ethylene and acrylonitrile production only**

Note that this figure is for ethylene production; this sub-table (with different secondary products) is available for acrylonitrile production



For the subcategory Other Petrochemical Production (2.B.9.x) only:

Guidance for inputting AD for other petrochemical production follows the guidance provided above for subcategories 2.B.8.a-2.B.8.f, except an additional column is available to specify the other type of petrochemical that is produced. For other petrochemical production, AD entry for Tier 1 and Tier 2 is as follows:

1. Column |Petrochemical type|: select from the drop-down menu the type of petrochemical produced (i.e. styrene) or if another petrochemical, manually enter the chemical name.

It is assumed that secondary products are not applicable for other petrochemicals.

When the Tier 3 Equations are applied:

As illustrated in the flowchart for the petrochemical and carbon black production source category, there are two Tier 3 approaches for estimating GHG emissions, one applying plant-specific data, and one relying on atmospheric measurements. AD for these two Tier 3 approaches are discussed, separately, below.

Tier 3 using plant-specific data (CO_2 and CH_4 emissions)

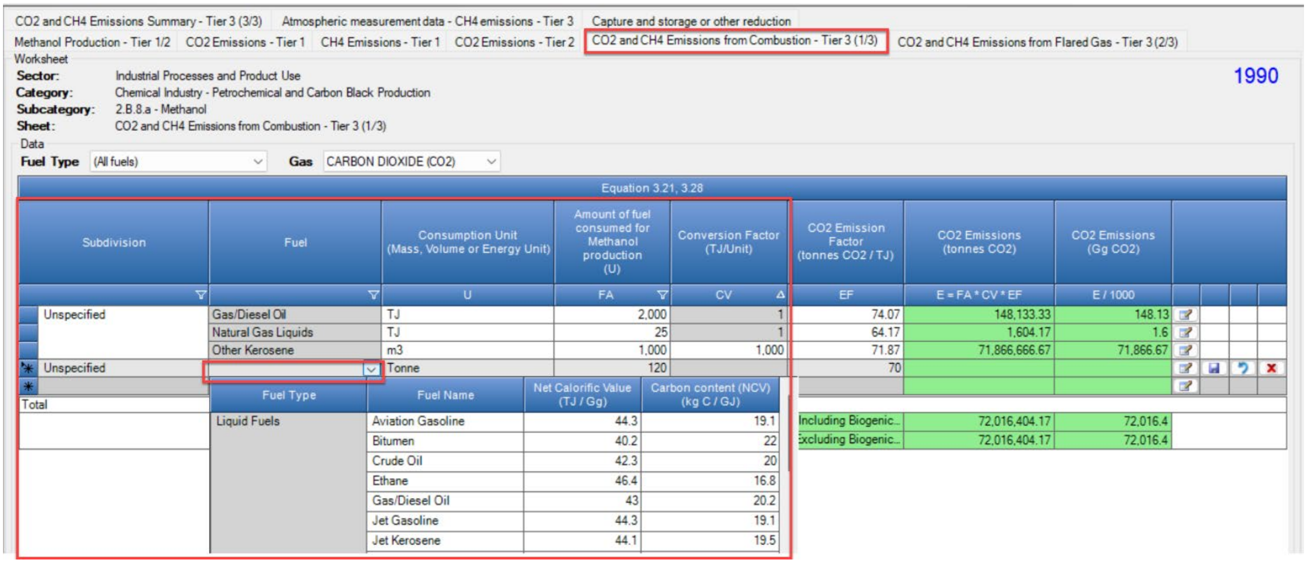
For each chemical, and each subdivision for that chemical in worksheet **CO_2 and CH_4 Emissions from Combustion – Tier 3 (1/3)**, the user will input information in a single row, or in a number of rows, plant-specific information as follows:

1. Column |Fuel|: select each fuel used from the drop-down menu (one row for each fuel). *Note that fuels shown in the drop-down 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|: select the unit of fuel consumption data (e.g. tonne, TJ, m^3) from the drop-down menu or overwrite with a user-specific unit.
3. Column |FA|: enter amount of fuel consumed.
4. Column |CV|: enter the conversion factor to convert the consumption unit to an energy unit (TJ). *Note that if Tonnes is selected, 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. m3) this cell becomes blank and the user shall enter the relevant conversion factor here the user shall enter the relevant conversion factor here.

Example: **AD for Tier 3 – amount of fuels combusted**

Note that this figure is for methanol production; this worksheet is available for each petrochemical and carbon black production.

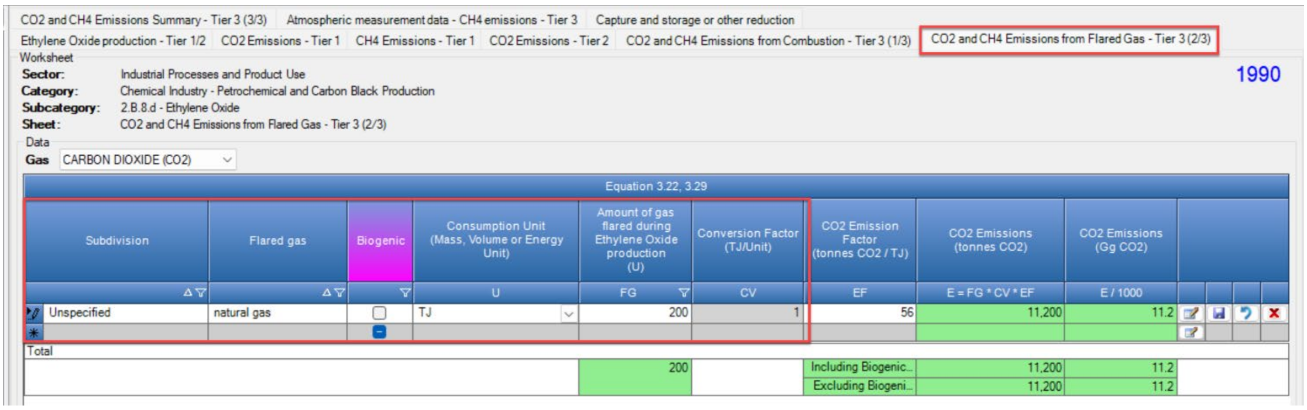


Then, for each chemical, and each subdivision for that chemical in worksheet **CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3)**, the user will input information in a single row, or in a number of rows, plant-specific information as follows:

1. Column |Flared Gas|: enter a name for, or description of, the flared gas (e.g. the type of gas).
2. Column |Biogenic| indicate with a check if the flared gas is of biogenic origin.
Note that CO_2 emissions from flared gas of biogenic origin will not be included in national totals.
3. Column |U|: select the unit of the amount of flared gas (e.g. GJ, TJ, m³) from the drop-down menu or overwrite with a user-specific unit.
5. Column |FG|: enter the amount of gas flared during production of the chemical.
6. Column |CV|: enter the conversion factor to convert the consumption unit to an energy unit (TJ).
Note that if the consumption unit is GJ or TJ the Software compiles the conversion factor cell with the value 0.001 or 1, respectively. Where other units are applied (e.g. tonne or m3) this cell becomes blank and the user shall enter the relevant conversion factor here.

Example: **AD for Tier 3 – amount of flared gas**

Note that this figure is for ethylene oxide production; this worksheet is available for each petrochemical and carbon black production.



Tier 3 using atmospheric measurements (CH_4 emissions)

The Tier 3 method using atmospheric measurements does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

For the subcategory Other Petrochemical Production (2.B.9.x) only:

Guidance for inputting AD for other petrochemical production follows the guidance provided above for subcategories 2.B.8.a-2.B.8.f, except an additional column is available to specify the other type of petrochemical that is produced. For other petrochemical production, AD entry for Tier 3 is as follows:

1. Column |Petrochemical type|: select from the drop-down the type of petrochemical produced (i.e. styrene) or if another petrochemical, manually enter the chemical name.

Emission factor input

Section 3.9.2.2 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for each subcategory of the petrochemical and carbon black production source category. The source for the IPCC default EFs for each chemical are presented in Table 2.

Table 3.11 provides the default feedstocks and processes assumed for each chemical for the Tier 1 method. IPCC default EFs are available for at least each default process/feedstock.

Table 2. Source of EFs for the petrochemical and carbon black production source category

Chemical	CO_2 EFs	CH_4 EFs
2.B.8.a Methanol	Table 3.12 and Table 3.10 (carbon content)	2.3 kg CH_4 emissions per tonne of methanol produced.
2.B.8.b Ethylene	Table 3.14, Table 3.15 (geographic adjustment factor), Table 3.10 (carbon content)	Table 3.16
2.B.8.c Ethylene dichloride and vinyl chloride monomer	Table 3.17, Table 3.10 (carbon content)	Table 3.19
2.B.8.d Ethylene oxide	Table 3.20, Table 3.10 (carbon content)	Table 3.21
2.B.8.e Acrylonitrile	Table 3.22, Table 3.10 (carbon content)	0.18 kg CH_4/tonne acrylonitrile produced
2.B.8.f Carbon black	Table 3.23, Table 3.10 (carbon content)	Table 3.24
2.B.8.x Other petrochemical production	User -specified	User -specified

For the input of CO_2 and CH_4 EFs the following worksheets are used for different Tiers:

- ✓ **CO_2 Emissions – Tier 1**
- ✓ **CH_4 Emissions – Tier 1**
- ✓ **CO_2 Emissions – Tier 2**
- ✓ **CO_2 and CH_4 Emissions from Combustion – Tier 3 (1/3)**
- ✓ **CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3)**

When the Tier 1 Equations are applied (CO_2 and CH_4):

i.CO_2 emissions

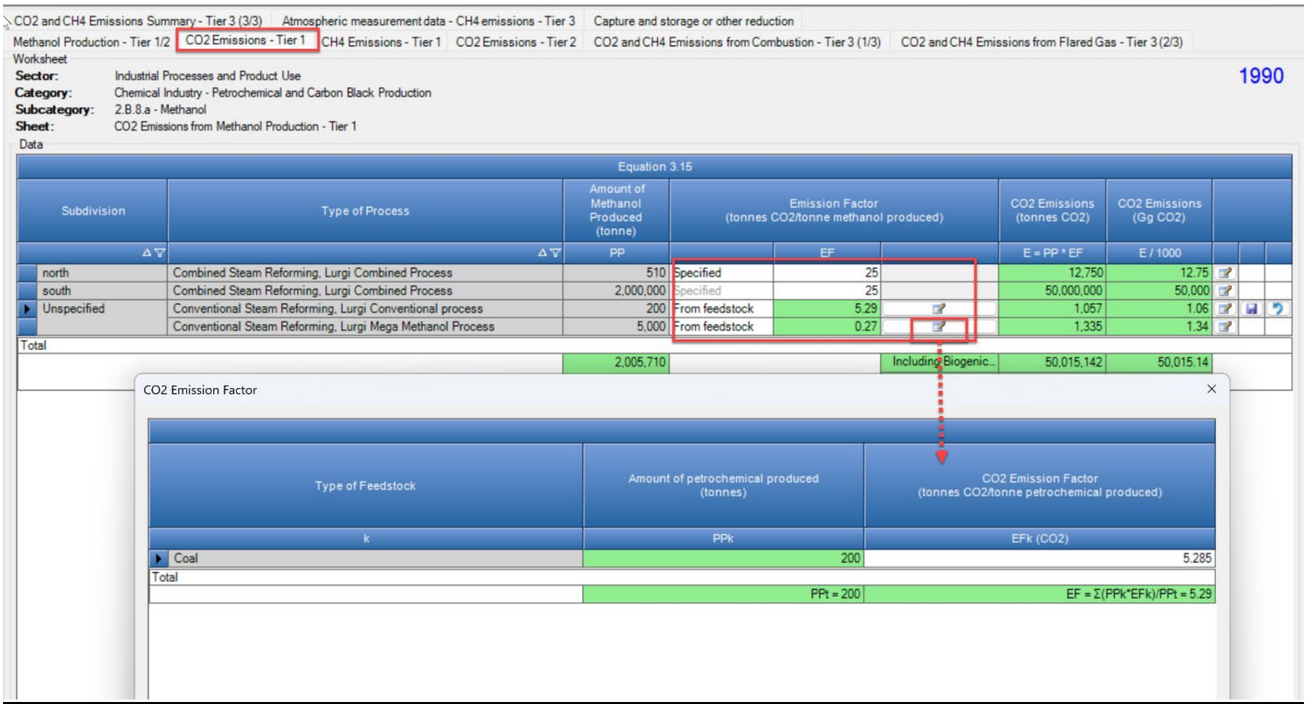
The **CO_2 Emissions – Tier 1** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of subdivision/type of process combinations that applied the Tier 1 CO_2 calculation method, as

entered in worksheet **[Methanol] [Ethylene] [Ethylene Dichloride and Vinyl Chloride Monomer] [Ethylene Oxide] [Acrylonitrile] [Carbon Black] [Other petrochemical] Production – Tier 1/2**.
Note that: for the subcategory Ethylene Dichloride and Vinyl Chloride Monomer, the rows are further stratified by product type (either EDC or VCM). For the subcategory Other petrochemical production, rows are further stratified by petrochemical type entered by the user.

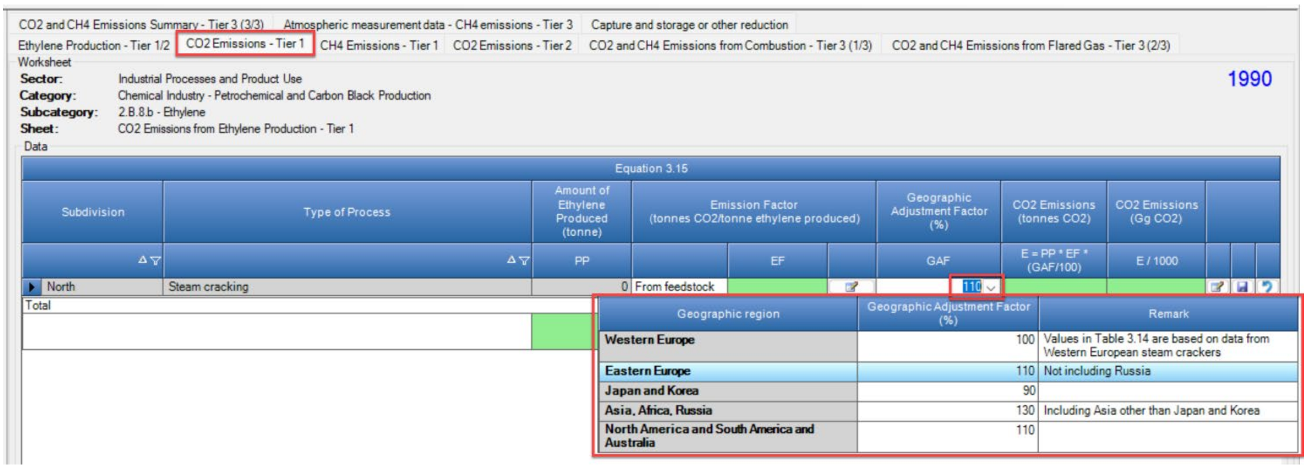
Then enter EF information for 2.B.8.a **Methanol** and 2.B.8.b **Ethylene** as follows:

1. Column |EF|: select whether the CO_2 EF is specified or calculated from feedstock.
   Note that:
   Specified: *-when selected the user enters the CO_2 EF directly*
   From feedstock: *– to calculate the CO_2 EF from the feedstock, select the icon for the drop-down table. Any feedstock entered in the AD worksheet will be automatically populated in the drop-down table, and accordingly the corresponding CO_2 EF available in the drop-down in |Column EFk(CO_2)|*
2. Column |GAF| (applicable for Ethylene production only): select from the drop-down the geographic adjustment factor corresponding to the relevant region. The geographic adjustment factor takes into account that the default CO_2 EF for ethylene production.
   Note that Tier 1 CO2 EFs for ethylene production have been developed based on data for ethylene steam crackers operating in Western Europe. Geographic Adjustment Factors are applied to the Tier 1 EF to account for regional variability in steam cracker operating efficiency.

Example: **Tier 1 CO_2 EFs for 2.B.8.a methanol and 2.B.8.b ethylene production**
Note that this figure is for methanol production; this worksheet is available for each ethylene production.



Example: **Tier 1 geographic adjustment factor for 2.B.8.b ethylene production**

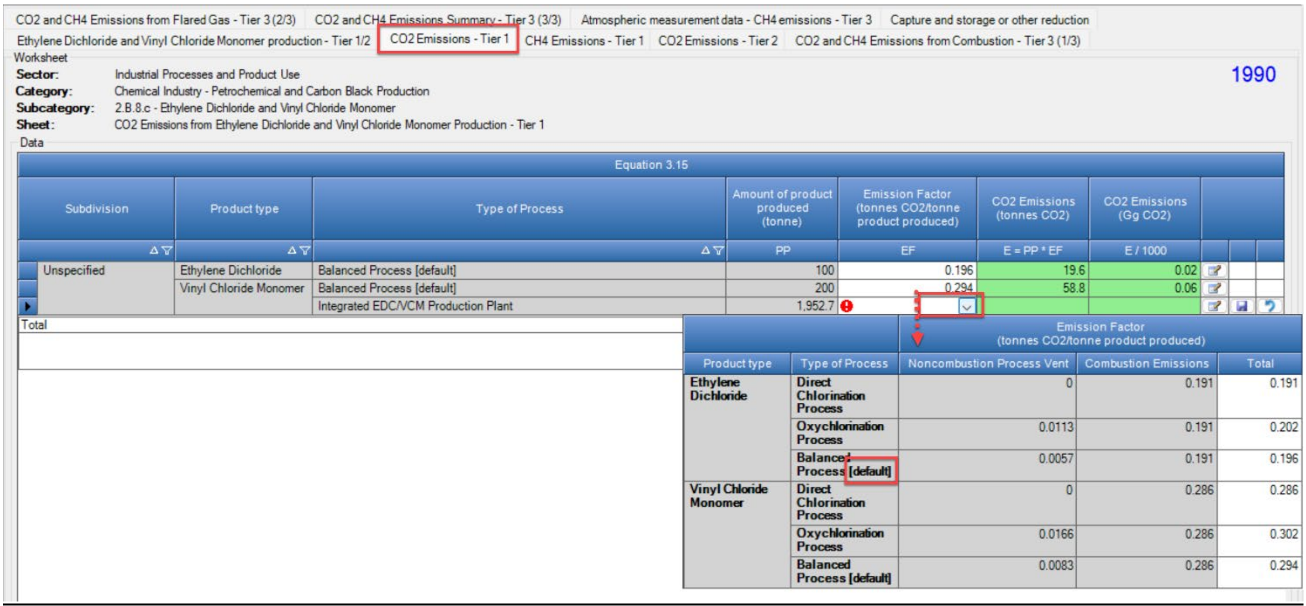


Then enter EF information for 2.B.8.c **Ethylene Dichloride and Vinyl Chloride Monomer,** 2.B.8.f **Carbon Black** and 2.B.8.x **Other petrochemical production** as follows:

1. <u>Column |EF|:</u> select from the drop-down the IPCC default value for the relevant type of process, if available, or enter a user-specific value, in tonnes CO_2/tonne product produced.
   <u>Note that:</u> the drop-down identifies the "default process" in accordance with Table 3.11 for EDC/VCM.

Example: **Tier 1 CO_2 EFs for 2.B.8.c EDC/VCM, 2.B.8.f carbon black, and other 2.B.8.x petrochemical production**

<u>Note that</u> this figure is for EDC/VCM production; a similar worksheet is available for carbon black and other petrochemical production.

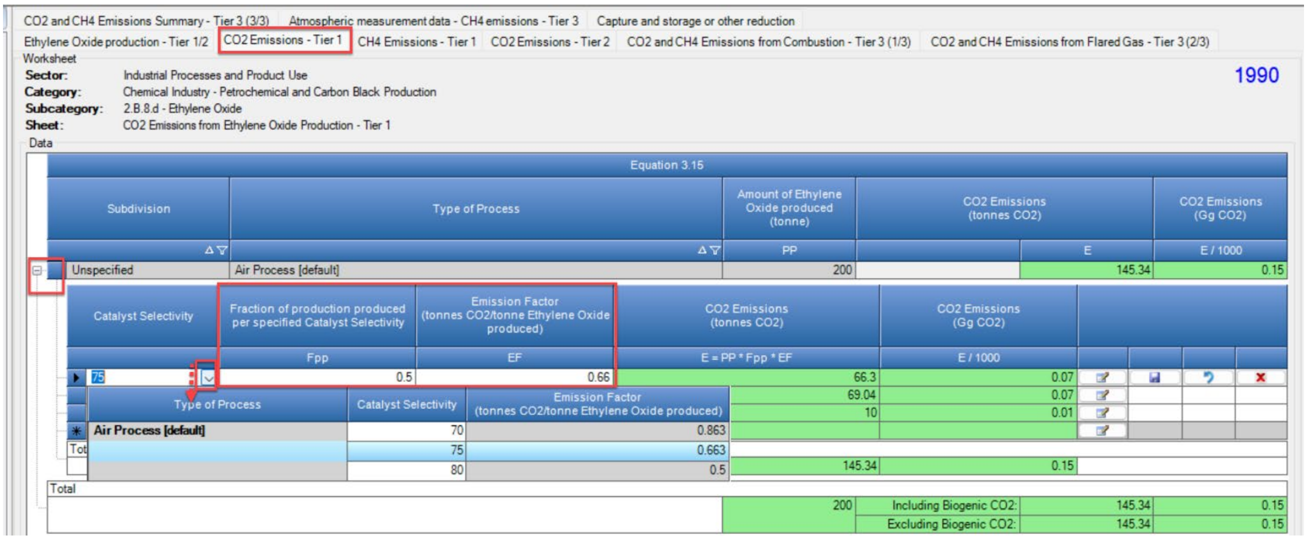


Then enter EF information for **2.B.8.d Ethylene Oxide** as follows:

1. 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 based on the catalyst specificity.
2. <u>Column |Catalyst selectivity|:</u> in the sub-table, select from the drop-down the catalyst selectivity (see <u>Table 3.20</u> of the *2006 IPCC Guidelines*, and accompanying guidance), otherwise enter in user-specific information.
3. <u>Column |Fpp|:</u> enter in the fraction (0-1) of the production produced using the catalyst selectivity identified in <u>Column |Catalyst selectivity|</u>
   <u>Note that:</u> The total in <u>Column |Fpp|</u> for each subdivision should equal 1.

4. Column |EF|: the *Software* automatically populates the IPCC default CO_2 EF, in tonnes CO_2/tonne ethylene oxide produced, based on the selection in Column |Catalyst selectivity|. The user may overwrite this value.

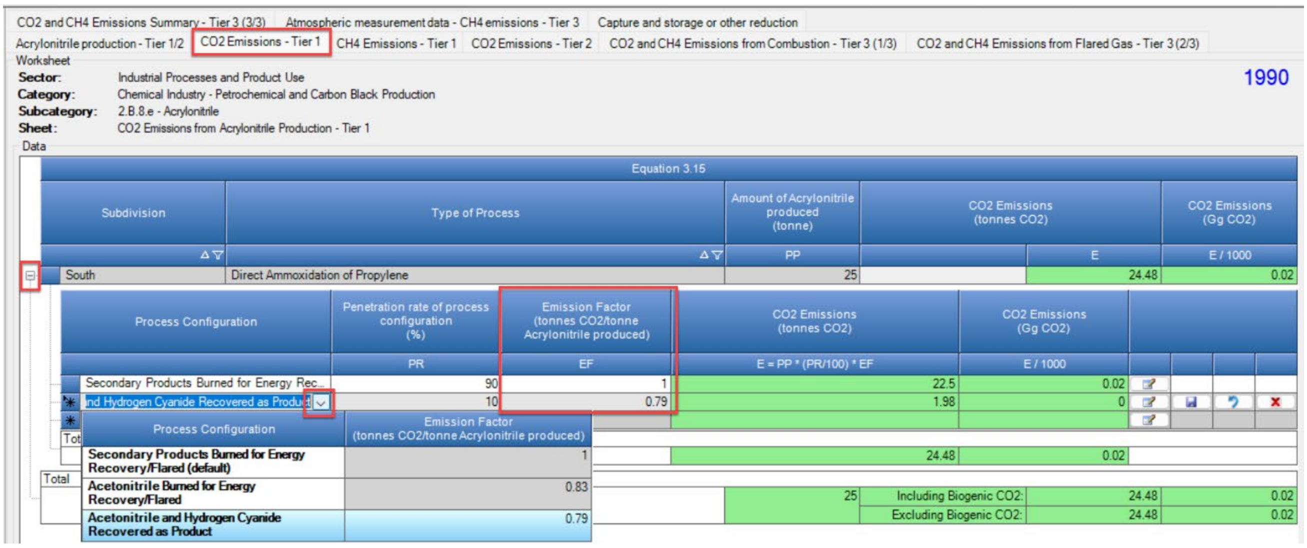
Example: **Tier 1 CO_2 EFs for 2.B.8.d ethylene oxide production**



Then enter EF information for 2.B.8.e **Acrylonitrile** as follows:

1. 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 based on the process configuration.
2. Column |Process Configuration|: in the sub-table, select from the drop-down the process configuration (see Table 3.22 of the *2006 IPCC Guidelines*, and accompanying guidance), otherwise enter in user-specific information.
3. Column |PR|: enter in the penetration rate (%) of the process configuration identified in Column |Process Configuration|
   Note that: The total in Column |PR| for each subdivision should equal 1.
4. Column |EF|: the *Software* automatically populates the IPCC default CO_2 EF, in tonnes CO_2/tonne acrylonitrile produced, based on the selection in Column |Process Configuration|. The user may overwrite this value.

Example: **Tier 1 CO_2 EFs for 2.B.8.e acrylonitrile production**



ii. CH_4 emissions

The **CH_4 Emissions – Tier 1** worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/type of process combinations entered in worksheet **[Methanol] [Ethylene] [Ethylene Dichloride and Vinyl Chloride Monomer][Ethylene Oxide][Acrylonitrile][Carbon Black][Other petrochemical] Production – Tier 1/2**.

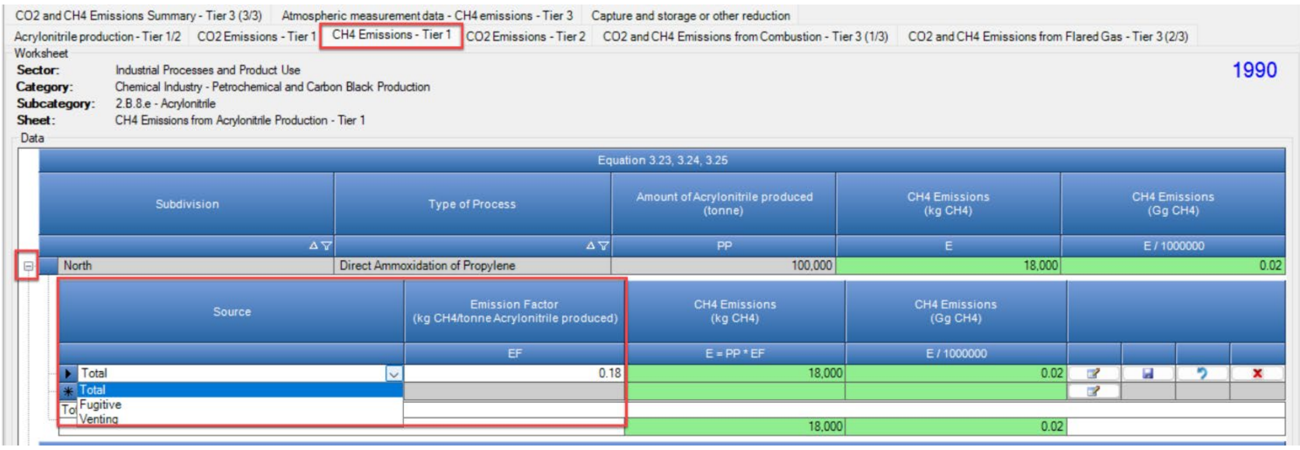
Note that: for the subcategory Ethylene Dichloride and Vinyl Chloride Monomer, the rows are further stratified by product type (either EDC or VCM). For the subcategory Other petrochemical production, rows are further stratified by petrochemical type entered by the user.

Then enter EF information for 2.B.8.a **Methanol,** 2.B.8.c **Ethylene Oxide**, 2.B.8.d **Acrylonitrile and** 2.B.8.x **Other petrochemical production** as follows:

1. 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 based on the amount of chemical produced, separated between fugitive, venting and total CH_4 emissions.
2. Column |Source|: select from the drop-down whether the CH_4 EFs to be entered are based on fugitive, vented or total emissions.
   Note that: the IPCC default CH_4 EFs are for total CH_4 emissions; if user has specific information separate CH_4 EFs could be entered for fugitive and vented emissions.
3. Column |EF|: select IPCC default CH_4 EFs from the drop-down, if available, otherwise enter in user-specific information, in kg CH_4/tonne product produced.

Example: **Tier 1 CH_4 EFs .for 2.B.8.a methanol, 2.B.8.d ethylene oxide, 2.B.8.e acrylonitrile and 2.B.8.x other petrochemical production**

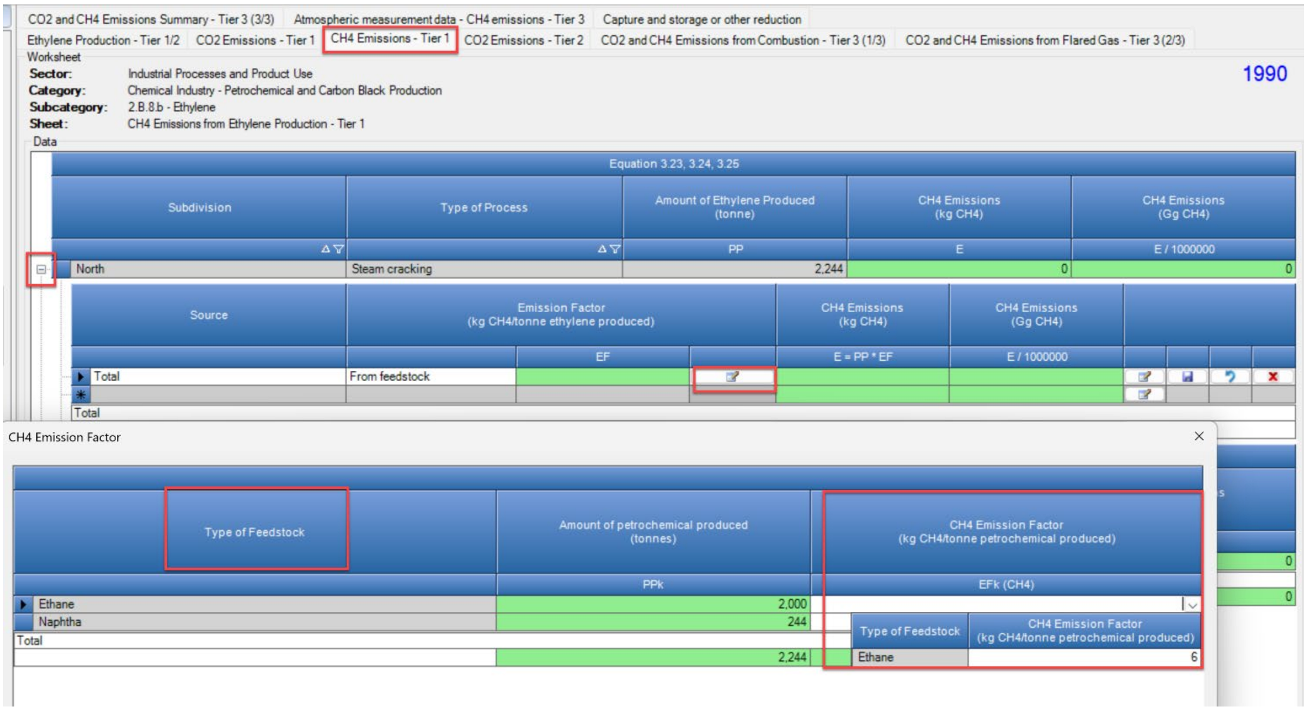
Note that this figure is for acrylonitrile production; a similar worksheet is available for the other listed chemicals



Then enter EF information for **2.B.8.b Ethylene Production** as follows:

1. 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 based on the type of feedstock used and amount of chemical produced.
2. Column |Source|: select from the drop-down menu whether the CH_4 EFs to be entered are based on fugitive, vented or total emissions.
3. Column |EF|: select whether the CH_4 EF is specified or based on feedstock.
   Note that:
   Specified: *-when selected the user enters the CH_4 EF directly*
   From feedstock: *– IPCC default CH_4 EFs for ethylene production are available based on feedstock used (EFs are available for ethane, naphtha and all other feedstocks). Information on the feedstocks are entered by selecting the icon for the drop-down table in Column |EF|: Note that: the option to enter an EF based on the feedstock consumed is only active in the case where the Tier 1 method was selected in worksheet* ***Ethylene Production – Tier 1/2*** *and the amount of ethylene produced in that worksheet was calculated from feedstock in Column |PP|.*
4. Column |Type of Feedstock|: The feedstocks are automatically populated based on information entered in **Ethylene Production – Tier 1/2.**
5. Column |EFk(CH_4)|: select the IPCC default CH_4 EF, otherwise enter in the user-specific value.

Example: **Tier 1 CH_4 EFs for 2.B.8.b ethylene production**



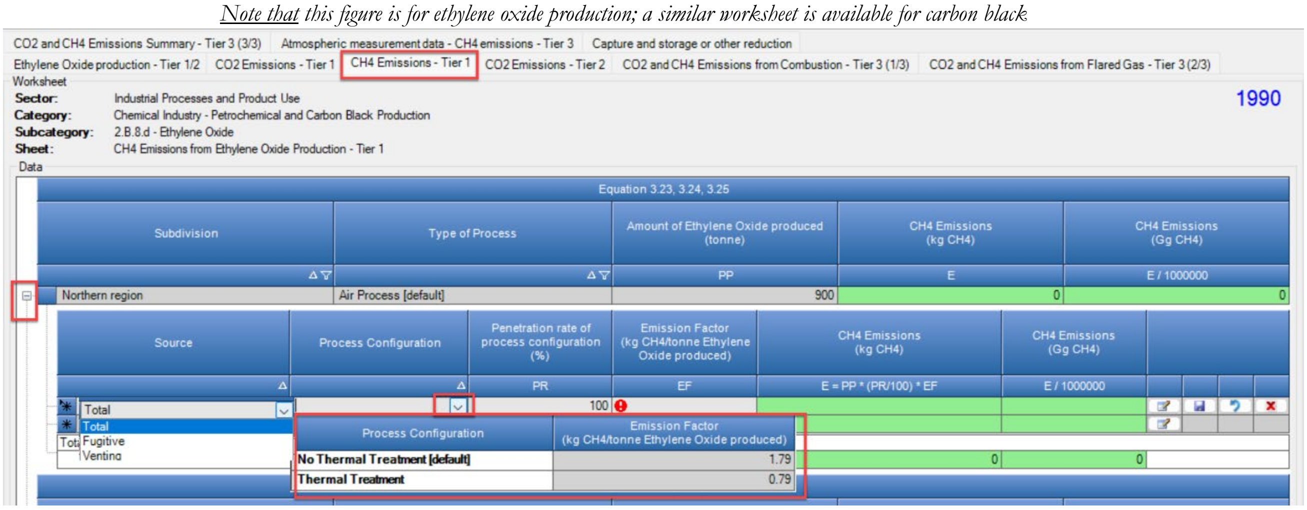
Then enter EF information for **2.B.8.d Ethylene Oxide** and **2.B.8.f Carbon Black** as follows:

1. 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 based on the source, process configuration (type and penetration rate).
2. Column |Source|: select from the drop-down whether the CH_4 EFs to be entered are based on fugitive, vented or total emissions.
3. Column |Process Configuration|: in the sub-table, select from the drop-down the appropriate process configuration. The default configurations as contained in Table 3.21 (ethylene oxide) and Table 3.24 (carbon black) of the 2006 IPCC Guidelines are identified.
4. Column |PR|: enter in the penetration rate (%) of the process configuration identified in Column |Process Configuration|

   Note that: The total in Column |PR| for each subdivision should equal 1.
5. Column |EF|: the *Software* automatically populates the IPCC default CH_4 EF, in kg CH_4/tonne chemical produced, based on the selection in Column |Process Configuration|, otherwise enter in the user-specific value.

Example: **Tier 1 CH_4 EFs for 2.B.8.d ethylene oxide and 2.B.8.f carbon black production**

Note that this figure is for ethylene oxide production; a similar worksheet is available for carbon black



When the Tier 2 Equations are applied (CO_2 only):

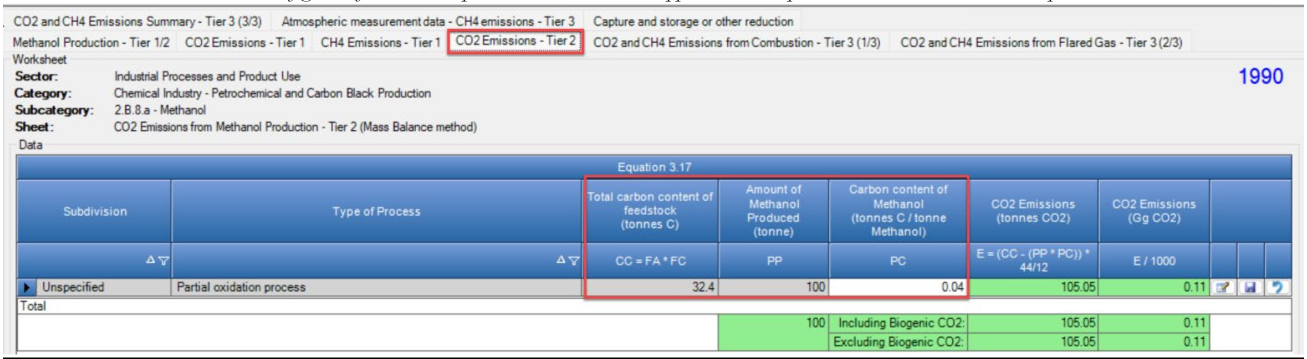
The **CO_2 Emissions – Tier 2** worksheet is pre-filled by the *Software* with a number of rows corresponding to the number of subdivision/type of process combinations that applied the Tier 2 CO_2 calculation method, as entered in worksheet **[Methanol] [Ethylene] [Ethylene Dichloride and Vinyl Chloride Monomer][Ethylene Oxide][Acrylonitrile][Carbon Black][Other petrochemical] Production – Tier 1/2.**
Note that: for the subcategory Ethylene Dichloride and Vinyl Chloride Monomer, the rows are further stratified by product type (either EDC or VCM). For the subcategory Other petrochemical production, rows are further stratified by petrochemical type entered by the user.

Then,

1. Column |CC|: the total carbon content of the feedstock is automatically populated, in tonnes C, based on information entered in the AD worksheet.
2. Column |PP|: the total amount of chemical produced is automatically populated, in tonnes, based on information entered in the AD worksheet.
3. Column |PC|: select from the drop-down menu the IPCC default carbon content for each petrochemical and carbon black from Table 3.10; otherwise enter in the user-specific value

Example: **Tier 2 CO_2 carbon content of primary products**

Note that this figure is for methanol production; but columns applicable to all petrochemicals and carbon black production

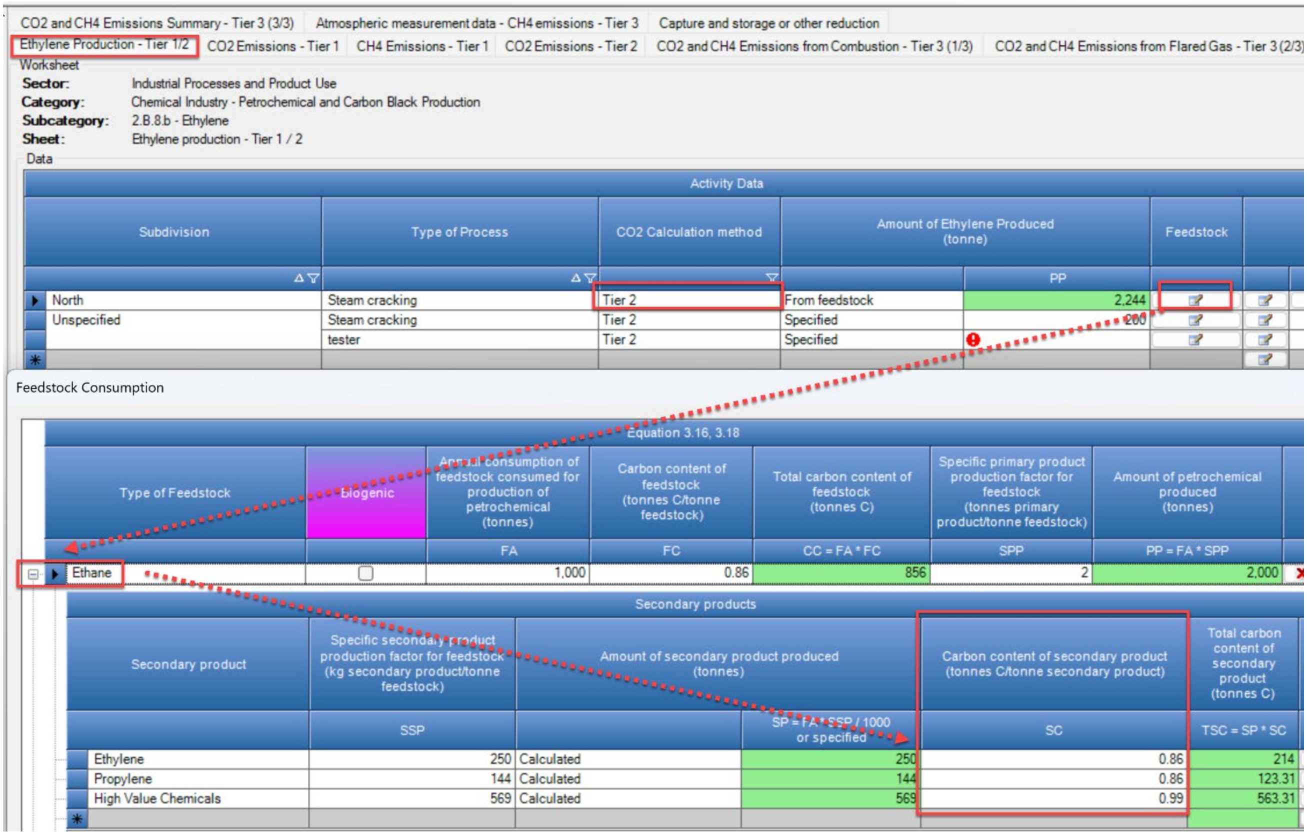


For 2.B.8.b **Ethylene Production** and **2.B.8.e Acrylonitrile Production**, the carbon content of secondary products shall also be considered in the mass balance equation. To incorporate the carbon content of these secondary products:

1. Column |SPC|: the total carbon content of the secondary product, in tonnes C, is automatically transferred to this table from the AD worksheet. To enter in the carbon content for these secondary products:
    a. In worksheets **[Ethylene Production – Tier 1/2]** and [**Acrylonitrile Production- Tier 1/2]** select the feedstock sub-table for those rows for which the Tier 2 Calculation Method was selected.
    b. For each row, users click the symbol "⊞" on the left of the row to open a drop-down table where secondar products are to be entered.
    c. Column |SC|: the *Software* automatically populates the carbon content of secondary products, in tonnes C/tonne secondary product where IPCC defaults exist; otherwise the user may enter user-specific carbon contents.

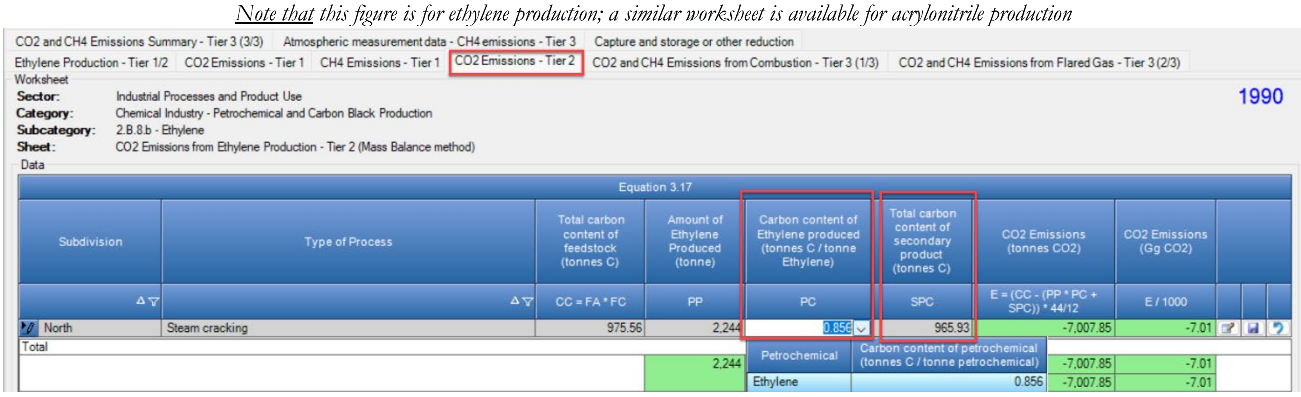
Example: **Tier 2 CO_2 carbon content of secondary products (2.B.8.b ethylene and 2.B.8.e acrylonitrile production)**

<u>Note that</u> this figure is for ethylene production; a similar worksheet is available for acrylonitrile production



Example: **Tier 2 CO_2 carbon content of products for 2.B.8.b ethylene and 2.B.8.e acrylonitrile production**

<u>Note that</u> this figure is for ethylene production; a similar worksheet is available for acrylonitrile production



When the Tier 3 Equations are applied:

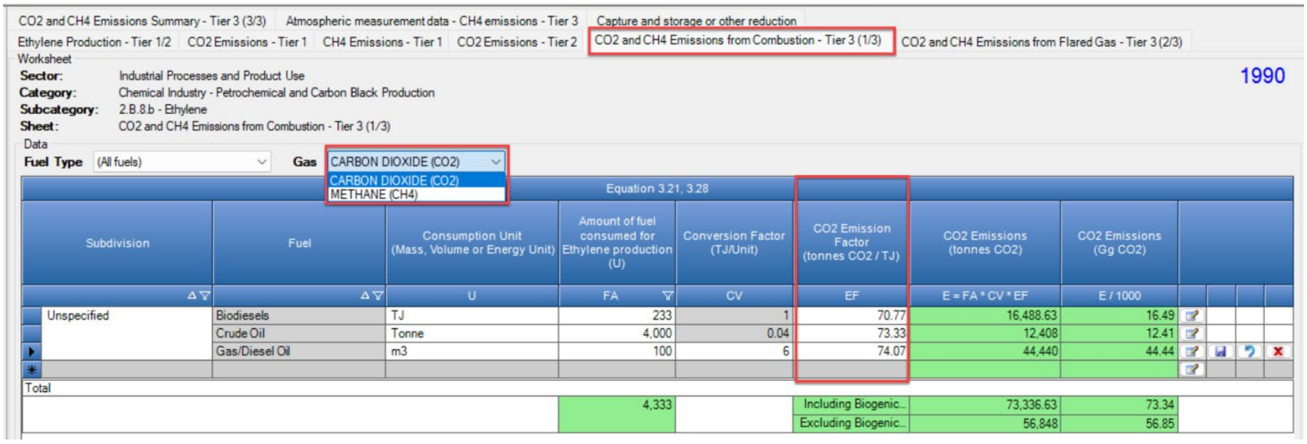
<u>Tier 3 CO_2 and CH_4 EFs using plant-specific data</u>

For each chemical/subdivision/fuel in worksheet **CO_2 and CH_4 Emissions from Combustion – Tier 3 (1/3)**, the user will input information in a single row, or in a number of rows, plant-specific information as follows:

1. <u>Column |EF|</u>: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in tonnes CO_2/TJ or kg CH_4/TJ.
   <u>Note that</u> 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.

Example: **Tier 3 CO_2 and CH_4 EF for combustion**

<u>Note that</u> this figure is for ethylene production; but the same worksheet is available for all petrochemicals

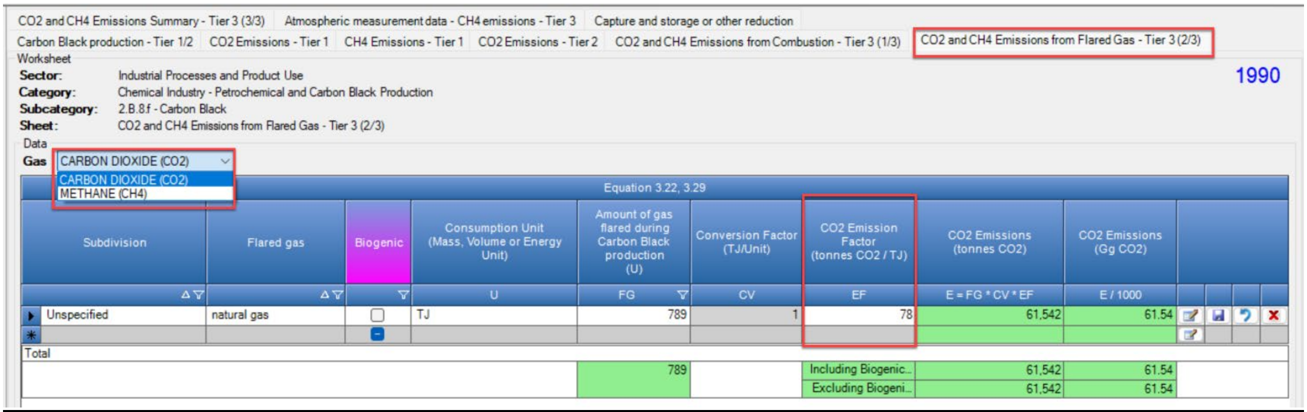


Then, for each chemical, and each subdivision for that chemical in worksheet **CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3)**, the user will input information in a single row, or in a number of rows, plant-specific information as follows:

1. <u>Column |EF|</u>: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in tonnes CO_2/TJ or kg CH_4/TJ.
   <u>Note that</u> 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.

Example: **Tier 3 CO_2 and CH_4 EF for flared gas**

<u>Note that</u> this figure is for carbon black production; but the same worksheet is available for all petrochemicals and carbon black



Then, for each chemical, the *Software* automatically transfers total CO_2 (fossil and biogenic) and CH_4 emissions from combustion and flared gas following the Tier 3 method into worksheet **CO_2 and CH_4 Emissions Summary – Tier 3 (3/3)**. For each chemical/subdivision/gas the user will input information in a single row, or in a number of rows, plant-specific information on emissions from process vents as follows:

When "Carbon dioxide (CO_2)" is selected in the "Gas" bar at the top:

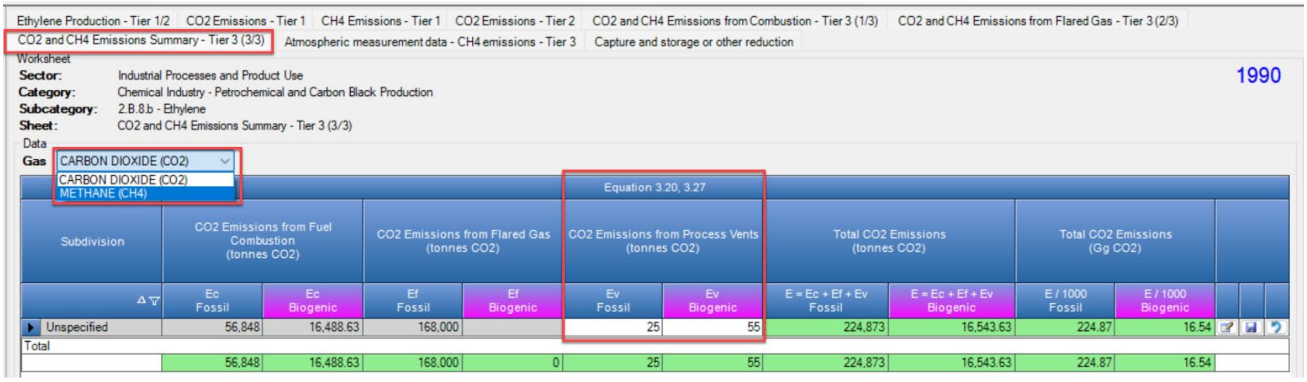
1. <u>Column |Ev Fossil|</u>: enter a user-specific value for CO_2 emissions from process vents that are of fossil origin, in tonnes CO_2.
2. <u>Column |Ev Biogenic|</u>: enter a user-specific value for CO_2 emissions from process vents that are of biogenic origin, in tonnes CO_2.

When "Methane (CH_4)" is selected in the "Gas" bar at the top:

1. <u>Column |Ev|</u>: enter a user-specific value for total CH_4 emissions from process vents, in kg CH_4.

Example: **Tier 3 –gas vented**

Note that this figure is for ethyelen production; but the same worksheet is available for all petrochemicals and carbon black



Tier 3 using atmospheric measurements (CH_4 emissions)

The Tier 3 method using atmospheric measurements does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

Direct measurement

For each subdivision in worksheet **Atmospheric measurement data - CH_4 Emissions– Tier 3**, the user will input information in a single row, or in a number of rows, plant-specific information as follows:

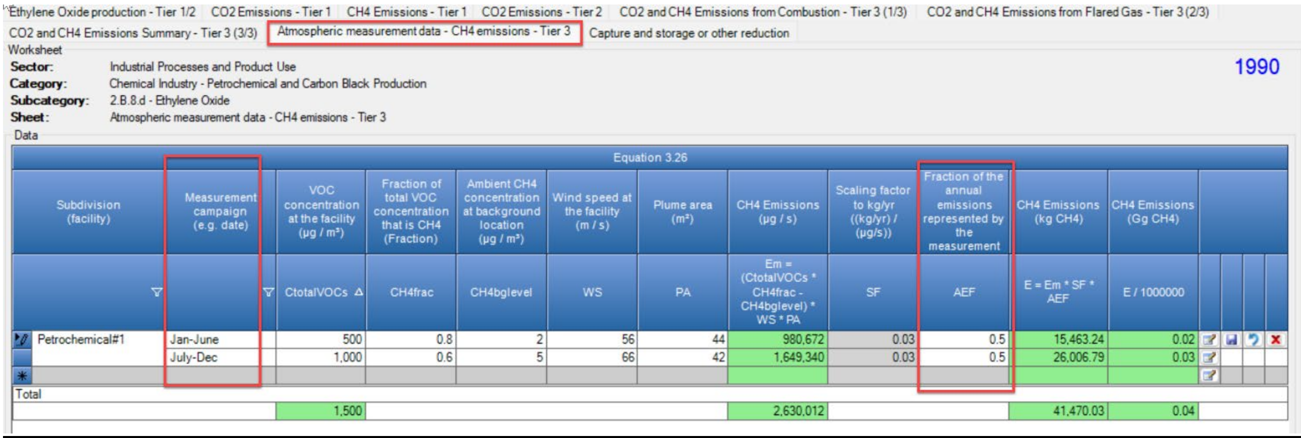
1. Column |Measurement Campaign|: enter name or dates of measurements campaigns.
   Note that: the dates of the measurement campaigns, when summed, must cover the entire reporting year.
2. Column |CtotalVOCs|: for each measurement campaign input concentration of total measured VOCs, in µg/m³.
3. Column |CH_{4frac}|: enter the CH_4 fraction in total VOC concentration, fraction.
4. Column | CH_4bglevel|: enter the ambient CH_4 concentration at the background location, in µg/m³.
5. Column |Wind Speed|: enter the wind speed at the plant in, m/s.
6. Column |Plume Area|: enter the plume area in m².

Then the *Software* calculates CH_4 emissions in µg/s. To convert it to kg per year, the factor 0.03154 is used, which is the conversion from µg to kg and from second to year.

7. Column |AEF|: individual measurement campaigns may only be a fraction of time during the year, the emissions must be summed over time to cover emissions from the entire year. In this column, enter the fraction of the year the measurement campaign was operational: (e.g. if Column |Measurement Campaign| indicates "January – June" Column |AEF| =0.5 to reflect half the year.
   Note that the sum of the fractions in column AEF for a given subdivision should =1.

Example: **CH_4 atmospheric measurements – Tier 3**

Note that this figure is for ethylene oxide production; this worksheet is available for each petrochemical and carbon black production.



Ethylene Oxide production - Tier 1/2 | CO2 Emissions - Tier 1 | CH4 Emissions - Tier 1 | CO2 Emissions - Tier 2 | CO2 and CH4 Emissions from Combustion - Tier 3 (1/3) | CO2 and CH4 Emissions from Flared Gas - Tier 3 (2/3)
CO2 and CH4 Emissions Summary - Tier 3 (3/3) | Atmospheric measurement data - CH4 emissions - Tier 3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Chemical Industry - Petrochemical and Carbon Black Production
Subcategory: 2.B.8.d - Ethylene Oxide
Sheet: Atmospheric measurement data - CH4 emissions - Tier 3

1990

Data

Equation 3.26											
Subdivision (facility)	Measurement campaign (e.g. date)	VOC concentration at the facility (µg / m³)	Fraction of total VOC concentration that is CH4 (Fraction)	Ambient CH4 concentration at background location (µg / m³)	Wind speed at the facility (m / s)	Plume area (m²)	CH4 Emissions (µg / s)	Scaling factor to kg/yr ((kg/yr) / (µg/s))	Fraction of the annual emissions represented by the measurement	CH4 Emissions (kg CH4)	CH4 Emissions (Gg CH4)
		CtotalVOCs	CH4frac	CH4bglevel	WS	PA	Em = (CtotalVOCs * CH4frac - CH4bglevel) * WS * PA	SF	AEF	E = Em * SF * AEF	E / 1000000
Petrochemical#1	Jan-June	500	0.8	2	56	44	980,672	0.03	0.5	15,463.24	0.02
	July-Dec	1,000	0.6	5	66	42	1,649,340	0.03	0.5	26,006.79	0.03
Total		1,500					2,630,012			41,470.03	0.04

Results

CO_2 and CH_4 emissions from the production of methanol, ethylene, ethylene oxide, ethylene dichloride and vinyl chloride monomer, acrylonitrile, carbon black and other petrochemicals are estimated for each chemical individually in mass units (tonnes of CO_2 and kg CH_4 and Gg) by the *Software*, for different Tiers in the following worksheets:

- ✓ **CO_2 Emissions – Tier 1**
- ✓ **CH_4 Emissions – Tier 1**
- ✓ **CO_2 Emissions – Tier 2**
- ✓ **CO_2 and CH_4 Emissions Summary – Tier 3 (3/3)**
- ✓ **Atmospheric measurement data – CH_4 Emissions – Tier 3**

Where the user has indicated use of biogenic feedstock in the production of a petrochemical or carbon black in the *Software*, CO_2 emissions are totalled including and excluding biogenic CO_2.

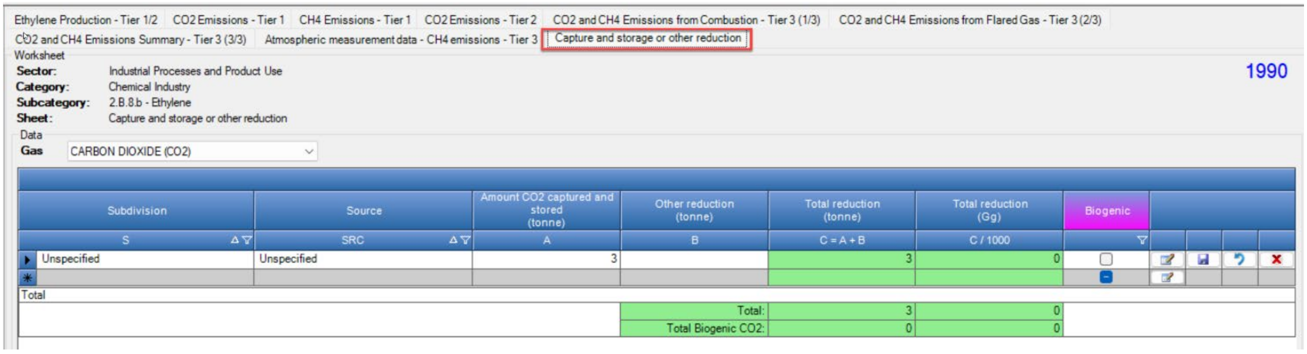
Total CO_2 and CH_4 emissions from the production of each chemical, is the sum of all emissions in the above worksheet for that chemical, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where CO_2 capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2 or CH_4, in tonnes.
   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.
4. Column |Biogenic|: indicate with a check if the process fuel is of biogenic origin.
   Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.

Example: **Capture and storage or other reduction – for each chemical produced**

Note that this figure is from the set of worksheets for ethylene production; this worksheet is available for each petrochemical and carbon black production.



2.B.9 Fluorochemical Production

Fluorochemical Production includes two subcategories:

- ✓ **2.B.9.a By-product Emissions**
- ✓ **2.B.9.b Fugitive Emissions**

Emissions of a chemical occur during its production and distribution or as a by-product during the production of a related chemical (HFC-23 from HCFC-22 production is specifically identified as a category). There may also be emissions of the material that is being produced; the so-called 'fugitive emissions.' Both by-product and fugitive emissions are calculated in the same way and for sources that are not key categories, fugitive and by-product emissions are considered the same.

For the purposes of data entry in the *Software*, and for interoperability with the UNFCCC ETF Reporting Tool, HFC-23 emissions from HCFC-22 emissions are always calculated under source category 2.B.9.a By-product Emissions. Fugitive emissions from production of HFC-134a, SF_6 and NF_3 should be calculated and reported pursuant to the corresponding worksheets under category 2.B.9.b Fugitive Emissions.

For other emissions from fluorinated gas production, it is assumed that if category 2.B.9 is a key category, and emissions of a particular gas are considered significant, then the release of that gas should be considered a by-product emission and calculated and reported under category 2.B.9.a. If category 2.B.9 is key, but release of a particular gas is not considered significant, or if category 2.B.9 is non-key, other emissions from fluorinated gas production should be considered a fugitive emissions and reported under source category 2.B.9.b Fugitive emissions. This is consistent with footnote 2 in IPCC worksheet 3 of 3 for this category.

Given the guidance above, and review of the corresponding decision trees in Figures 3.16 and 3.17 of Volume 3, Chapter 3 of the *2006 IPCC Guidelines* the user shall consider whether emissions from fluorochemical production should be should be calculated and reported following worksheets for:

- ✓ 2.B.9.a By-product Emissions – HFC-23 emissions from HCFC-22 production
- ✓ 2.B.9.a By-product Emissions – Other fluorinated compounds
- ✓ 2.B.9.b Fugitive Emissions – Other fluorinated compounds

Once the user identifies where emissions should be reported, the corresponding guidance below can be consulted to support data entry. The IPPU Users' Guidebook separates the guidance for these three sets of activities to ease data entry and enhance comparability in reporting across users.

2.B.9.a By-product Emissions – HFC-23 emissions from HCFC-22 production

Information

HFC-23 is generated as a by-product during the manufacture of HCFC-22.

The *2006 IPCC Guidelines* provide three Tiers to estimate HFC-23 emissions from HCFC-22 production. The Tier 1 method is relatively simple, involving the application of a default EF to the quantity of HCFC-22 produced at individual plants or, if there is no abatement by destruction, to the total national output of HCFC-22. The Tier 2 method involves application of a Tier 2 EF based on knowledge of process efficiencies, and if known, abatement. Tier 3 has three approaches based on direct measurement: Tier 3a (direct measurements of vent streams), Tier 3b (proxy method – when emissions are correlated with a proxy parameter) and Tier 3c (in-process measurements in a reactor when HFC-23 emissions related to HCFC-22 production).

GHGs

The *Software* includes the following GHGs for HFC-23 emissions from HCFC-22 production under the By-product Emissions (2.B.9.a) source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
			X	X	X	X

IPCC Equations

- ✓ Tier 1: Equations 3.30
- ✓ Tier 2: Equations 3.31, 3.32 and 3.33
- ✓ Tier 3: Tier 3a (Direct measurement of vent streams): Equations 3.34 and 3.37, Tier 3.b (Proxy method): Equations 3.35, 3.38, and 3.39, and Tier 3c (Monitoring reactor product): Equations 3.36 and 3.40

As explained in section **1.1.3 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

By-product Emissions – HFC-23 emissions from HCFC-22 production are estimated using the following worksheets:

- ✓ **1.1.2 F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **HFC-23 emissions from HCFC-22 production:** this worksheet contains for each subdivision the amount of HCFC-22 produced and HFC-23 default EFs. The users may input country-specific EFs. The worksheet calculates the associated HFC-23 emissions.
- ✓ **HFC-23 emissions from HCFC-22 production – Tier 2:** contains for each subdivision the amount of HCFC-22 produced and EF based on carbon-balance and fluorine-balance efficiencies. The worksheet calculates the associated HFC-23 emissions.
- ✓ **HFC-23 emissions from individual process streams (Direct Method) – Tier 3a:** contains for each stream and measurement campaign the concentrations of HFC-23 in the vented gas stream(s), the flow rate and time parameters needed to produce annual emissions. The worksheet calculates the associated HFC-23 emissions.
- ✓ **HFC-23 Emission Factor per unit of proxy quantity – Tier 3b (1/2):** contains for each stream and trial campaign the concentrations of HFC-23, the flow rate and the proxy quantity. The worksheet calculates a HFC-23 EF per unit of proxy.
- ✓ **Mass emissions of HFC-23 – Tier 3b (2/2):** contains for each subdivision and each stream the correlation parameter (emission rate to operation rate) and duration of venting. It also contains information on recovery (destruction) of HFC-23. The worksheet calculates the associated by-product HFC-23 emissions.
- ✓ **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (1/2):** contains for each subdivision and release period the concentrations of HFC-23 in the reactor, amount of HCFC-22 produced during the release and duration when HFC-23 was vented, rather than destroyed. The worksheet calculates HFC-23 emissions during individual release periods and for the year.
- ✓ **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (2/2):** contains for each subdivision and each stream the amount of recovery (destruction) of HFC-23. The worksheet calculates the annual HFC-23 emissions.
- ✓ **Capture and storage or other reduction:** contains information on any other amount of recovered (reduced) fluorinated compounds, which are not accounted for in the Tier 1, 2 and 3 worksheets.

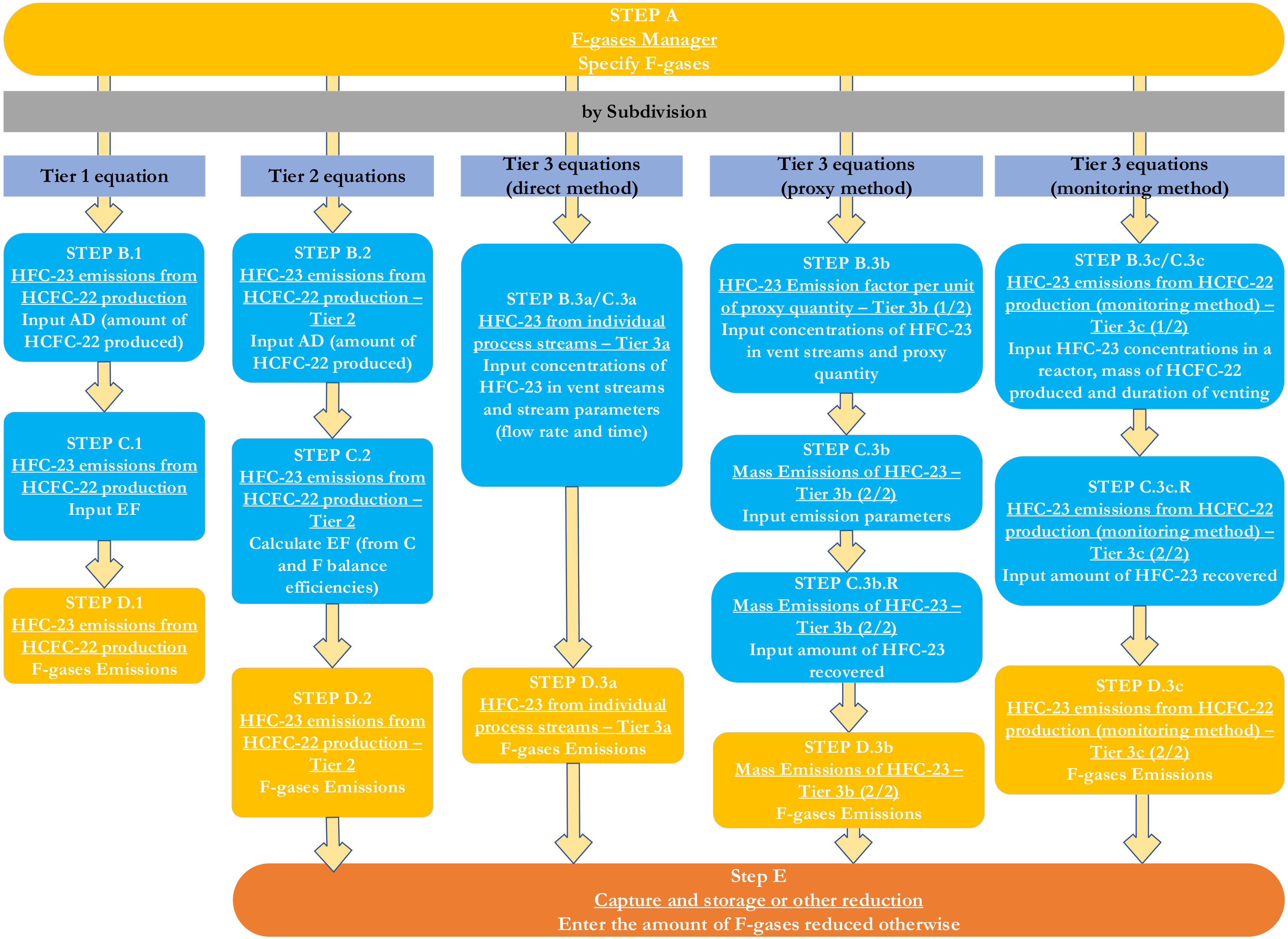
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.16 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse users follow the following flowchart for By-product Emissions – HFC-23 emissions from HCFC-22 production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

By-product emissions-HFC-23 emissions from HCFC-22 Production - flowchart



Thus, for the source-category:

Step A, **1.1.2 F-gases Manager**, users ensure that all F-gases emitted for this source category (in this case, HFC-23) have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step B.1, in the worksheet **HFC-23 emissions from HCFC-22 production,** users collect and input in the *Software* information on the amount of HCFC-22 produced.

Step C.1, in the worksheet **HFC-23 emissions from HCFC-22 production,** users collect and input an EF for HFC-23 emissions from HCFC-22 production.

Step D.1, in the worksheet **HFC-23 emissions from HCFC-22 production,** the *Software* calculates the associated HFC-23 emissions in mass units (kg and Gg of HFC-23).

When the Tier 2 Equations are applied:

Step B.2, in the worksheet **HFC-23 emissions from HCFC-22 production – Tier 2,** users collect and input in the Software information on the amount of HCFC-22 produced.

Step C.2, in the worksheet **HFC-23 emissions from HCFC-22 production – Tier 2,** users input the carbon-balance and fluorine-balance efficiencies to calculate an average EF.

Step D.2, in the worksheet **HFC-23 emissions from HCFC-22 production – Tier 2,** the *Software* calculates the associated HFC-23 emissions in mass units (kg and Gg of HFC-23).

When the Tier 3 Equations are applied:

Tier 3.a Direct method

Step B.3a/C.3.a, in the worksheet **HFC-23 emissions from individual process streams (Direct Method) – Tier 3a,** users collect and input in the *Software* for each stream and measurement campaign the concentrations of HFC-23 in the gas streams which are vented, as well as the flow rate and time parameters needed to produce annual emissions.

Step D.3a, in the worksheet **HFC-23 emissions from individual process streams (Direct Method) – Tier 3a,** the *Software* calculates the associated HFC-23 emissions for each vent stream in mass units (kg and Gg of HFC-23).

Tier 3.b Proxy method

Step B.3b, in the worksheet **HFC-23 Emission Factor per unit of proxy quantity – Tier 3b (1/2),** users collect and input in the *Software*, for each stream and trial campaign, information on the concentrations of HFC-23, as well as the flow rate and the proxy quantity.

Step C.3b, in the worksheet **Mass emissions of HFC-23 – Tier 3b (2/2),** users input process parameters on the measured standard emission rate to the actual rate at the facility, the current process operating rate for the proxy quantity, and the duration of venting.

Step C.3b.R, in the worksheet **Mass emissions of HFC-23 – Tier 3b (2/2),** for each vent stream users input in the *Software* the amount of recovered (destroyed) HFC-23.

Step D.3b, in the worksheet **Mass emissions of HFC-23 – Tier 3b (2/2),** the *Software* calculates the associated HFC-23 emissions for each vent stream and total emissions in mass units (kg and Gg of HFC-23).

Tier 3.c Monitoring method

Step B.3c /C.3c, in the worksheet **HFC-23 emissions from HCFC-22 (Monitoring method) – Tier 3c (1/2),** users collect and input in the *Software* information for each release period on the concentrations of HFC-23 in the reactor, the amount of HCFC-22 produced during the release and duration when HFC-23 was vented, rather than destroyed.

Step C.3c.R, in the worksheet **HFC-23 emissions from HCFC-22 (Monitoring method) – Tier 3c (2/2),** users input the amount of recovered (destroyed) HFC-23.
Note that: where there is abatement then it must be shown that the abatement actually treats all streams that may be released into the atmosphere, including direct gas vents and the outgassing of aqueous streams. The latter, especially, may not be passed to the destruction facility. If all potential vent streams are not treated, the method cannot be used.

Step D.3c, in the worksheet **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (2/2),** the *Software* calculates the associated HFC-23 emissions in mass units (kg and Gg of HFC-23).

Then, for each tier, as appropriate:

Step E, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of recovered/reduced fluorinated compounds, not accounted for elsewhere in calculation worksheets.

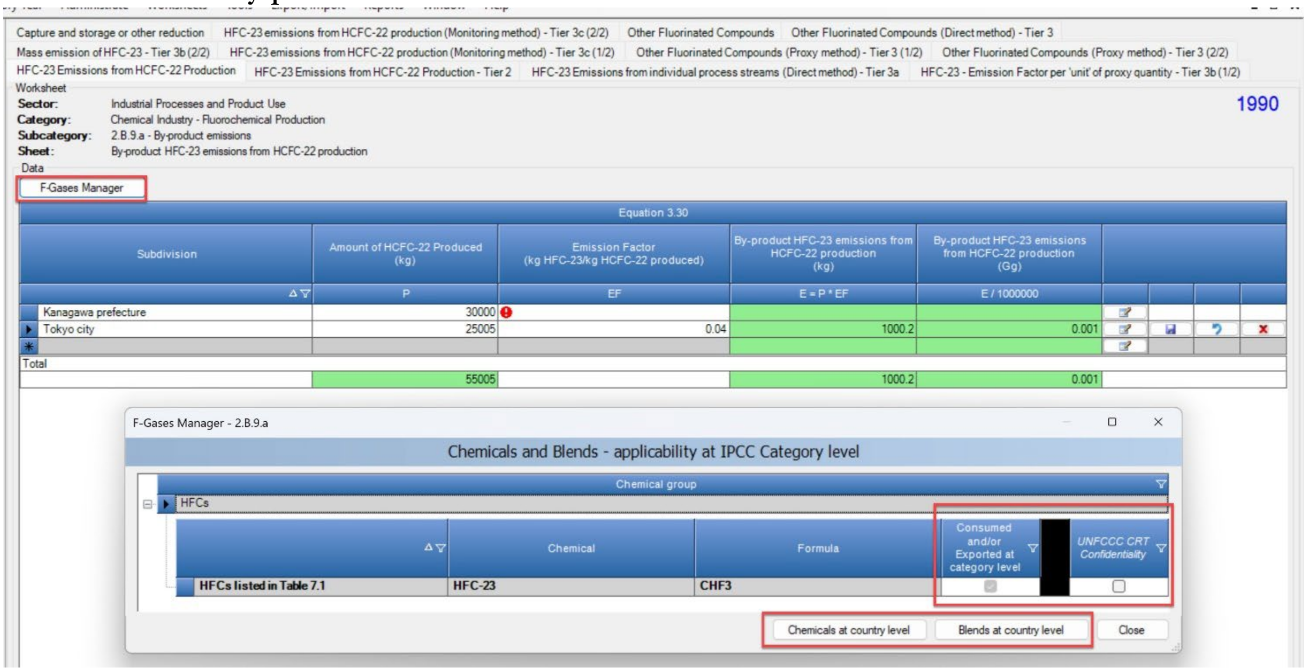
Activity data input

Section 3.10.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for By-product emissions of HFC-23 from HCFC-22 production.

As a **Starting step**, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases (or, if applicable, blends) to be reported for the source category By-product emissions of HFC-23 from HCFC-22 production. In this case, the only relevant F-gas is HFC-23.
*Note that if HFC-23 is not checked in the F-gases Manager, then it will not be possible to enter any data. If data entry is not possible, select the **F-Gases Manager** from any tab. This will open the F-gases Manager – applicability at IPCC Category Level. Navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the country level- F-gases Manager to check HFC-23. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager.*

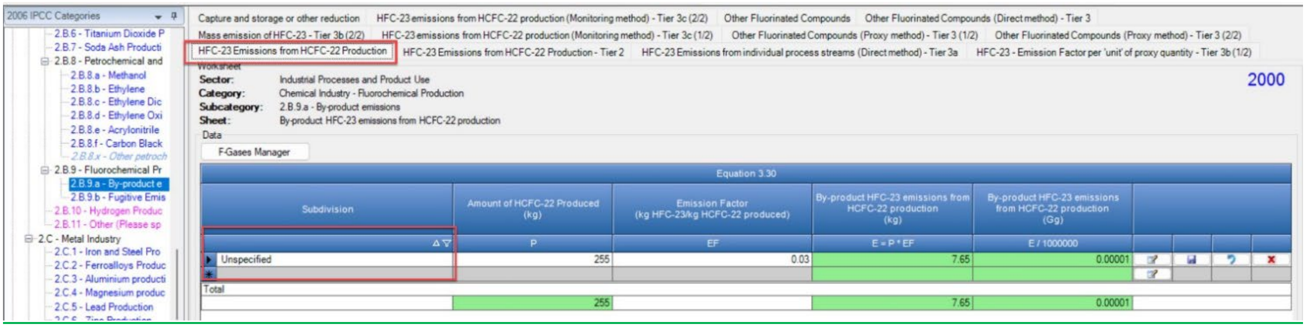
The user is not required to further select relevant F-gases for this category (HFC-23 will be automatically checked).
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT, as unspecified mix of HFCs and PFCs, in tonnes CO_2 equivalents.

Example: **Populating the F-gases manager and designating confidentiality for category: By-product emissions-HFC-23 emissions from HCFC-22 Production**



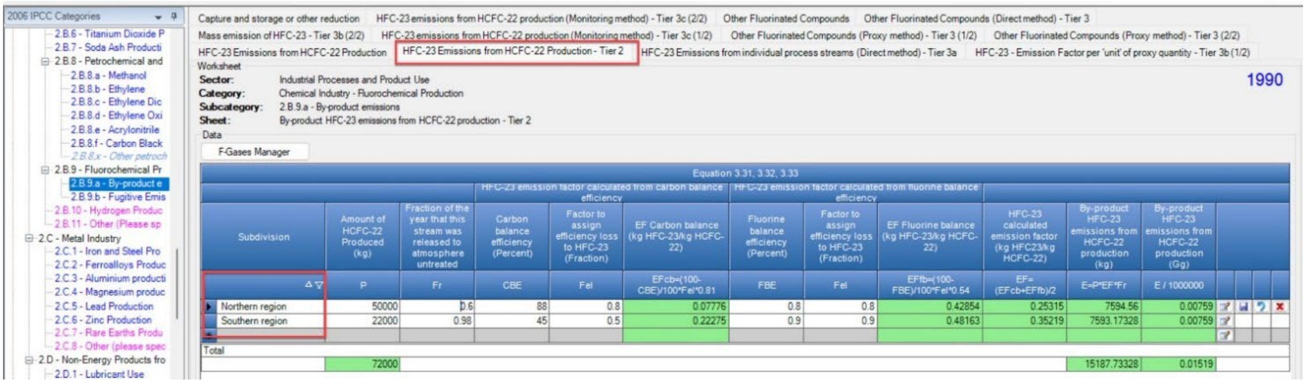
Second, input of AD for the By-product emissions of HFC-23 from HCFC-22 production requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in **HFC-23 emissions from HCFC-22 production** worksheet, row by row, as follows:

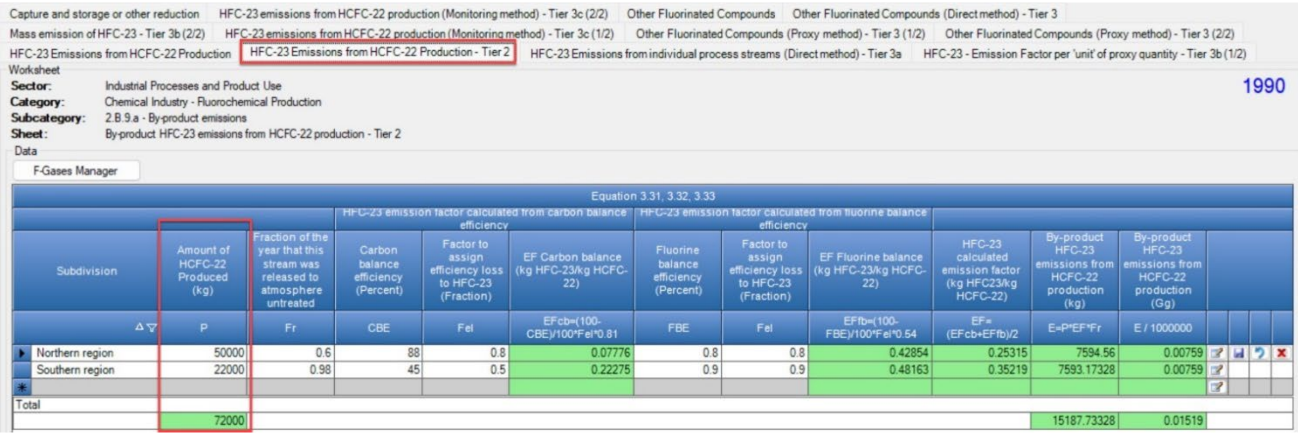
1. Column |P|: input the amount of HCFC-22 produced, in kg.

When Tier 2 Equations are applied:

For each subdivision in Column |Subdivision|, data are entered in **HFC-23 emissions from HCFC-22 production – Tier 2** worksheet, row by row, as follows:

1. Column | P|: input the amount of HCFC-22 produced, in kg.

Example: **AD input – Tier 2**


Capture and storage or other reduction | HFC-23 emissions from HCFC-22 production (Monitoring method) - Tier 3c (2/2) | Other Fluorinated Compounds | Other Fluorinated Compounds (Direct method) - Tier 3
Mass emission of HFC-23 - Tier 3b (2/2) | HFC-23 emissions from HCFC-22 production (Monitoring method) - Tier 3c (1/2) | Other Fluorinated Compounds (Proxy method) - Tier 3 (1/2) | Other Fluorinated Compounds (Proxy method) - Tier 3 (2/2)
HFC-23 Emissions from HCFC-22 Production | HFC-23 Emissions from HCFC-22 Production - Tier 2 | HFC-23 Emissions from individual process streams (Direct method) - Tier 3a | HFC-23 - Emission Factor per 'unit' of proxy quantity - Tier 3b (1/2)

Worksheet
Sector: Industrial Processes and Product Use
Category: Chemical Industry - Fluorochemical Production
Subcategory: 2.B.9.a - By-product emissions
Sheet: By-product HFC-23 emissions from HCFC-22 production - Tier 2
1990

Data
F-Gases Manager

Equation 3.31, 3.32, 3.33

Subdivision	Amount of HCFC-22 Produced (kg)	Fraction of the year that this stream was released to atmosphere untreated	HFC-23 emission factor calculated from carbon balance efficiency: Carbon balance efficiency (Percent)	Factor to assign efficiency loss to HFC-23 (Fraction)	EF Carbon balance (kg HFC-23/kg HCFC-22)	HFC-23 emission factor calculated from fluorine balance efficiency: Fluorine balance efficiency (Percent)	Factor to assign efficiency loss to HFC-23 (Fraction)	EF Fluorine balance (kg HFC-23/kg HCFC-22)	HFC-23 calculated emission factor (kg HFC23/kg HCFC-22)	By-product HFC-23 emissions from HCFC-22 production (kg)	By-product HFC-23 emissions from HCFC-22 production (Gg)
	P	Fr	CBE	Fel	EFcb=(100-CBE)/100*Fel*0.81	FBE	Fel	EFfb=(100-FBE)/100*Fel*0.54	EF=(EFcb+EFfb)/2	E=P*EF*Fr	E / 1000000
Northern region	50000	0.6	88	0.8	0.07776	0.8	0.8	0.42854	0.25315	7594.56	0.00759
Southern region	22000	0.98	45	0.5	0.22275	0.9	0.9	0.48163	0.35219	7593.17328	0.00759
Total	72000									15187.73328	0.01519

When Tier 3 Equations are applied:

Tier 3.a Direct method

The Tier 3.a Direct method does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

Tier 3.b Proxy method

The Tier 3.b Proxy method does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

Tier 3.c Monitoring method

The Tier 3.c Monitoring method does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

Emission factors input

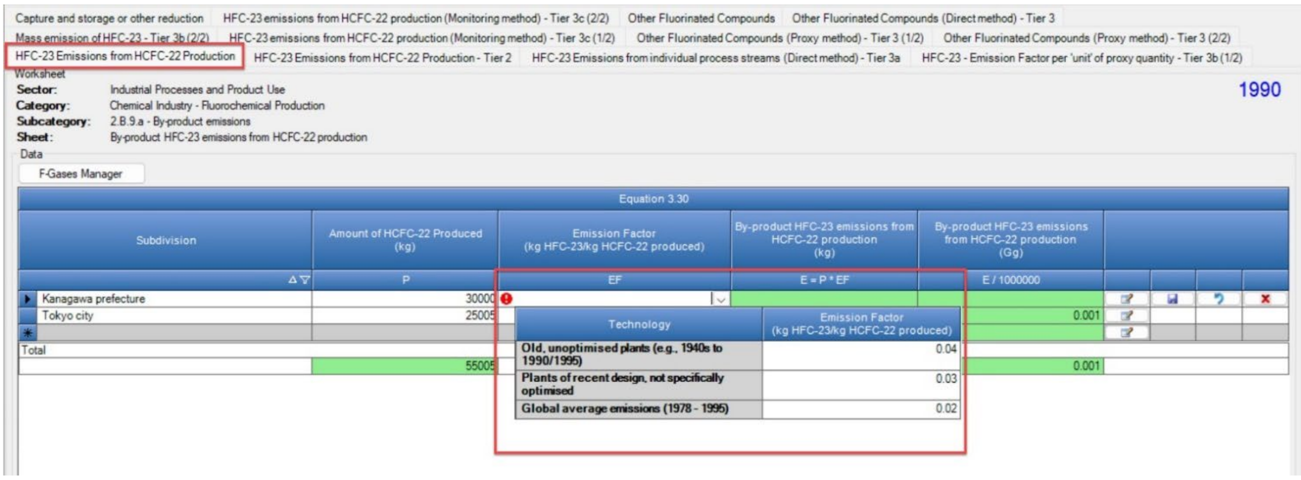
Section 3.10.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for By-product emissions of HFC-23 from HCFC-22. Higher-tier methods rely on plant-specific measurements or sampling. Tier 1 default EFs are provided in Table 3.28

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, in worksheet **HFC-23 emissions from HCFC-22 production** row by row, as follows**:**

1. Column |EFi|: select from the drop-down menu the IPCC default EF, otherwise input a user-specific value, in kg of HFC-23/kg of HCFC-22 produced.

Example: **Tier 1 EFs - By-product emissions of HFC-23 from HCFC-22**



When Tier 2 Equations are applied:

In the Tier 2 methodology, the HFC-23 EF is derived from records of process efficiencies. The EF is generally calculated as the average of the carbon efficiency (Equation 3.32) and the fluorine efficiency (Equation 3.33), unless there are overriding considerations (such as a much lower uncertainty of one of the efficiency measures) that can be adequately documented.

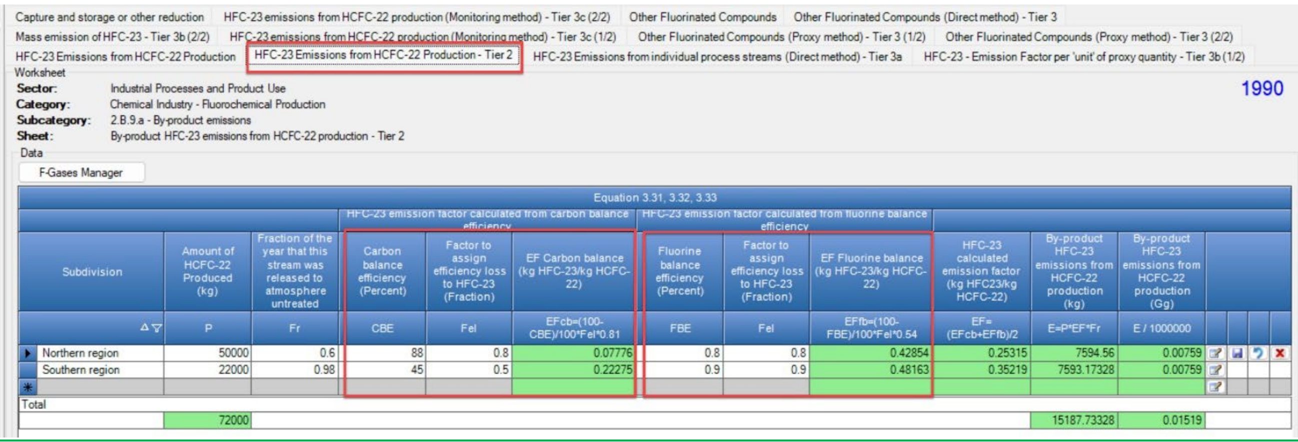
Annual average carbon and fluorine balance efficiencies are features of a well-managed HCFC-22 plant and are normally available to the plant operator or may be obtained by examination of process accounting records. Similarly, if there is a vent treatment system, the length of time that this stream was in operation, and treatment of that vent stream should also be available from plant records.

To calculate the EF, for each subdivision in Column |Subdivision|, data are entered in **By-product emissions of HFC-23 from HCFC-22. Tier 2:** worksheet, row by row, as follows:

1. Column |Fr|: enter the fraction of the year when the vent stream was released to the atmosphere without treatment.
2. Column |CBE|: enter the carbon balance efficiency taken from the plant operator, in percent.
3. Column |Fel|: enter the efficiency loss factor, fraction.
   Note that the factor to assign the efficiency loss to HFC-23 is specific to each plant and, if this method of calculation is used, the factor should have been established by the process operator. By default, the value is 1; that is all of the loss in efficiency is due to co-production of HFC-23. In practice, this is commonly the most significant efficiency loss, being much larger than losses of raw materials or products.
4. Column |FBE|: enter the fluorine balance efficiency taken from the plant operator, in percent.
5. Column |Fel|: enter in the efficiency loss factor, fraction.
   Note that the factor to assign the efficiency loss to HFC-23 is specific to each plant and, if this method of calculation is used, the factor should have been established by the process operator. By default, the value is 1; that is all of the loss in efficiency is due to co-production of HFC-23. In practice, this is commonly the most significant efficiency loss, being much larger than losses of raw materials or products.

Equations 3.32 and 3.33 also include variables for carbon content and fluorine content. The factors for carbon and fluorine contents are calculated from the molecular compositions of HFC-23 and HCFC-22 and are common to all HCFC-22 plants at 0.81 for carbon and 0.54 for fluorine. These contents are directly incorporated into the EF calculations in the *Software*.

Example: **Tier 2 EFs - By-product emissions of HFC-23 from HCFC-22**



Equation 3.31, 3.32, 3.33											
			HFC-23 emission factor calculated from carbon balance efficiency			HFC-23 emission factor calculated from fluorine balance efficiency					
Subdivision	Amount of HCFC-22 Produced (kg)	Fraction of the year that this stream was released to atmosphere untreated	Carbon balance efficiency (Percent)	Factor to assign efficiency loss to HFC-23 (Fraction)	EF Carbon balance (kg HFC-23/kg HCFC-22)	Fluorine balance efficiency (Percent)	Factor to assign efficiency loss to HFC-23 (Fraction)	EF Fluorine balance (kg HFC-23/kg HCFC-22)	HFC-23 calculated emission factor (kg HFC23/kg HCFC-22)	By-product HFC-23 emissions from HCFC-22 production (kg)	By-product HFC-23 emissions from HCFC-22 production (Gg)
	P	Fr	CBE	Fel	EFcb=(100-CBE)/100*Fel*0.81	FBE	Fel	EFfb=(100-FBE)/100*Fel*0.54	EF=(EFcb+EFfb)/2	E=P*EF*Fr	E / 1000000
Northern region	50000	0.6	88	0.8	0.07776	0.8	0.8	0.42854	0.25315	7594.56	0.00759
Southern region	22000	0.98	45	0.5	0.22275	0.9	0.9	0.48163	0.35219	7593.17328	0.00759
Total											
	72000									15187.73328	0.01519

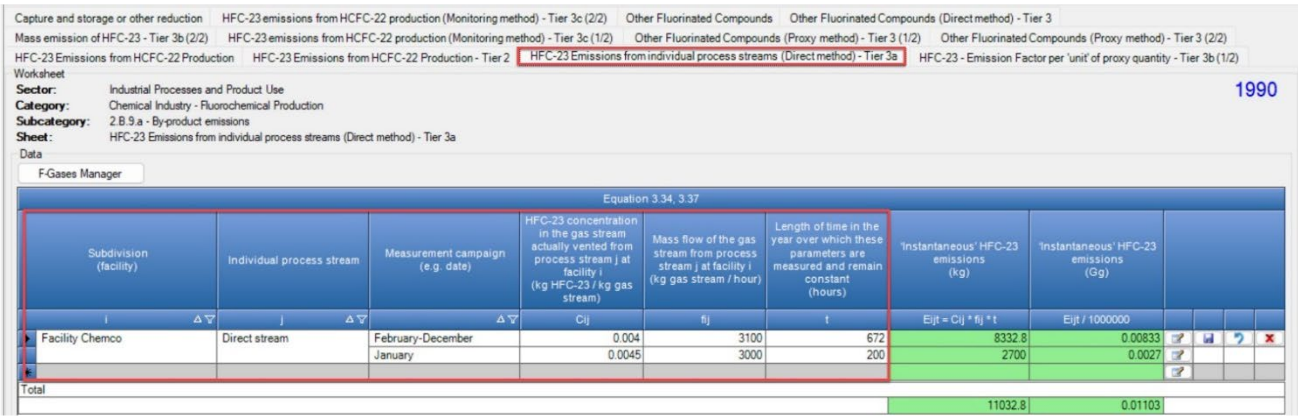
Direct measurement

Tier 3.a Direct method

For each subdivision in Column |i|, data are entered in worksheet **HFC-23 emissions from individual process streams (Direct Method) – Tier 3a,** row by row, as follows:

1. Column |j|. enter a name for individual process stream.
2. Column |Measurement campaign|: for each subdivision/process stream input the name or dates of the measurement campaigns.
3. Column |Cij|: For each subdivision/process stream/measurement campaign, input the concentration of HFC-23 in the gas stream which is actually vented, in kg HFC-23/ kg of gas stream.
4. Column |f_{ij}|: For each subdivision/process stream/measurement campaign input the flow rate of the gas, in kg of gas stream per hour.
5. Column |t|: For each subdivision/process stream/measurement campaign enter the length of time in hours, these parameters are measured.
   Note that the sum of hours input in column "t" shall correspond to the total time, in hours, of activity of the facility (i) in the reporting year, for which individual jet streams (j) are input in the worksheet.

Example: **Tier 3a – direct method**



Equation 3.34, 3.37							
Subdivision (facility)	Individual process stream	Measurement campaign (e.g. date)	HFC-23 concentration in the gas stream actually vented from process stream j at facility i (kg HFC-23 / kg gas stream)	Mass flow of the gas stream from process stream j at facility i (kg gas stream / hour)	Length of time in the year over which these parameters are measured and remain constant (hours)	'Instantaneous' HFC-23 emissions (kg)	'Instantaneous' HFC-23 emissions (Gg)
i	j		Cij	fij	t	Eijt = Cij * fij * t	Eijt / 1000000
Facility Chemco	Direct stream	February-December	0.004	3100	672	8332.8	0.00833
		January	0.0045	3000	200	2700	0.0027
Total							
						11032.8	0.01103

Tier 3.b Proxy method

For each subdivision in Column |i| (Tier 3 requires plant- or facility- specific input), data are entered in worksheet **HFC-23 Emission Factor per unit of proxy quantity – Tier 3b (1/2),** row by row, as follows:

1. Column |j|. enter a name for the individual vent stream.

2. Column |T|: for each subdivision (plant)/vent stream, input the name or date of the trial campaigns.
3. Column |CT_{ij}|: for each subdivision/vent stream/trial campaign input the concentration of HFC-23 in the vent stream, in kg HFC-23/kg of gas stream.
4. Column |fT_{ij}|: for each subdivision/vent stream/trial campaign, input the average mass flow rate of the vent stream, in kg of vent stream/hour.
5. Column |$PORT_{ij}$|:for each subdivision/vent stream/trial campaign, input the proxy quantity (e.g. operating rate) in units per hour.
   Note that the 'unit' depends on the proxy quantity adopted for plant i vent stream j (for example, kg/hour or m³/hour of feedstock). In almost all cases, the rate of plant operation is considered a suitable proxy and the quantity of HFC-23 emitted depends on the current plant operating rate and the length of time the vent flow was released.

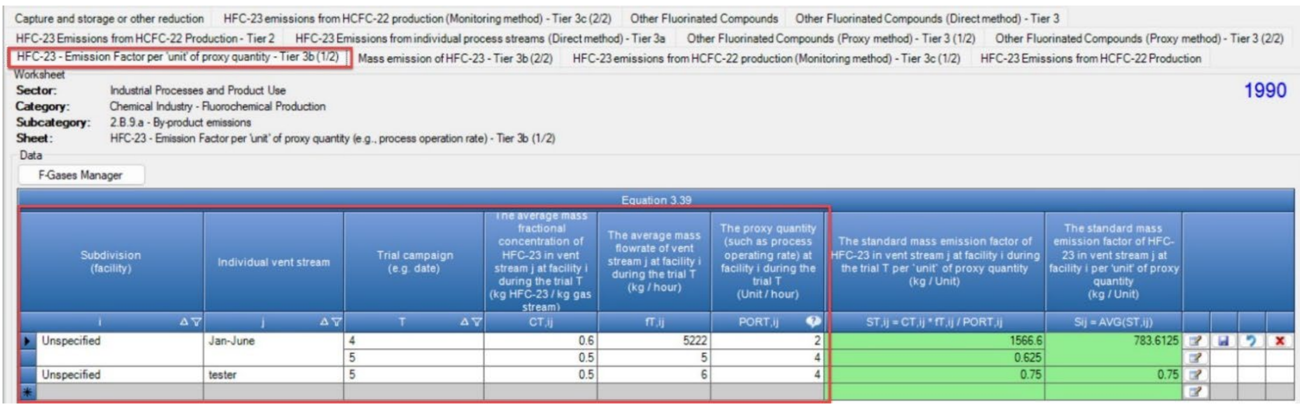
The worksheet calculates an **average** HFC-23 EF per unit of proxy. Then, the subdivisions/vent streams and the calculated EF entered in worksheet **HFC-23 Emission Factor per unit of proxy quantity – Tier 3b (1/2)** are transferred automatically.to worksheet **Mass emissions of HFC-23 – Tier 3b (2/2).**

Then, for each subdivision/individual vent stream,

6. Column | F_{ij}|. the users enter a dimensionless factor relating the measured standard mass emission rate to the emission rate at the actual plant operating rate.
   Note that in many cases, the fraction produced is not sensitive to operating rate and Fi is unity (i.e., the emission rate is proportional to operating rate). In other cases the emission rate is a more complex function of the operating rate. In all cases Fi should be derived during the plant trial by measuring HFC-23 production at different operating rates. ***For situations where a simple function relating the emissions to the operating rate cannot be determined from testing, the proxy method is not considered appropriate and continuous measurement is desirable****.*

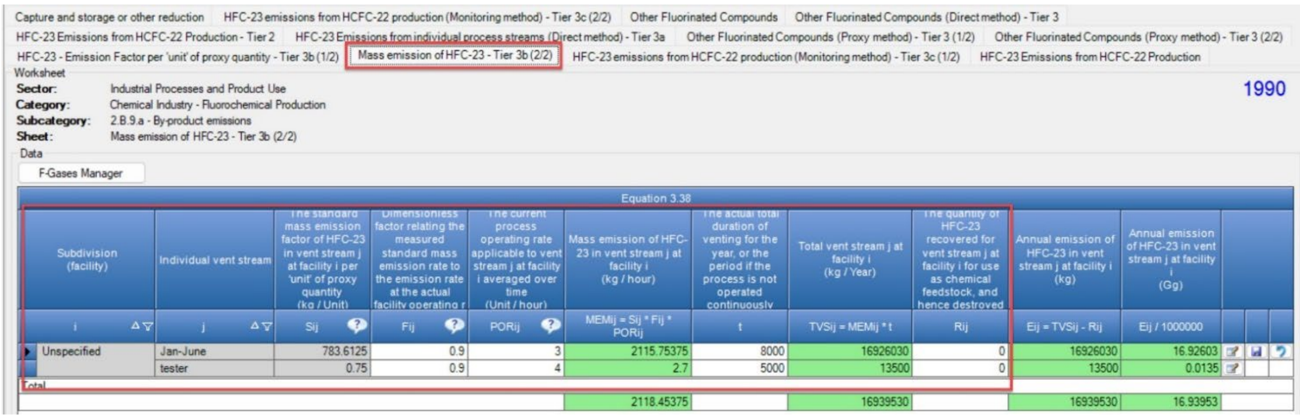
7. Column |POR_{ij}|: Users enter the current process operating rate applicable to that vent stream, j, averaged over the time period, t, in 'unit/hour'.
   Note that the units of this parameter must be consistent between the plant trial establishing the standard emission rate and the estimate of ongoing, operational emissions
8. Column |t|.: enter the time, in hours, of actual venting for the year, or the period if the process is not operated continuously.
   Note that annual emissions become the sum of all the periods during the year. The periods during which the vent stream is processed in a destruction system should not be counted here.
9. Column |Rij|: enter in the quantity of HFC-23 recovered from each vent stream for use as chemical feedstock, and hence destroyed, in kg/year.

Example: **AD for Tier 3b – proxy method (1/2)**



Subdivision (facility)	Individual vent stream	Trial campaign (e.g. date)	The average mass fractional concentration of HFC-23 in vent stream j at facility i during the trial T (kg HFC-23 / kg gas stream)	The average mass flowrate of vent stream j at facility i during the trial T (kg / hour)	The proxy quantity (such as process operating rate) at facility i during the trial T (Unit / hour)	The standard mass emission factor of HFC-23 in vent stream j at facility i during the trial T per 'unit' of proxy quantity (kg / Unit)	The standard mass emission factor of HFC-23 in vent stream j at facility i per 'unit' of proxy quantity (kg / Unit)
i	j	T	CT,ij	fT,ij	PORT,ij	ST,ij = CT,ij * fT,ij / PORT,ij	Sij = AVG(ST,ij)
Unspecified	Jan-June	4	0.6	5222	2	1566.6	783.6125
		5	0.5	5	4	0.625	
Unspecified	tester	5	0.5	6	4	0.75	0.75

Example: **AD for Tier 3b – proxy method (2/2)**



Sector: Industrial Processes and Product Use
Category: Chemical Industry - Fluorochemical Production
Subcategory: 2.B.9.a - By-product emissions
Sheet: Mass emission of HFC-23 - Tier 3b (2/2)

1990

Equation 3.38

Subdivision (facility)	Individual vent stream	The standard mass emission factor of HFC-23 in vent stream j at facility i per 'unit' of proxy quantity (kg / Unit)	Dimensionless factor relating the measured standard mass emission rate to the emission rate at the actual facility operating r	The current process operating rate applicable to vent stream j at facility i averaged over time (Unit / hour)	Mass emission of HFC-23 in vent stream j at facility i (kg / hour)	The actual total duration of venting for the year, or the period if the process is not operated continuously	Total vent stream j at facility i (kg / Year)	The quantity of HFC-23 recovered for vent stream j at facility i for use as chemical feedstock, and hence destroyed	Annual emission of HFC-23 in vent stream j at facility i (kg)	Annual emission of HFC-23 in vent stream j at facility i (Gg)
i	j	Sij	Fij	PORij	MEMij = Sij * Fij * PORij	t	TVSij = MEMij * t	Rij	Eij = TVSij - Rij	Eij / 1000000
Unspecified	Jan-June	783.6125	0.9	3	2115.75375	8000	16926030	0	16926030	16.92603
	tester	0.75	0.9	4	2.7	5000	13500	0	13500	0.0135
Total					2118.45375		16939530		16939530	16.93953

Tier 3.c Monitoring method

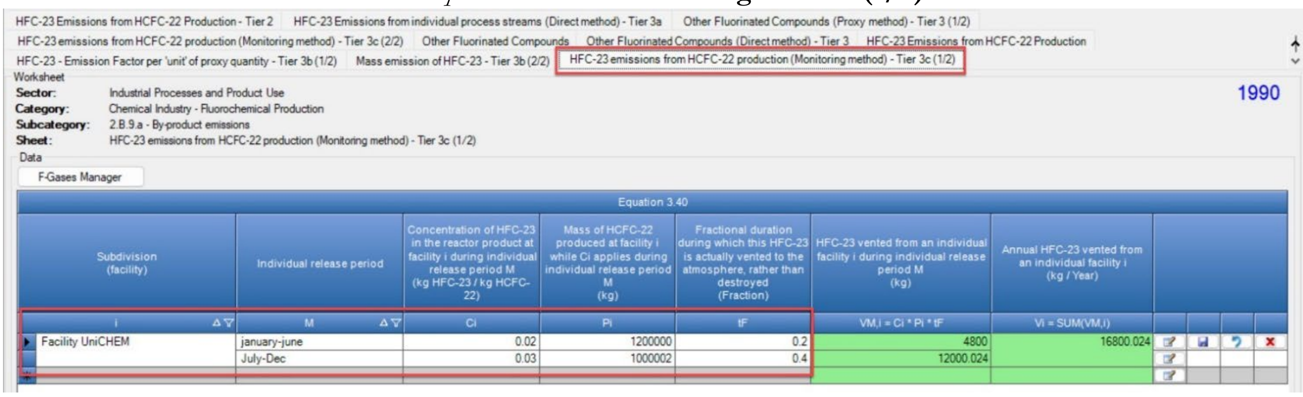
For each subdivision in Column |i|, plant-specific data are entered in worksheet **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (1/2),** row by row, as follows:

1. Column |M| users input the name or time for individual release period(s).
2. Column |C_i|:For each subdivision/individual release period input the concentration of HFC-23 in the reactor product, in kg HFC-23 per kg HCFC-22 produced.
3. Column |P_i|: input the mass of HCFC-22 produced during individual release period M, in kg.
4. Column |tF|: enter the fraction of the period during which this HFC-23 is actually vented to the atmosphere rather than destroyed.

Worksheet **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (1/2)** then sums the vented HFC-23 from each facility during the year, in kg. Then, in worksheet **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (2/2):**

5. Column |R_i|: enter the amount of HFC-23 recovered from the facility for use as chemical feedstock and hence destroyed.
   Note that: where there is abatement then it must be shown that the abatement actually treats all streams that may be released into the atmosphere, including direct gas vents and the outgassing of aqueous streams. The latter, especially, may not be passed to the destruction facility. If all potential vent streams are not treated, the method cannot be used.

Example: **Tier 3.c – monitoring method (1/2)**



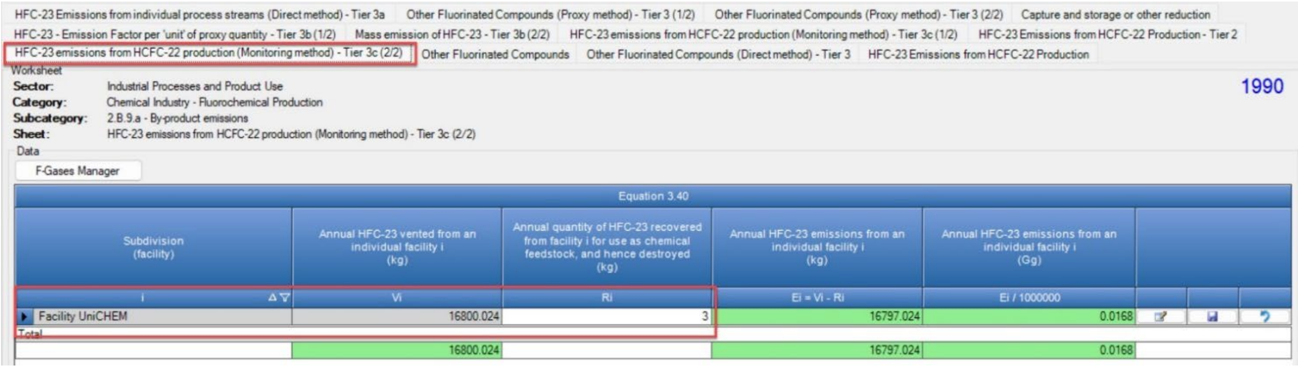
Sector: Industrial Processes and Product Use
Category: Chemical Industry - Fluorochemical Production
Subcategory: 2.B.9.a - By-product emissions
Sheet: HFC-23 emissions from HCFC-22 production (Monitoring method) - Tier 3c (1/2)

1990

Equation 3.40

Subdivision (facility)	Individual release period	Concentration of HFC-23 in the reactor product at facility i during individual release period M (kg HFC-23 / kg HCFC-22)	Mass of HCFC-22 produced at facility i while Ci applies during individual release period M (kg)	Fractional duration during which this HFC-23 is actually vented to the atmosphere, rather than destroyed (Fraction)	HFC-23 vented from an individual facility i during individual release period M (kg)	Annual HFC-23 vented from an individual facility i (kg / Year)
i	M	Ci	Pi	tF	VM,i = Ci * Pi * tF	Vi = SUM(VM,i)
Facility UniCHEM	january-june	0.02	1200000	0.2	4800	16800.024
	July-Dec	0.03	1000002	0.4	12000.024	

Example: **Tier 3.c – monitoring method (2/2)**



Results

By-product Emissions- HFC-23 emissions from HCFC-22 production are estimated in mass units (kg and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets.

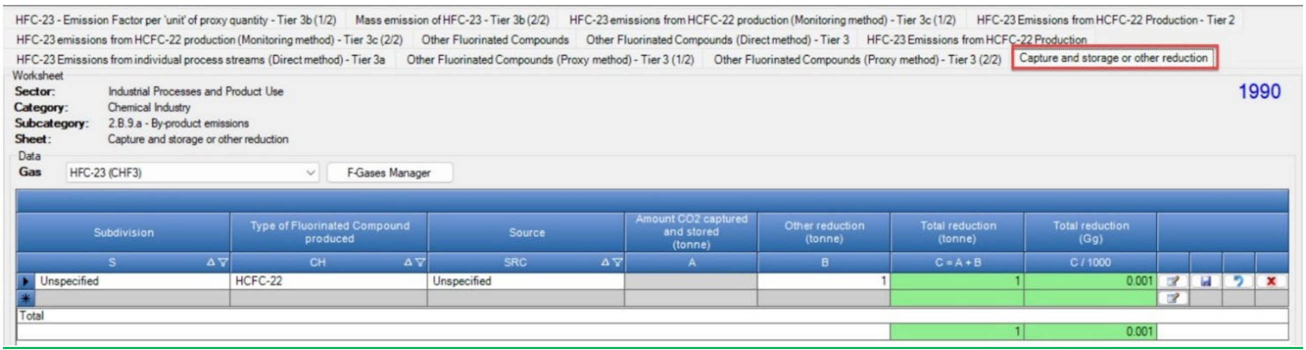
- ✓ **HFC-23 emissions from HCFC-22 production**
- ✓ **HFC-23 emissions from HCFC-22 production – Tier 2**
- ✓ **HFC-23 emissions from individual process streams (Direct Method) – Tier 3a**
- ✓ **Mass emissions of HFC-23 – Tier 3b (2/2)**
- ✓ **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (2/2)**

Total HFC-23 emissions from HFC-23 emissions from HCFC-22 production is the sum of all emissions in the above worksheets, taking into account any capture or destruction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions. As described above, recovery and destruction are already accounted for in the Tier 2 and Tier 3 worksheets above. Users shall ensure that recovery /destruction reported in the worksheet **Capture and storage or other reduction** does not double count that already reported.

In the worksheet **Capture and storage or other reduction,** for each subdivision and each F-gas:

1. Column |CH|: select from the drop-down menu HCFC-22
2. Column |SRC|: enter any identifying information for the source, if applicable.
3. Column |B|: collect and input information on any other long-term reduction of HFC-23, in tonnes.

Example: **Capture and storage or other reduction**



2.B.9.a By-product Emissions – other fluorinated compounds

Information

A large number of fluorine containing GHGs can be produced as by-product emissions during fluorochemical manufacture and emitted into the atmosphere.

For the purposes of data entry in the *Software*, and for interoperability with the UNFCCC ETF Reporting Tool, HFC-23 emissions from HCFC-22 emissions are always calculated under source category 2.B.9.a By-product Emissions. Fugitive emissions from production of HFC-134a, SF_6 and NF_3 should be calculated and reported pursuant to the corresponding worksheets under category 2.B.9.b Fugitive Emissions.

For other emissions from fluorinated gas production, it is assumed that if category 2.B.9 is a key category, and emissions of a particular gas are considered significant, then the release of that gas should be considered a by-product emission and calculated and reported under category 2.B.9.a. If category 2.B.9 is key, but release of a particular gas is not considered significant, or if category 2.B.9 is non-key, other emissions from fluorinated gas production should be considered a fugitive emissions and reported under source category 2.B.9.b Fugitive emissions. This is consistent with footnote 2 in IPCC worksheet 3 of 3 for this category.

The *2006 IPCC Guidelines* provide two Tiers to estimate by-product emissions from other fluorinated compounds (other than HFC-23 emissions from HCFC-22 production). The Tier 1 methodology relies on information on total production of the fluorinated gas (individual species of HFCs, PFCs, SF_6 and other fluorinated GHGs) and a default EF. There are two Tier 3 approaches: Tier 3a and Tier 3b. In the Tier 3a methodology, total emissions equal the sum of factory-specific emissions of each by-product fluorinated gas determined using standard methods to estimate the composition and flowrate of gas streams vented to the atmosphere after any abatement technology. In the Tier 3b proxy methodology, the emission rate of the by-product is normalised to a more easily (or accurately) measurable parameter, such as feedstock flow rate.

The Tier 2 method based on process efficiencies, which works for HFC-23 emissions from HCFC-22 plants, is considered of less value for other types of fluorinated gas production plants, and thus not included in the *Software*. In accordance with the 2006 IPCC Guidelines, in the absence of country-specific information, the quantity of emissions estimated from process inefficiencies may be used in a qualitative decision as to whether or not these emissions are a significant subcategory under a key category, in which case, a Tier 3 methodology in the *Software* should be used.

GHGs

The *Software* includes the following GHGs for production of other fluorinated compounds under the By-product Emissions (2.B.9.a) source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
			X	X	X	X

IPCC Equations

- ✓ Tier 1: Equation 3.41
- ✓ Tier 2: no IPCC Tier 2 Equation provided in the *2006 IPCC Guidelines*
- ✓ Tier 3: Equation 3.42 (Direct method) and Equation 3.43, 3.38 and 3.39 (Proxy method)

As explained in section **1.1.3 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

GHG emissions from By-product emissions- from production of other fluorinated compounds are estimated using the following worksheets:

- ✓ **1.1.2 F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.

- ✓ **Other Fluorinated Compounds:** this worksheet contains for each subdivision and each principal fluorinated compound produced the amount of production of principal compound and a default EF. The worksheet calculates the by-product emissions of other fluorinated compounds.
- ✓ **Other Fluorinated Compounds (Direct Method) – Tier 3** contains for each stream and measurement campaign the concentrations of fluorinated compounds in the gas streams which are vented, the flow rate and the time parameters needed to produce annual emissions. The worksheet calculates the by-product emissions of other fluorinated compounds.
- ✓ **Other Fluorinated Compounds (Proxy Method) – Tier 3 (1/2):** contains for each stream and trial campaign the concentrations of fluorinated compounds, the flow rate and the proxy quantity. The worksheet calculates EF of fluorinated compounds per unit of proxy.
- ✓ **Other Fluorinated Compounds (Proxy Method) – Tier 3 (2/2):** contains for each subdivision and each stream the correlation parameter (emission rate to operation rate) and duration of venting. It also contains information on recovery (destruction) of fluorinated compounds. The worksheet calculates the by-product emissions of other fluorinated compounds.
- ✓ **Capture and storage or other reduction:** contains information on any other amount of recovered (reduced) fluorinated compounds, which are not accounted for in the Tier 1, 2 and 3 worksheets.

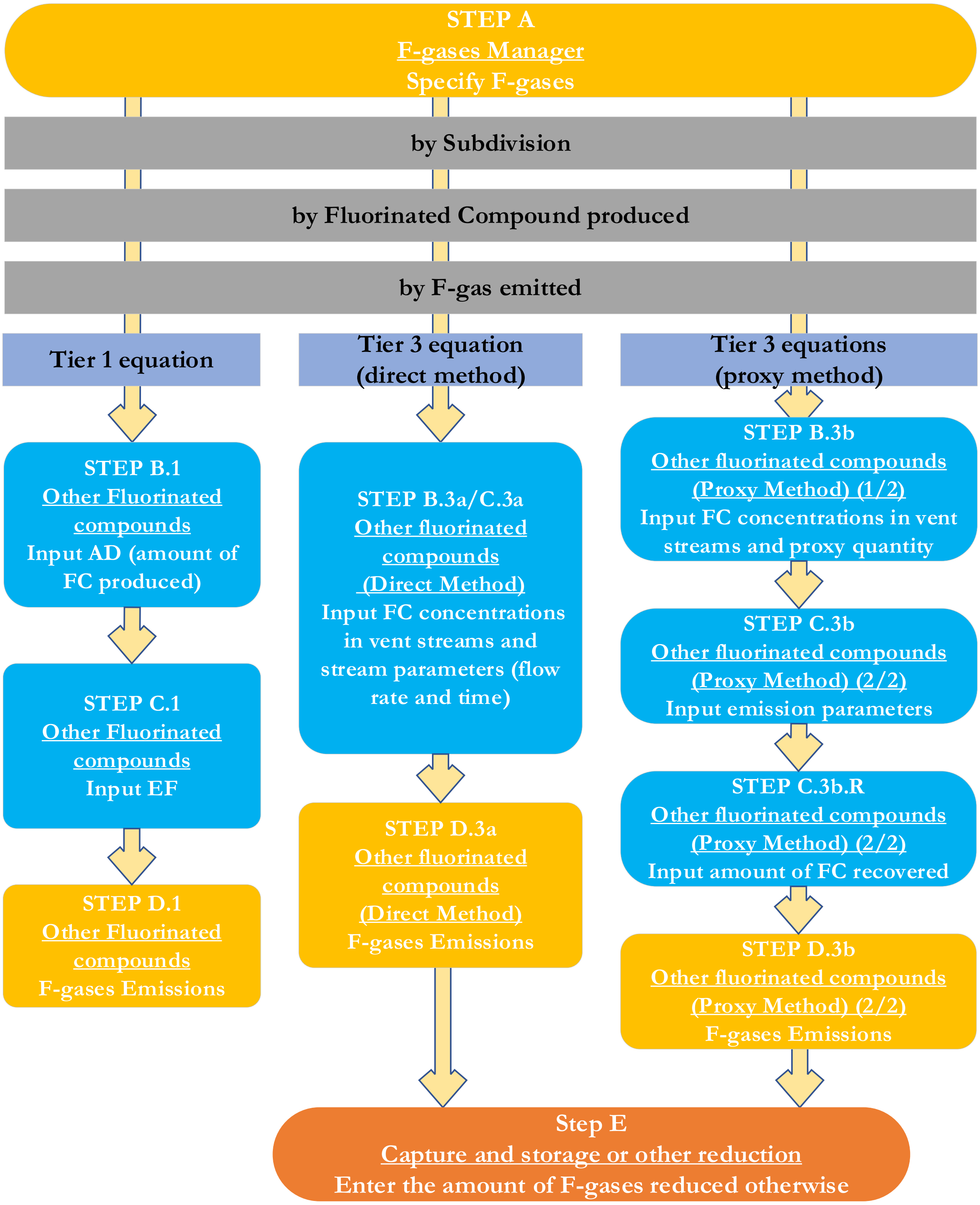
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.17 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for By-product Emissions-from production of other fluorinated compounds.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

By-product emissions from production of other fluorinated compounds – flowchart



Thus, for the source-category:

Step A, 1.1.2 F-gases Manager, users ensure that all F-gases emitted for this source category have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step B.1, in the worksheet **Other Fluorinated Compounds,** users collect and input in the *Software* information on the amount of a principal fluorochemical compound produced, and the gase(es) emitted.
Step C.1, in the worksheet **Other Fluorinated Compounds,** users input an EF for by-product fluorinated compounds emitted.
Step D.1, in the worksheet **Other Fluorinated Compounds,** the *Software* calculates the associated fluorochemical compounds emissions in mass units (kg and Gg).

When Tier 3 Equations are applied:

<u>Tier 3.a Direct method</u>

Step B.3a/C.3.a in the worksheet **Other Fluorinated Compounds (Direct Method) – Tier 3,** users collect and input in the *Software,* for each stream and measurement campaign, the concentrations of fluorochemical compounds in the gas streams which are vented, the flow rate and time parameters needed to produce annual emissions.

Step D.3a, in the worksheet **Other Fluorinated Compounds (Direct Method) – Tier 3,** the *Software* calculates the associated fluorochemical compounds emissions for each vent stream in mass units (kg and Gg).

<u>Tier 3.b Proxy method</u>

Step B.3b, in the worksheet **Other Fluorinated Compounds (Proxy Method) – Tier 3 (1/2),** users collect and input in the *Software* information for each stream and trial campaign the concentrations of fluorochemical compounds, as well as the flow rate and the proxy quantity.

Step C.3b, in the worksheet **Other Fluorinated Compounds (Proxy Method) – Tier 3 (2/2),** for each vent stream users input in the *Software* the measured standard emission rate to the actual rate at the facility, the current process operating rate for the proxy quantity, and the duration of venting

Step C.3b.R, in the worksheet **Other Fluorinated Compounds (Proxy Method) – Tier 3 (2/2),** for each vent stream, users input the amount of recovered (destroyed) fluorochemical compound.

Step D.3b, in the worksheet **Other Fluorinated Compounds (Proxy Method) – Tier 3 (2/2),** the *Software* calculates the associated fluorochemical compounds emissions for each vent stream and total emissions in mass units (kg and Gg).

Then, for each tier, as appropriate:

Step E, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of recovered/reduced fluorinated compounds, which are not accounted for elsewhere in calculation worksheets.

Activity data input

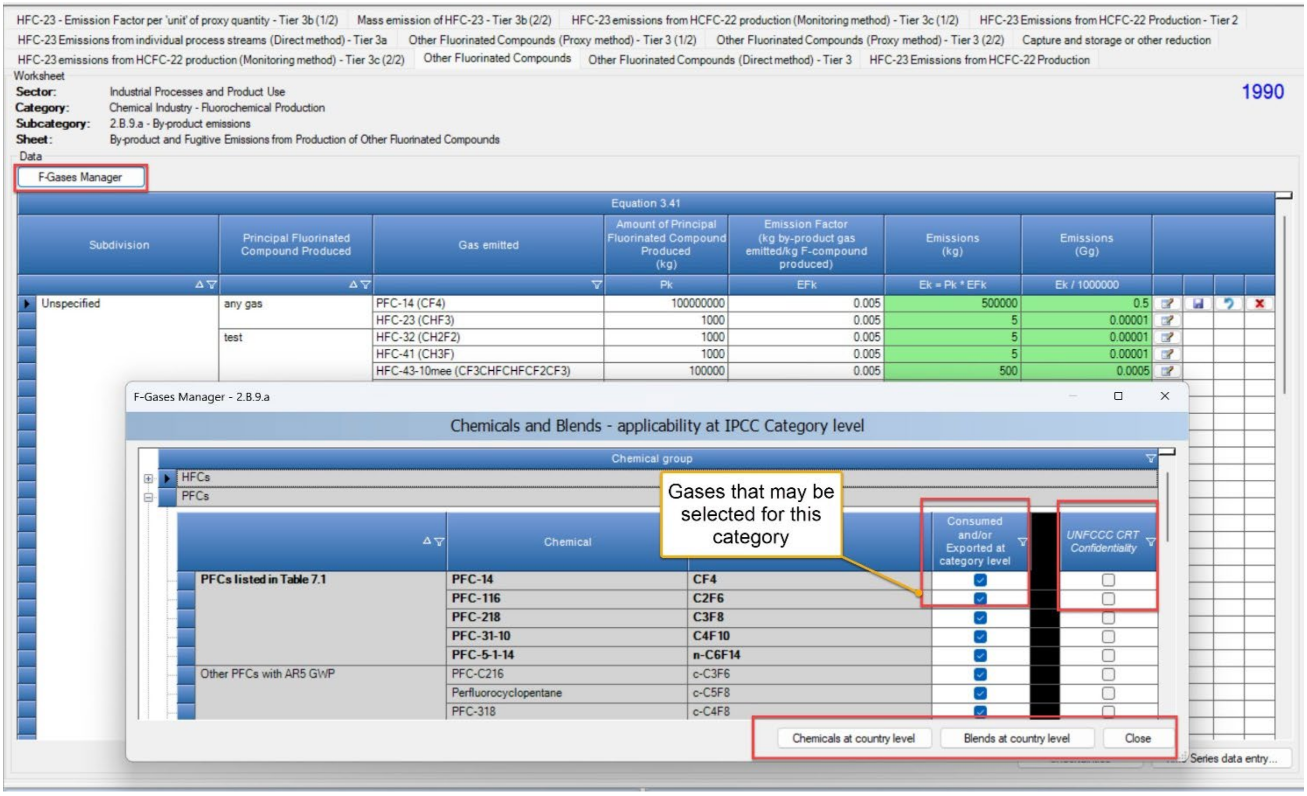
Section 3.10.2.2 Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for By-product emissions from production of other fluorinated compounds.

As a **Starting step**, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases (or, if applicable, blends) to be reported for the source category By-product emissions from production of other fluorinated compounds.

Note that if no F-gases are checked in the F-gases Manager, it will not be possible to enter any data in this worksheet. If data entry is not possible, select the ***F-Gases Manager*** *from any tab. This will open the F-gases Manager – applicability at IPCC Category Level. Navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the country level- F-gases Manager to check all F-gases consumed (including imported) and produced and exported. Save and close the dialogue box for the country level F-gases Manager and the user returns to the IPCC Category level F-gases Manager. In the IPCC Category level F-gases Manager, the user selects which of the relevant F-gases are applicable for this category.*

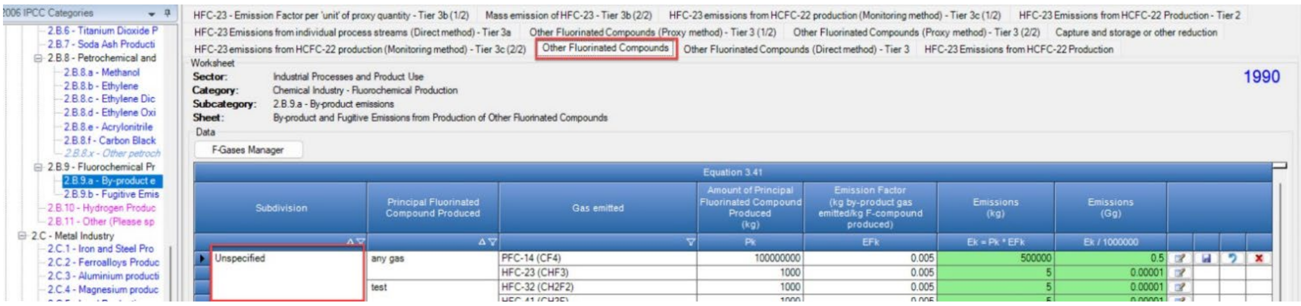
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. If checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate.

Example: **Populating the F-gases manager and designating confidentiality for category: By-product emissions from production of other fluorinated compounds**



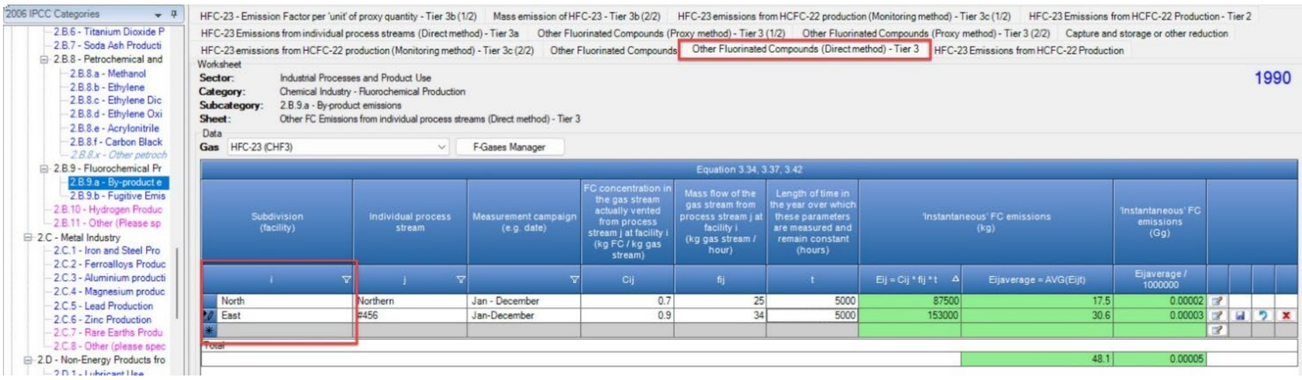
Second, input of AD for By-product emissions from production of other fluorinated compounds requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**

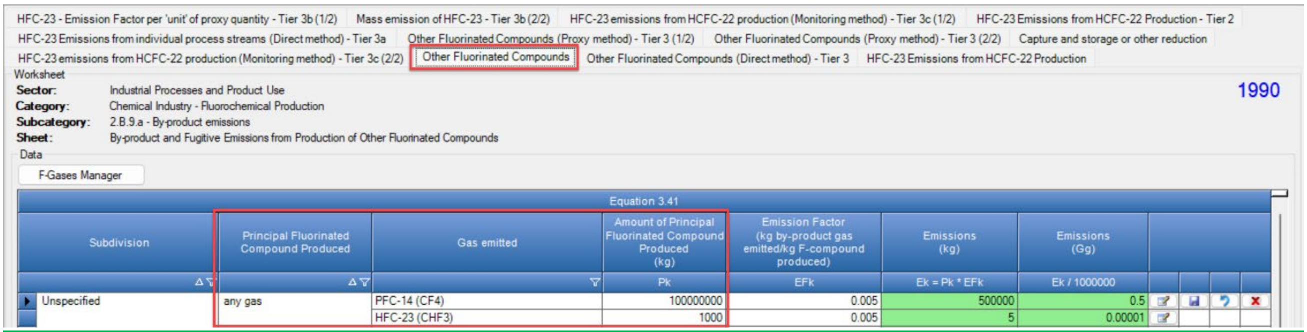


When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in **Other fluorinated compounds** worksheet, row by row, as follows:

1. Column |Principal compound produced|: enter the principal compound produced.
2. Column |Gas emitted|: select from the drop-down menu, the gas emitted.
3. Column |Pk|: enter the amount of principal fluorinated compound produced, in kg.

Example: **AD for other fluorinated compounds – Tier 1**



When Tier 3 Equations are applied:

Tier 3.a Direct method

The Tier 3.a Direct method does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

Tier 3.b Proxy method

The Tier 3.b Proxy method does not rely on AD*EF. Refer to section Direct measurement below to learn how to enter data in the *Software* for this method.

Emission factors input

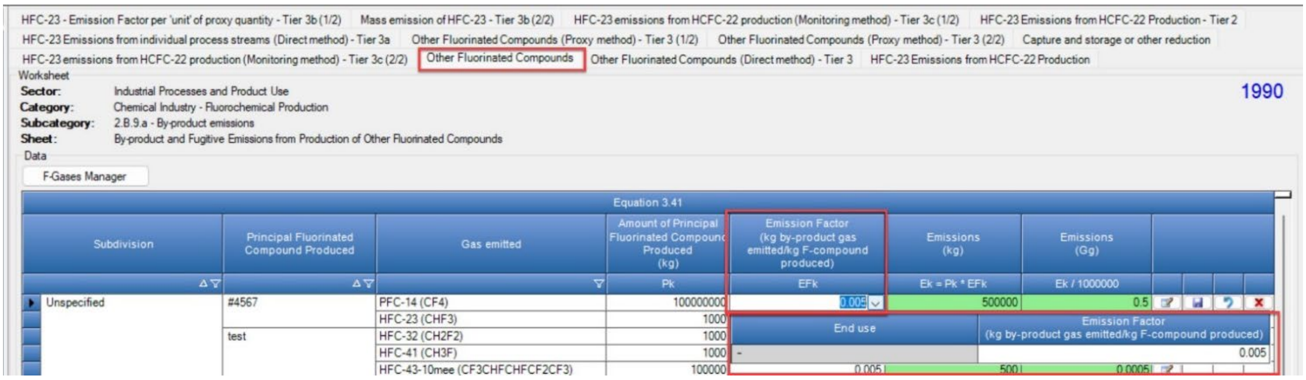
Section 3.10.2.2 Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for By-product emissions from production of other fluorinated compounds.

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, in worksheet **Other fluorinated compounds** row by row, as follows:

1. Column |EFk|: select from the drop-down menu the IPCC default EF, otherwise input a user-specific value, in kg of by-product gas emitted per kg of principal gas produced.

Example: **Tier 1 EFs – other fluorinated compounds**



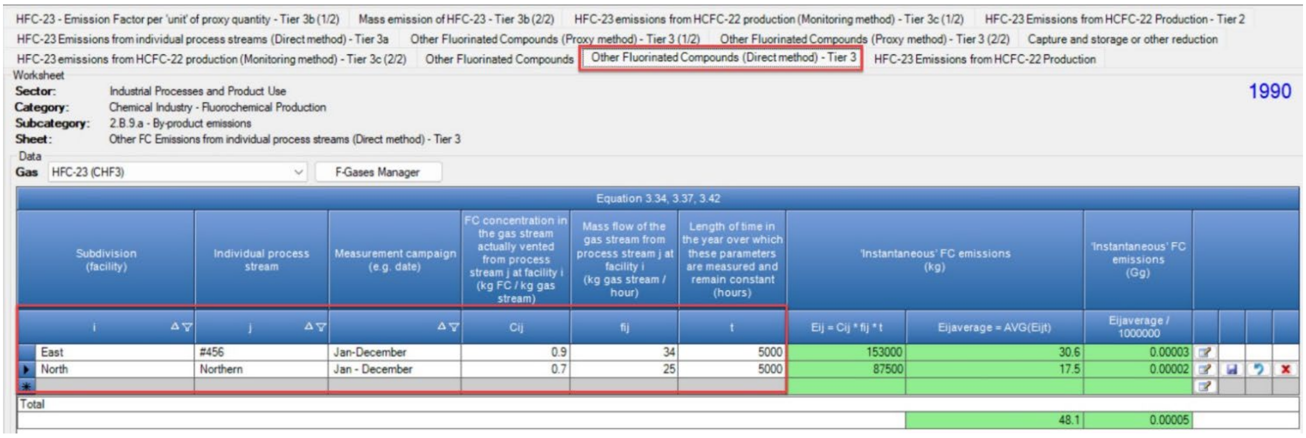
Direct measurement

Tier 3.a Direct method

For each subdivision in Column |i|, data are entered in worksheet **Other Fluorinated Compounds (Direct Method) – Tier 3,** row by row, as follows:

1. Column |j|: enter a name for individual process stream.
2. Column |Measurement campaign|: for each subdivision/process stream input the name or dates of the measurement campaigns.
3. Column |Cij|: For each subdivision/process stream/measurement campaign, input the concentration of HFC-23 in the gas stream which is actually vented, in kg fluorinated compound/kg of gas stream.
4. Column |f_{ij}|: For each subdivision/process stream/measurement campaign input the flow rate of the gas, in kg of gas stream/ hour.
5. Column |t|: For each subdivision/process stream/measurement campaign enter the length of time in hours, these parameters are measured.
   Note that the sum of hours input in column "t" shall correspond to the total time, in hours, of activity of the facility (i) in the reporting year, for which individual jet streams (j) are input in the worksheet.

Example: **Tier 3 – direct method**



Tier 3.b Proxy method

For each subdivision in Column |i| (Tier 3 requires plant- or facility- specific input), data are entered in worksheet **Other Fluorinated Compounds (Proxy method) – Tier 3 (1/2),** row by row, as follows:

1. Column |j|. enter a name for the individual vent stream.
2. Column |T|: for each subdivision (plant)/vent stream, input the name or date of the trial campaigns.
3. Column $|CT_{ij}|$: for each subdivision/vent stream/trial campaign input the concentration of fluorinated compound in the vent stream, in kg fluorinated compound/kg of gas stream.
4. Column $|fT_{ij}|$: for each subdivision/vent stream/trial campaign, input the average mass flow rate of the vent stream, in kg of vent stream/hour.
5. Column $|PORT_{ij}|$: for each subdivision/vent stream/trial campaign, input the proxy quantity (e.g. operating rate) in units per hour.
   Note that the 'unit' depends on the proxy quantity adopted for plant i vent stream j (for example, kg/hour or m^3/hour of feedstock). In almost all cases, the rate of plant operation is considered a suitable proxy and the quantity of fluorinated compound emitted depends on the current plant operating rate and the length of time the vent flow was released.

The worksheet calculates an **average** Fluorinated compound EF per unit of proxy. Then, the subdivisions/vent streams and the calculated EF entered in worksheet **Other Fluorinated Compounds (Proxy method) – Tier 3 (1/2),** are transferred automatically.to worksheet **Other Fluorinated Compounds (Proxy method) – Tier 3 (2/2).**

Then, for each subdivision/individual vent stream,

6. Column $|F_{ij}|$. the users enter a dimensionless factor relating the measured standard mass emission rate to the emission rate at the actual plant operating rate.
   Note that in many cases, the fraction produced is not sensitive to operating rate and Fi is unity (i.e., the emission rate is proportional to operating rate). In other cases the emission rate is a more complex function of the operating rate. In all cases Fi should be derived during the plant trial by measuring HFC-23 production at different operating rates. ***For situations where a simple function relating the emissions to the operating rate cannot be determined from testing, the proxy method is not considered appropriate and continuous measurement is desirable****.*
7. Column $|POR_{ij}|$: Users enter the current process operating rate applicable to that vent stream, j, averaged over the time period, t, in 'unit/hour'.
   Note that the units of this parameter must be consistent between the plant trial establishing the standard emission rate and the estimate of ongoing, operational emissions
8. Column |t|.: enter the time, in hours, of actual venting for the year, or the period if the process is not operated continuously.
   Note that annual emissions become the sum of all the periods during the year. The periods during which the vent stream is processed in a destruction system should not be counted here.
9. Column |Rij|: enter in the quantity of fluorinated compound recovered from each vent stream for use as chemical feedstock, and hence destroyed.

Results

By-product emissions from production of other fluorinated compounds are estimated in mass units (kg and Gg) by the *Software* in the following worksheets for different Tiers.

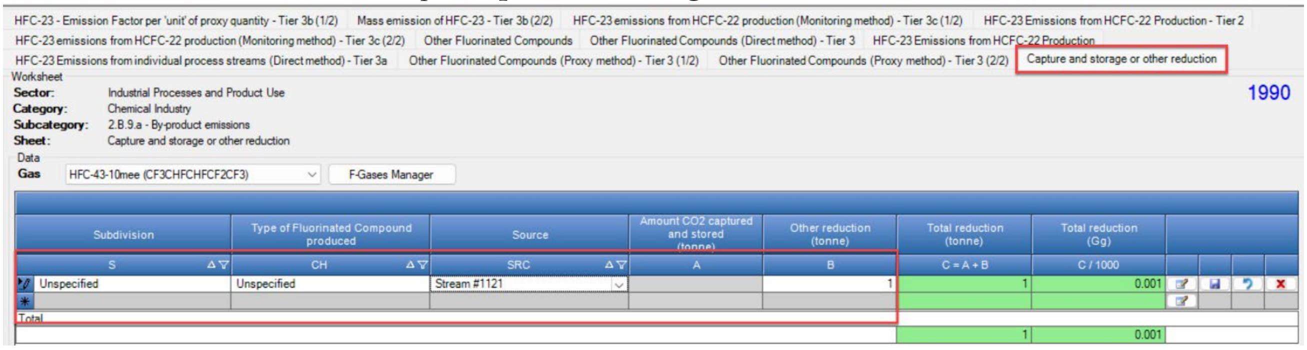
- ✓ **Other Fluorinated Compounds:**
- ✓ **Other Fluorinated Compounds (Direct Method) – Tier 3**
- ✓ **Other Fluorinated Compounds (Proxy Method) – Tier 3 (2/2)**

Total emissions from production of other fluorinated compounds is the sum of all emissions in the above worksheets, taking into account any capture or destruction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions. As described above, recovery and destruction are already accounted for in the Tier 3 worksheets above. Users shall ensure that recovery /destruction reported in the worksheet **Capture and storage or other reduction** does not double count that already reported.

In the worksheet **Capture and storage or other reduction**, for each subdivision and each F-gas:

1. Column |CH|: enter in the drop-down menu the type of fluorinated compound produced, for which the destruction / reduction activity is taking place.
2. Column |SRC|: enter any identifying information for the source, if applicable.
3. Column |B|: collect and input information on any other long-term reduction of fluorinated GHGs emitted, in tonnes.

Example: **Capture and storage or other reduction**



2.B.9.b Fugitive Emissions – from production of other fluorinated compounds

Information

Emissions of a chemical occur during its production and distribution or as a by-product during the production of a related chemical (HFC-23 from HCFC-22 production is covered specifically and described above). There may also be emissions of the material that is being produced; the so-called **'fugitive emissions'**.

For the purposes of data entry in the *Software*, and for interoperability with the UNFCCC ETF Reporting Tool, HFC-23 emissions from HCFC-22 emissions are always calculated under source category 2.B.9.a By-product Emissions. Fugitive emissions from production of HFC-134a, SF_6 and NF_3 should be calculated and reported pursuant to the corresponding worksheets under category 2.B.9.b Fugitive Emissions.

For other emissions from fluorinated gas production, it is assumed that if category 2.B.9 is a key category, and emissions of a particular gas are considered significant, then the release of that gas should be considered a by-product emission and calculated and reported under category 2.B.9.a. If category 2.B.9 is key, but release of a particular gas is not considered significant, or if category 2.B.9 is non-key, other emissions from fluorinated gas production should be considered a fugitive emissions and reported under source category 2.B.9.b Fugitive emissions. This is consistent with footnote 2 in IPCC worksheet 3 of 3 for this category.

The Software provides only a Tier 1 method for fugitive emissions from fluorochemical production, based on the production of the fluorinated compound and a default EF.

GHGs

The *Software* includes the following GHGs for production of other fluorinated compounds under the Fugitive Emissions (2.B.9.b) source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
			X	X	X	X

IPCC Equations

- ✓ Tier 1: Equation 3.41
- ✓ Tier 2: no IPCC Tier 2 Equation provided in the *2006 IPCC Guidelines*
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*

As explained in section **1.1.3 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

GHG emissions from the Fugitive emissions source category are estimated using the following two worksheets:

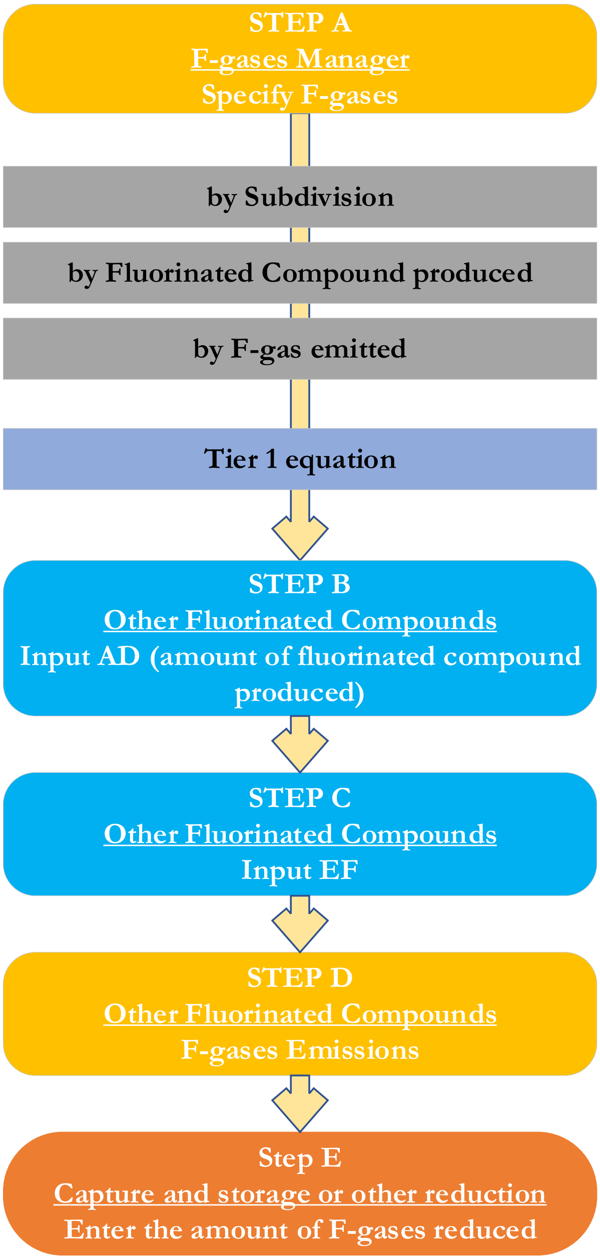
- ✓ **1.1.2 F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Other Fluorinated Compounds:** contains for each subdivision information on the amount of fluorinated gas produced and the fugitive EF. The worksheet calculates the associated F-gases emissions.
- ✓ **Capture and storage or other reduction:** contains information on reduction of F-gases.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.17 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Fugitive Emissions-from production of other fluorinated compounds.

Fugitive Emissions – flowchart



Thus, for the source-category:

Step A, 1.1.2 F-gases Manager, users ensure that all F-gases emitted for this source category have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step B, in the worksheet **Other fluorinated compounds,** users collect and input in the *Software* information on the amount of fluorinated principal compound produced and the gas(es) emitted.

Step C, in worksheet **Other fluorinated compounds,** users input an EF for fluorinated compounds.

Step D, in the worksheet **Other fluorinated compounds,** the *Software* calculates the associated fluorochemical compounds emissions in mass units (kg and Gg).

Step E, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of recovered/reduced fluorinated compounds, which are not accounted for elsewhere in calculation worksheets.

Activity data input

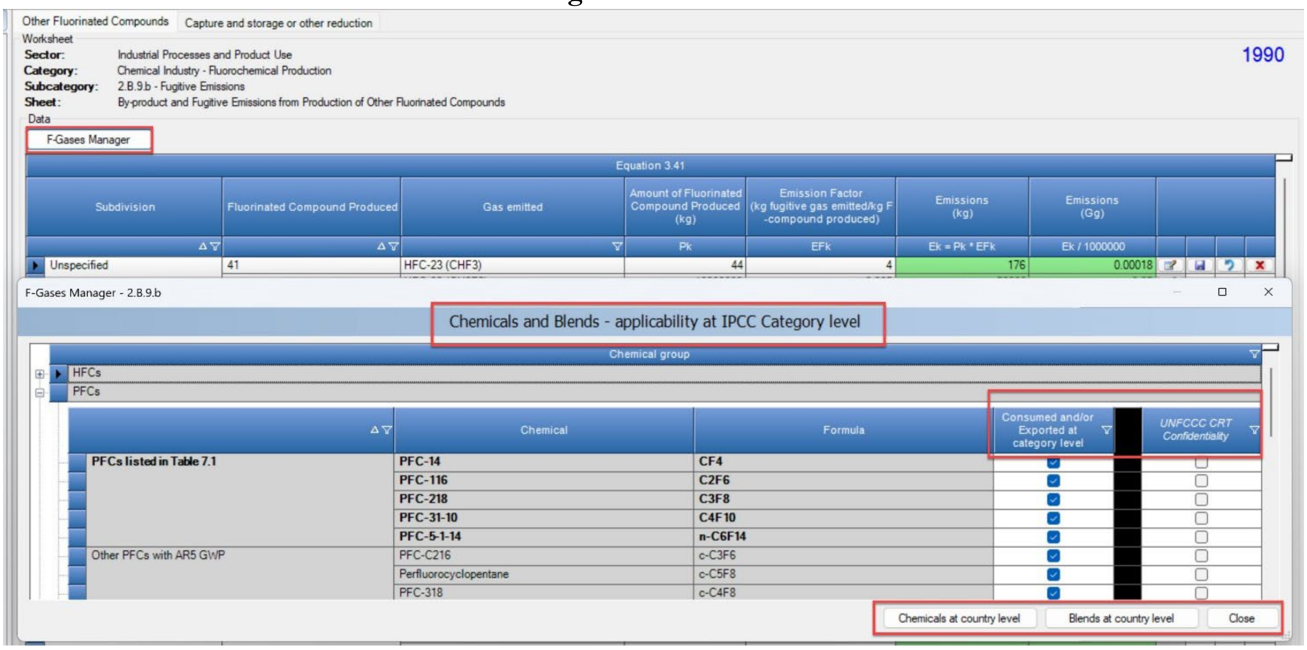
Section 3.10.2.2 Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for fugitive emissions from production of other fluorinated compounds.

As a **Starting step**, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases (or, if applicable, blends) to be reported for the source category Fugitive Emissions.

*Note that if no F-gases are checked in the F-gases Manager, it will not be possible to enter any data in this worksheet. If data entry is not possible, select the **F-Gases Manager** from any tab. This will open the F-gases Manager – applicability at IPCC Category Level. Navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the country level- F-gases Manager to check all F-gases consumed (including imported) and produced and exported. Save and close the dialogue box for the country level F-gases Manager and the user returns to the IPCC Category level F-gases Manager. In the IPCC Category level F-gases Manager, the user selects which of the relevant F-gases are applicable for this category.*

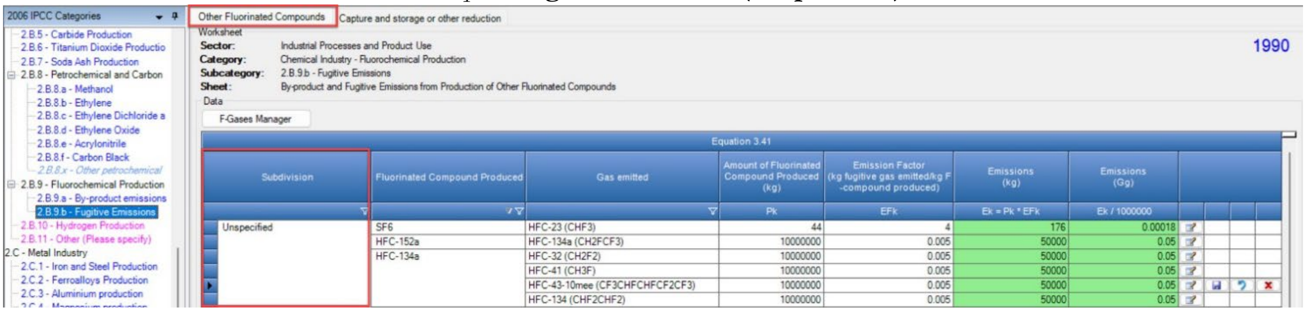
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. If checked, "C" will be reported for AD and emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate.

Example: **Populating the F-gases manager and designating confidentiality for category: Fugitive Emissions**



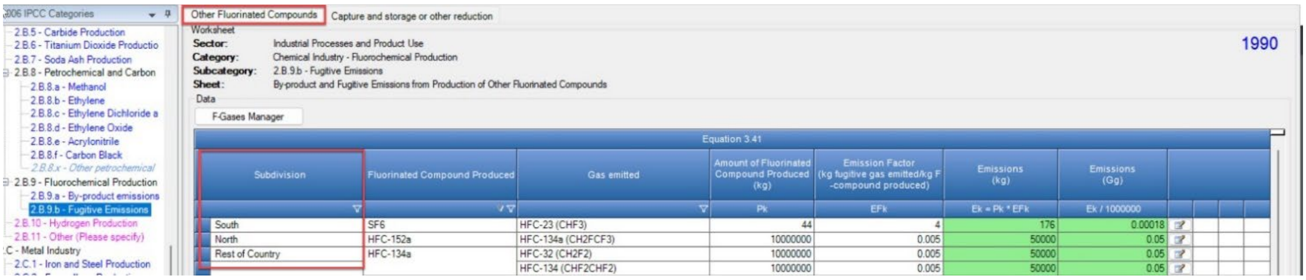
Second, input of AD for Fugitive Emissions requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> for each subdivision.

Example: **multiple subdivisions**



Then, for each subdivision in <u>Column |Subdivision|</u>, data are entered in **Other fluorinated compounds** worksheet, row by row, as follows:

1. <u>Column |Principal compound produced|:</u> enter the principal compound produced.
2. <u>Column |Gas emitted|:</u> select from the drop-down menu, the gas emitted.
3. <u>Column |Pk|</u>: enter the amount of principal fluorinated compound produced, in kg.

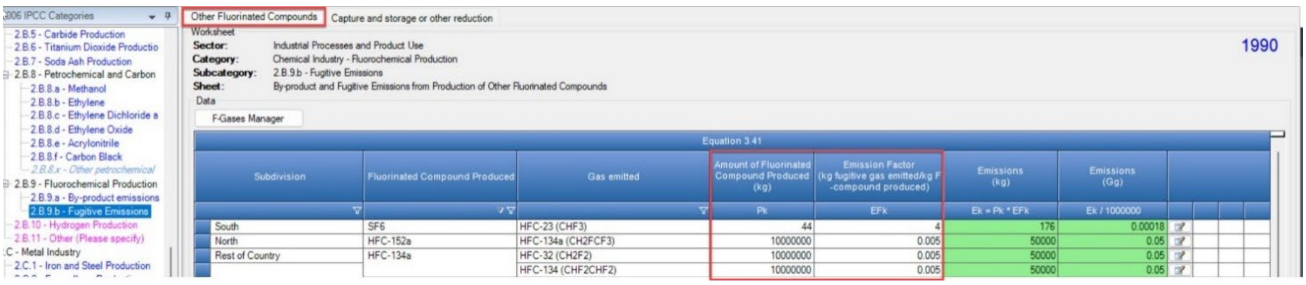
Emission factors input

<u>Section 3.10.2.2</u> Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Fugitive emissions from production of other fluorinated compounds.

For each subdivision in <u>Column |Subdivision|</u>, in worksheet **Other fluorinated compounds** row by row, as follows**:**

1. <u>Column |EFk</u>|: select from the drop-down menu the IPCC default EF, otherwise input a user-specific value, in kg of fugitive gas emitted/kg of principal gas produced.

Example: **AD and EFs for fugitive emissions – Tier 1**



Results

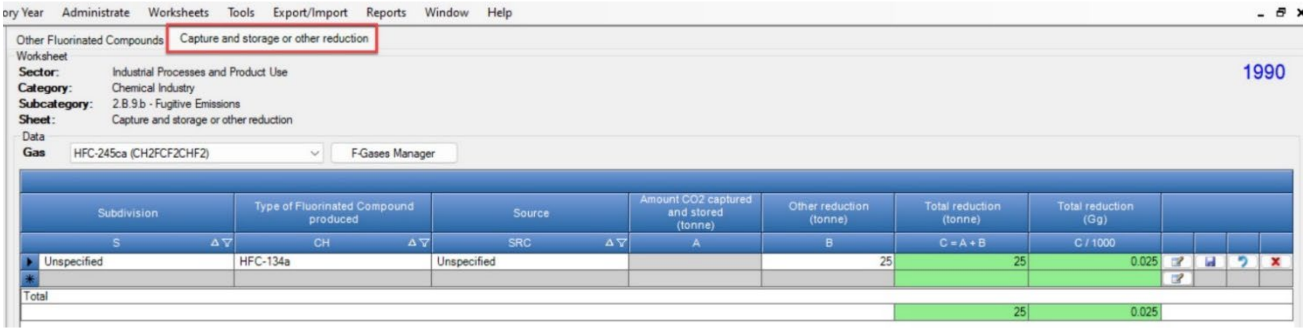
Fugitive emissions from production of other fluorinated compounds are estimated in mass units (kg and Gg) by the *Software* in the worksheet **Other Fluorinated Compounds.**

Total emissions from production of other fluorinated compounds is the sum of emissions in the above worksheet, taking into account any capture or destruction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction,** for each subdivision and each F-gas:

1. Column |SRC|: enter any identifying information for the source, if applicable.
2. Column |B|: collect and input information on any other long-term reduction of fluorinated GHGs emitted, in tonnes.

Example: **Capture and storage or other reduction**



2.B.10 Hydrogen Production

Information

Section 3.11 Chapter 3, Volume 3 of the *2019 IPCC Guidelines* provides three Tiers to estimate CO_2 emissions from Hydrogen Production. The Tier 1 methods use national or regional level AD on hydrogen production or feedstock consumption together with default factors and data on recovered CO_2 to derive emissions. The Tier 2 method allows the use of the same AD, but with and country-specific factors along with data on recovered CO_2. Tier 3 requires plant-specific AD and factors. Tier 1a is the default method based on national total of hydrogen production, where Tier 1b assumes feedstock requirements for hydrogen production and Tier 1c is based on the amount of feedstock consumption. Tier 2b and Tier 2c requires information on feedstock requirements for hydrogen production, and hydrogen production, respectively and country specific carbon content factors. Tier 3b and Tier 3c require plant-specific data.

The *2019 Refinement* guidance provides estimation methods for CO_2 only.

As for CH_4 and N_2O emissions, steam reforming and gasification produce very minor emissions of CH_4 and N_2O, in addition to CO_2 emissions. The available literature indicates that emissions of CH_4 and N_2O are very low, activity data for the process combustion source are likely to be hard to obtain, and the literature evidence is insufficient to establish an estimation method. Hence, no reporting of CH_4 and N_2O is required per the *2019 Refinement.*[1] For the purposes of interoperability with the UNFCCC ETF Reporting Tool, the *Software* provides an option to estimate and report these emissions through use of a generic worksheet.

GHGs

The *Software* includes the following GHG for the Hydrogen Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

CO_2

- ✓ Tier 1: Equations 3.44 (New), 3.45 (New) and 3.46 (New)
- ✓ Tier 2: Equations 3.47 (New) and 3.48 (New)
- ✓ Tier 3: Equations 3.49 (New) and 3.50 (New)

CH_4 and N_2O

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 CH_4 and N_2O emissions from hydrogen production.

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

Software Worksheets

The *Software* calculates GHG emissions from Hydrogen Production using 7 worksheets:

- ✓ **1.1.1 Fuel Manager**: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b):** contains for each subdivision, individual type of process and feedstock, information on the amount of hydrogen produced and feedstock requirement (with carbon content) and amount of CO_2 recovered. The worksheet calculates the associated CO_2 emissions.

[1] See page. 3.35 of Chapter 3 Volume 3 of the *2019 Refinement.*

- ✓ **CO_2 Emissions from Hydrogen Production (Tier 1c/2c):** contains for each subdivision, individual type of process (if known) and type of feedstock information on the amount of feedstock used (with carbon content) and amount of CO_2 recovered. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 3b):** contains for each subdivision, individual type of process and feedstock, information on the amount of hydrogen produced and feedstock requirement (with plant-specific carbon content) and amount of CO_2 recovered, and solid C stored. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 3c):** contains for each subdivision, individual type of process and type of feedstock information on the amount of feedstock used (with plant-specific carbon content) and amount of CO_2 recovered and solid C stored. The worksheet calculates the associated CO_2 emissions.
- ✓ **CH_4 and N_2O Emissions from Hydrogen Production:** a generic worksheet that contains for each subdivision and production process information on AD (type and amount) and EF for CH_4 and N_2O. The worksheet calculates the associated CH_4 and N_2O emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, N_2O and CH_4, not accounted previously in the worksheets for different Tiers.

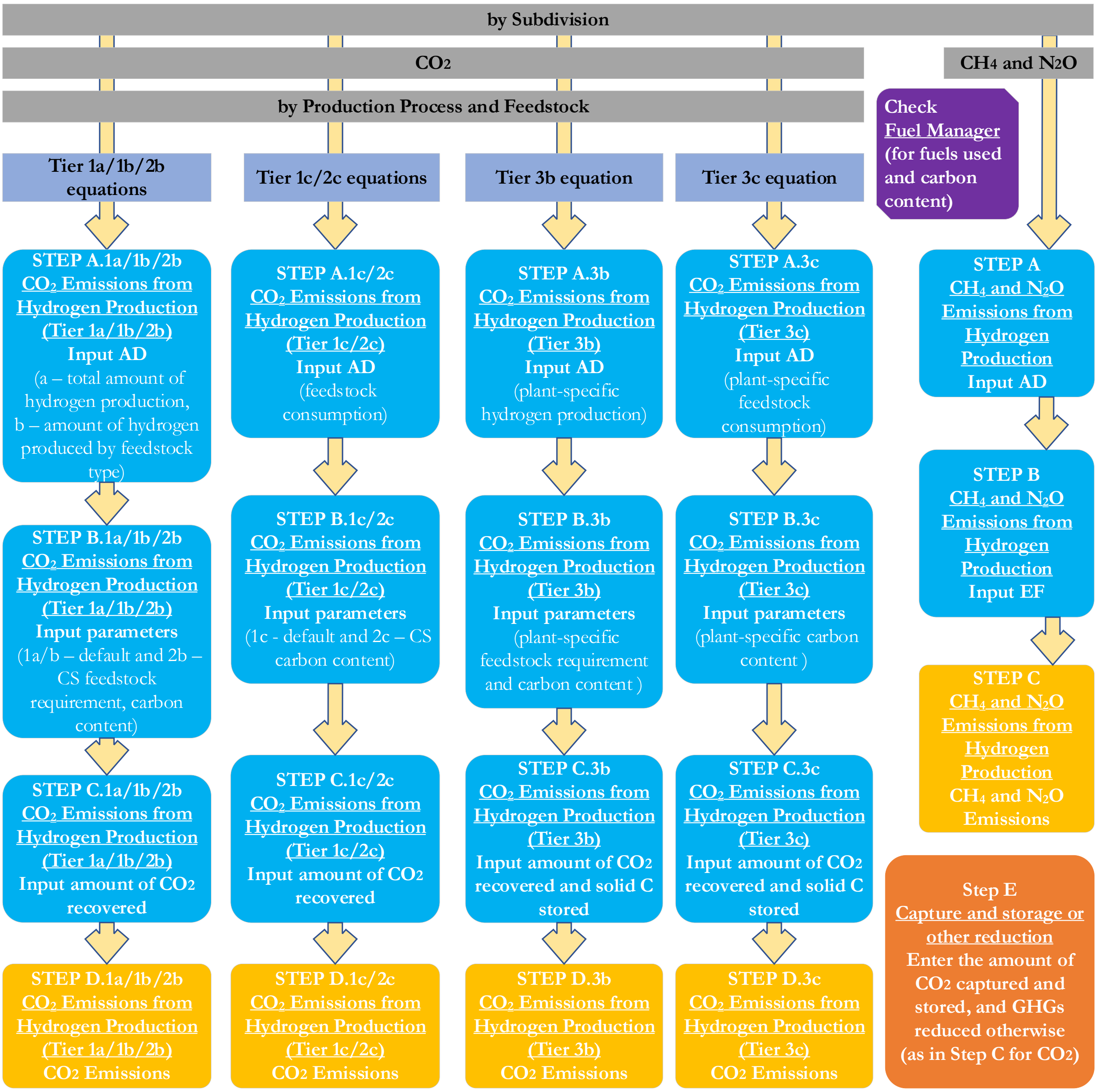
User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 3.20 of the *2019 Refinement*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of country- or plant-specific[1] EFs.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Hydrogen Production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Hydrogen Production – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or plants).

Then, for each subdivision, if any:

When Tier 1 Equations are applied:

Step A.1a, A.1b and A.1c, in the worksheets **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** users collect and input in the *Software* information on the amount of hydrogen produced or the amount of feedstock.

Step B.1a, B.1b and B.1c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** users input in the *Software* default feedstock requirement (Tier 1a/1b only) and default carbon content.

Step C.1a, C.1b and C.1c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** users input in the *Software* information on CO_2 recovered (if no information available it is good practice to assume 0 recovery).

Step D.1a, D.1b and D.1c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** for each subdivision, CO_2 emissions are calculated in mass units (tonnes and Gg). In addition, total CO_2 emissions are calculated.

When Tier 2 Equations are applied:

Step A.2b and A.2c, in the worksheets **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** users collect and input in the *Software* information on the amount of hydrogen produced or the amount of feedstock.

Step B.2b and B.2c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** users input in the *Software* country-specific and process-specific feedstock requirement and country-specific carbon content.

Step C.2b and C.2c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** users input in the *Software* information on CO_2 recovered.

Step D.2b and D.2c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** for each subdivision, type of production process and type of feedstock, CO_2 emissions are calculated in mass units (tonnes and Gg). In addition, total CO_2 emissions are calculated.

When the Tier 3 Equation is applied:

Step A.3b and A.3c, in the worksheets **CO_2 Emissions from Hydrogen Production (Tier 3b)** and **CO_2 Emissions from Hydrogen Production (Tier 3),** users collect and input in the *Software* plant-specific information on the amount of hydrogen produced or the amount of feedstock consumed.

Step B.3b and B.3c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 3b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 3c),** users input in the *Software* plant-specific and process-specific feedstock requirement and plant-specific carbon content.

Step C.3b and C.3c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 3)** and/or **CO_2 Emissions from Hydrogen Production (Tier 3c),** users input in the *Software* information on CO_2 recovered and the amount of solid carbon stored.

Step D.3b and D.3c, in the worksheet **CO_2 Emissions from Hydrogen Production (Tier 3b)** and/or **CO_2 Emissions from Hydrogen Production (Tier 3c),** for each subdivision, type of production process and type of feedstock, CO_2 emissions are calculated in mass units (tonnes and Gg). In addition, total CO_2 emissions are calculated.

Then as appropriate:

i) if emissions of CH_4 and N_2O are estimated

Step A, in the worksheet **CH₄ and N₂O Emissions from Hydrogen Production,** users collect and input in the *Software* information on AD relevant for CH_4 and N_2O emissions.

Step B, in the worksheet **CH₄ and N₂O Emissions from Hydrogen Production,** users collect and input in the *Software* information on EFs relevant for CH_4 and N_2O emissions.

Step C, in the worksheet **CH₄ and N₂O Emissions from Hydrogen Production,** for each subdivision, CH_4 and N_2O emissions are calculated in Gg.

ii) if there is capture additional to that in Step C for CO_2

Step E, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) and reduction of CH_4 and N_2O.

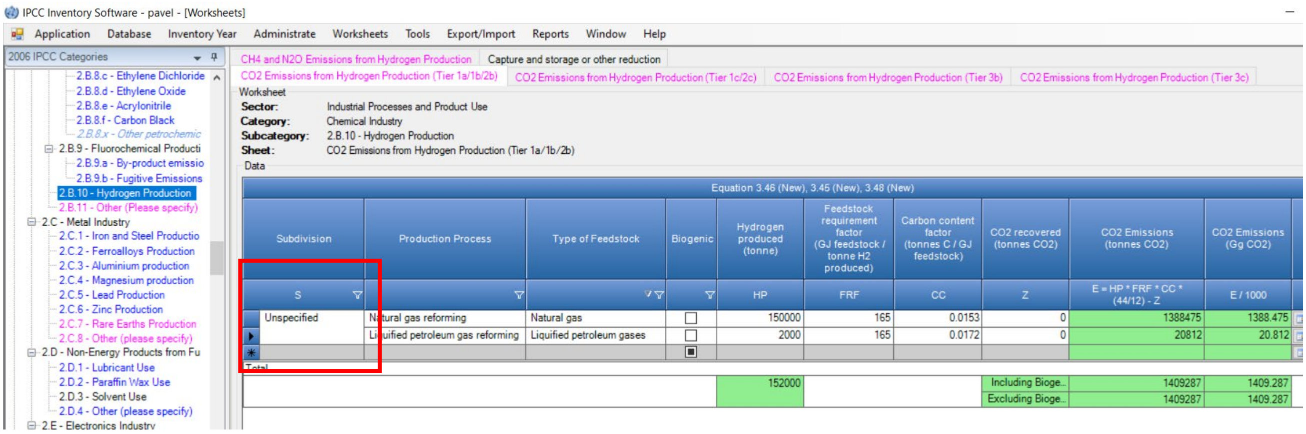
Activity data input

Section 3.11.2.3 in Chapter 3 Volume 3 of the *2019 Refinement* contains information on the choice of AD for hydrogen production.

As a **Starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for hydrogen production (if the Tier 1c, Tier 2.c, or Tier 3 methods are applied); 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 drop-down menu.

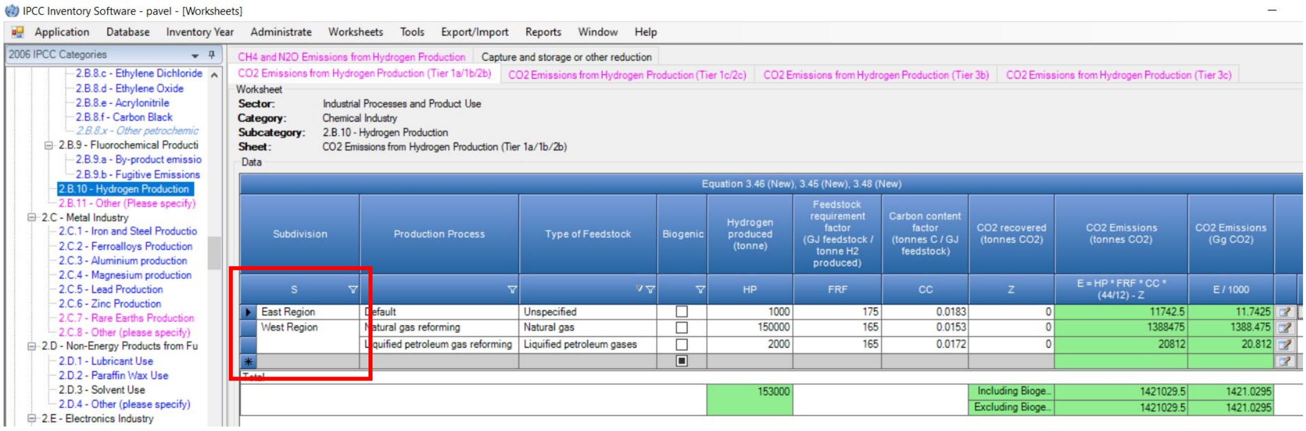
Second, input of AD for the Hydrogen Production source category requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |S| for each subdivision.

Example: **multiple subdivisions**



Then,

When Tier 1 and Tier 2 Equations are applied:

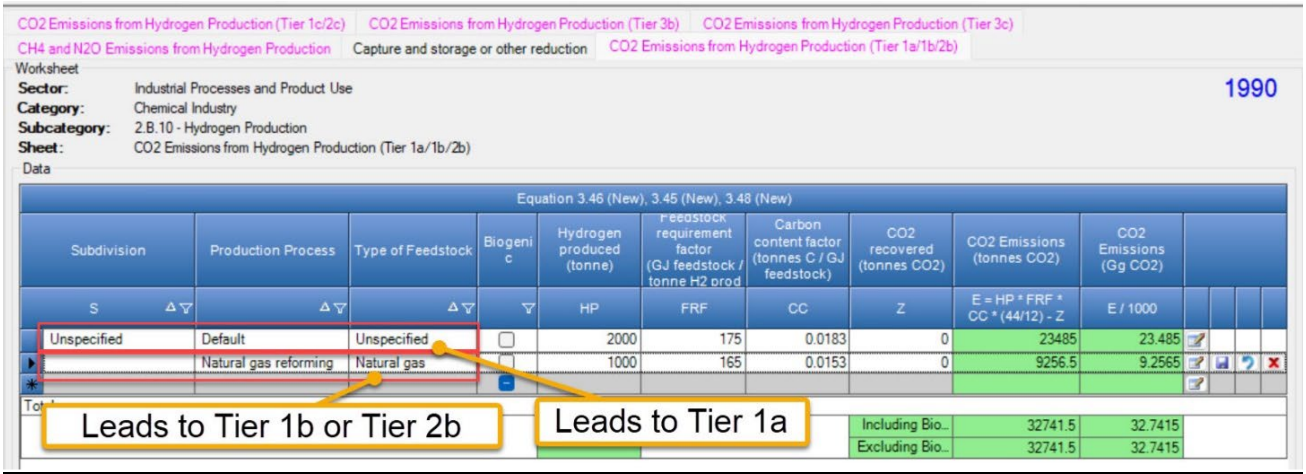
Following a Tier1 or Tier 2 approach, the following AD are entered, depending on the method chosen:

- ✓ Tier 1a: requires total national production of hydrogen.
- ✓ Tier 1b/2b: requires total national production, by type of feedstock.
- ✓ Tier 1c/2c: requires total national feedstock consumption for hydrogen production, by type of feedstock.

For the Tier 1a, Tier 1b and Tier 2b methods: for each subdivision in Column |S|, data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)**, row by row, as follows:

1. Column |Production process|: select the type of production process, or, if unknown, select Unspecified (one row for each type of production process). A country-specific production process may also be entered. The Tier 1a method assumes a default production process and that the feedstock type is unspecified.
2. Column |Type of feedstock|: if a particular production process is selected, the type of feedstock will appear automatically (depending on the process). The user may overwrite the type of feedstock. If the user applies a Tier 1a method and assumes a default production process, the feedstock type is automatically listed as unspecified.
3. Column |Biogenic|: indicate with a check if the process feedstock is of biogenic origin.
4. Column |HP|: input the amount of hydrogen produced, in tonnes.

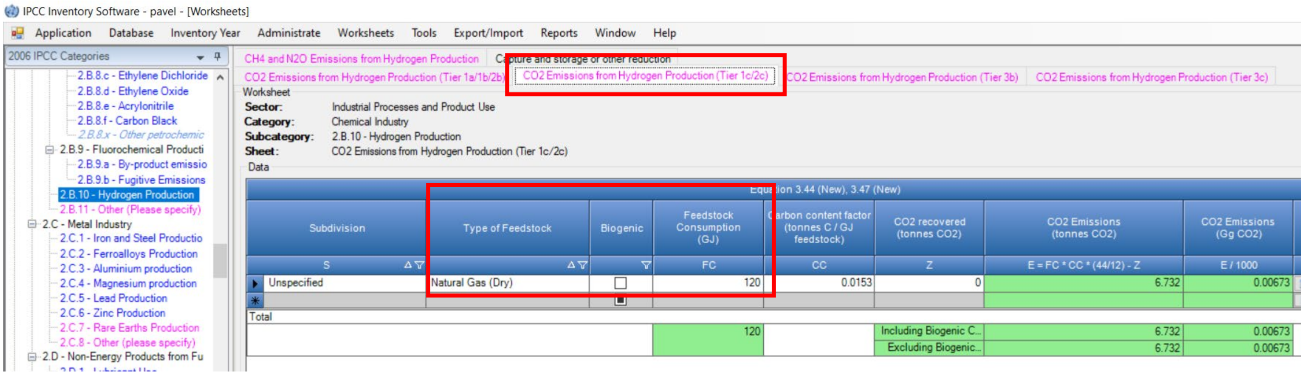
Example: **AD input for Tier 1a/1b /2b Hydrogen Production**



For the Tier 1c and Tier 2c methods: for each subdivision in Column |S|, data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 1c/2c),** row by row, as follows:

1. Column |Type of feedstock|: select the relevant fuel used as feedstock (one row for each feedstock) from the drop-down menu.
   Note that fuels shown in the drop-down menu are those listed in the Fuel Manager.
2. Column |Biogenic|: indicate with a check if the process feedstock is of biogenic origin.
3. Column |FC|: input the amount of feedstock consumed, in GJ.

Example: **AD input for Tier 1c/2c Hydrogen Production (AD – feedstock consumption)**



When Tier 3 Equations are applied:

The Tier 3b and Tier 3c methods require the same type of AD as described above on hydrogen production (Tier 3b) or feedstock consumption (Tier 3c), but the AD must be plant-specific. Tier 3b data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3b)**, while for Tier 3c data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3c).**

Emission factor input

Section 3.11.2.2 Chapter 3 Volume 3 of the *2019 Refinement* contains information on the choice of EFs for Hydrogen Production.

There are two types of EFs: i) feedstock requirement and ii) carbon content of feedstock. Default parameters for Tier 1 and Tier 2 are provided in Table 3.30 (New) Chapter 3 Volume 3 of the *2019 Refinement*.

The Tier 1 assumes default parameters and no capture of CO_2. For Tier 2, users need to collect country-specific parameters and for Tier 3 – plant-specific feedstock requirement and carbon content by process and feedstock types.

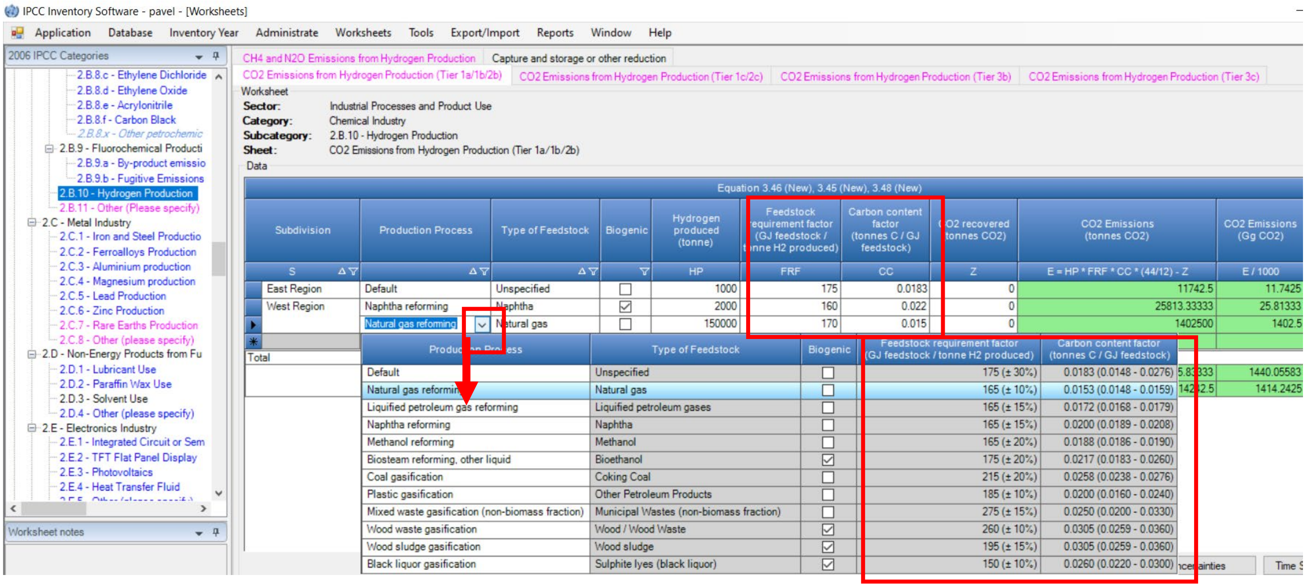
When Tier 1 and Tier 2 Equations are applied:

For the Tier 1a, Tier 1b and Tier 2b methods: for each combination of subdivision/production process/type of feedstock, data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)**, row by row, as follows.

1. Column |FRF|: input feedstock requirement in GJ per tonne of hydrogen produced.
2. Column |CC|: input carbon content of feedstock in tonnes of C per GJ of feedstock.

In Tier 1 and Tier 2 the values below are automatically populated based on the selection made in Column |Production Process|. The user may overwrite these values. The default values are provided in a drop-down table. See the example below.

Example: **Tier 1a/b and Tier 2b parameters for Hydrogen Production (AD – hydrogen production)**



For the Tier 1c/2c methods: for each combination of subdivision/production process/type of feedstock, data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 1c/2c)**, row by row, as follows.

1. Column |CC|: input carbon content of feedstock in tonnes of C per GJ of feedstock. This value is automatically populated based on the selection made in Column |Type of Feedstock| (Tier 1c) and may be overwritten by the user (Tier 2c).

When Tier 3 Equations are applied:

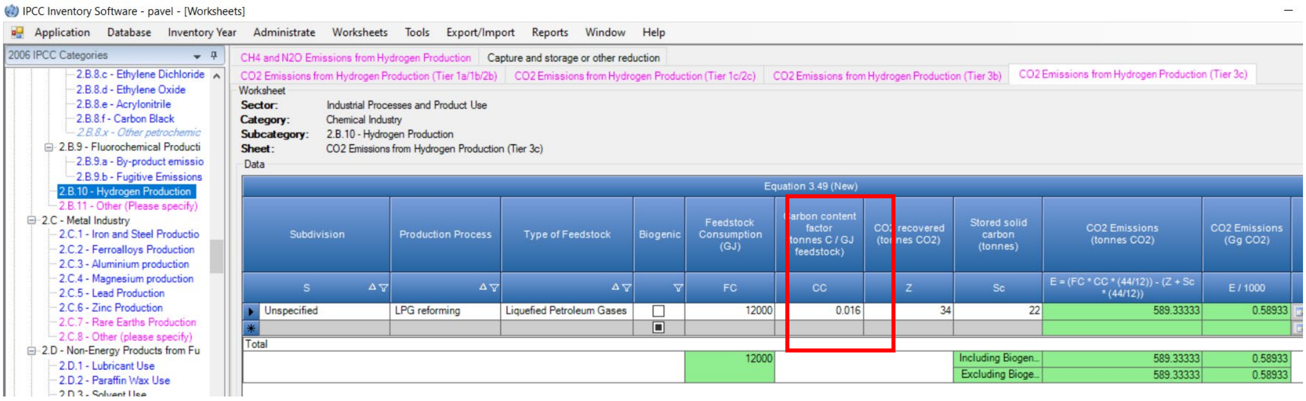
For the Tier 3b method: for each combination of subdivision/production process/type of feedstock, data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3b)**, row by row, as follows.

1. Column |FRF|: input plant-specific feedstock requirement in GJ per tonne of hydrogen produced.
2. Column |CC|: input carbon content of feedstock in tonnes of C per GJ of feedstock. The value may be selected from the drop-down, or the user may overwrite the value.
   Note that the Tier 3 method requires plant-specific information on carbon content, so if the value available from the Fuel Manager is not specific for this plant, the user must overwrite the value.

For the Tier 3c method: for each combination of subdivision/production process/type of feedstock, data are entered in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3c)**, row by row, as follows.

1. Column |CC|: input carbon content of feedstock in tonnes of C per GJ of feedstock. This value is automatically populated based on the selection made in Column |Type of Feedstock|.
   Note that the Tier 3 method requires plant-specific information on carbon content, so if the value available from the Fuel Manager is not specific for this plant, the user must overwrite the value.

Example: **Tier 3c EF parameters for Hydrogen Production**



CH_4 and N_2O Emissions from Hydrogen Production

A generic worksheet contains for each subdivision and production process information on AD (type and amount) and EF for CH_4 and N_2O. The worksheet calculates the associated CH_4 and N_2O emissions.

Activity data input

Input of AD for CH_4 and N_2O Emissions from Hydrogen Production requires the user first to enter information on the subdivisions in the country. 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 drop-down 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 **CH_4 and N_2O Emissions from Hydrogen Production,** row by row, as follows:

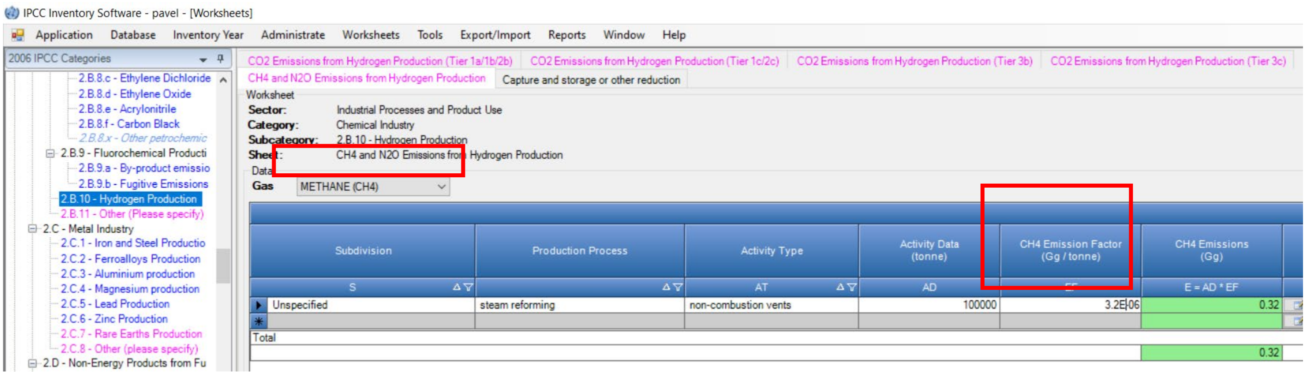
1. Column |Production Process|: describe the type of production process emitting GHG emissions from this category (e.g. consider those identified for estimating CO_2 emissions).
2. Column |AT|: enter the activity type corresponding to the production process identified.
3. Column |AD|: enter AD (quantity), in tonnes.

Emission factor input

For each row of data entered in worksheet **CH_4 and N_2O Emissions from Hydrogen Production**, data are entered as follows:

1. Column |EF|: enter CH_4 or N_2O EF;
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: **CH_4 emissions from Hydrogen Production**



Results

The Tier 1/2 and Tier 3 worksheets all include the possibility to account for CO_2 recovered, and for the Tier 3 methods only, stored solid carbon (i.e. solid carbon or coke formed unintentionally during the production process and disposed of as waste (i.e., not combusted at the production facility)).

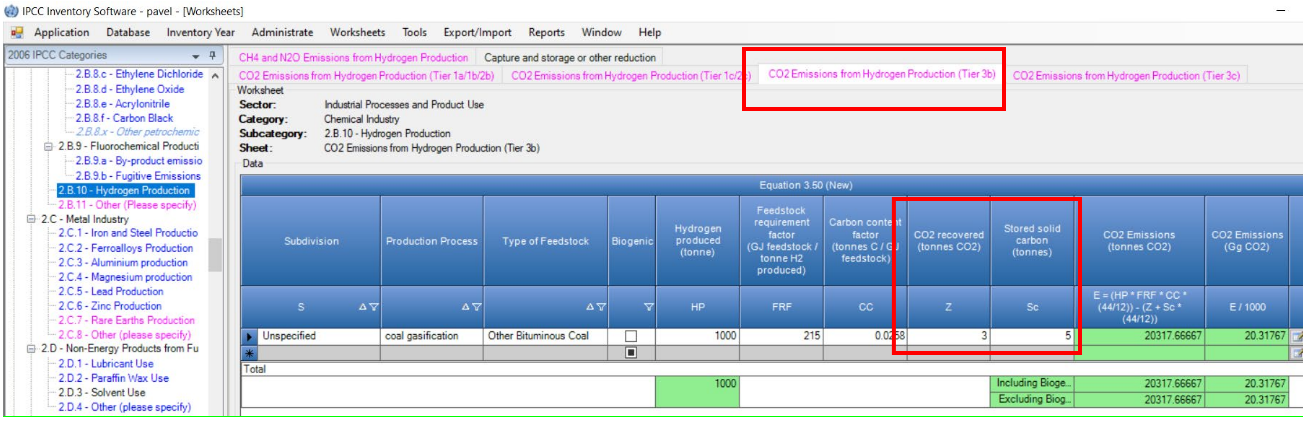
To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead recovered is to be entered in Gg CO_2 in Column |Z| of the following worksheets:

- ✓ **CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)**
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 1c/2c)**
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 3b)**
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 3c)**

In addition, the amount of solid carbon or coke formed unintentionally during the production process and disposed of as waste is to be entered in tonnes in Column |Sc| of the following worksheets:

- ✓ **CO_2 Emissions from Hydrogen Production (Tier 3b)**
- ✓ **CO_2 Emissions from Hydrogen Production (Tier 3c)**

Example: **Carbon recovered and solid carbon stored for Tier 3 for Hydrogen Production**



Then, CO_2 emissions from Hydrogen Production are estimated in mass units (tonnes and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets:

- ✓ **For Tier 1: CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and **CO_2 Emissions from Hydrogen Production (Tier 1c/2c)**
- ✓ **For Tier 2: CO_2 Emissions from Hydrogen Production (Tier 1a/1b/2b)** and **CO_2 Emissions from Hydrogen Production (Tier 1c/2c)**
- ✓ **For Tier 3: CO_2 Emissions from Hydrogen Production (Tier 3b)** and **CO_2 Emissions from Hydrogen Production (Tier 3c).**

CH_4 and N_2O Emissions from Hydrogen Production are estimated in Gg by the *Software* in the following worksheet **CH_4 and N_2O Emissions from Hydrogen Production.**

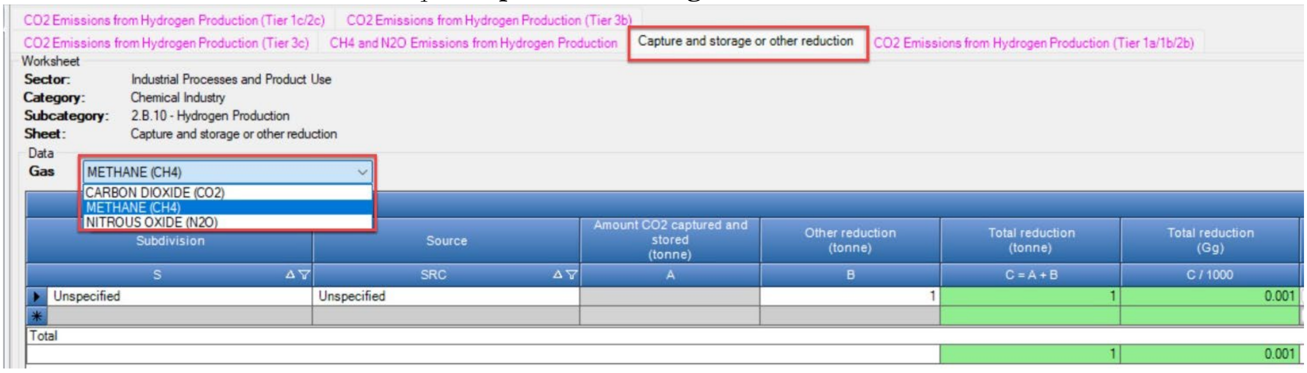
Total emissions from hydrogen production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage and any other reduction of CO_2, CH_4 and N_2O.

Please note that CO_2 recovery and the amount of Carbon stored may be already accounted in the worksheets for different Tiers, so only the additional amount of captured or reduced CO_2 shall be entered into the worksheet **Capture and storage or other reduction**.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A| users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on other long-term reduction of CO_2 (e.g., re-conversion to carbonates), in tonnes. Column |B| may include short-term CO_2 capture only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.
4. Column |Biogenic|: indicate with a check if the reductant is of biogenic origin. *Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.*

Example: **Capture and storage or other reduction**



2.B.11 Other

Information

This section describes calculation of other sources of emissions in the chemical industry not included in source categories 2.B.1-2.B.10.

This category also allows for estimating of GHG emissions from categories for which specific methods are not provided in the *2006 IPCC Guidelines* or the *2019 Refinement*, but for which information is contained in the common reporting tables of the MPGs, specifically:

- ✓ CH_4 and N_2O emissions from Ammonia Production
- ✓ CO_2 emissions from Adipic Acid, Caprolactam, Glyoxal and Glyoxylic Acid Production

GHGs

Other emissions from the chemical industry include the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X	X	X	X	X

IPCC Equations

Given that there are no specific equations in the *2006 IPCC Guidelines* or the *2019 Refinement* for this category, a generic worksheet is thus provided to enable calculation of other sources of emissions from the chemical industry.

- ✓ Tier 1: no IPCC Tier 1 Equation provided in the *2006 IPCC Guidelines* or the *2019 Refinement*
- ✓ Tier 2: IPCC basic equation with user-specific EF
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines* or the *2019 Refinement*

As explained in section **1.1.3 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 2 basic equation.

Software Worksheets

The *Software* calculates emissions from Other (Chemical industry) using worksheets:

- ✓ **Other**: contains source, AD (type, amount and unit), and EF for each GHG, and calculates associated emissions.
- ✓ **Capture and storage or other reduction**: Capture and storage or other reduction: contains information on CO_2 capture (with subsequent storage) and other reduction of GHGs, not accounted previously.

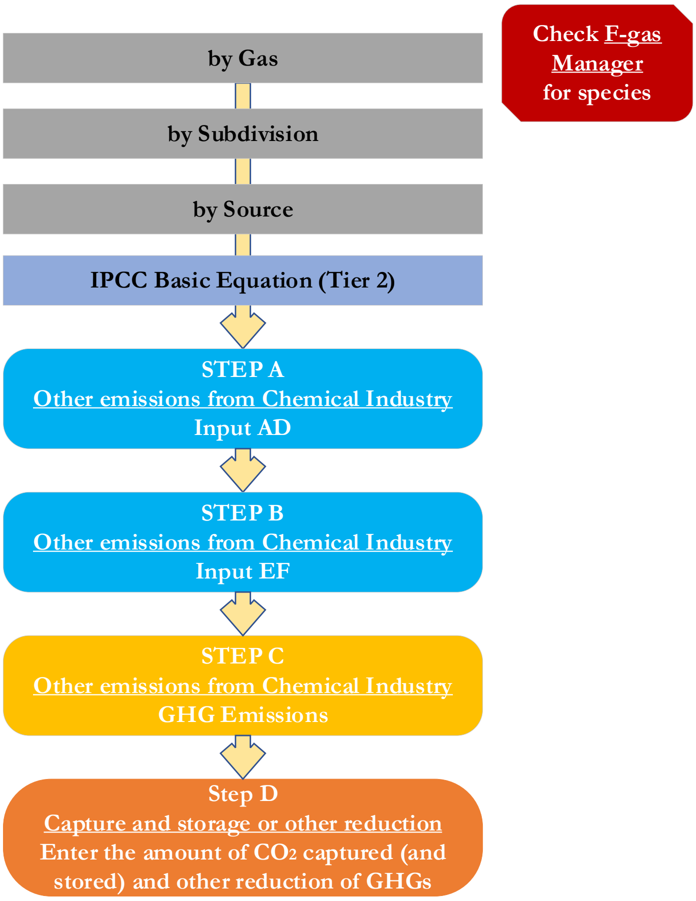
User's work Flowchart

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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Other (Chemical industry).

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Other (Chemical Industry) – flowchart



Thus, for the source-category:

If applicable, users ensure that all F-gases emitted for this source category have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step A, in **Other** worksheet, users collect and enter data on the source of emissions and activity data.

Step B, in **Other** worksheet, users collect and enter in each row the associated EF.

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

Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and/or other reduction of GHG.

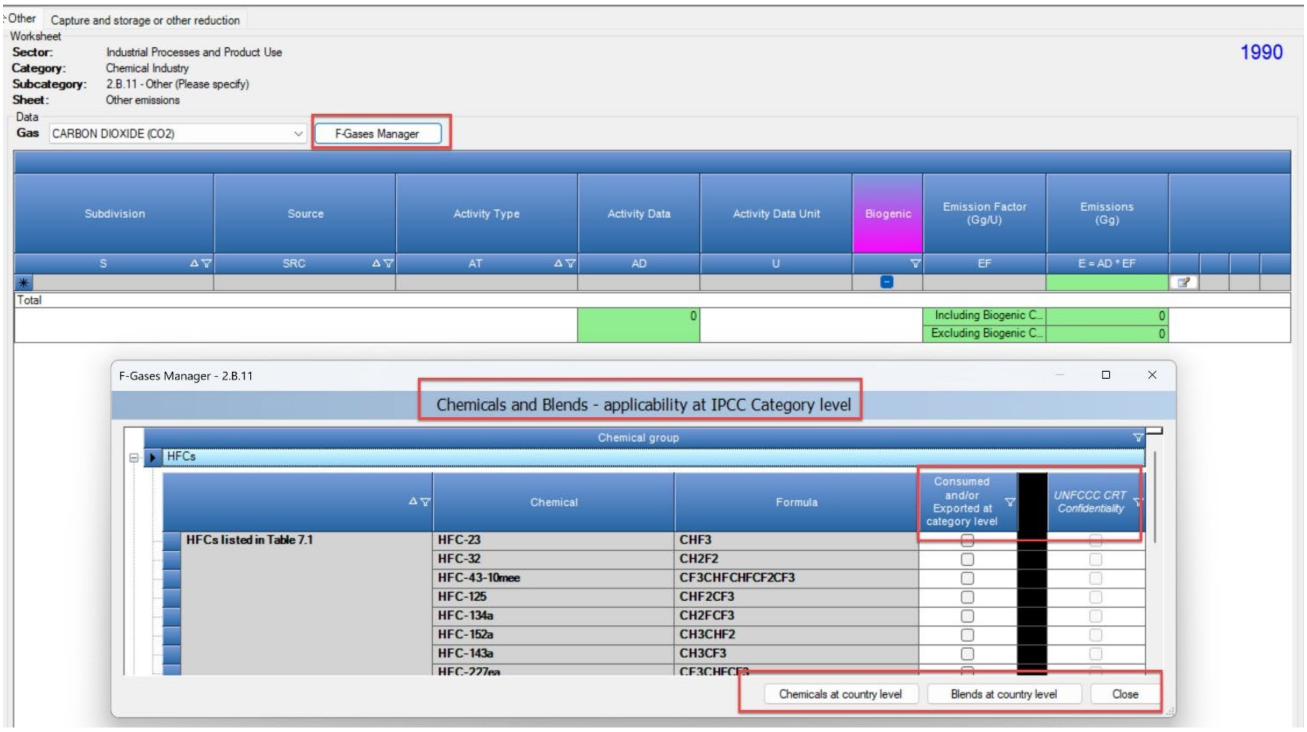
Activity data input

As a **Starting step**, if the source to be entered results in emission of F-gases, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases (or, if applicable, blends) to be reported.

*Note that if no F-gases are checked in the F-gases Manager, it will not be possible to select an F-gas from the **Gas** drop-down menu. If F-gas selection is not possible, select the **F-Gases Manager** from any tab. This will open the F-gases Manager – applicability at IPCC Category Level. Navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the country level- F-gases Manager to check all F-gases consumed (including imported) and produced and exported. Save and close the dialogue box for the country level F-gases Manager and the user returns to the IPCC Category level F-gases Manager. In the IPCC Category level F-gases Manager, the user selects which of the relevant F-gases are applicable for this category.*

For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. If checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate.

Example: **Populating the F-gases manager and designating confidentiality for category: Other (Chemical Industry)**



Second, input of AD for the Other source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in <u>Column |S|</u> [e.g. "*country name*" or "*unspecified*" as selected from the drop-down menu], or with subnational aggregations, and for each of those the univocal name/code entered in <u>Column |S|</u>.

For each subdivision in <u>Column |S|</u>, data are entered in worksheet **Other**, row by row, as follows:

4. <u>Column |SRC|</u>: describe the type of activity emitting GHG emissions from this category. The user may select from the drop-down (which includes pre-defined categories that are included in the UNFCCC ETF Reporting Tool (see Annex I), or enter user-specific categories.
   Note that once a category and amount of AD are entered for a particular gas, the category name automatically appears for each gas. If the category is not relevant for another gas, the user should leave the EF column blank. Do not change the AD again, as this will result in the updating of AD for all worksheets in this tab.
5. <u>Column |AT|:</u> enter the activity type corresponding to the source selected.
6. <u>Column |AD|</u>: enter AD (quantity).
7. <u>Column |U|</u>: enter Unit of the AD.

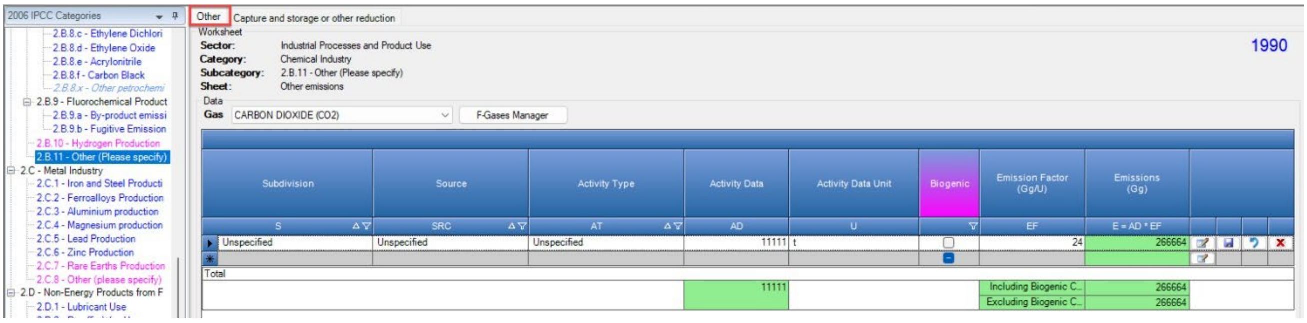
8. Column |Biogenic|(CO_2 only): indicate with a check, and if applicable, if the process feedstock is of biogenic origin.

Emission factor input

For each row of data entered in worksheet **Other**, data are entered as follows:

1. Column |EF|: enter EF for each GHG;
   Note that user shall select the relevant gas in the "Gas" bar at the top, to enter data for each GHG one by one. As noted above, if the category is not relevant for a particular gas, the user should leave the EF column blank.

Example: **single subdivision**



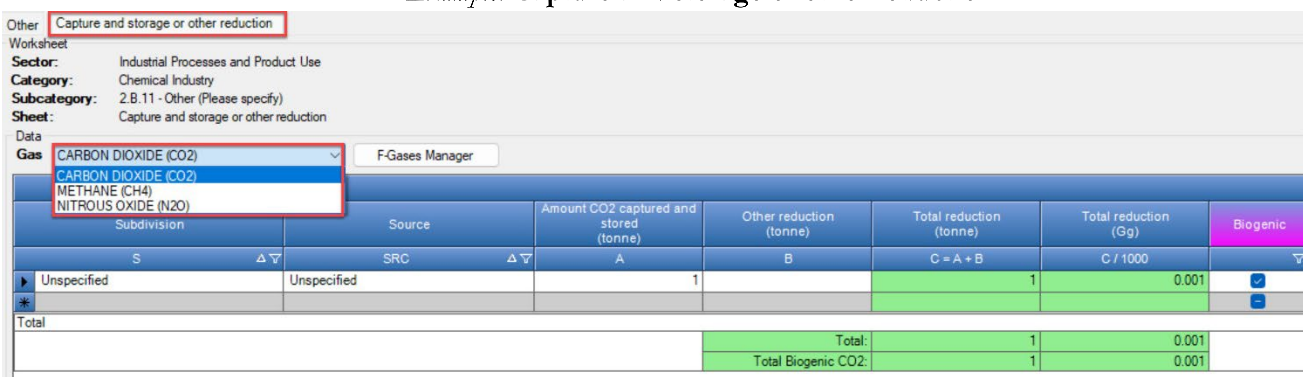
Results

Total GHG emissions from Other is the sum of all subdivisions in the above worksheet, taking into account any CO_2 capture with subsequent storage or other GHG reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage and other GHG reduction.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other reduction of GHGs, in tonnes. Column |B| may include short-term CO_2 capture or reduction of other GHGs only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.
4. Column |Biogenic|: indicate with a check if the reductant is of biogenic origin.
   Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.

Example: **Capture and storage or other reduction**



2.C Metal Industry

2.C.1 Iron and Steel Production

<u>Information</u>

The *2006 IPCC Guidelines* provide guidance for estimation of CO_2 and CH_4 emissions from Iron and Steel Production and from Coke Production (emissions from Coke Production should be reported in the Energy sector). Estimation methodologies from the *2019 Refinement* have also been incorporated in the *Software* to estimate CO_2 emissions for Coke production.

There are three Tiers for both Iron and Steel Production and for Coke Production: Tier 1 – EF method, Tier 2 – mass-balance method based on national / country-specific data and Tier 3 – mass-balance method based on plant-specific data (if plant-specific CO_2 emissions data are not available, CO_2 emissions can be calculated from plant-specific AD applying the Tier 2 method). The Tier 2/3 (mass-balance) method is used only for estimation of CO_2 emissions. In addition, a simplified carbon balance method (Tier 1b) from the *2019 Refinement* is available for Coke Production.

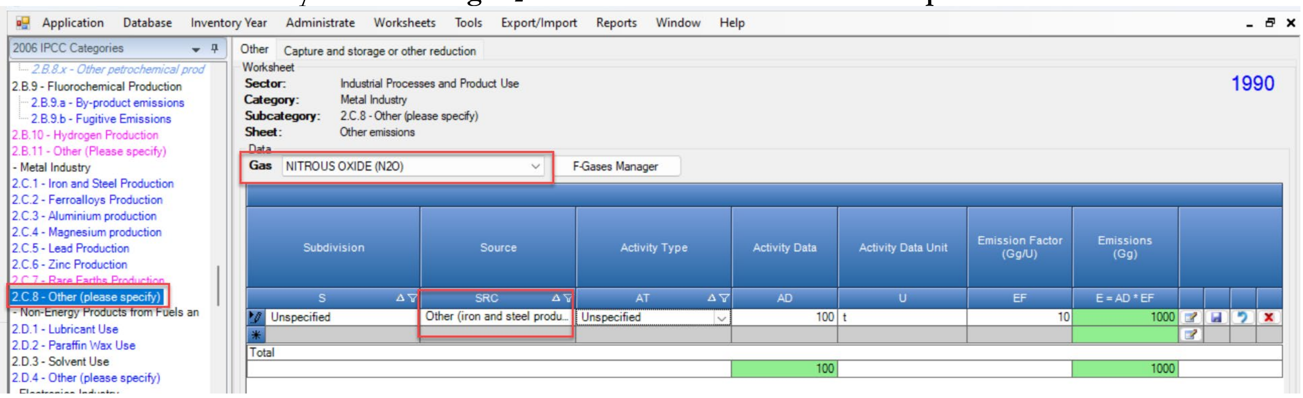
<u>GHGs</u>

The *Software* includes the following GHGs for the Iron and Steel Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	--	--	--	--	--

According to the 2006 *IPCC Guidelines*, N_2O may be emitted from iron and steel production. However, these emissions are likely to be small and no methodologies are provided for N_2O emissions. Users can calculate estimates of N_2O for this category, provided they develop country-specific methods based on researched data. These emissions can be reported in the IPCC inventory worksheet for category **2.C.8 Other**.

Example: **Estimating N_2O emissions from iron and steel production**



<u>IPCC Equations</u>

<u>Coke Production</u> Emissions estimated here and reported in the Energy sector. References are from the *2006 IPCC Guidelines* and the *2019 Refinement*:

- ✓ Tier 1 <u>(CO_2, CH_4)</u>: <u>Equation 4.1</u> or, for CO_2 only, <u>4.1B (New)</u>
- ✓ Tier 2 <u>(CO_2)</u>: <u>Equation 4.2 (Updated)</u>
- ✓ Tier 3 <u>(CO_2, CH_4)</u>: Either measure emissions or, for CO_2 only, apply the Tier 2 equations, using plant-specific carbon contents of all materials used and produced

<u>Iron and Steel Production</u> (*2006 IPCC Guidelines*):

- ✓ <u>Tier 1 (CO_2)</u>: <u>Equations 4.4, 4.5, 4.6, 4.7 and 4.8</u>
- ✓ <u>Tier 1 (CH_4)</u>: <u>Equations 4.12, 4.13 and 4.14</u>

- ✓ Tier 2 (CO_2): Equations 4.9, 4.10 and 4.11
- ✓ Tier 3 (CO_2): Either measure emissions or apply the Tier 2 equations, using plant-specific AD

As explained in section **1.1.3 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 CO_2 and CH_4 from Coke Production (to be reported in Energy Sector) using the following worksheets:

- ✓ **1.1.1 Fuel Manager**: contains data on carbon content and calorific value of each fuel used in the NGHGI.
- ✓ **CO_2 and CH_4 emissions from Coke Production:** contains for each subdivision information on the coke production process, the amount of coke produced and CO_2 and CH_4 EFs. The worksheet calculates the associated CO_2 and CH_4 emissions for Tier 1.
- ✓ **CO_2 Emissions from metallurgical coke production (mass balance):** contains for each subdivision the mass balance of the carbon in the input and output materials (amount of the materials and their carbon content). The worksheet calculates the associated CO_2 emissions.

The *Software* calculates emissions of CO_2 and CH_4 from Iron and Steel Production using the following worksheets:

- ✓ **1.1.1 Fuel Manager**: contains data on carbon content and calorific value of each fuel used in the NGHGI.
- ✓ **CO_2 and CH_4 emissions from Iron and Steel Production:** contains for each subdivision information on the amount of iron, steel, pellet, sinter, and/or direct reduced iron (DRI) produced and CO_2 and CH_4 EFs. The worksheet calculates the associated CO_2 and CH_4 emissions for Tier 1.
- ✓ **CO_2 emissions from Iron and Steel Production – Tier 2/3:** contains for each subdivision the mass balance of the carbon in the input and output materials (amount of the materials and their carbon content). The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 emissions from Sinter Production – Tier 2/3:** contains for each subdivision the mass balance of the carbon in the input and output materials (amount of the materials and their carbon content). The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 emissions from Pellet Production – Tier 2/3:** contains for each subdivision information on fuel consumption and fuel carbon content. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 emissions from Direct Reduced Iron Production – Tier 2/3:** contains for each subdivision information on fuel consumption and fuel carbon content. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2 and CH_4, not accounted previously in the worksheets for different Tiers.

User's work Flowchart

Consistent with the key category analysis and the decision tree in Figure 4.6 of the *2006 IPCC Guidelines* or Figure 4.6 (Updated) of the *2019 Refinement,* GHG estimates are calculated for Coke Production using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements.

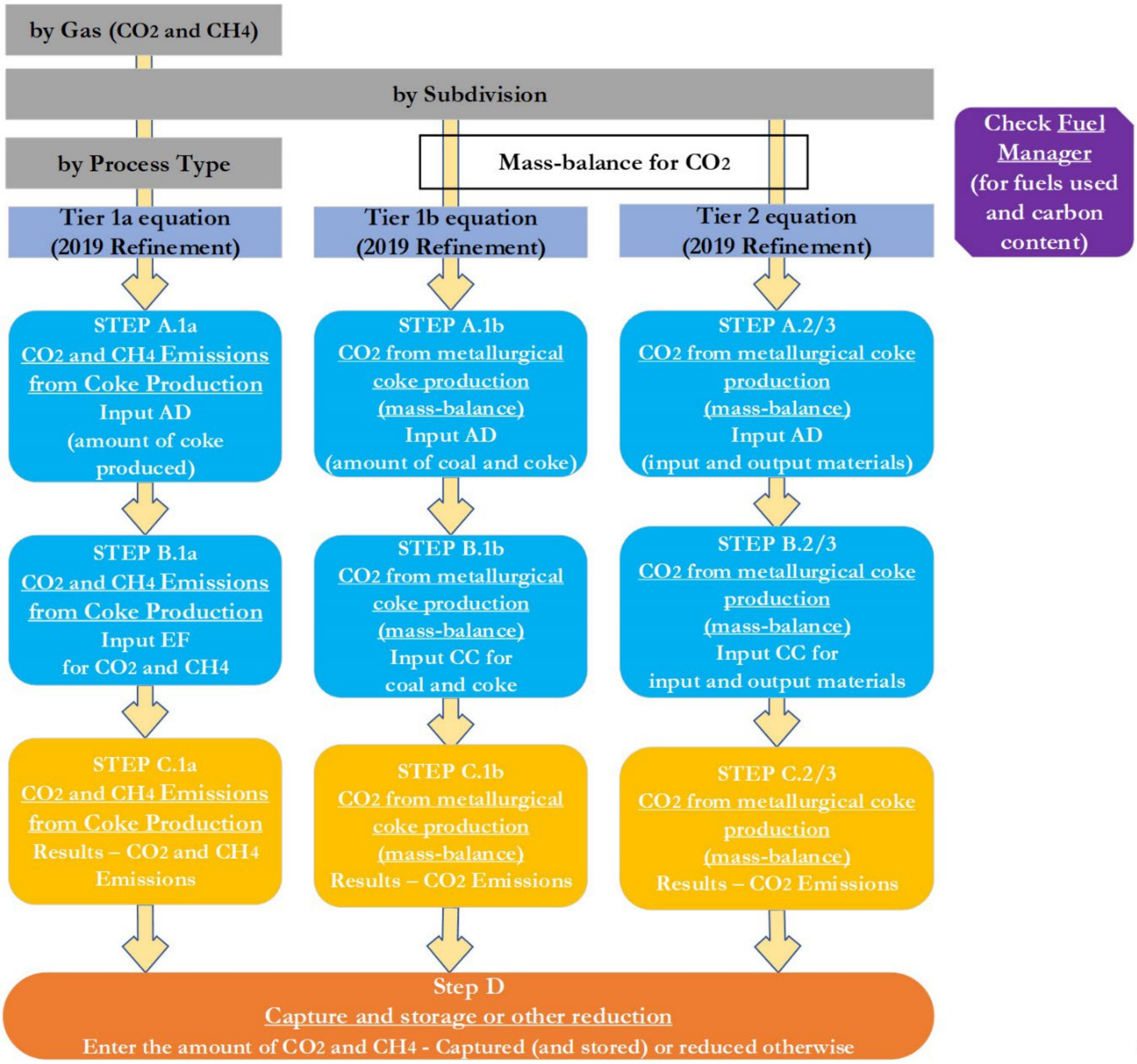
Similarly, consistent with the key category analysis and the decision trees in Figure 4.7 for CO_2 and Figure 4.8 for CH_4 of the *2006 IPCC Guidelines,* GHG estimates are calculated for Iron and Steel Production.

To ease the use of the *Software* as well as to avoid its misuse, users follow the following two flowcharts to estimate GHG emissions for Coke Production and Iron and Steel Production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Coke Production

Coke Production - flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step A.1a, in the worksheet **CO_2 and CH_4 emissions from Coke Production**, users collect and input in the *Software* information on the amount coke produced.

Step B.1a, in the worksheet **CO_2 and CH_4 emissions from Coke Production** users input CO_2 and CH_4 EFs.

Step C.1a in the worksheet **CO_2 and CH_4 emissions from Coke Production,** the *Software* calculates the associated emissions for each subdivision in mass units (tonne for CO_2 and kg for CH_4, and Gg). In addition, the total emissions of all subdivisions are shown.

When the Tier 1b Equation is applied:

Step A.1b, in the worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, users collect and input in the *Software* information on the quantity of coking coal consumed and coke produced.

Step B.1b in the worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, users collect and input in the *Software* information on the carbon content of coking coal consumed and coke produced.

Step C.1b in the worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, the *Software* calculates the associated emissions for each subdivision in mass units (tonne for CO_2 and Gg). In addition, the total emissions of all subdivisions are shown.

When the Tier 2 Equation is applied:

Step A.2/3, in the worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, users collect and input in the *Software* information on the amount of each input and output. National statistics are appropriate for the Tier 2 method; for Tier 3 plant-level data are required.

Step B.2/3, in the worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, users input carbon content of each input and output material. National statistics are appropriate for the Tier 2 method; for Tier 3 plant-level carbon content information is required.

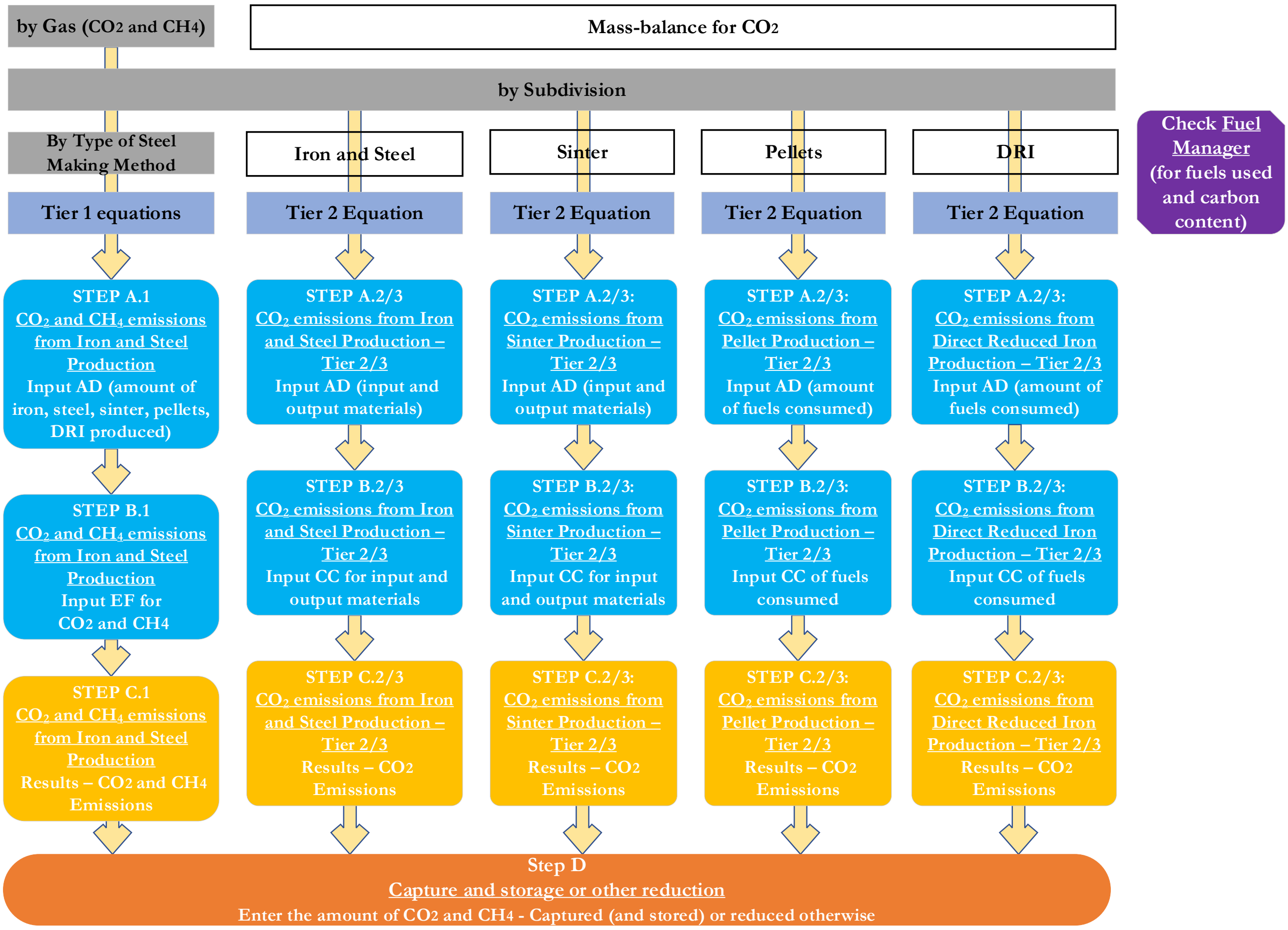
Step C.2/3, in the worksheet **CO_2 Emissions from metallurgical coke production (mass balance),** the *Software* calculates the associated emissions for each subdivision in mass units (tonne for CO_2 and Gg). In addition, the total emissions of all subdivisions are shown.

Then, for each tier, as appropriate:

Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of GHG, not otherwise captured in the worksheets above.

Iron and Steel Production

Iron and Steel Production -flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When Tier 1 Equations are applied

Step A.1, in the worksheet **CO_2 and CH_4 emissions from Iron and Steel Production**, users collect and input in the *Software* information on the amount of iron, sinter, pellet and DRI produced and for each steel making method – the amount of steel produced.

Step B.1, in the worksheet **CO_2 and CH_4 emissions from Iron and Steel Production**, for each subdivision and steel making method/product users input respective CO_2 and CH_4 EFs.

Step C.1, in the worksheet **CO_2 and CH_4 emissions from Iron and Steel Production,** the *Software* calculates the associated emissions for each subdivision in mass units (tonne for CO_2 and kg for CH_4, and Gg). In addition, the total emissions of all subdivisions are shown.

When Tier 2 Equations are applied

Step A.2/3, in the worksheets **CO_2 emissions from Iron and Steel Production – Tier 2/3** and **CO_2 emissions from Sinter Production – Tier 2/3**, users collect and input in the *Software* information on the amount of each input and output material used and in the worksheets **CO_2 emissions from Pellet Production – Tier 2/3** and **CO_2 emissions from Direct Reduced Iron Production – Tier 2/3**, users collect and input in the *Software* information on the amount of fuel consumption. National statistics are appropriate for the Tier 2 method; for Tier 3 plant-level data are required.

Step B.2/3, in the worksheets **CO_2 emissions from Iron and Steel Production – Tier 2/3** and **CO_2 emissions from Sinter Production – Tier 2/3**, users input carbon content of each input and output material and in the worksheets **CO_2 emissions from Pellet Production – Tier 2/3** and **CO_2 emissions from Direct Reduced Iron Production – Tier 2/3**, users input fuel carbon content. National statistics are appropriate for the Tier 2 method; for Tier 3 plant-level carbon content information is required.

Step C.2/3, in the worksheets **CO_2 emissions from Iron and Steel Production – Tier 2/3, CO_2 emissions from Sinter Production – Tier 2/3**, **CO_2 emissions from Pellet Production – Tier 2/3**, and **CO_2 emissions from Direct Reduced Iron Production – Tier 2/3,** the *Software* calculates the associated emissions for each subdivision in mass units (tonne for CO_2 and Gg). In addition, the total emissions of all subdivisions are shown in each worksheet.

Then, for each tier, as appropriate:

Step D, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) or other reduction of CO_2 and reduction of CH_4, not otherwise captured in the worksheets above.

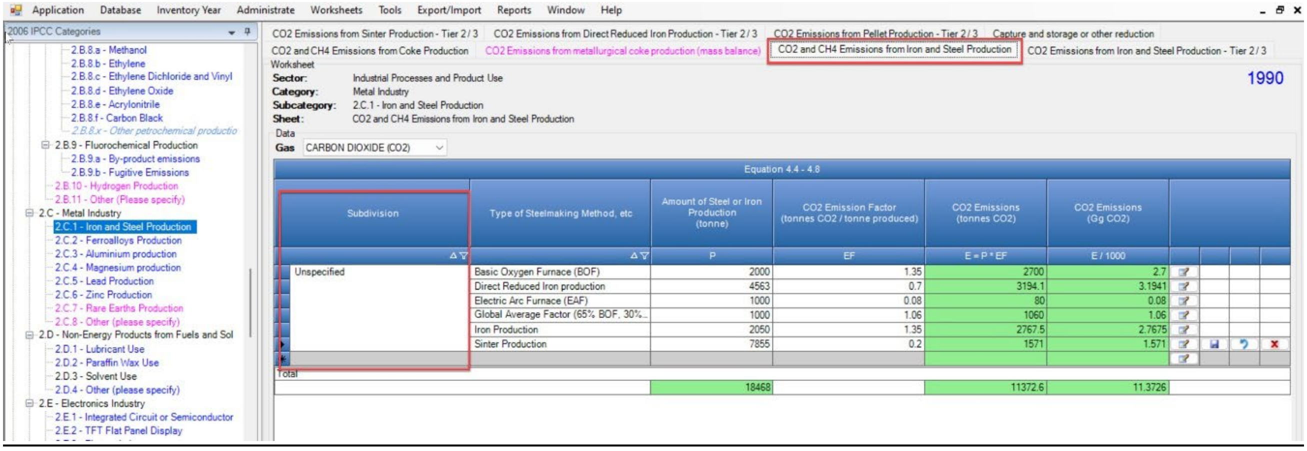
Activity data input

Section 4.2.2.4 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Coke Production and Iron and Steel Production. The collection of the AD for this source category is challenging, particularly the overlap between emissions to be reported in the Energy Sector and the IPPU sector. As such, the user may also wish to consult the introduction to section 4.2, Volume 3 of the 2006 IPCC Guidelines, as well as Box 1.1 in Chapter 1, Volume 3.

As a **Starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for coke production and iron and steel production (Tier 1b (coke production only), Tier 2 and Tier 3); 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, input of AD for the Iron and Steel Production source category requires the user first to enter information on the subdivisions in the country for both Coke Production and Iron and Steel Production. Users compile the calculation worksheets either with a single row of data for the entire category (in the case of Iron and Steel Production, for each steelmaking method), with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the dropdown menu].

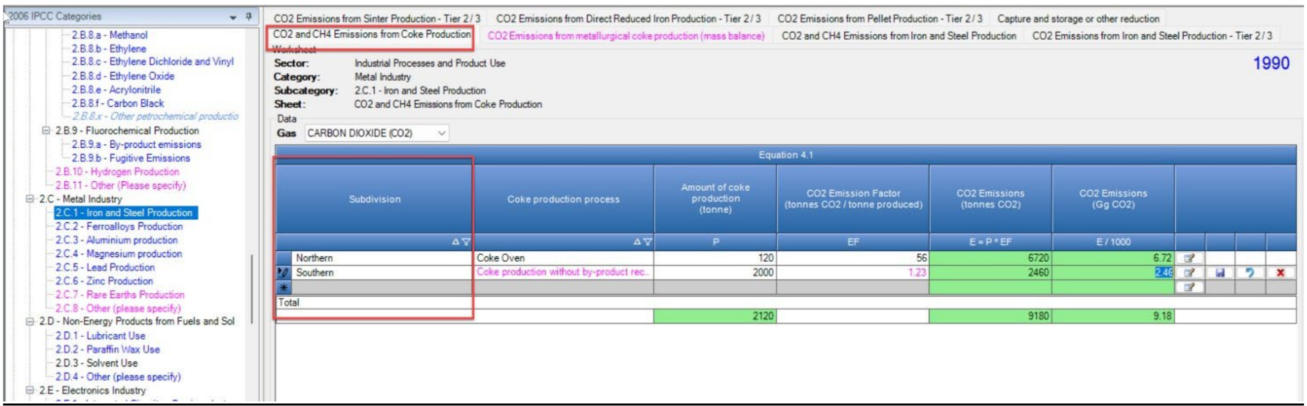
When identifying subdivisions for worksheet **CO_2 Emissions from metallurgical coke production (mass balance),** the user must ensure consistency between the naming of subdivisions in this worksheet, and worksheet **Emissions from Coke Oven Gas flaring** in category 1.B.1.c.ii Coke Production. This is because an automatic subtraction takes place for CO_2 emissions from coke oven gas flaring, in cases where a Tier 2/3 method is applied. For this subtraction to take place, the subdivision names must be the same.

Example: **single subdivision (unspecified) -iron and steel production**



Where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> for each subdivision.

Example: **multiple subdivisions – coke production**



<u>Then, for Coke Production</u>

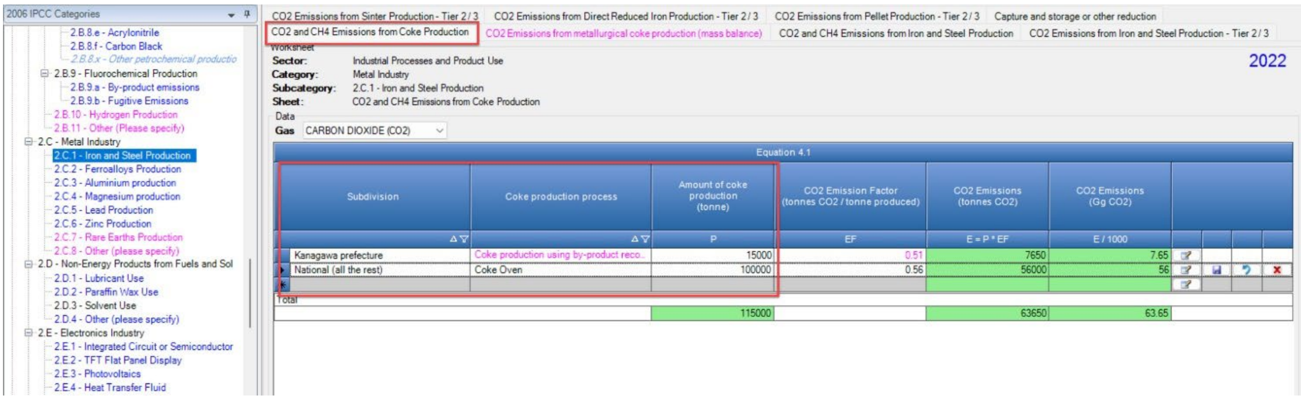
When Tier 1 Equations are applied:

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 and CH_4 emissions from Coke Production** and/or **CO_2 Emissions from metallurgical coke production (mass balance),** row by row, as follows (to be reported in the Energy Sector):

In worksheet **CO_2 and CH_4 emissions from Coke Production**

1. <u>Column |Coke production process|</u>: input from the drop-down menu the default process <Coke oven>, select additional processes included in the *2019 Refinement,* or input manually country-specific process.
2. <u>Column |P|</u>: input the amount/mass of coke produced, in tonnes.

Example: **coke production- Tier 1: AD input for CO_2 – multiple subdivision**



In worksheet **CO₂ Emissions from metallurgical coke production (mass balance)**

1. Column |CC|: input the amount/mass of coking coal consumed for coke production, in tonnes.
2. Column |CO|: input the amount/mass of coke produced, in tonnes.

Note that the Tier 1b method requires information only on the quantity of coking coal consumed and coke produced. There is an opportunity for users to include information on additional inputs and outputs in this worksheet; the additional inputs are required under a Tier 2 method.

When the Tier 2 Equation is applied:

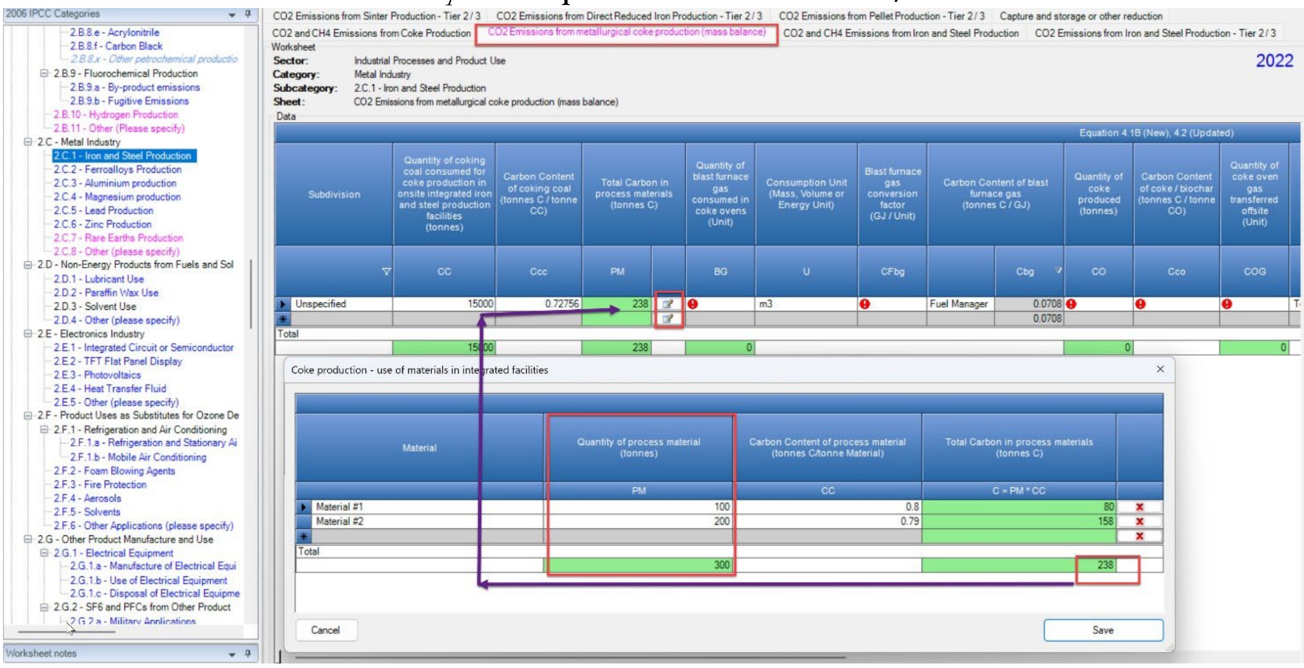
For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from metallurgical coke production (mass balance),** row by row, as follows, recalling that national statistics are appropriate for a Tier 2 method, while plant-specific data are required for Tier 3.

The mass balance method requires information on input and output materials

Input materials

1. Column |CC|: input the amount/mass of coking coal consumed for coke production, in tonnes.
2. Column |PM|: input the amount of process materials used for coke production, in tonnes. This information is entered in the sub-table associated with Column |PM|.
3. Column |Bg|: input the amount/mass blast furnace gas consumed in coke ovens
4. Column |U|: enter the unit of the blast furnace gas entered (e.g. Gg, TJ, m^3, tonne). The user may enter a user-specific unit (e.g. BTUs).
5. Column |CFbg|: enter the conversion factor to convert the consumption unit to GJ.
Note that, where GJ, TJ or tonnes of fuel are selected in Column |U|, CFbg *is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m^3 or a user defined unit) the user shall enter the relevant conversion unit here.*

Example: **Coke production – AD for Tier 2/3**



Output materials

6. Column |CO|: input the amount/mass of coke produced, in tonnes.
7. Column |COG|: input the amount/mass of coke oven gas transferred offsite.
8. Column |U|: enter the unit of the coke oven gas entered (e.g. Gg, TJ, m³, tonne). The user may enter a user-specific unit (e.g. BTUs).
9. Column |CFcog|: enter conversion factor to convert the consumption unit to GJ.
   Note that, where GJ, TJ or tonnes of fuel are selected in Column |U|, CFcog *is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³ or a user defined unit) the user shall enter the relevant conversion unit here.*
10. Column |BPC|: input the amount of coke oven by-product transferred offsite, in tonnes. This information is entered in Column |COB| of the sub-table associated with Column |BPC|, in the same manner as is shown for Column |PM| above.

Then, for Iron and Steel Production

When Tier 1 Equations are applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 and CH_4 emissions from Iron and Steel Production,** row by row:

1. Column |Type of Steel Making Method, etc/|: input from the drop-down menu the type of steelmaking method, if known (e.g. basic oxygen furnace (BOF), pellet, sinter, iron and DRI Production. If unknown, select the Global Average Factor or input manually country-specific method.
2. Column |P|: input the amount/mass of individual type of product produced (steel – BOF, electric arc furnace (EAF), open hearth furnace (OHF) or total production, as well as iron, pellet, sinter and DRI) in tonnes.

When Tier 2 Equations are applied:

AD required to implement the Tier 2/Tier 3 methods differ for the different processes. For each process, and for each subdivision in Column |Subdivision|, data are entered row by row, recalling that national statistics are appropriate for a Tier 2 method, while plant-specific data are required for Tier 3.

i. CO_2 emissions from Iron and Steel Production – Tier 2/3 worksheet:

The mass balance method requires information on input and output materials, as applicable. Data are entered row by row, as follows:

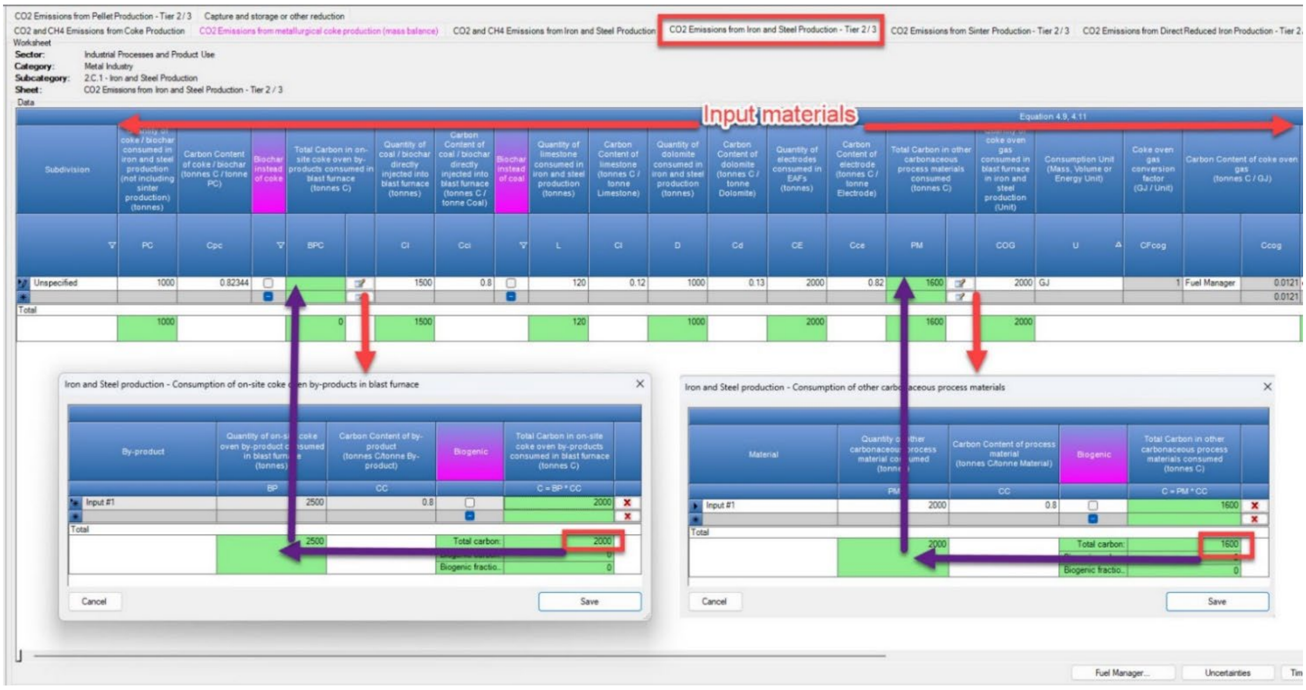
Input materials

1. Column |PC|: input the quantity of coke or biochar consumed in iron and steel production in tonnes.
2. Column |Biochar instead of coke|: check if biochar is used instead of coke for iron and steel production. By default this column is unchecked.
3. Column |BPC|: input the quantity of onsite coke oven by-products consumed in the blast furnace, in tonnes. This information is entered the sub-table associated with Column |BPC| (see image below).
4. Column |CI|: input the quantity of coal directly injected into the blast furnace, in tonnes.
5. Column |L|: input the quantity of limestone consumed in iron and steel production, in tonnes.
6. Column |D|: input the quantity of dolomite consumed in iron and steel production, in tonnes.
7. Column |CE|: input the quantity of carbon electrodes consumed in EAFs, in tonnes.
8. Column |PM|: input the quantity of other carbonaceous and process materials consumed in iron and steel production, such as sinter or waste plastic, in tonnes. This information is entered the sub-table associated with Column |PM|(see image below).
9. Column |COG|: input the quantity of coke oven gas consumed in the blast furnace.
10. Column |U|: enter the unit of the coke oven gas entered (e.g. Gg, TJ, m^3, tonne). The user may enter a user-specific unit (e.g. BTUs).
11. Column |CFcog|: enter the conversion factor to convert the consumption unit to GJ.
    Note that, where GJ, TJ or tonnes of fuel are selected in Column |U|, *CFcog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m^3 or a user defined unit) the user shall enter the relevant conversion unit here.*

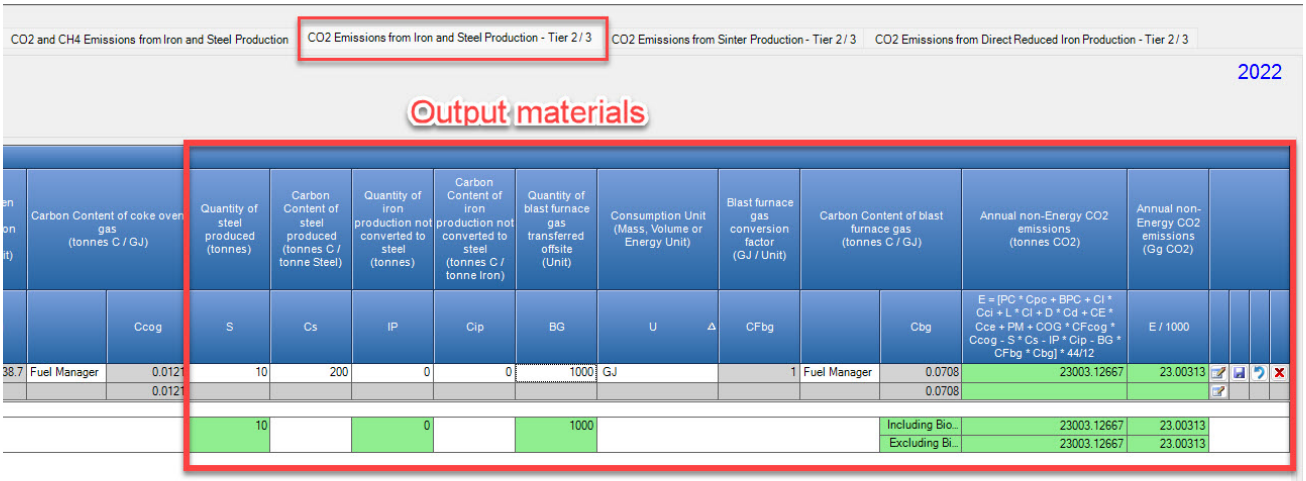
Output Materials

12. Column |S|: quantity of steel produced, in tonnes.
13. Column |IP|: quantity of iron production not converted to steel, in tonnes.
14. Column |BG|: quantity of blast furnace gas transferred offsite.
15. Column |U|: enter the unit of the blast furnace gas entered (e.g. Gg, TJ, m^3, tonne). The user may enter a user-specific unit (e.g. BTUs).
16. Column |CFbg|: enter the conversion factor to convert the consumption unit to GJ.
    Note that, where GJ, TJ or tonnes of fuel are selected in Column |U|, *CFbg is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m^3 or a user defined unit) the user shall enter the relevant conversion unit here.*

Example: **Iron and Steel Production – AD for input materials for Tier 2/3**



Example: **Iron and steel production – AD for output materials for Tier 2/3**



ii. CO_2 emissions from Sinter Production – Tier 2/3 worksheet:

For Sinter production, the Tier 2/3 method is similar to Iron and Steel production, and the illustrations are broadly applicable to sinter production, although with input and output materials unique to sinter production. Data are entered row by row, as follows and as applicable.

Input Materials

1. <u>Column |CBR|</u>: input the quantity of coke breeze/biochar purchased and produced onsite for sinter production, in tonnes.
2. <u>Column |Biochar instead of coke breeze|</u>: check if biochar is used instead of coke breeze for sinter production. By default this column is unchecked.
3. <u>Column |COG|</u>: input the quantity of coke oven gas consumed in the blast furnace for sinter production.

4. Column |U|: enter the unit of the coke oven gas entered (e.g. Gg, TJ, m^3, tonne). The user may enter a user-specific unit (e.g. BTUs).
5. Column |CFcog|: enter the conversion factor to convert the consumption unit to GJ.
   Note that, where GJ, TJ or tonnes of fuel are selected in Column |U|, CFcog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m^3 or a user defined unit) the user shall enter the relevant conversion unit here.
6. Column |BG|: quantity of blast furnace gas consumed in sinter production.
7. Column |U|: enter the unit of the blast furnace gas entered (e.g. Gg, TJ, m^3, tonne). The user may enter a user-specific unit (e.g. BTUs).
8. Column |CFbg|: enter the conversion factor to convert the consumption unit to GJ.
   Note that, where GJ, TJ or tonnes of fuel are selected in Column |U|, CFbg is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m^3 or a user defined unit) the user shall enter the relevant conversion unit here.
9. Column |OPM|: input the quantity of other process materials, such as natural gas and fuel oil, consumed, in tonnes. This information is entered the sub-table associated with Column |OPM|

Output Materials

10. Column |SOG|: input the quantity of sinter off gas transferred offsite either to iron and steel production facilities or other facilities.
11. Column |U|: enter the unit of the sinter off gas entered (e.g. Gg, TJ, m^3, tonne). The user may enter a user-specific unit (e.g. BTUs).
12. Column |CFsog|: enter the conversion factor to convert the consumption unit to GJ.
    Note that, where GJ or TJ of fuel is selected in Column |U|, CFsog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m^3, tonnes, or a user defined unit) the user shall enter the relevant conversion unit here.

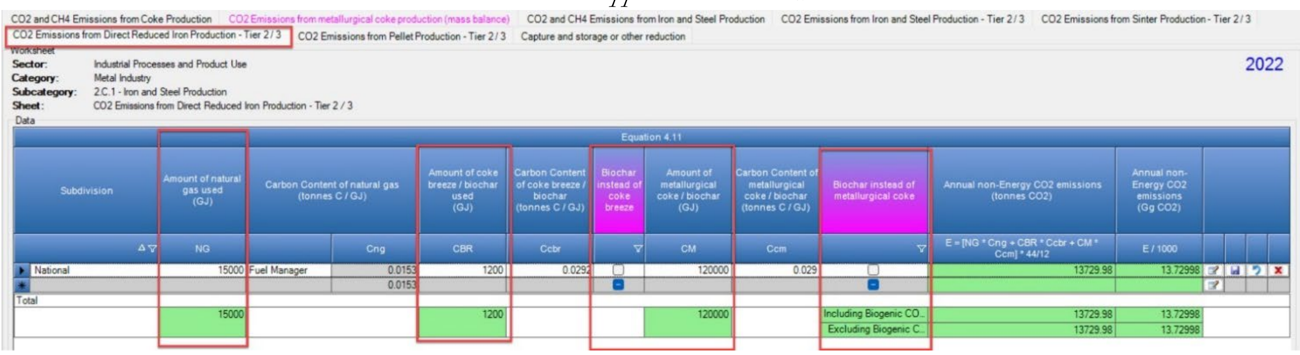
iii. CO_2 emissions from Direct Reduced Iron Production – Tier 2/3 and CO_2 emissions from Pellet Production – Tier 2/3

The worksheets for DRI production and Pellet Production are the same. The Tier 2/3 method is based on fuel consumption and fuel carbon content. Emissions are derived from combusting fuel, coke breeze, metallurgical coke and/or biochar. Data are entered row by row, as follows, and as applicable:

1. Column |NG|: input the amount of natural gas used in DRI/pellet production, in GJ.
2. Column |CBR|: input the amount of coke breeze/biochar used in DRI/pellet production, in GJ.
3. Column |Biochar instead of coke breeze|: check if biochar is used instead of coke breeze for DRI/pellet production. By default this column is unchecked.
4. Column |CM|: input the amount of metallurgical coke /biochar used in DRI/pellet production, in GJ.
5. Column |Biochar instead of metallurgical coke|: check if biochar is used instead of metallurgical for DRI/pellet production. By default, this column is unchecked.

Example: **DRI Production – AD for Tier 2/3**

Illustration also applies to Pellet Production



Emission factor input

Section 4.2.2.3 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for the Iron and Steel Production source category and coke production. For coke production, section 4.2.2.3 of the *2019 Refinement* is also relevant. There are three sets of default EFs:

i) Tier 1 EFs for CO_2 (Table 4.1 in Chapter 4, Volume 3 of the *2006 IPCC Guidelines*), and, additionally for coke production, Table 4.1 (Updated) in Chapter 4, Volume 3 of the *2019 Refinement*
ii) Tier 1 EFs for CH_4 (Table 4.2 in Chapter 4, Volume 3 of the 2006 IPCC Guidelines)
iii) Tier 2/3 EFs for CO_2 – carbon content of materials/fuels (Table 4.3 Chapter 4, Volume 3 of the *2006 IPCC Guidelines*)

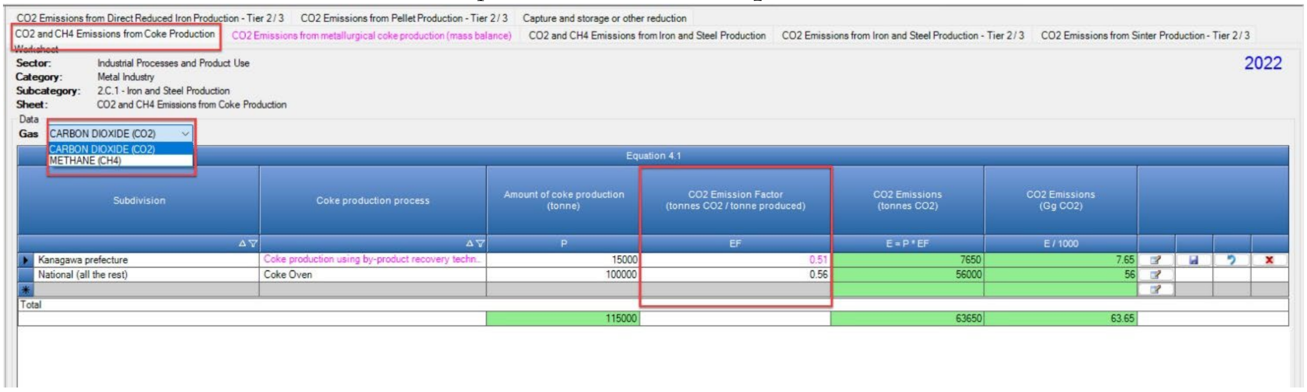
Then, for Coke Production

When Tier 1 Equations are applied:

For each combination of subdivision/coke production process in worksheet **CO_2 and CH_4 Emissions from Coke Production**:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in tonnes CO_2/tonne coke produced or kg CH_4/tonne coke 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.

Example: **Tier 1 EF for coke production**



For each subdivision in worksheet **CO_2 Emissions from metallurgical coke production (mass balance):**

1. Column |Ccc|: select from the drop-down menu the carbon content for coking coal taken from the **1.1.1 Fuel Manager** or enter a user-specific value, in tonnes C/tonne coking coal.
2. Column |Cco|: select from the drop-down menu the carbon content for coke taken from the **1.1.1 Fuel Manager** or enter a user-specific value, in tonnes C/tonne coke.

Note that the Tier 1b method requires information only on the quantity of coking coal consumed and coke produced. There is an opportunity for users to include EF information for additional inputs and outputs in this worksheet; the additional inputs are required under a Tier 2 method. For information on the entry of these additional factors, see instruction for the Tier 2 equation below.

When the Tier 2 Equation is applied:

For each subdivision in worksheet **CO_2 Emissions from metallurgical coke production (mass balance):**

1. Column |Ccc|: select from the drop-down menu the carbon content for coking coal taken from the **1.1.1 Fuel Manager** or enter a user-specific value, in tonnes C/tonne coking coal.
2. Column |PM|: input the carbon content of process materials used for coke production, in tonnes C/tonne material. This information is entered in Column |CC| in the sub-table associated with Column |PM|.

3. Column |Cbg|: indicate whether the carbon content for blast furnace gas shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user shall input the carbon content of blast furnace gas, in tonnes C/GJ.

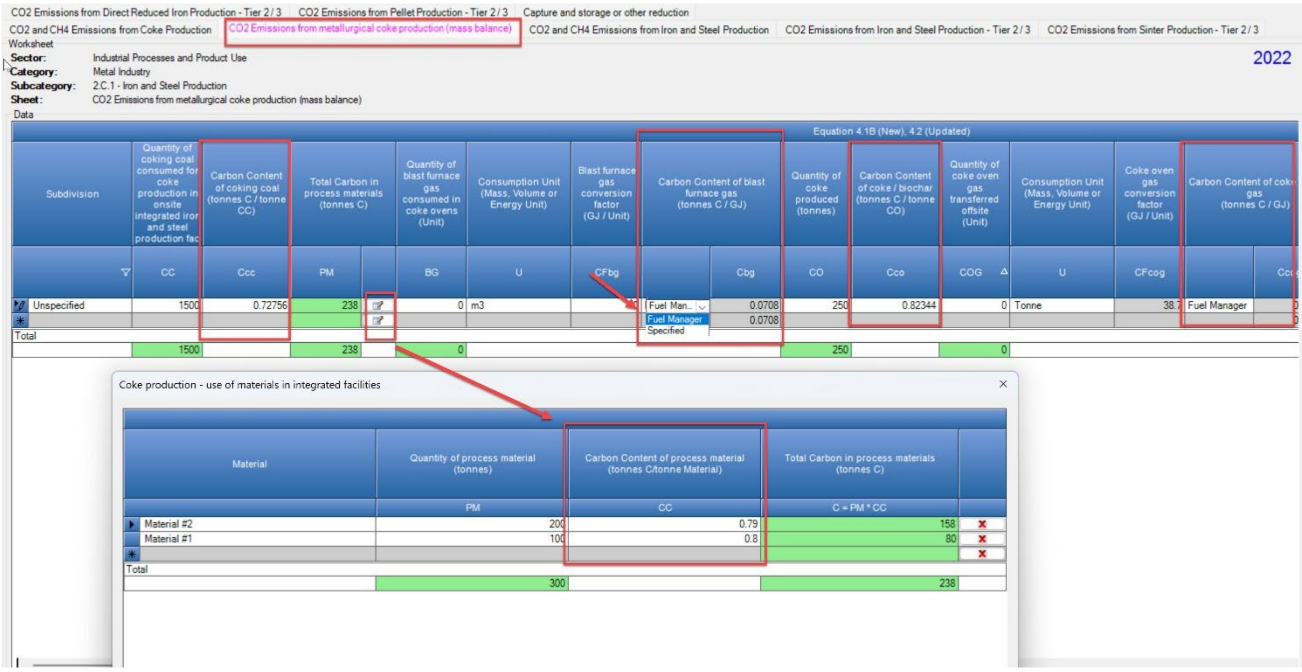
   Note that: section 1.1.1 Fuel **Manager** *provides further information on populating the Fuel Manager.*

4. Column |Cco|: select from the drop-down menu the carbon content for coke taken from the **1.1.1 Fuel Manager** or enter a user-specific value, in tonnes C/tonne coke.

5. Column |Ccog|: indicate whether the carbon content for coke oven gas shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user shall input the carbon content of coke oven gas, in tonnes C/GJ.

   Note that: section 1.1.1 Fuel **Manager** *provides* further *information on populating the Fuel Manager.*

Example: **Tier 2 EF for coke production**



Then, for Iron and Steel Production

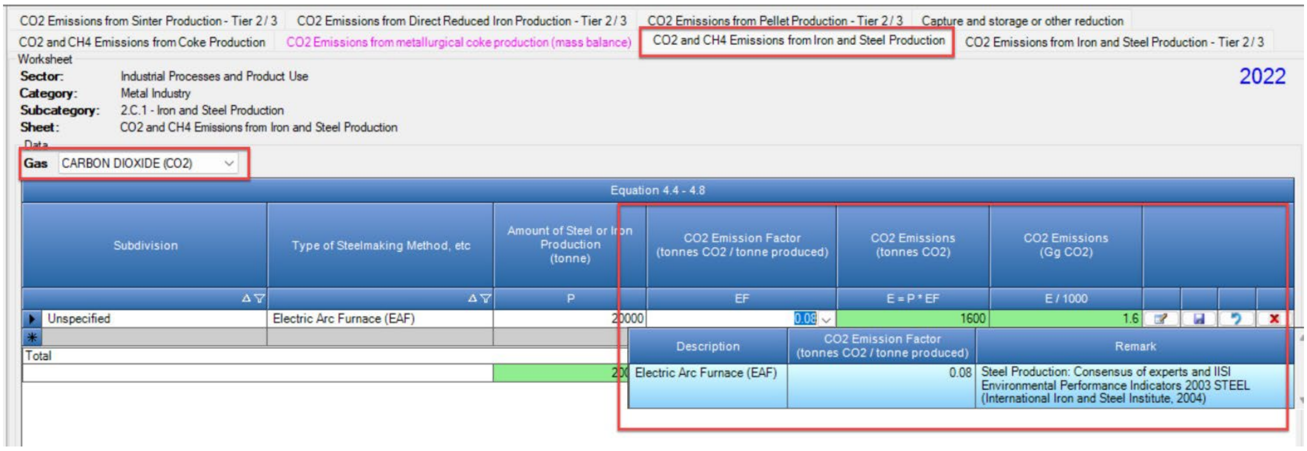
When Tier 1 Equations are applied:

For each combination of subdivision/ type of steelmaking method, etc in worksheet **CO_2 and CH_4 Emissions from Iron and Steel Production**:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in tonnes CO_2/tonne produced or kg CH_4/tonne 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.

Example: **Tier 1 EF for iron and steel production**



When Tier 2 Equations are applied:

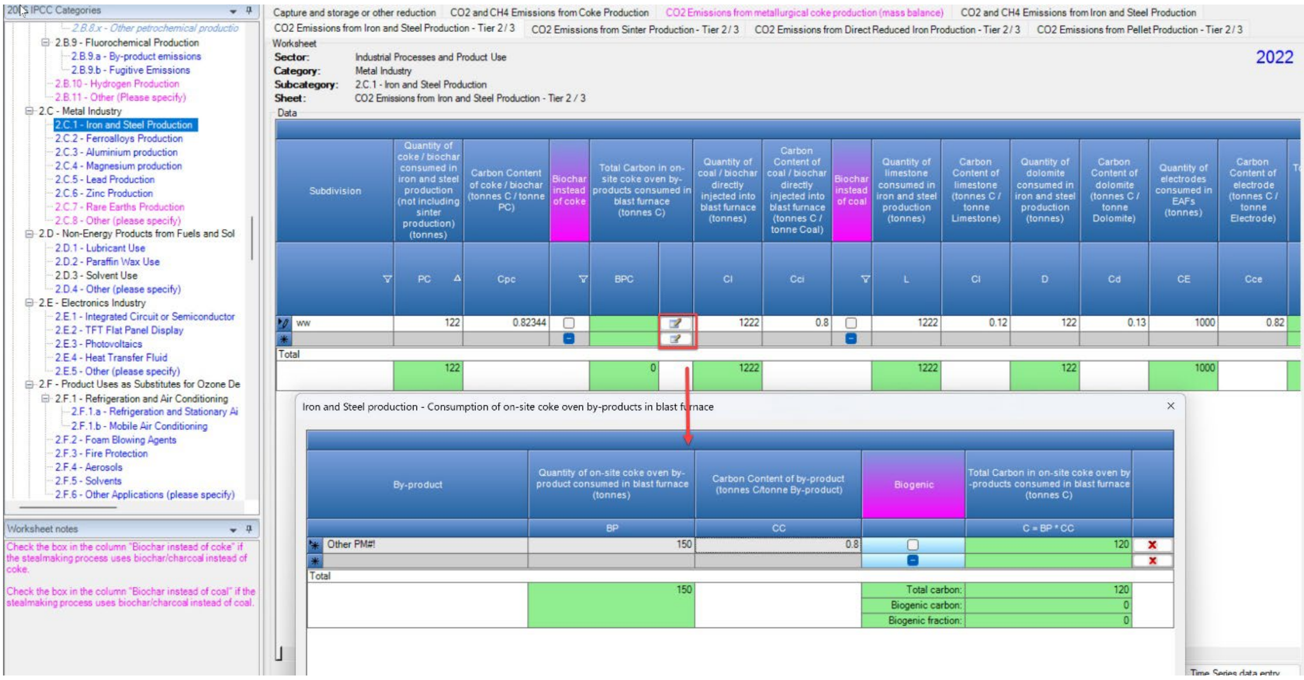
For each subdivision in worksheet **CO_2 emissions from Iron and Steel Production – Tier 2/3**, as applicable. *Note that the default carbon contents should be used only if an inventory compiler does not have information on conditions in iron and steel-making facilities but has detailed activity data for the process materials and offsite transfers.*

1. Column |Cpc|: select from the drop-down menu the IPCC default value for coke or enter a user-specific value, including for biochar, in tonnes C/tonne coking coal/biochar.
2. Column |BPC|: input the carbon content of by-products, in tonnes C/tonne by-product. This information is entered in Column |CC| in the sub-table associated with Column |BPC|.
3. Column |Ci|: select from the drop-down menu the IPCC default value for the carbon content of coal directly injected into the blast furnace, or enter a user-specific value, in tonnes C/tonne coal/biochar.
4. Column |Cl|: select from the drop-down menu the IPCC default value for the carbon content of limestone, or enter a user-specific value, in tonnes C/tonne limestone.
5. Column |Cd|: select from the drop-down menu the IPCC default value for the carbon content of dolomite, or enter a user-specific value, in tonnes C/tonne dolomite.
6. Column |Cce|: select from the drop-down menu the IPCC default value for the carbon content of electrodes, or enter a user-specific value, in tonnes C/tonne electrode.
7. Column |PM|: input the carbon content of other carbonaceous process materials used for iron and steel production, in tonnes C/tonne material. This information is entered in Column |CC| in the sub-table associated with Column |PM|.
8. Column |Ccog|: indicate whether the carbon content for coke oven gas shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified* , the cell becomes white and the user shall input the carbon content of coke oven gas, in tonnes C/GJ.

   Note that: section 1.1.1 Fuel **Manager** *provides further information on populating the Fuel Manager.*
9. Column |Cs|: select from the drop-down menu the IPCC default value for the carbon content of steel, or enter a user-specific value, in tonnes C/tonne steel.
10. Column |Cip|: select from the drop-down menu the IPCC default value for the carbon content of iron production not converted to steel, or enter a user-specific value, in tonnes C/tonne iron.
11. Column |Cbg|: indicate whether the carbon content for blast furnace gas transferred offsite shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user shall input the carbon content of blast furnace gas, in tonnes C/GJ.

    Note that: section 1.1.1 Fuel **Manager** provides further *information on populating the Fuel Manager.*

Example: **Tier 2 EF for iron and steel production**



Then, for each subdivision in worksheet **CO_2 emissions from Sinter Production – Tier 2/3,** as applicable:

1. Column |Ccbr|: enter a user-specific value, in tonnes C/tonne coke breeze or biochar.
2. Column |Ccog|: indicate whether the carbon content for coke oven gas shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user shall input the carbon content of coke oven gas, in tonnes C/GJ.

   Note that: section 1.1.1 Fuel **Manager** provides further *information on populating the Fuel Manager.*

12. Column |Cbg|: indicate whether the carbon content for blast furnace gas consumed in sinter production shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user shall input the carbon content of blast furnace gas, in tonnes C/GJ.

    Note that: section 1.1.1 Fuel **Manager** provides further *information on populating the Fuel Manager.*

3. Column |OPM|: input the carbon content of other process materials used for sinter production, in tonnes C/tonne material. This information is entered in Column |CC| in the sub-table associated with Column |OPM|.
4. Column |Csog|: enter a user-specific value, in tonnes C/tonne sinter off-gas transferred offsite.

Then, for each subdivision in worksheet **CO_2 emissions from Direct Reduced Iron Production – Tier 2/3** and worksheet **CO_2 emissions from Pellet Production – Tier 2/3,** as applicable:

1. Column |Cng|: indicate whether the carbon content for natural gas shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user shall input the carbon content of natural gas, in tonnes C/GJ.

   Note that: section 1.1.1 Fuel **Manager** provides further *information on populating the Fuel Manager.*

2. Column |Ccbr|: enter a user-specific value, in tonnes C/tonne coke breeze or biochar.
3. Column |Ccm|: enter a user-specific value, in tonnes C/tonne metallurgical coke or biochar.

Results

Coke Production

CO_2 and CH_4 emissions from Coke Production (to be reported in the Energy sector) are estimated in mass units (tonnes and Gg for CO_2 and kg and Gg for CH_4) by the *Software* in the following worksheets:

- ✓ **CO_2 and CH_4 emissions from Coke Production**
- ✓ **CO_2 Emissions from metallurgical coke production (mass balance)**

It is important to note that total emissions from coke production estimated in worksheet **CO_2 Emissions from metallurgical coke production (mass balance)** automatically subtract in Column |Eflaring|. CO_2 emissions from flaring of coke oven gas, estimated in worksheet **Emissions from Coke Oven Gas flaring** in category 1.B.1.c.ii Coke Production. This subtraction should only take place where the Tier 2/3 method is applied in worksheet **CO_2 Emissions from metallurgical coke production (mass balance);** the Tier 1b method assumes that coke oven gas produced is burned on site for energy recovery, and therefore CO_2 emissions from flaring are equal to zero. To ensure that the proper CO_2 is deducted, separate subdivisions should be entered for Tier1b and Tier 2/3, and these subdivisions should be consistent with those entered in the worksheet **Emissions from Coke Oven Gas flaring** in category 1.B.1.c.ii Coke Production.

All emissions from coke production will be reported under the Energy sector, under category 1.A.1.c.i Manufacture of Solid Fuels.

Iron and Steel Production

CO_2 and CH_4 emissions from Iron and Steel Production are estimated in mass units (tonnes and Gg for CO_2 and kg and Gg for CH_4) by the *Software* in the following worksheets:

- ✓ **CO_2 and CH_4 emissions from Iron and Steel Production – Tier 1**
- ✓ **CO_2 emissions from Iron and Steel Production – Tier 2/3**
- ✓ **CO_2 emissions from Sinter Production – Tier 2/3**
- ✓ **CO_2 emissions from Pellet Production – Tier 2/3**
- ✓ **CO_2 emissions from Direct Reduced Iron Production – Tier 2/3**

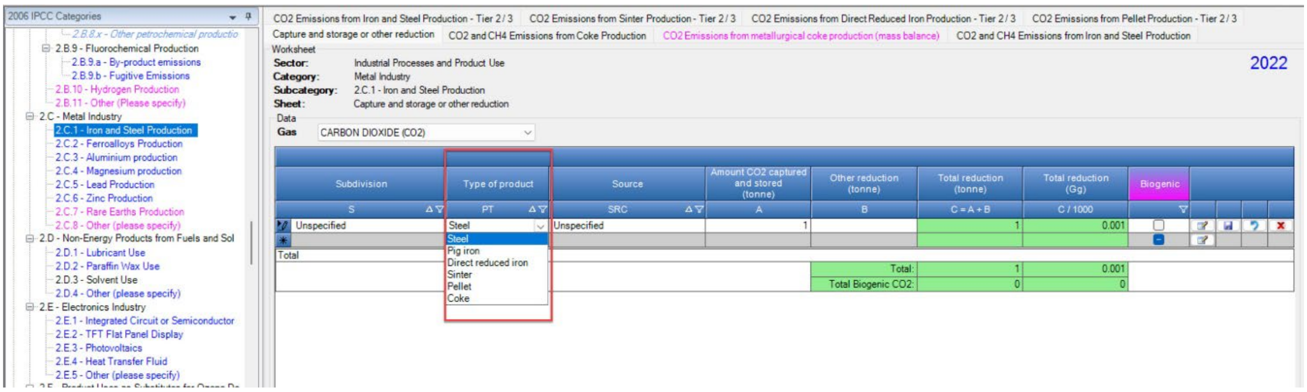
For both coke production and iron and steel production, where the user has indicated use of biochar in production in the *Software*, CO_2 emissions are totalled including and excluding biogenic CO_2.

Total CO_2 and CH_4 emissions from coke and iron and steel production, is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2 or CH_4, in tonnes. *Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.*
4. Column |Biogenic|: indicate with a check if the reducing agent/fuel is of biogenic origin. *Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.*

Example: **Capture and storage or other reduction**



2.C.2 Ferroalloys Production

Information

The *2006 IPCC Guidelines* provide guidance for estimation of CO_2 and CH_4 emissions from Ferroalloy Production.

There are three methodological Tiers: Tier 1 – EF method for CO_2 and CH_4, Tier 2 – mass-balance method using national / country-specific data for carbon content and EF for reducing agents and Tier 3 – mass-balance method based on plant-specific data and carbon content of input and output materials, including reducing agents. Tiers 2 and 3 (mass-balance) are used only for estimation of CO_2 emissions.

GHGs

The *Software* includes the following GHGs for the Ferroalloy Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	--	--	--	--	--

According to the 2006 *IPCC Guidelines*, N_2O emissions are possible, but the errors associated with estimates or measurements of N_2O emissions from the ferroalloys industry are very large and thus, a methodology is not provided. Users can calculate estimates of N_2O for this category, provided they develop country-specific methods based on researched data. These emissions can be reported in the IPCC inventory worksheet for category **2.C.8 Other**.

IPCC Equations

- ✓ Tier 1: Equations 4.15 (CO_2) and 4.18 (CH_4 from ferrosilicon and silicon metal production)
- ✓ Tier 2: Equation 4.16
- ✓ Tier 3: Equations 4.17 and 4.19

As explained in section **1.1.3 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 CO_2 and CH_4 from Ferroalloys Production using the following worksheets:

- ✓ **CO_2 and CH_4 Emissions from Ferroalloy Production:** contains for each subdivision, each type of ferroalloy and furnace type (if known), information on the amount of ferroalloy produced and CO_2 and CH_4 EFs. The worksheet calculates the associated CO_2 and CH_4 emissions.
- ✓ **CO_2 Emissions in Reducing Agents – Tier 2:** contains for each subdivision, each type of ferroalloy and each type of reducing agent, information on the amount of reducing agents consumed and CO_2 EFs. The worksheet calculates the associated CO_2 emissions from reducing agents.
- ✓ **CO_2 Emissions in Reducing Agents – Tier 3:** contains for each subdivision, each type of ferroalloy and each type of reducing agent, information on the amount and carbon content of reducing agents (carbon content can be calculated in the pop-up table based on plant-specific data). The worksheet calculates the associated CO_2 emissions from reducing agents.
- ✓ **CO_2 Emissions in Ore – Tier 2/3:** contains for each subdivision, each type of ferroalloy and each type of ore, information on the amount and carbon content of ore consumed. The worksheet calculates the associated CO_2 emissions from ore.
- ✓ **CO_2 Emissions in Slag forming material – Tier 2/3:** contains for each subdivision, each type of ferroalloy and each type of slag forming material, information on the amount and carbon content of slag forming material consumed. The worksheet calculates the associated CO_2 emissions from slag forming material.
- ✓ **CO_2 Emissions in Products – Tier 2/3:** contains for each subdivision and each type of ferroalloy produced, information on the amount and carbon content of ferroalloys produced. The worksheet calculates the associated CO_2 "contained" in ferroalloys produced.

- ✓ **CO_2 Emissions in Non-product outgoing streams – Tier 2/3:** contains for each subdivision, each type of ferroalloy produced and each non-product outgoing stream, information on the amount and carbon content of non-product outgoing streams. The worksheet calculates the associated CO_2 "contained" in non-product outgoing streams.
- ✓ **CO_2 Emissions Summary – Tier 2/3:** (non-editable table) contains for each subdivision and each type of ferroalloy produced, the results of the estimation of CO_2 emissions from input and output materials for Tier 2 and Tier 3.
- ✓ **Capture and storage or other reduction** contains for each subdivision and each type of ferroalloy produced, information on CO_2 capture (with subsequent storage) and other reduction of CO_2 and CH_4, not accounted previously in the worksheets for different Tiers.

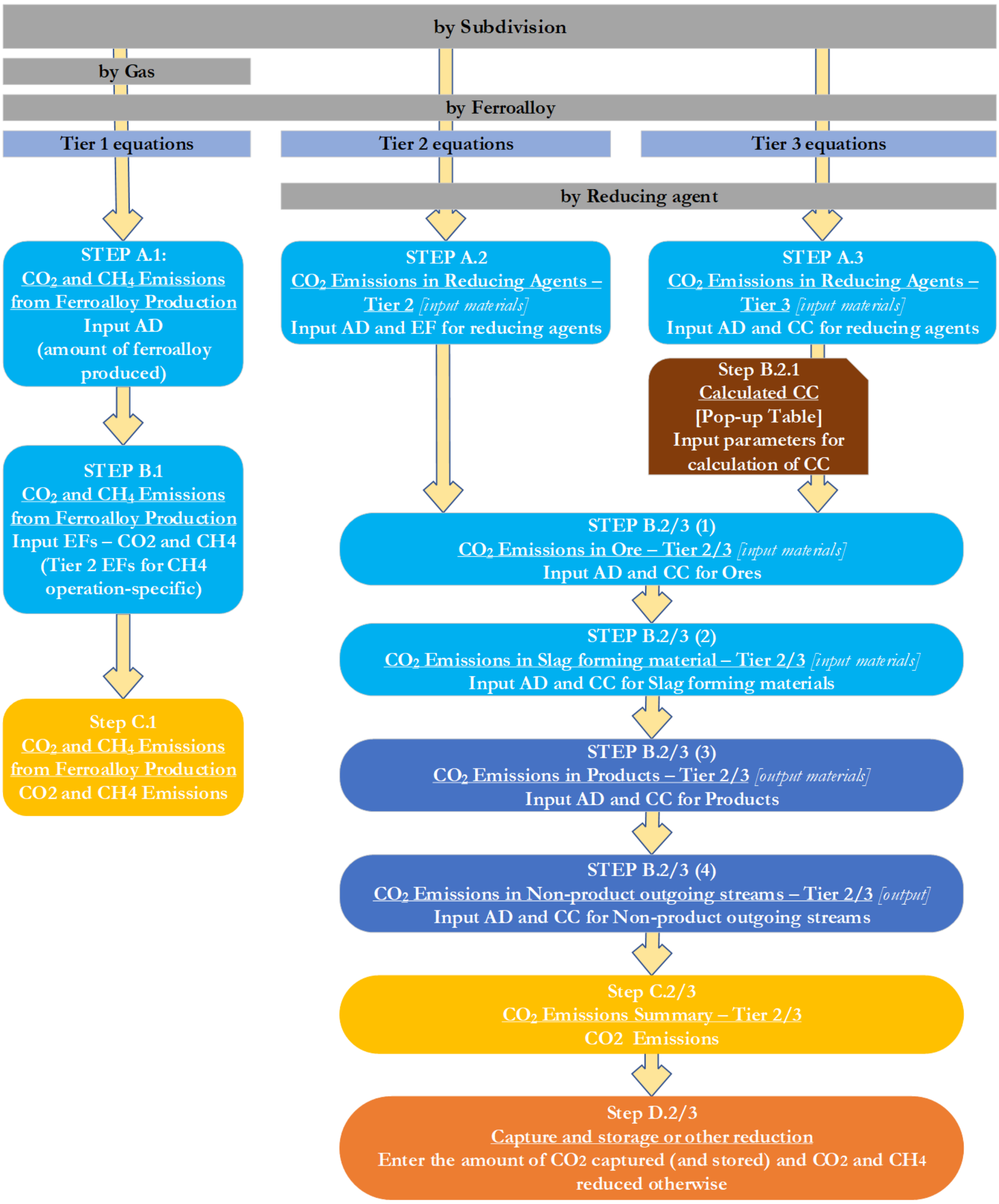
User's work Flowchart

Consistent with the key category analysis and decision trees in Figure 4.9 of the *2006 IPCC Guidelines* (for CO_2) and Figure 4.10 GHG estimates are calculated using three methodological Tiers: Tier 1 or Tier 2 or Tier 3 or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, users follow the following flowchart for the Ferroalloy Production source category.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Ferroalloy Production – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When Tier 1 Equations are applied

Step A.1, in the worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production,** for each subdivision, each type of ferroalloy produced and each type of furnace, if known, users collect and input in the *Software* information on the amount of each type of ferroalloy produced.

Step B.1, in the worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production**, for each subdivision, each type of ferroalloy produced and each type of furnace, if known, users input respective CO_2 and CH_4 EFs.

Step C.1, in the worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production**, the *Software* calculates the associated emissions for each subdivision in mass units (tonne for CO_2 and kg for CH_4 and Gg). In addition, the total emissions of all subdivisions are shown.

When Tier 2 / Tier 3 Equations are applied

Step A.2, in the worksheet **CO_2 Emissions in Reducing Agents – Tier 2,** for each subdivision and each type of ferroalloy produced, users collect and input information on the type (name of reducing agent and whether biogenic or fossil in origin) and amount of reducing agent used and CO_2 EFs based on the reducing agent used.

Step A.3, in the worksheet **CO_2 Emissions in Reducing Agents – Tier 3,** for each subdivision and each type of ferroalloy produced, users collect and input information on the type (name of reducing agent and whether biogenic or fossil in origin) and amount of reducing agent used and the carbon content of the reducing agent. Carbon content can either be specified or calculated in a pop-up table (**Step B.2.1**). When applying Tier 3, plant-specific data are required.

Then for both Tier 2 and Tier 3 (applying plant-specific data for Tier 3):

Step B.2/3, in the worksheets **CO_2 Emissions in Ore – Tier 2/3, CO_2 Emissions in Slag forming material – Tier 2/3, CO_2 Emissions in Products – Tier 2/3, and CO_2 Emissions in Non-product outgoing streams – Tier 2/3** for each subdivision and each type of ferroalloy produced, users collect and input information on additional input materials (ore, slag forming materials) and output materials (products/ferroalloys and non-product streams), as well as the carbon content of those materials.

Step C.2/3, in the worksheet **CO_2 Emissions Summary – Tier 2/3**, for each subdivision and type of ferroalloy, the *Software* calculates the total emissions from each input and output material in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown in each worksheet. CO_2 emissions from reducing agents of biogenic origin are estimated separately from those of fossil origin.

Then, for each tier, as appropriate:

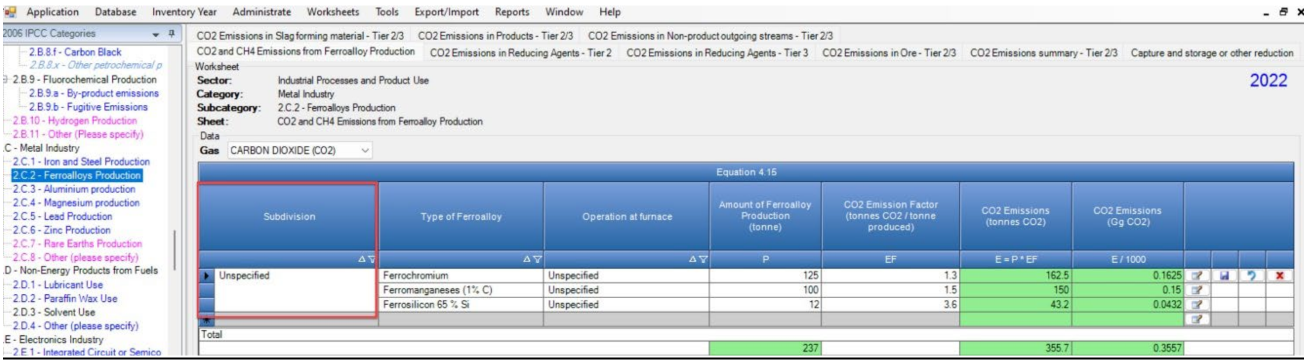
Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) and reduction of CH_4, , not otherwise captured in the worksheets above.

Activity data input

Section 4.3.2.3 Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Ferroalloy Production.

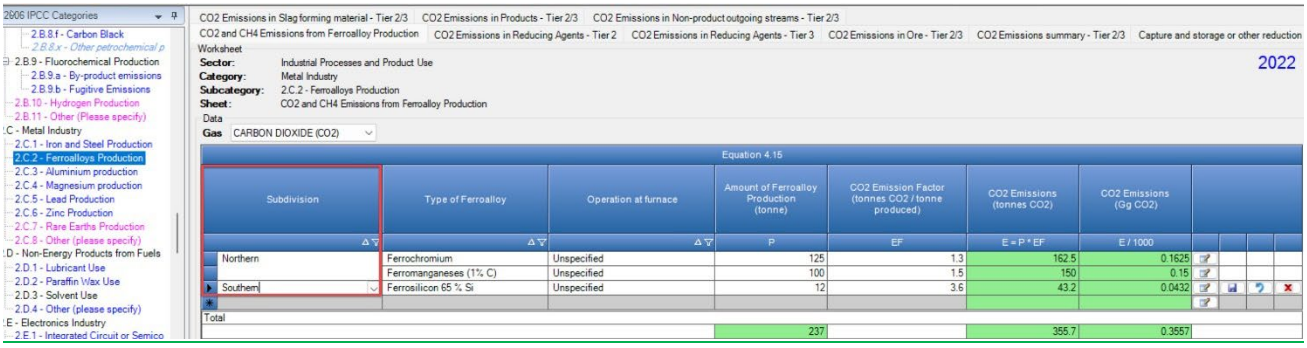
Input of AD for the Ferroalloy Production source category requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**



When Tier 1 Equations are applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 and CH_4 emissions from Ferroalloy Production,** row by row, as follows:

1. Column |Type of Ferroalloy|: select from the drop-down menu the default type of ferroalloy produced or input manually a country-specific type of ferroalloy.
2. Column |Operation of furnace|: select from the drop-down menu the default type of furnace or input manually a country-specific type of furnace, if known. For Tier 1, the user may select Unspecified.
3. Column |P|: input the amount/mass of the individual type of ferroalloy produced, in tonnes.

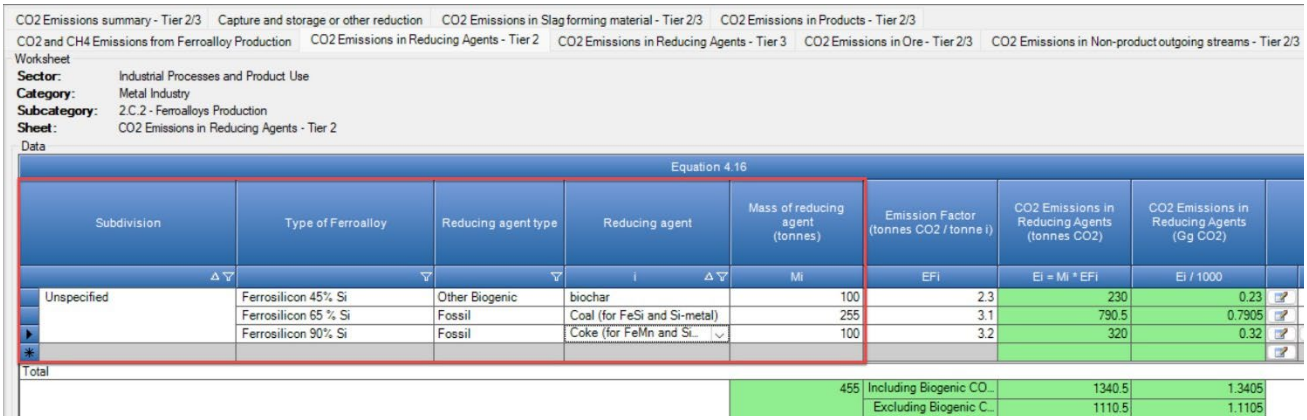
When Tier 2/Tier 3 Equations are applied:

The types of AD are the same for Tier 2 and Tier 3; the only difference being that Tier 3 requires plant-specific data. Thus, for each subdivision in Column |Subdivision|, data are entered in worksheets **CO_2 emissions in Reducing Agents – Tier 2** and **CO_2 emissions in Reducing agents – Tier 3,** row by row, as follows:

Note that there is not an automatic link of subdivisions among the Tier 2/Tier 3 worksheets. In particular, where Tier 3 is used, the user should ensure that all relevant worksheets for each plant are filled in. Further, note that not all worksheets may necessarily be relevant, they are to be used, as applicable.

1. Column |Type of Ferroalloy|: select from the drop-down menu the default type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. Column |Reducing agent type|: select from the drop-down menu the default type of reducing agent (fossil or select from options of biogenic origin). Manual input is not allowed, what is critical is the distinction between reducing agents of fossil and biogenic origin since emissions from bio-reducing agents will not be counted to the national total.
3. Column |i|: select from the drop-down menu the default reducing agent (e.g. coke) or input manually country-specific reducing agent.
4. Column |Mi|: input the amount/mass of reducing agent, in tonnes.

Example: **AD input for reducing agents – Tier 2 and Tier 3**

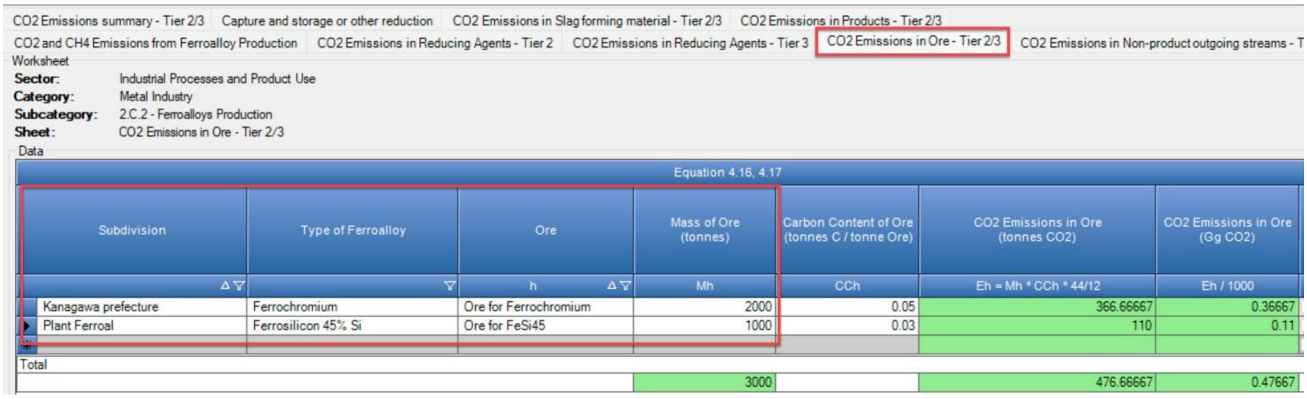


Then, for both Tier 2 and Tier 3

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions in Ore – Tier 2/3,** row by row, as follows:

1. <u>Column |Type of Ferroalloy|:</u> select from the drop-down menu the default type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. <u>Column |h|:</u> input manually the name of the ore used for ferroalloy production.
3. <u>Column |Mh|</u>: input the amount/mass of ore used, in tonnes.

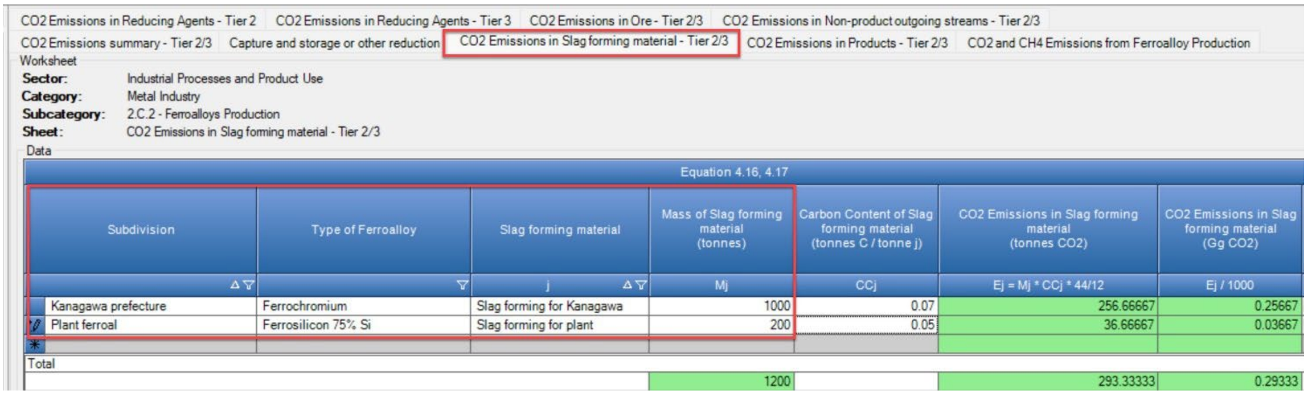
Example: **AD input for ore – Tier 2/3**



Then, for each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions in Slag forming materials – Tier 2/3,** row by row, as follows:

1. <u>Column |Type of Ferroalloy|:</u> select from the drop-down menu the default type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. <u>Column |j|</u>: input manually the name of the slag forming material used for ferroalloy production.
3. <u>Column |Mj|</u>: input the amount/mass of slag forming material used, in tonnes.

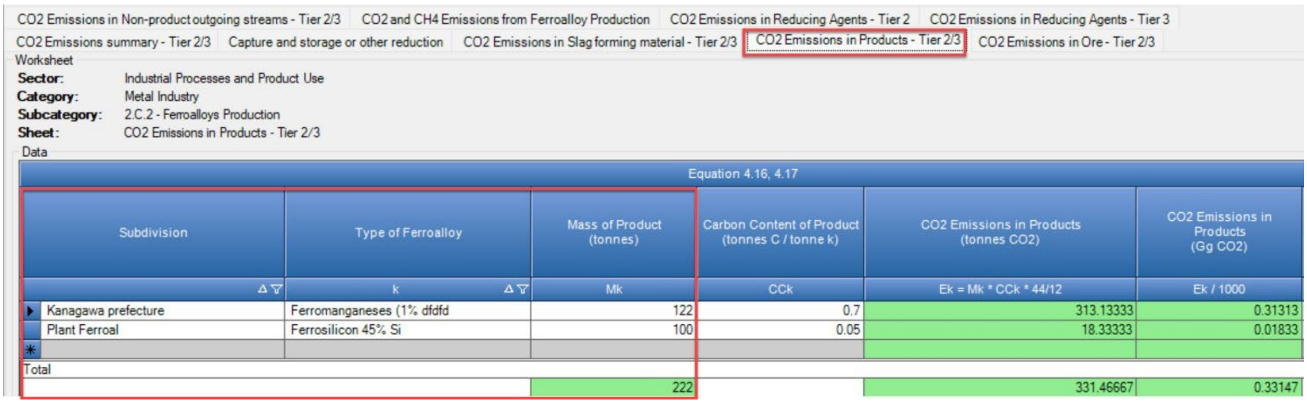
Example: **AD input for slag forming materials – Tier 2/3**



Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 emissions in Products – Tier 2/3,** row by row, as follows:

1. Column |Type of Ferroalloy|: select from the drop-down menu the default type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. Column |k|: input manually the name of the type of ferroalloy produced.
3. Column |Mk|: input the amount/mass of ferroalloy produced, in tonnes.

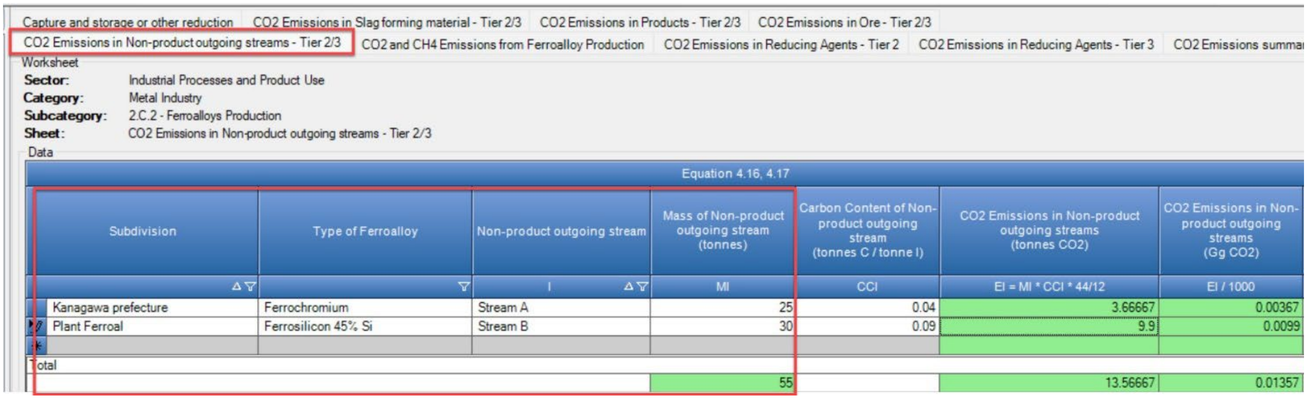
Example: **AD input for products (ferroalloys) – Tier 2/3**



Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions in Non-product outgoing streams – Tier 2/3,** row by row, as follows:

1. Column |Type of Ferroalloy|: select from the drop-down menu the default type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. Column |l|: input manually the name of the non-product outgoing stream from ferroalloy production.
3. Column |Ml|: input the amount/mass of non-product outgoing stream, in tonnes.

Example: **AD input for non-product outgoing streams – Tier 2/3**



Emission factor input

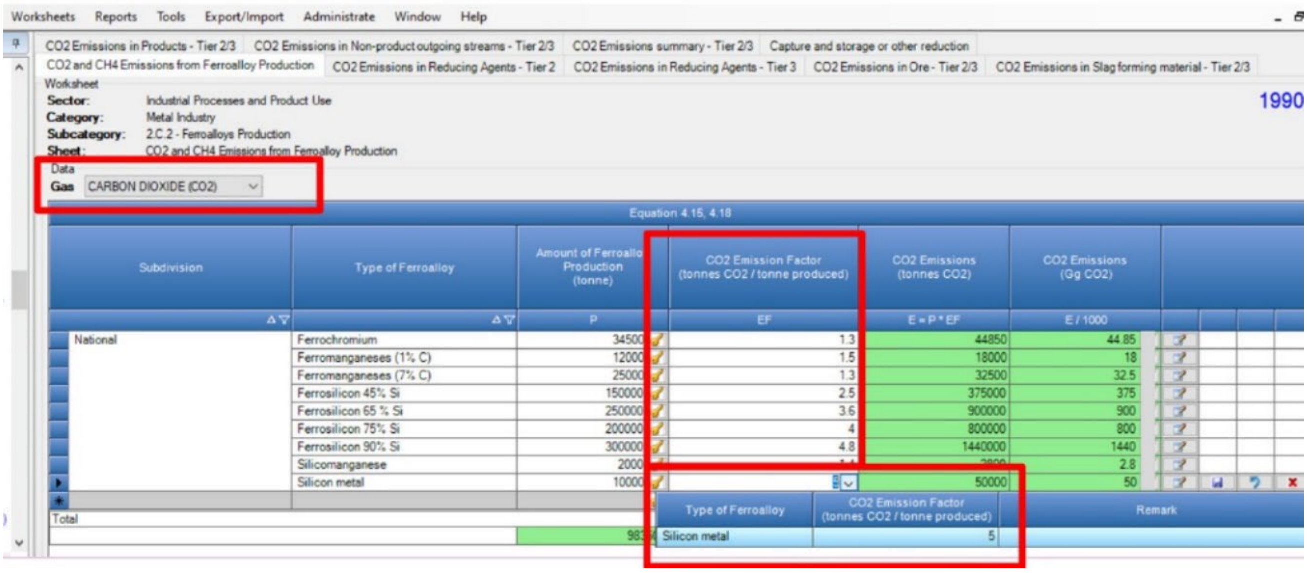
Section 4.3.2.2 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Ferroalloy Production. There are four sets of default EFs:

1. Tier 1 EFs for CO_2 (Table 4.5 Chapter 4 Volume 3 of the *2006 IPCC Guidelines*)
2. Tier 2 EFs for CO_2 (Table 4.6 Chapter 4 Volume 3 of the *2006 IPCC Guidelines*)
3. Tier 1 EFs for CH_4 (Table 4.7 Chapter 4 Volume 3 of the *2006 IPCC Guidelines*)
4. Tier 2 EFs for CH_4 (Table 4.8 Chapter 4 Volume 3 of the *2006 IPCC Guidelines*)

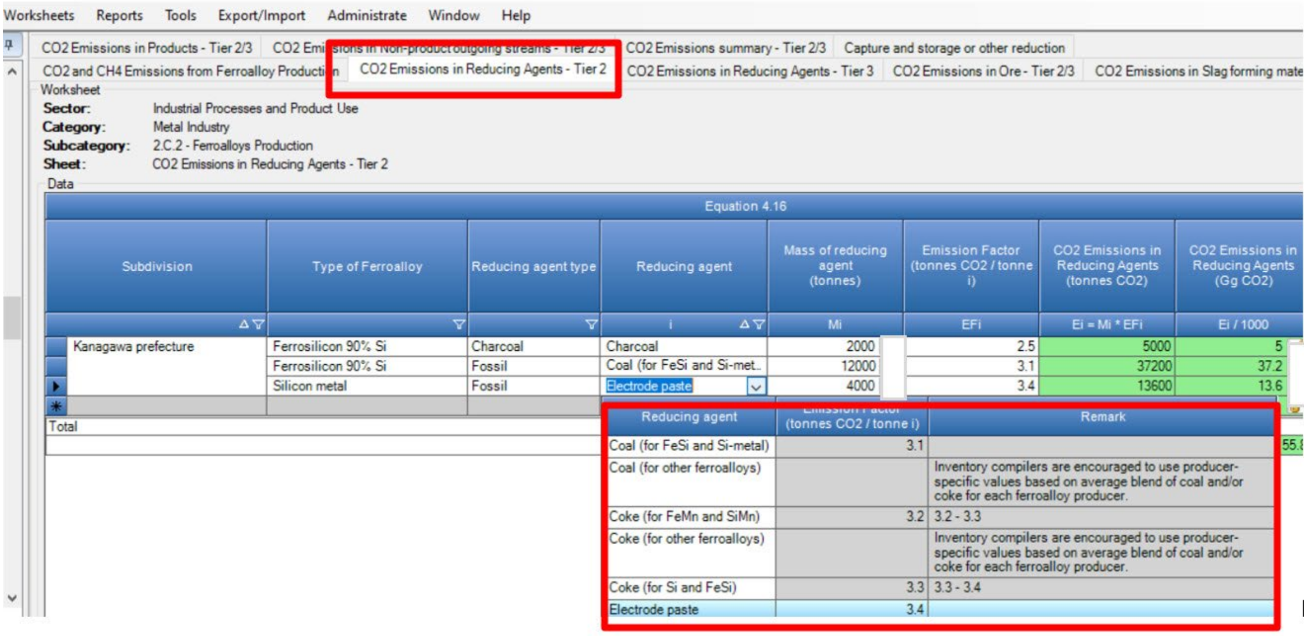
The first, third and fourth sets of default EFs are entered in Column |EF| of the worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production**. The second set is entered in Column |EFi| in the worksheet **CO_2 Emissions in Reducing Agents – Tier 2** (Tier 2 for Reducing Agents is a EF approach). The default EFs are embedded in the *Software*. Users may manually over-write EFs with country-specific values.

Note that the 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.

Example: **Ferroalloy Production – Tier 1 EFs for CO_2**



Example: **Ferroalloy Production – Tier 2 EFs for CO_2**



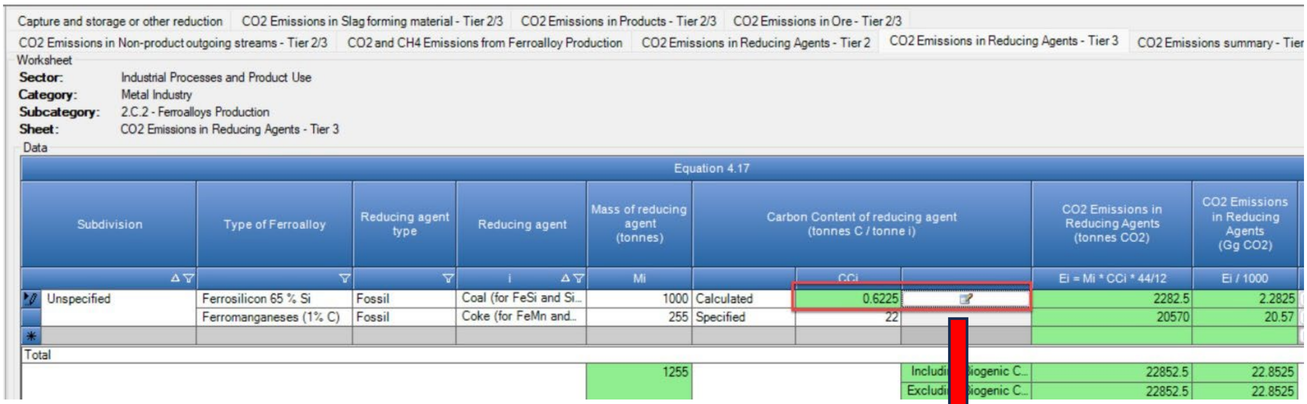
The Tier 3 method for Ferroalloy Production requires plant-specific data on carbon content of the input and output materials. These carbon contents must be input by users manually in the following worksheets **CO_2 Emissions in Ore – Tier 2/3** (in Column |CCh|), **CO_2 Emissions in Slag forming material – Tier 2/3** (in Column |CCj|), **CO_2 Emissions in Products – Tier 2/3** (in Column |CCk|), and **CO_2 Emissions in Non-product outgoing streams – Tier 2/3** (in Column |CCl|).

In worksheet **CO_2 Emissions in Reducing Agents – Tier 3,** users may either input the carbon content manually (i.e. specify the value in Column |CCi|) or calculate the carbon content in reducing agents (Tier 3) based on the mass fraction of fixed carbon, mass fraction of volatiles and carbon content of volatiles in the reducing agent (Equation 4.19).

Thus for each subdivision in Column |Subdivision|, when Column |CCi| is calculated, users must collect and input in the pop-up table plant-specific data, row by row, as follows:

1. Column |FFixC|: users collect and input the mass fraction of fixed C in the reducing agent, in tonnes of carbon/ tonne of reducing agent.
2. Column |Fvol|: users collect and input the mass fraction of volatiles in reducing agent, in tonnes volatiles/ tonne reducing agent.
3. Column |Cvol|: users collect and input carbon content in volatiles, tonnes C/tonne volatiles. *Note that unless other information is available, Cvol = 0.65 for coal and 0.80 for coke.*

Example: **Ferroalloy Production – Calculation of Carbon Content in Reducing Agents (Tier 3)**

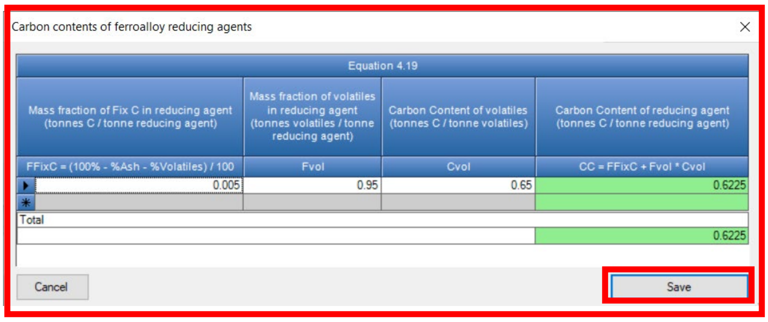


Capture and storage or other reduction | CO2 Emissions in Slag forming material - Tier 2/3 | CO2 Emissions in Products - Tier 2/3 | CO2 Emissions in Ore - Tier 2/3
CO2 Emissions in Non-product outgoing streams - Tier 2/3 | CO2 and CH4 Emissions from Ferroalloy Production | CO2 Emissions in Reducing Agents - Tier 2 | CO2 Emissions in Reducing Agents - Tier 3 | CO2 Emissions summary - Tier

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.2 - Ferroalloys Production
Sheet: CO2 Emissions in Reducing Agents - Tier 3
Data

Equation 4.17

Subdivision	Type of Ferroalloy	Reducing agent type	Reducing agent	Mass of reducing agent (tonnes)	Carbon Content of reducing agent (tonnes C / tonne i)			CO2 Emissions in Reducing Agents (tonnes CO2)	CO2 Emissions in Reducing Agents (Gg CO2)
			i	Mi		CCi		Ei = Mi * CCi * 44/12	Ei / 1000
Unspecified	Ferrosilicon 65 % Si	Fossil	Coal (for FeSi and Si...	1000	Calculated	0.6225		2282.5	2.2825
	Ferromanganeses (1% C)	Fossil	Coke (for FeMn and...	255	Specified	22		20570	20.57
Total				1255			Includi... Biogenic C...	22852.5	22.8525
							Excludi... Biogenic C...	22852.5	22.8525



Carbon contents of ferroalloy reducing agents

Equation 4.19

Mass fraction of Fix C in reducing agent (tonnes C / tonne reducing agent)	Mass fraction of volatiles in reducing agent (tonnes volatiles / tonne reducing agent)	Carbon Content of volatiles (tonnes C / tonne volatiles)	Carbon Content of reducing agent (tonnes C / tonne reducing agent)
FFixC = (100% - %Ash - %Volatiles) / 100	Fvol	Cvol	CC = FFixC + Fvol * Cvol
0.005	0.95	0.65	0.6225
Total			0.6225

Cancel | Save

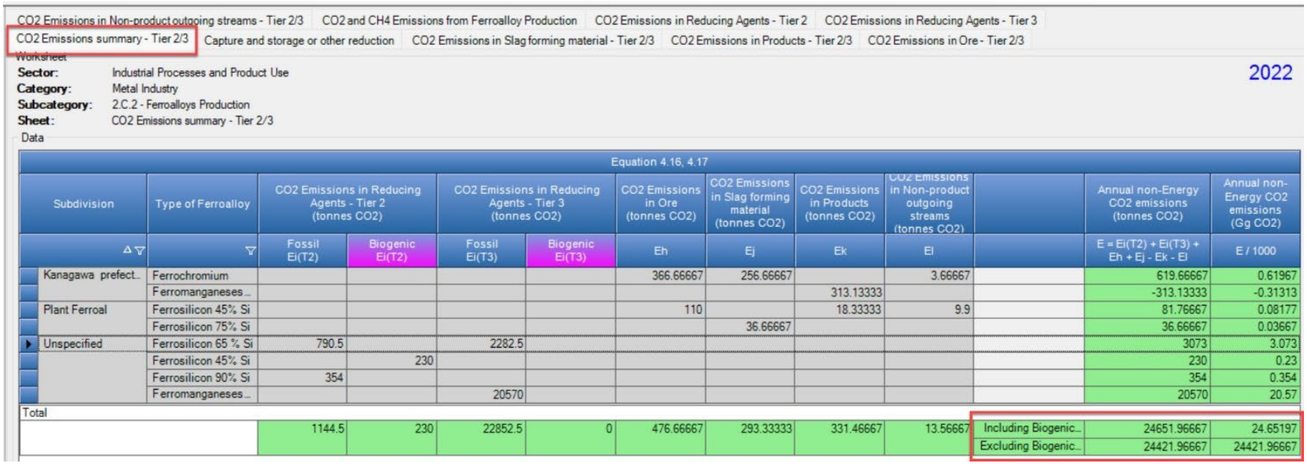
Results

CO_2 and CH_4 emissions from Ferroalloy Production are estimated in mass units (tonnes and Gg for CO_2 and kg and Gg for CH_4) by the *Software* in the following worksheets:

- ✓ **CO_2 and CH_4 emissions from Ferroalloy Production**
- ✓ **CO_2 Emissions Summary – Tier 2/3**.

Total CO_2 and CH_4 emissions from ferroalloy production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage or other GHG reduction. For Tier 2/3, note that the CO_2 emissions include both CO_2 of biogenic and fossil origin, and totals are provided both including and excluding biogenic CO_2.

Example: **Results of CO_2 emissions – Tier 2/3.**



CO2 Emissions in Non-product outgoing streams - Tier 2/3 | CO2 and CH4 Emissions from Ferroalloy Production | CO2 Emissions in Reducing Agents - Tier 2 | CO2 Emissions in Reducing Agents - Tier 3
CO2 Emissions summary - Tier 2/3 | Capture and storage or other reduction | CO2 Emissions in Slag forming material - Tier 2/3 | CO2 Emissions in Products - Tier 2/3 | CO2 Emissions in Ore - Tier 2/3

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.2 - Ferroalloys Production
Sheet: CO2 Emissions summary - Tier 2/3
Data

2022

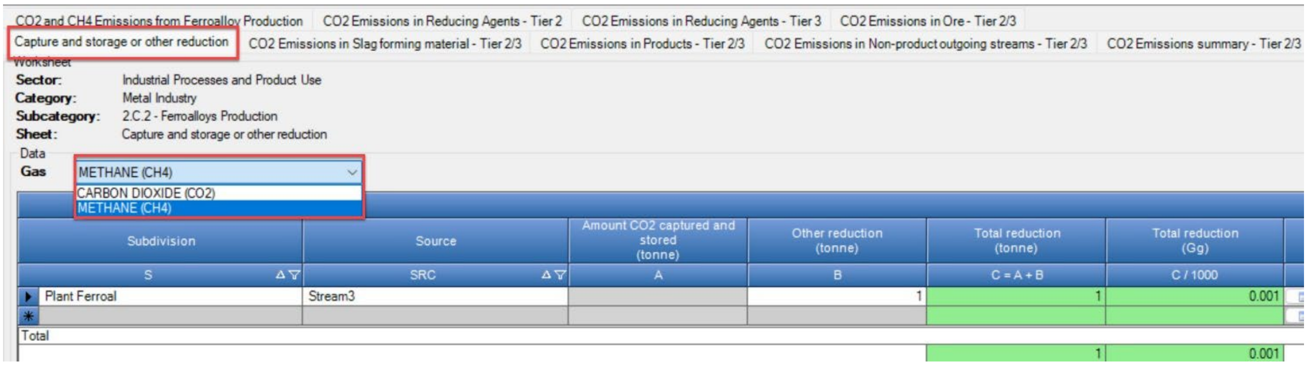
Equation 4.16, 4.17

Subdivision	Type of Ferroalloy	CO2 Emissions in Reducing Agents - Tier 2 (tonnes CO2)		CO2 Emissions in Reducing Agents - Tier 3 (tonnes CO2)		CO2 Emissions in Ore (tonnes CO2)	CO2 Emissions in Slag forming material (tonnes CO2)	CO2 Emissions in Products (tonnes CO2)	CO2 Emissions in Non-product outgoing streams (tonnes CO2)		Annual non-Energy CO2 emissions (tonnes CO2)	Annual non-Energy CO2 emissions (Gg CO2)
		Fossil Ei(T2)	Biogenic Ei(T2)	Fossil Ei(T3)	Biogenic Ei(T3)	Eh	Ej	Ek	El		E = Ei(T2) + Ei(T3) + Eh + Ej - Ek - El	E / 1000
Kanagawa prefect...	Ferrochromium					366.66667	256.66667		3.66667		619.66667	0.61967
	Ferromanganeses...							313.13333			-313.13333	-0.31313
Plant Ferroal	Ferrosilicon 45% Si					110		18.33333	9.9		81.76667	0.08177
	Ferrosilicon 75% Si						36.66667				36.66667	0.03667
Unspecified	Ferrosilicon 65 % Si	790.5		2282.5							3073	3.073
	Ferrosilicon 45% Si		230								230	0.23
	Ferrosilicon 90% Si	354									354	0.354
	Ferromanganeses...			20570							20570	20.57
Total		1144.5	230	22852.5	0	476.66667	293.33333	331.46667	13.56667	Including Biogenic...	24651.96667	24.65197
										Excluding Biogenic...	24421.96667	24421.96667

In the worksheet **Capture and storage or other reduction,** for each subdivision and each gas (CO_2 and CH_4):

1. <u>Column |SRC|</u>: users either select from the dropdown, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. <u>Column |A|</u>: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. <u>Column |B|</u>: users collect and input information on any other long-term reduction of CO_2, in tonnes.
   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.
4. <u>Column |Biogenic|</u>: indicate with a check if the reductant is of biogenic origin.
   Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.

Example: **Capture and storage or other reduction**



2.C.3 Aluminium Production

Information

The *2006 IPCC Guidelines* provide guidance for estimation of CO_2 and PFCs (CF_4 and C_2F_6) emissions from Aluminium Production.

For CO_2, the Tier 1 method for calculating CO_2 emissions uses only broad cell technology characterizations (Prebake or Søderberg); Tier 2/3 are calculated using a mass balance approach The choice of method between the Tier 2 and Tier 3 method will depend on whether anode or paste composition data are available at the individual plant level.

For PFCs, the Tier 1 method uses technology-based default emission factors for the four main production technology types (Centre-Worked Prebake (CWPB), Side-Worked Prebake (SWPB), Horizontal Stud Søderberg (HSS) and Vertical Stud Søderberg (VSS). The Tier 2/3 methods utilizes equations for estimating CF_4 emissions based on the relationship between anode effect and performance: the slope and the overvoltage coefficient equations. Tier 3 requires measurements at the individual facility (plant-specific data). In Tier 2/3, because the process mechanisms that produce PFC emissions are similar for CF_4 and C_2F_6, the two gases should be considered together (C_2F_6 emissions are calculated as a fraction of CF_4 emissions).

Note that, for users using the Software for reporting to the UNFCCC ETF Reporting Tool, the MPGs include a category under Aluminium Production, ***2.C.3.b F-gases used in foundries****. The CRT contains a footnote for this category that reads "According to the 2006 IPCC Guidelines, possible SF_6 from casting are to be included under Mg production. However, in the current CRT a separate subcategory exists and is reported by Parties.". For users wishing to report under CRT 2.C.3.b, F-gases used in foundries, this information can be entered in category 2.C.8 Other of the Software, and will map to the appropriate category in the CRT.*

GHGs

The *Software* includes the following GHGs for the Aluminium Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	--	--	--	X	--	--

IPCC Equations

GHG emissions from the Aluminium Production source category are estimated by applying the following IPCC equations (Chapter 4 Volume 3 of the *2006 IPCC Guidelines*):

For CO_2

- ✓ Tier 1: Equation 4.20
- ✓ Tier 2/3: Equations 4.21, 4.22, 4.23 (Prebake) and 4.24 (Søderberg)

For PFCs

- ✓ Tier 1: Equations 4.25
- ✓ Tier 2/3: Equations 4.26 (Prebake) and 4.27 (Søderberg)

As explained in section **1.1.3 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 CO_2 and PFC emissions from Aluminium Production using the following ten worksheets:

CO_2 emissions:

- ✓ **CO_2 Emissions from Aluminium Production:** contains for each subdivision and each type of technology (Prebake and Soderberg) information on the amount of aluminium produced and default CO_2 EFs. The worksheet calculates the associated CO_2 emissions.

- ✓ **CO_2 Emissions from Prebake Anode Consumption– Tier 2/3:** contains for each subdivision information on the amount of aluminium produced by Prebake technology, net Prebake anode consumption, and the sulphur and ash content in baked anodes. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3:** contains for each subdivision information on the initial weight and hydrogen content of green anodes, baked anode production and waste tar collected. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Bake Furnace Packing Materials (Prebake) – Tier 2/3:** contains for each subdivision information on packing coke consumption, baked anode production, and the sulphur and ash content in packing coke. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Paste Consumption (Søderberg) – Tier 2/3:** contains for each subdivision information on the amount of aluminium produced by Søderberg technology, paste consumption, emissions of cyclohexane soluble matter, binder content in paste, sulphur, hydrogen and ash content in pitch, sulphur and ash content in calcined coke, and carbon in skimmed dust from Søderberg cells. The worksheet calculates the associated CO_2 emissions.

PFCs emissions:

- ✓ **1.1.2 F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ✓ **PFC Emissions from Aluminium Production:** contains for each subdivision and each production technology type information on the amount of aluminium produced and corresponding default CF_4 and C_2F_6 EFs. The worksheet calculates the associated PFCs emissions for Tier 1.
- ✓ **PFC Emissions from Aluminium Production – Slope Method – Tier 2/3:** contains for each subdivision and each production technology type information on the amount of aluminium produced, anode effect in minutes per cell-day, slope coefficient for CF_4 and weight fraction of C_2F_6 per CF_4. The worksheet calculates the associated PFCs emissions.
- ✓ **PFC Emissions from Aluminium Production – Overvoltage Method – Tier 2/3:** contains for each subdivision and each production technology type information on the amount of aluminium produced, anode effect overvoltage, overvoltage coefficient for CF_4, process current efficiency and weight fraction of C_2F_6 per CF_4. The worksheet calculates the associated PFCs emissions.

Capture and storage or other reduction (CO_2 and PFCs):

- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2 and PFCs, not accounted previously in the worksheets for different Tiers.

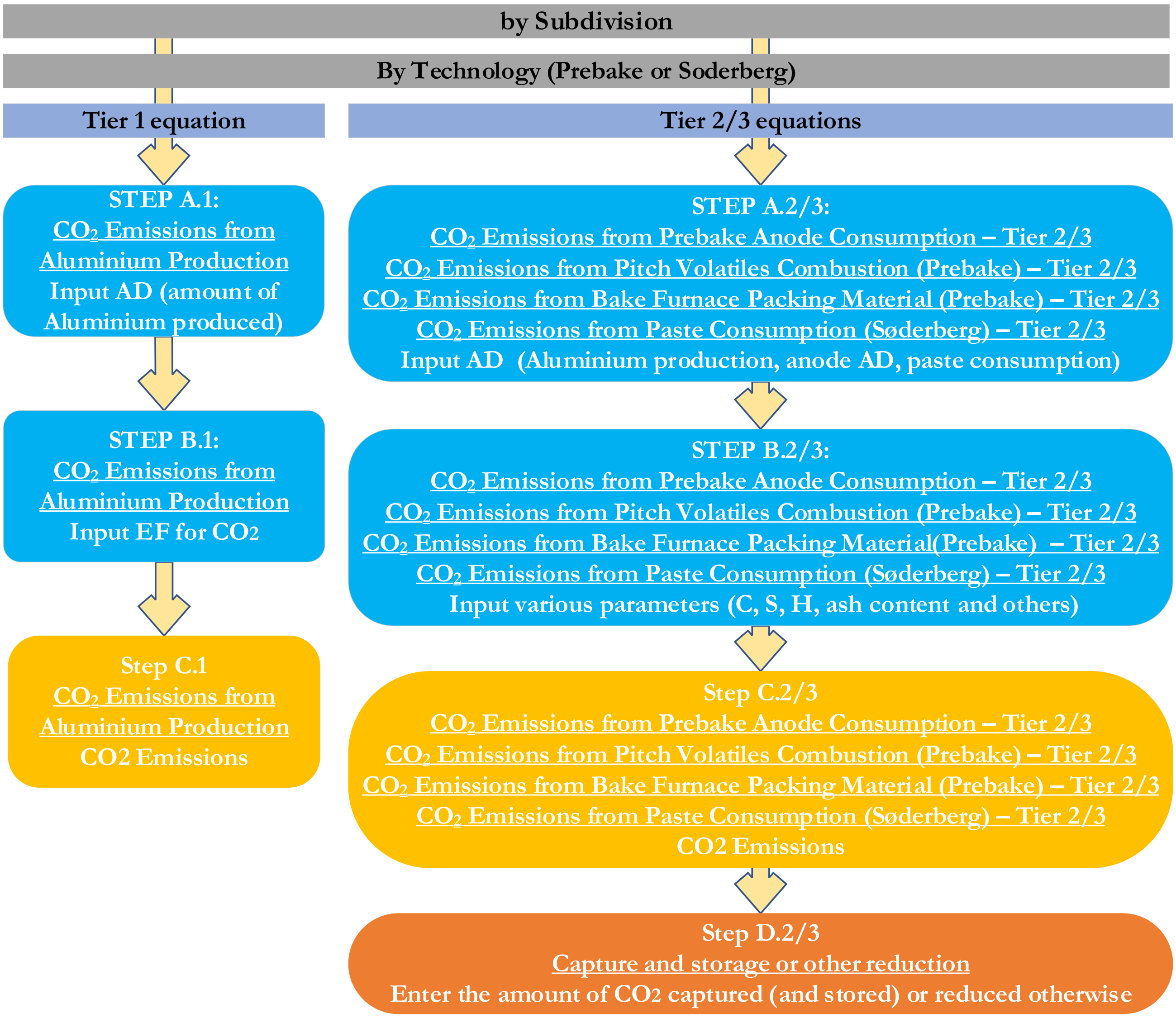
User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 4.11 (for CO_2) and Figure 4.12 (for PFCs) 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following two flowcharts for the estimation of CO_2 and PFC emissions from aluminium production

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Aluminium Production – CO_2 – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step A.1, in the worksheet **CO_2 Emissions from Aluminium Production**, users collect and input in the *Software* information on the amount of aluminium produced by each type of technology (Prebake or Søderberg).

Step B.1, in the worksheet **CO_2 Emissions from Aluminium Production**, users collect and input CO_2 EFs for each type of technology (Prebake or Søderberg).

Step C.1, in the worksheet **CO_2 Emissions from Aluminium Production,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

When the Tier 2/Tier 3 Equations are applied:

For Prebake technology

Step A.2/3, in the worksheet **CO_2 Emissions from Prebake Anode Consumption – Tier 2/3,** users collect and input in the *Software* information on the amount of aluminium produced by Prebake technology and net Prebake anode consumption; in the worksheet **CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3 ,** users collect and input information on the initial weight of green anodes and baked anode production; and in the worksheet **CO_2 Emissions from Bake Furnace Packing Material (Prebake)– Tier 2/3 ,** users collect and input information on baked anode production and packing coke consumption. For Tier 3, plant-specific AD should be input by users manually.

Step B.2/3, in the worksheet **CO_2 Emissions from Prebake Anode Consumption – Tier 2/3,** users collect and input sulphur and ash content in baked anodes; in the worksheet **CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3 ,** users collect and input hydrogen content in green anodes and waste tar collected, and in the worksheet **CO_2 Emissions from Bake Furnace Packing Material (Prebake) – Tier 2/3,** users collect and input sulphur and ash content in packing coke.

Step C.2/3, in the worksheets **CO_2 emissions from Prebake Anode Consumption – Tier 2/3, CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3,** and **CO_2 emissions from Bake Furnace Packing Material (Prebake)– Tier 2/3**, the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown in each worksheet.

For Søderberg technology

Step A.2/3, in the worksheet **CO_2 Emissions from Paste Consumption (Søderberg) – Tier 2/3**, users collect and input in the *Software* information on the amount of aluminium produced by Soderberg technology and paste consumption. For Tier 3 plant-specific AD should be input by users manually.

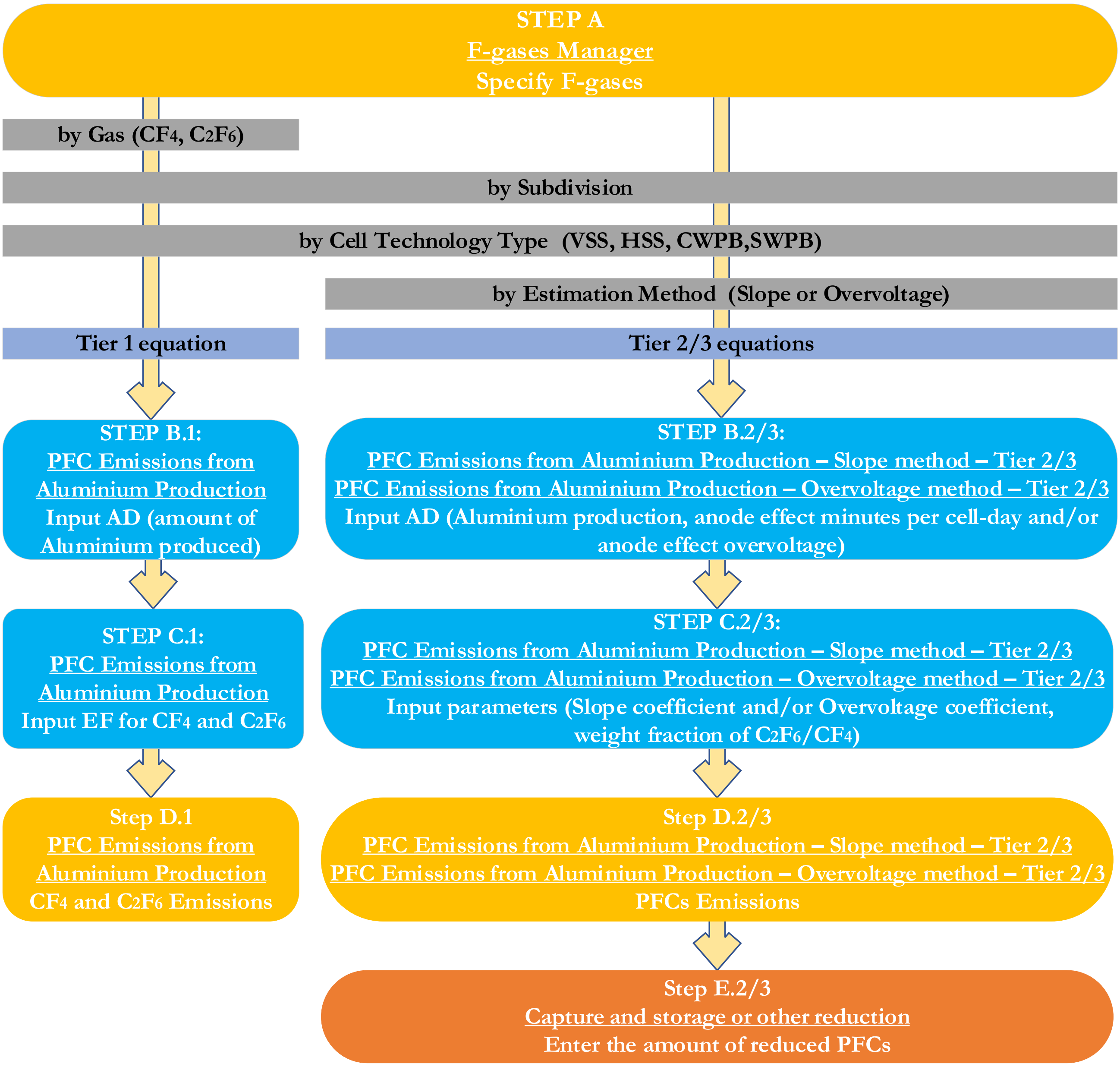
Step B.2/3, in the worksheet **CO_2 Emissions from Paste Consumption (Søderberg) – Tier 2/3**, users collect and input emissions of cyclohexane soluble matter, binder content in paste, sulphur, hydrogen and ash content in pitch, sulphur and ash content in calcined coke, and carbon in skimmed dust from Soderberg cells.

Step C.2/3, in the worksheet **CO_2 Emissions from Paste Consumption (Søderberg) – Tier 2/3**, the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

Then, for each tier, as appropriate:

Step D.2/3, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) or other GHG, not otherwise captured in the worksheets above.

Aluminium Production – PFCs – flowchart



Thus, for the source-category:

Step A, **1.1.2 F-gases Manager**, users ensure that all F-gases emitted for this source category (in this case, PFCs) have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step B.1, in the worksheet **PFC Emissions from Aluminium Production**, users collect and input in the *Software* information on the amount of aluminium produced by each type of technology (CWPB, SWPB, VSS and HSS).

Step C.1, in the worksheet **PFC Emissions from Aluminium Production**, for each type of technology (CWPB, SWPB, VSS and HSS) users input respective CF_4 and C_2F_6 EFs.

Step D.1, in the worksheet **PFC Emissions from Aluminium Production,** the *Software* calculates the associated PFCs emissions (C_2F_6 and CF_4) for each subdivision in mass units (kg and Gg). In addition, the total emissions of all subdivisions are shown.

When Tier 2/Tier 3 Equations are applied:

For Slope method

Step B.2/3, in the worksheet **PFC Emissions from Aluminium Production – Slope method – Tier 2/3**, users collect and input in the *Software* information on the amount of aluminium produced by each production technology type (CWPB, SWPB, VSS and HSS) and anode effect in minutes per cell-day.

Step C.2/3, in the worksheet **PFC Emissions from Aluminium Production – Slope method – Tier 2/3**, for each production technology type (CWPB, SWPB, VSS and HSS) users input slope coefficient for CF_4 and weight fraction of C_2F_6 per CF_4.

Step D.2/3, in the worksheet **PFC Emissions from Aluminium Production – Slope method – Tier 2/3,** the *Software* calculates the associated PFC emissions (C_2F_6 and CF_4) for each subdivision in mass units (kg and Gg). In addition, the total emissions of all subdivisions are shown in each worksheet.

For Overvoltage method

Step B.2/3, in the worksheet **PFC Emissions from Aluminium Production – Overvoltage method – Tier 2/3,** users collect and input in the *Software* information on the amount of aluminium produced by each production technology type (CWPB and SWPB) and the corresponding anode effect overvoltage.

Step C.2/3, in the worksheet **PFC Emissions from Aluminium Production – Overvoltage method – Tier 2/3,** for each production technology type (CWPB and SWPB) users input the overvoltage coefficient for CF_4, process current efficiency and weight fraction of C_2F_6 per CF_4.

Step D.2/3, in the worksheet **PFC Emissions from Aluminium Production – Overvoltage method – Tier 2/3,** the *Software* calculates the associated PFC emissions (C_2F_6 and CF_4) for each subdivision in mass units (kg and Gg). In addition, the total emissions of all subdivisions are shown in each worksheet.

Then, for each tier, as appropriate:

Step E.2/3, in the worksheet **Capture and storage or other reduction,** users collect and input in the *Software* information on the amount of reduced PFCs (C_2F_6 and CF_4) , not otherwise captured in the worksheets above.

Activity data input

Section 4.4.2.5 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Aluminium Production.

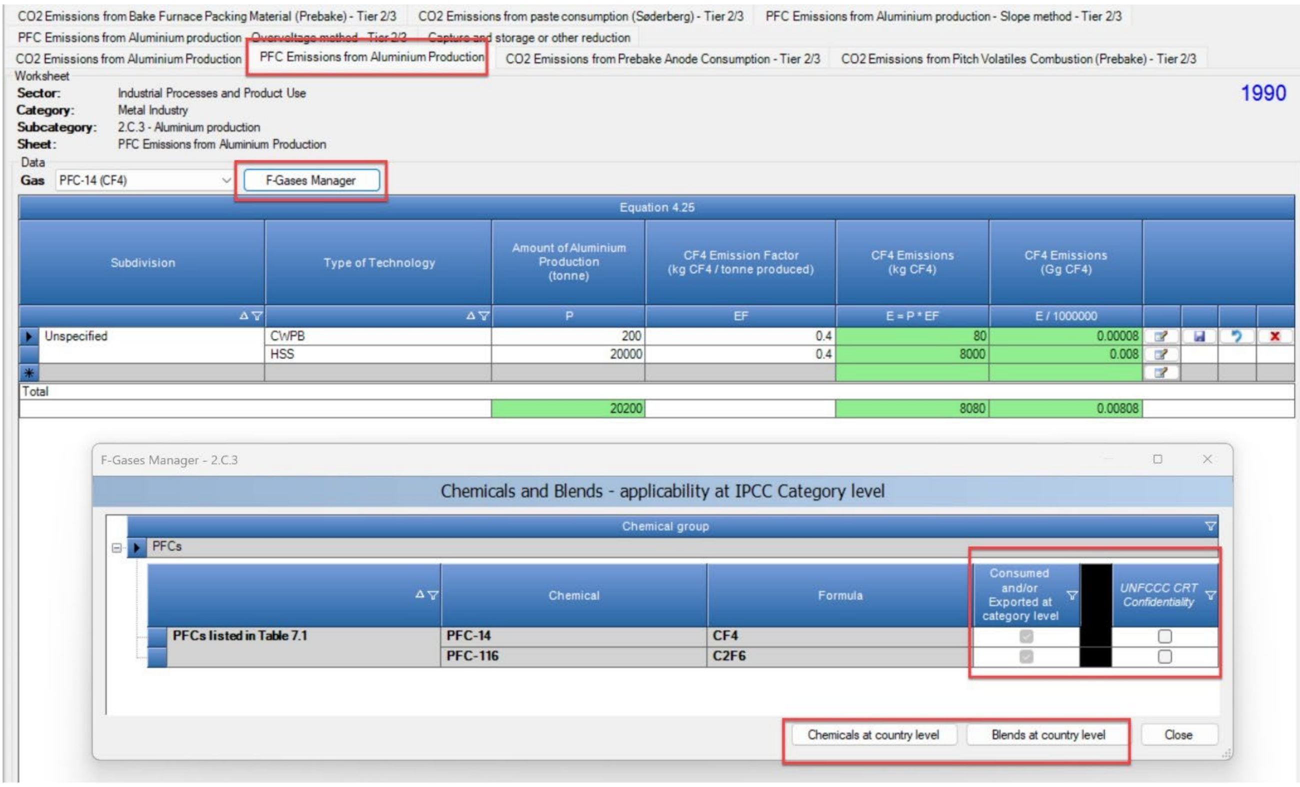
As a **Starting step**, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases to be reported for the source category Aluminium Production. In this case, the only relevant F-gases are CF_4 and C_2F_6.

*Note that if either of these gases is not checked in the F-gases Manager, then it will not be possible to enter any data. If data entry is not possible, select the **F-Gases Manager** from any tab for PFC emissions. This will open the F-gases Manager – applicability at IPCC Category Level. Navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the country level- F-gases Manager to check CF_4 and C_2F_6. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager.*

The user is not required to further select relevant F-gases for this category (CF_4 and C_2F_6 will be automatically checked).

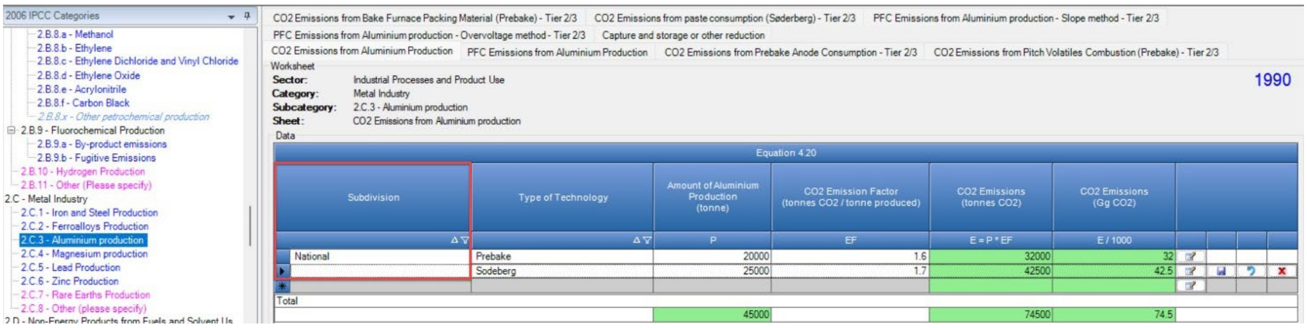
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT, as unspecified mix of HFCs and PFCs, in tonnes CO_2 equivalents.

Example: **Populating the F-gases manager and designating confidentiality for category: Aluminium Production**



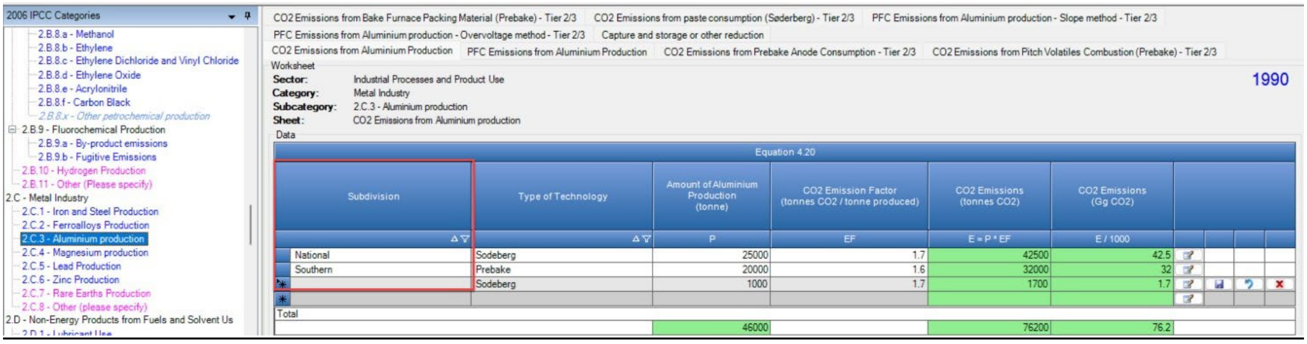
Second, input of AD for the Aluminium Production source category requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**

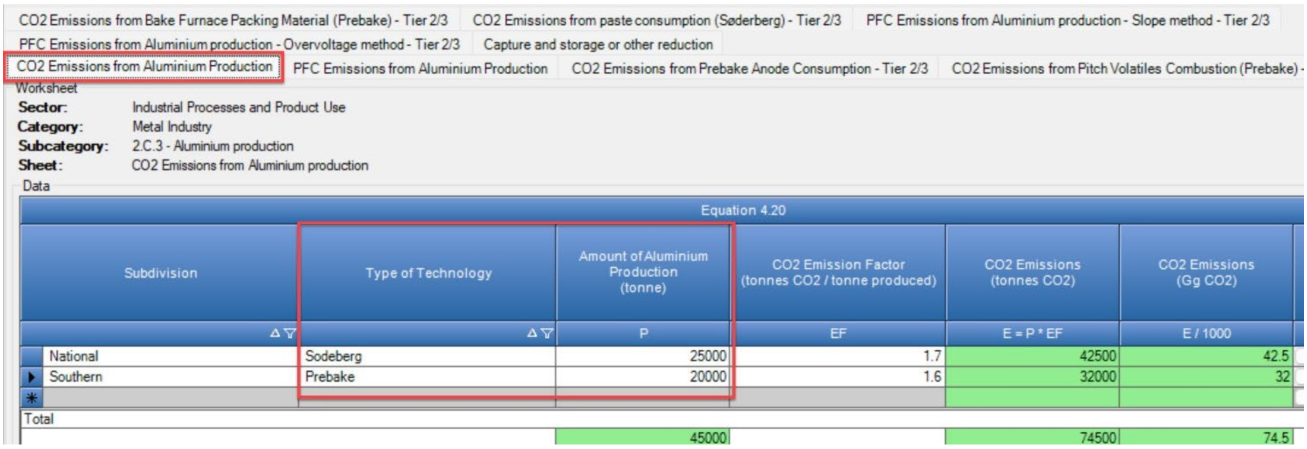


When Tier 1 Equations are applied:

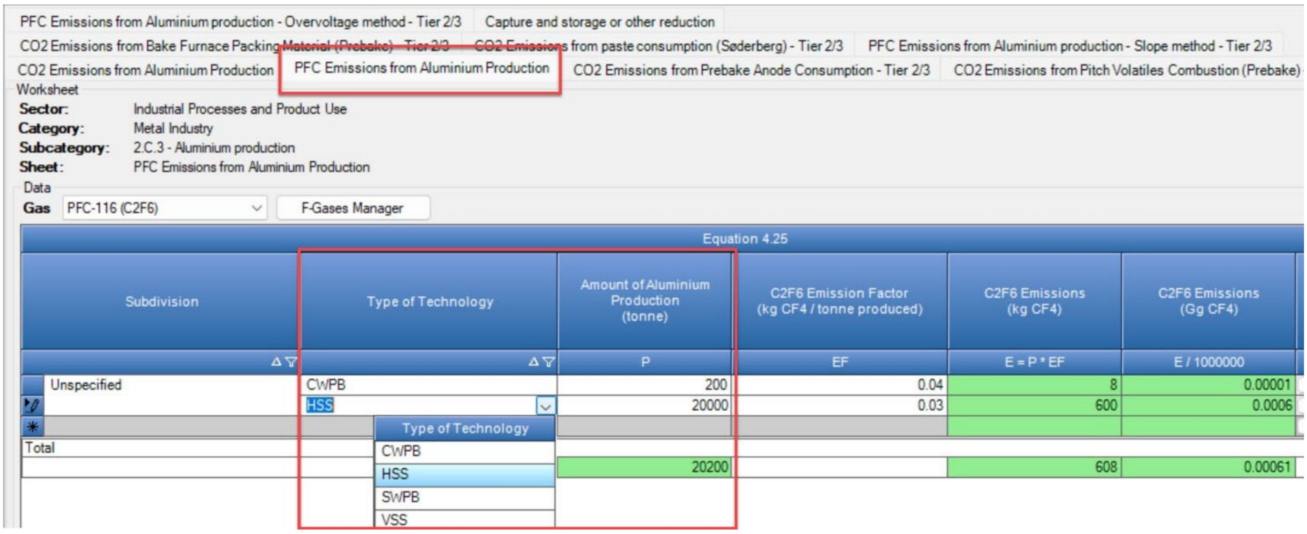
For each subdivision in Column |Subdivision|, data are entered in worksheets **CO_2 Emissions from Aluminium Production and PFC Emissions from Aluminium Production,** row by row, as follows:

1. Column |Type of Technology|: input from the drop-down menu the default type of technology or input manually country-specific type of technology (the technology can be repeated with a different name if it has different EFs, e.g. Prebake 1 or HSS 1).
   Note that, for CO_2 emissions, the distinction is between Prebake or Søderberg. For PFC Emissions, the user has the choice of CWPB, SWPB, HSS, and VSS.
2. Column |P|: input the amount/mass of aluminium produced by each type of technology, in tonnes.

Example: **AD input for CO_2 – Tier 1**



Example: **AD input for PFCs – Tier 1**



When Tier 2/Tier 3 Equations are applied:

The Tier 2 methods for both Prebake and Søderberg processes make use of typical industry values for impurities while the Tier 3 methods use actual concentrations of impurities. The choice of method between the Tier 2 and Tier 3 method will depend on whether anode or paste composition data are available at the individual plant level. For CO2 emissions, the choice of worksheet depends on if the technology type is Prebake or Søderberg. For PFC emissions, the choice of worksheet depends of if the slope or overvoltage method are selected.

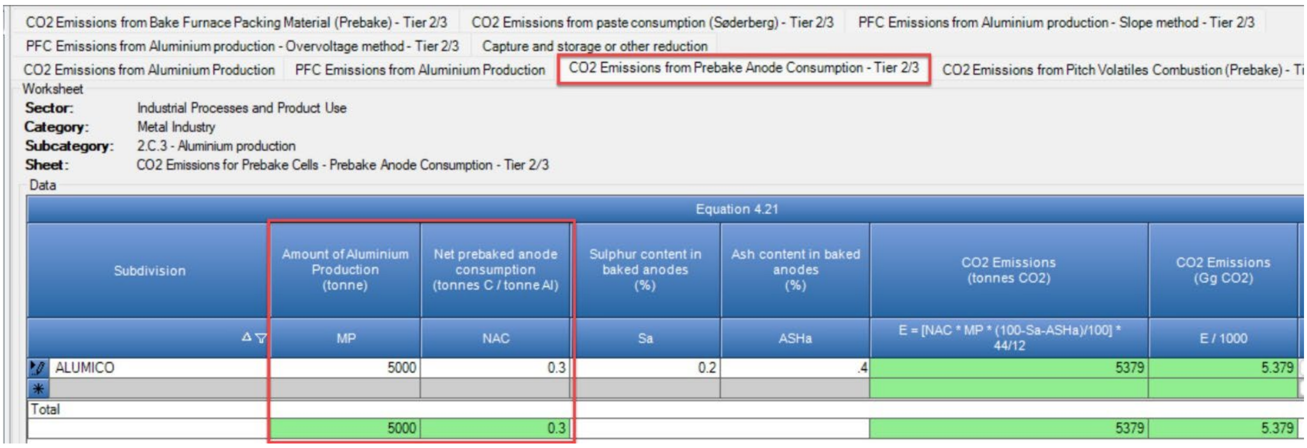
i. CO_2 Emissions

Prebake:

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Prebake Anode Consumption- Tier 2/3,** row by row, as follows:

1. Column |MP|: input the amount/mass of aluminium produced by Prebake technology in tonnes.
2. Column |NAC|: input net prebaked anode consumption per tonne of aluminium produced, in tonnes of C per tonne Al.

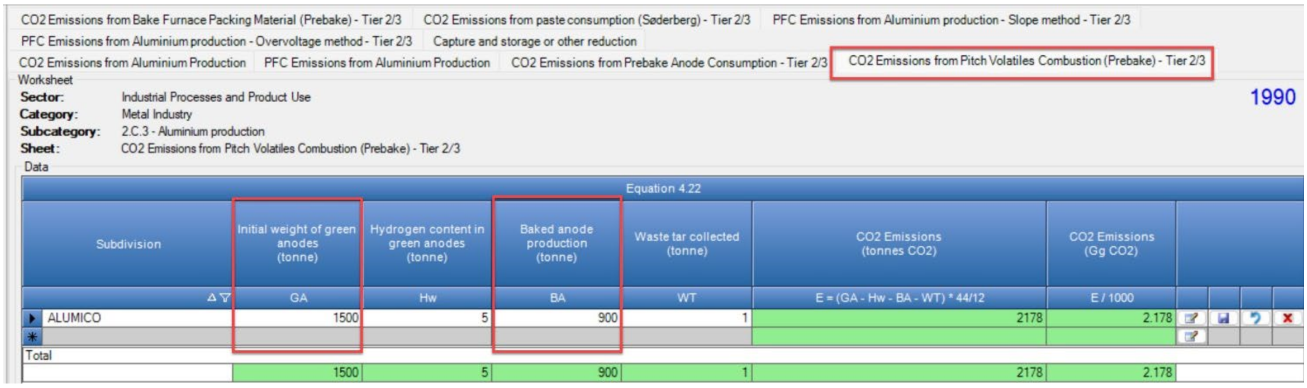
Example: **AD input for prebake anode consumption – Tier 2/3**



Then, data are entered in worksheet **CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3,** row by row, as follows:

1. Column |GA|: input the amount/mass of the initial weight of green anodes, in tonnes.
2. Column |BA|: input the amount/mass of baked anode production, in tonnes.

Example: **AD input for pitch volatiles combustion – Tier 2/3**

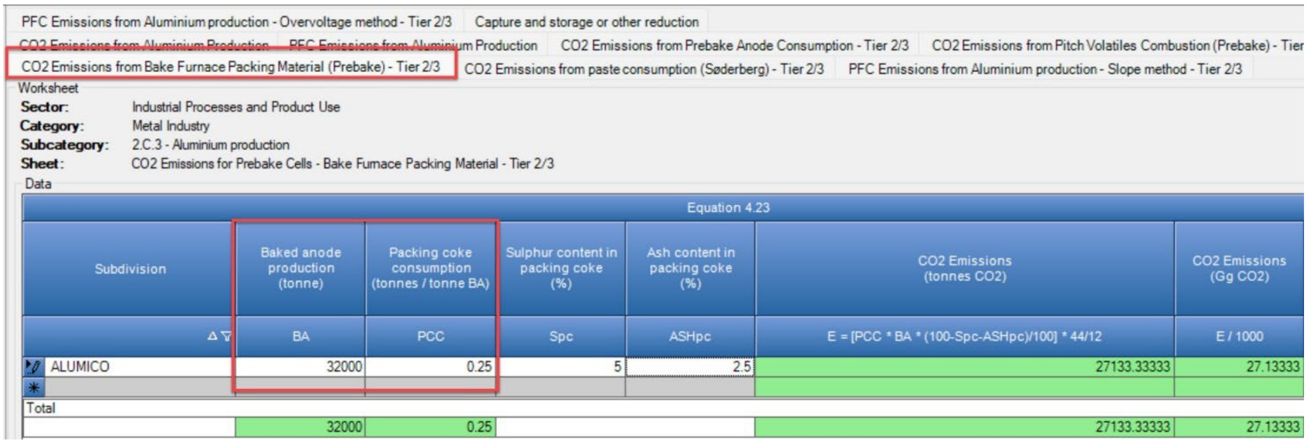


Subdivision	Initial weight of green anodes (tonne)	Hydrogen content in green anodes (tonne)	Baked anode production (tonne)	Waste tar collected (tonne)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	GA	Hw	BA	WT	E = (GA - Hw - BA - WT) * 44/12	E / 1000
ALUMICO	1500	5	900	1	2178	2.178
Total	1500	5	900	1	2178	2.178

Then, data are entered in worksheet **CO_2 Emissions from Bake Furnace Packing Materials (Prebake) – Tier 2/3,** row by row, as follows:

1. Column |BA|: input the amount/mass of baked anode production in tonnes.
2. Column |PCC|: input the amount/mass of packing coke consumed per tonne of based anode production.

Example: **AD input for bake furnace packing material (Prebake) – Tier 2/3**



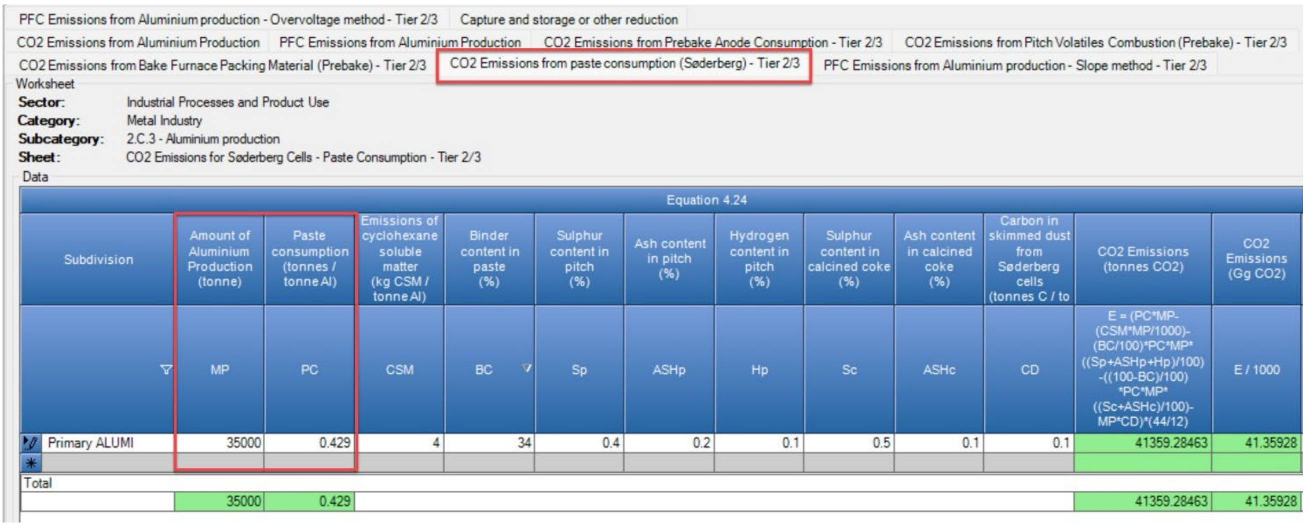
Subdivision	Baked anode production (tonne)	Packing coke consumption (tonnes / tonne BA)	Sulphur content in packing coke (%)	Ash content in packing coke (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	BA	PCC	Spc	ASHpc	E = [PCC * BA * (100-Spc-ASHpc)/100] * 44/12	E / 1000
ALUMICO	32000	0.25	5	2.5	27133.33333	27.13333
Total	32000	0.25			27133.33333	27.13333

Søderberg:

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from paste consumption (Søderberg) -Tier 2/3,** row by row, as follows:

1. Column |MP|: input the amount/mass of aluminium produced by Soderberg technology, in tonnes.
2. Column |PC|: input the amount/mass of paste consumption, in tonnes per tonne of aluminium produced.

Example: **AD input for paste consumption – Tier 2/3**



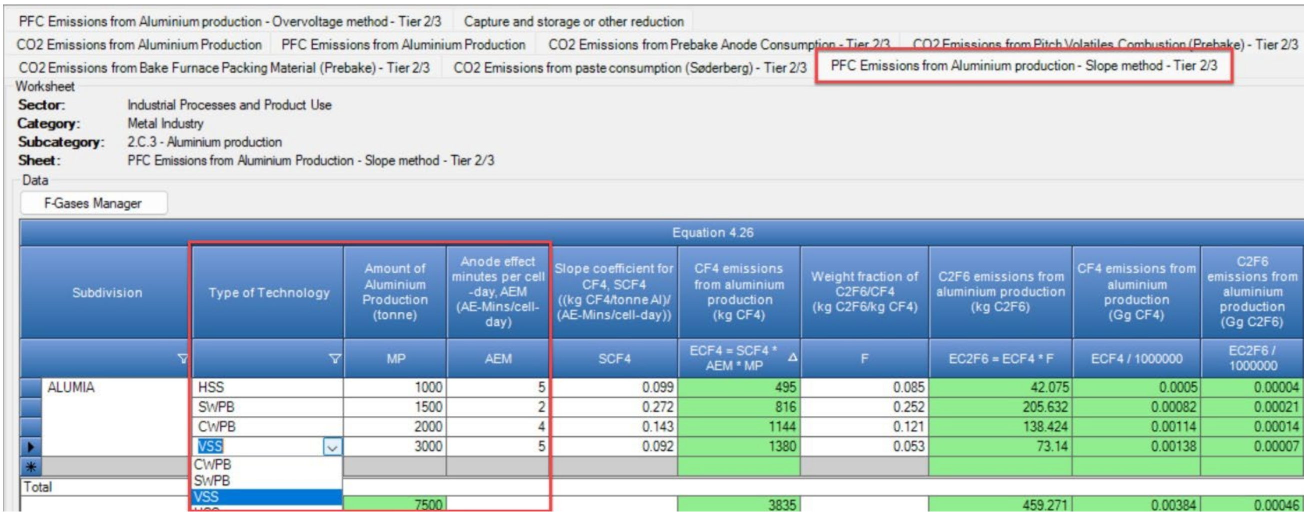
ii. PFC Emissions

Slope method

For each subdivision in Column |Subdivision|, data are entered in worksheet **PFC Emissions from Aluminium Production – Slope method – Tier 2/3,** row by row, as follows:

1. Column |Type of Technology|: input from the drop-down menu the default type of technology or input manually country-specific type of technology (the technology can be repeated with a different name if it has different EFs, e.g. HSS 1, HSS 2).
2. Column |MP|: input the amount/mass of aluminium produced, in tonnes.
3. Column |AEM|: manually input the anode effect in minutes per cell-day.

Example: **AD for PFC emissions from aluminium production (slope method) – Tier 2/3**



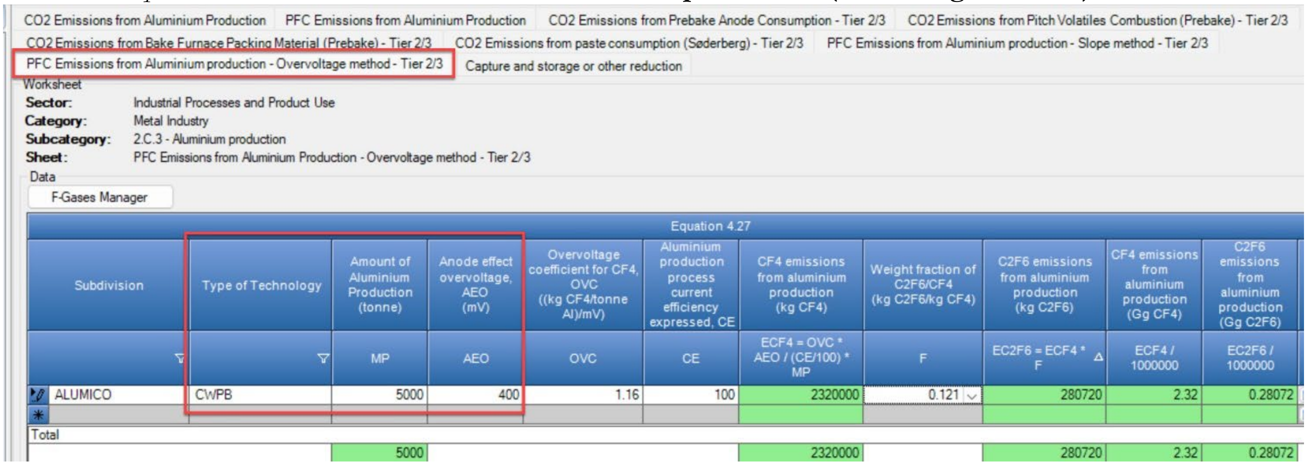
Overvoltage method

For each subdivision in Column |Subdivision|, data are entered in worksheet **PFC Emissions from Aluminium Production – Overvoltage method – Tier 2/3,** row by row, as follows:

1. Column |Type of Technology|: input from the drop-down menu the default type of technology or input manually country-specific type of technology (the technology can be repeated with a different name if it has different EFs, e.g. HSS 1, HSS 2).

2. Column |MP|: input the amount/mass of aluminium produced, in tonnes.
3. Column |AEO|: input anode effect overvoltage, in mV.

Example: **AD for PFC emissions from aluminium production (overvoltage method) – Tier 2/3**



Emission factor input

Sections 4.4.2.2 and 4.4.2.3 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of EFs for Aluminium Production. There are four sets of default EFs:

i) Tier 1 EFs for CO_2 (Table 4.10)
ii) Tier 2/3 EFs for CO_2 (Tables 4.11, 4.12, 4.13 and 4.14)
iii) Tier 1 EFs for PFCs (Table 4.15)
iv) Tier 2/3 EFs for PFCs (Table 4.16)

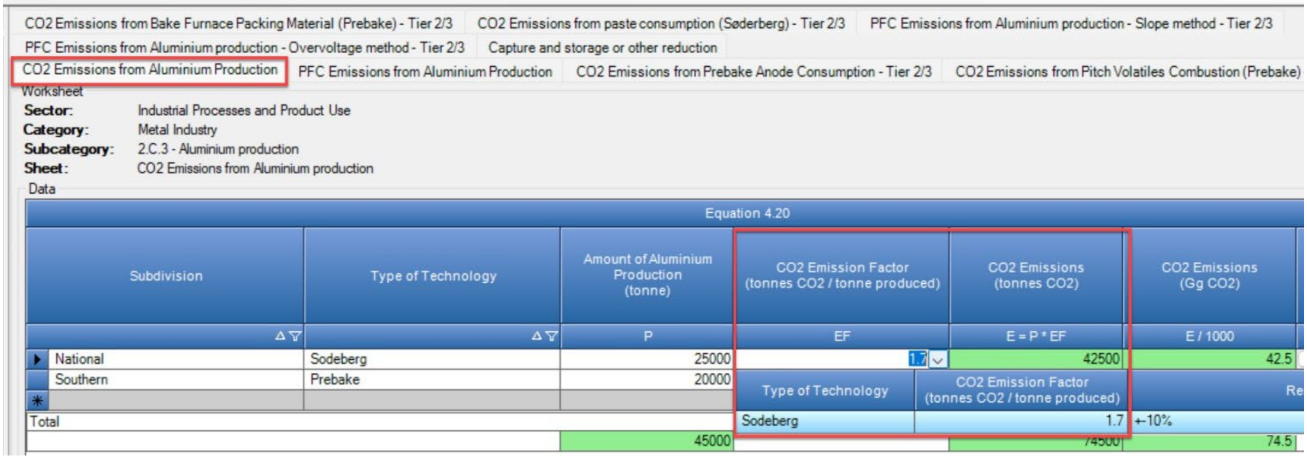
The default EFs are embedded in the *Software*. Users may manually over-write EFs with country-specific values. See examples of input of EFs for CO_2 emissions, followed by PFCs emissions, for different Tiers below.

When Tier 1 Equations are applied:

i. CO_2 Emissions

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Aluminium Production,** row by row in Column |EF|. The user selects either default CO_2 EFs from the drop-down menu or enters manually country-specific EFs, in tonne of CO_2 per tonne of aluminium produced.

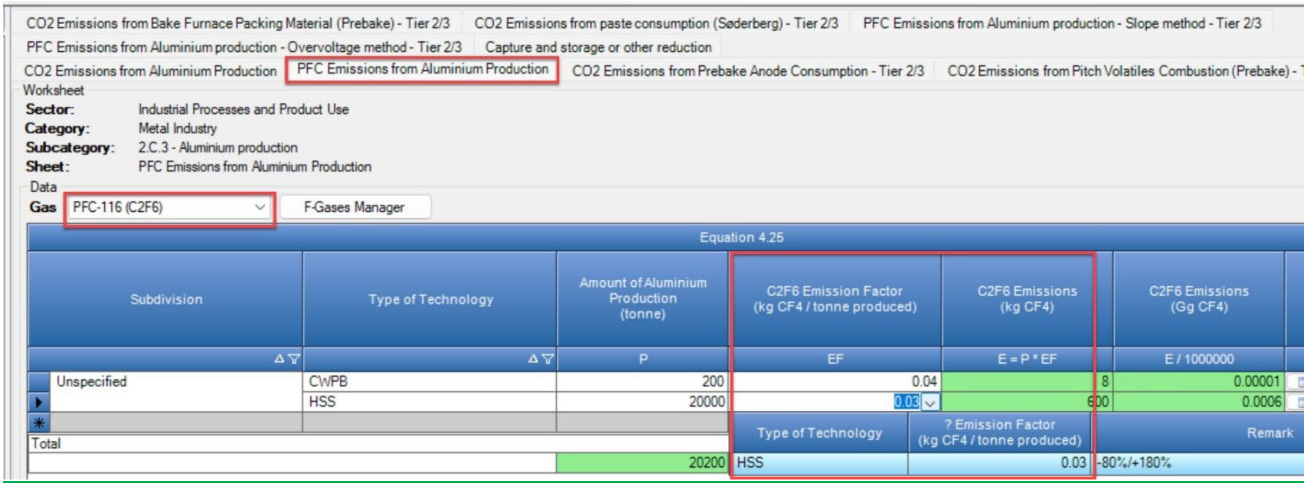
Example: **Tier 1 EFs for CO_2**



ii. PFC Emissions

For each combination of subdivision, gas and type of technology, data are entered in worksheet **PFC Emissions from Aluminium Production,** row by row in Column |EF|. The user selects either default CF_4 or C_2F_6 EFs from the drop-down menu or enters manually country-specific EFs in kg of CF_4 or C_2F_6 per tonne of aluminium produced. *Note that the user shall select "PFC-14(CF_4)" or "PFC-116(C_2F_6)" in the "Gas" bar at the top, to enter data for each GHG one by one*

Example: **Tier 1 EFs input for PFCs**



When Tier 2/3 Equations are applied:

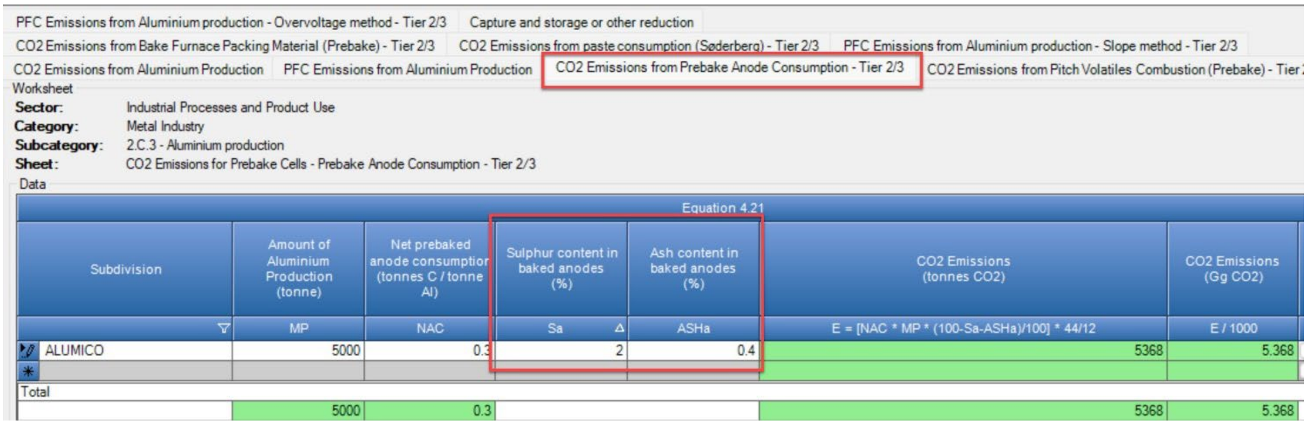
i. CO_2 Emissions

Prebake

For each subdivision in worksheet **CO_2 emissions from Prebake Anode Consumption – Tier 2/3**::

1. Column |Sa| input either the default Tier 2 value of 2% sulphur content in baked anodes or plant-specific Tier 3 parameters, in %
2. Column |ASHa| input either the default Tier 2 value of 0.4% ash content in baked anodes or plant-specific Tier 3 parameters, in %.

Example: **Tier 2/3 EFs (parameters) Input for Prebake Anode Consumption for CO_2**



Then, for each subdivision in worksheet **CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3:**

1. Column |Hw|: the user has the option to specify the hydrogen content in green anodes directly, in tonnes, or calculate it, as follows:

   Specified: User enters the hydrogen content in green anodes directly in the cell, in tonnes, noting the default assumption of 0.005 multiplied by the value entered in Column |GA| for the initial weight of green anodes processed.

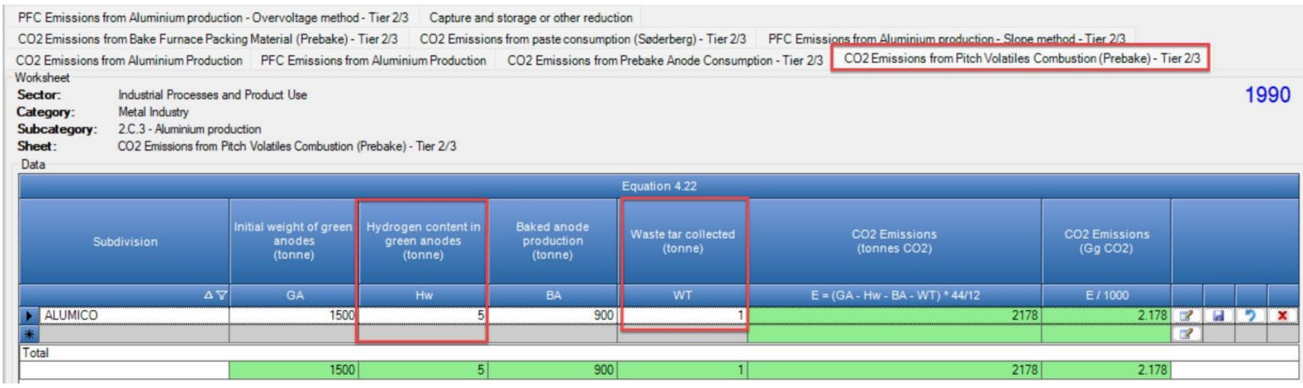
   Calculated (to be added): User selects the drop-down table and selects from the drop-down menu the IPCC default hydrogen content in green anodes (fraction) of 0.005 or enter in a plant-specific Tier 3 parameter. This is then multiplied by the value entered in Column |GA| to calculate the total hydrogen content in green anodes processed.

2. Column |WT|: the user has the option to specify the waste tar collected, in tonnes, or calculate it, as follows:

   Specified: User enters the mass of waste tar collected directly in the cell, in tonnes, noting the default assumption of 0.005 multiplied by the value entered in Column |GA| (for Riedhammer furnaces), and insignificant for all other furnace types.

   Calculated (to be added): User selects the drop-down table and selects from the drop-down menu the appropriate IPCC default value for waste tar collected (0.005 for Riedhammer furnaces or enter in a plant-specific Tier 3 parameter. This value is then multiplied by the value entered in Column |GA| to calculate the total tonnes of waste tar collected.

Example: **Tier 2/3 EFs (parameters) input for pitch volatiles combustion for CO_2**

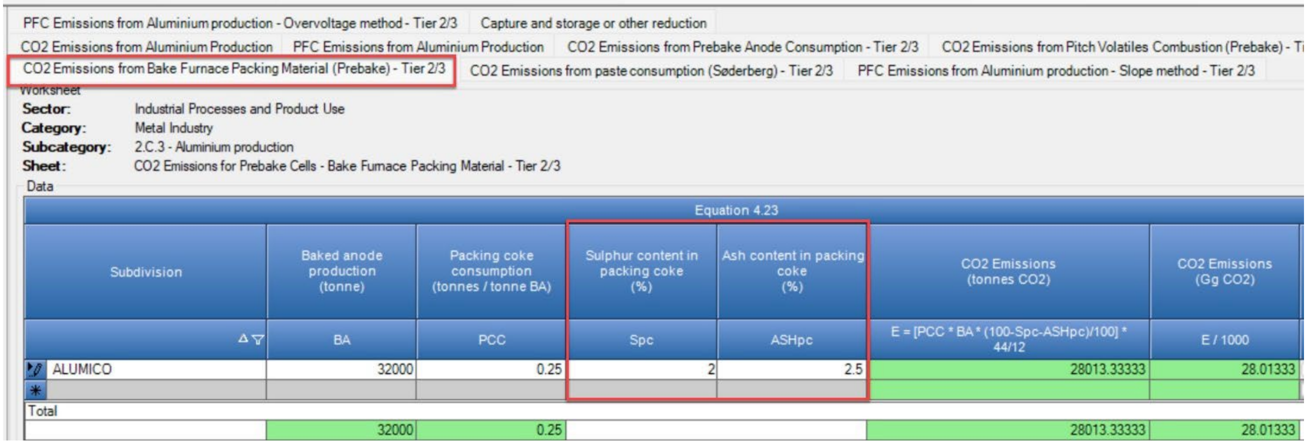


Then, for each subdivision in worksheet **CO_2 Emissions from Bake Furnace Packing Materials (Prebake) – Tier 2/3:**

1. Column |Spc| input either the default Tier 2 value of 2% of sulphur content in packing coke (wt %) or plant-specific Tier 3 parameters.

2. Column |ASHpc| input either the default Tier 2 value of 2.5 % ash content in packing coke (wt %) or plant-specific Tier 3 parameters.

Example: **Tier 2/3 EFs (parameters) input for bake furnace packing materials for CO_2**

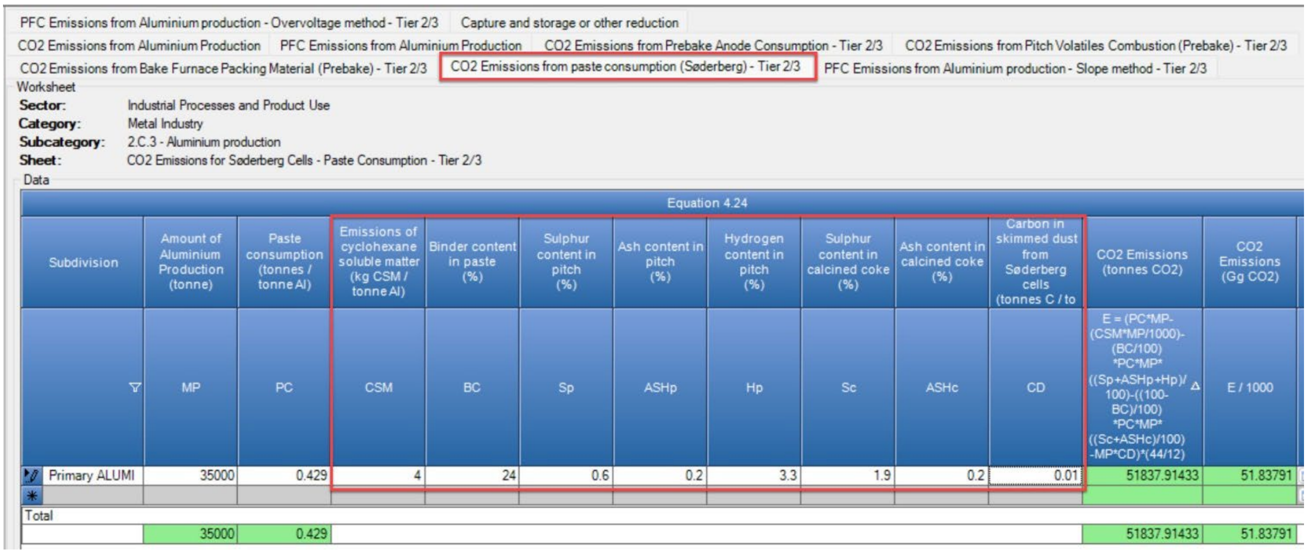


Søderberg

Then, for each subdivision in worksheet **CO_2 Emissions from paste consumption (Soderberg) – Tier 2/3:**

1. Column |CSM|:select from the drop-down menu the emissions of cyclohexane soluble matter in kg per tonne Al (the default Tier 2 value for HSS =4.0 and for VSS = 0.5 kg/tonne) or enter a user-specific value.
2. Column |BC|: select from the drop-down menu the binder content in paste in % (the default Tier 2 value is for Dry Paste – 24% and for Wet Paste – 27%) or enter a user-specific value.
3. Column |Sp|: select from the drop-down menu the sulphur content in pitch in % (the default Tier 2 value is 0.6%) or enter a user-specific value.
4. Column |ASHp|: select from the drop-down menu the ash content in pitch in % (the default Tier 2 value is 0.2%) or enter a user-specific value.
5. Column |Hp|: select from the drop-down menu the hydrogen content in pitch in % (the default Tier 2 value is 3.3%) or enter a user-specific value.
6. Column |Sc|: select from the drop-down menu the sulphur content in calcined coke in % (the default Tier 2 value is 1.9%) or enter a user-specific value.
7. Column |ASHc|: select from the drop-down menu the ash content in calcined coke in % (the default Tier 2 value is 0.2%) or enter a user specific value.
8. Column |CD|: select from the drop-down menu the carbon in skimmed dust from Soderberg cells in tonnes per tonne Al (the default Tier 2 value is 0.01 tonne/tonne) or enter a user specific value.

Example: **Tier 2/3 EFs (parameters) input for paste consumption for CO_2**



ii. PFC Emissions

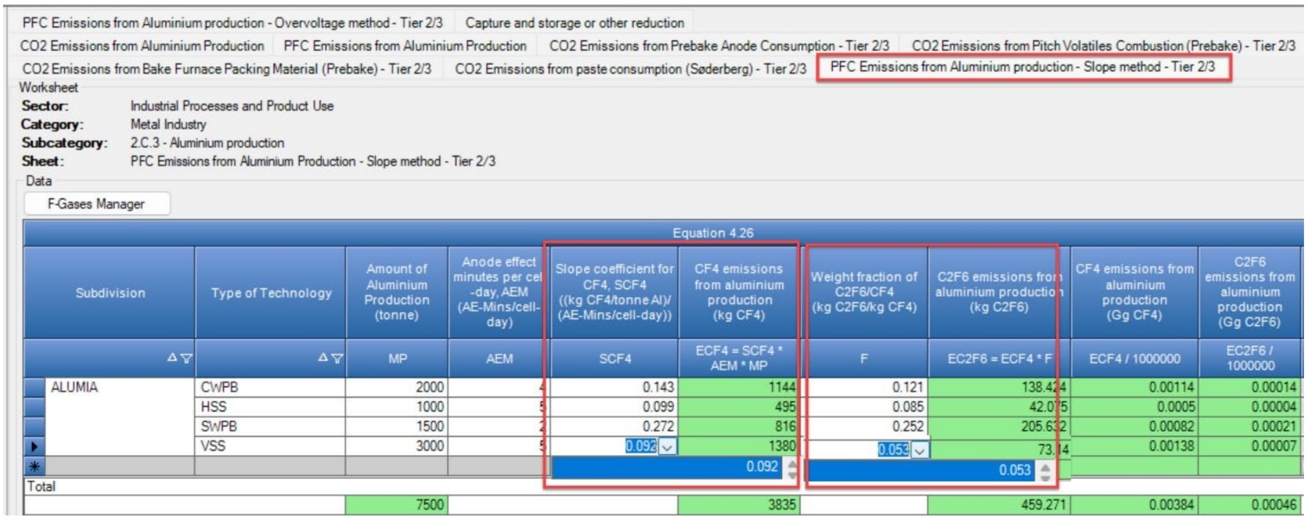
Slope method

For each subdivision and type of technology (CWPB, SWPB, VSS and HSS) in worksheet **PFC Emissions from Aluminium Production – Slope Method – Tier 2/3**:

1. Column |S CF_4|: select from the drop-down menu the default slope coefficient for CF_4 or input a plant-specific Tier 3 parameter, in (kg CF_4/tonne Al)/(AE-Mins/cell-day)

2. Column |F|: select from the drop-down menu the weight fraction of C_2F_6 per CF_4 or input a plant-specific Tier 3 parameter in kg C_2F_6 per kg CF_4.

Example: **Tier 2/3 EFs (parameters) input for aluminium production (slope method) for PFCs**



PFC Emissions from Aluminium production - Overvoltage method - Tier 2/3 | Capture and storage or other reduction
CO2 Emissions from Aluminium Production | PFC Emissions from Aluminium Production | CO2 Emissions from Prebake Anode Consumption - Tier 2/3 | CO2 Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3
CO2 Emissions from Bake Furnace Packing Material (Prebake) - Tier 2/3 | CO2 Emissions from paste consumption (Søderberg) - Tier 2/3 | PFC Emissions from Aluminium production - Slope method - Tier 2/3

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.3 - Aluminium production
Sheet: PFC Emissions from Aluminium Production - Slope method - Tier 2/3

Data
F-Gases Manager

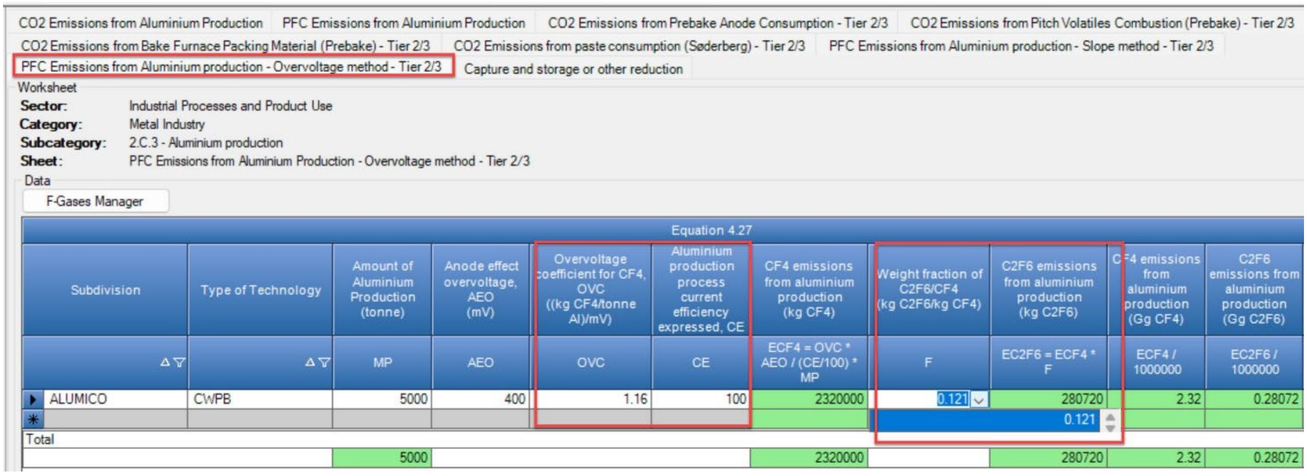
Equation 4.26									
Subdivision	Type of Technology	Amount of Aluminium Production (tonne)	Anode effect minutes per cell-day, AEM (AE-Mins/cell-day)	Slope coefficient for CF4, SCF4 ((kg CF4/tonne Al)/(AE-Mins/cell-day))	CF4 emissions from aluminium production (kg CF4)	Weight fraction of C2F6/CF4 (kg C2F6/kg CF4)	C2F6 emissions from aluminium production (kg C2F6)	CF4 emissions from aluminium production (Gg CF4)	C2F6 emissions from aluminium production (Gg C2F6)
		MP	AEM	SCF4	ECF4 = SCF4 * AEM * MP	F	EC2F6 = ECF4 * F	ECF4 / 1000000	EC2F6 / 1000000
ALUMIA	CWPB	2000	4	0.143	1144	0.121	138.424	0.00114	0.00014
	HSS	1000	5	0.099	495	0.085	42.075	0.0005	0.00004
	SWPB	1500	2	0.272	816	0.252	205.632	0.00082	0.00021
	VSS	3000	5	0.092	1380	0.053	73.14	0.00138	0.00007
				0.092		0.053			
Total		7500			3835		459.271	0.00384	0.00046

Overvoltage method

For each subdivision and type of technology (CWPB, SWPB, VSS and HSS) in worksheet **PFC Emissions from Aluminium Production – Overvoltage Method – Tier 2/3**:

1. Column |OVC|: select from the drop-down menu the default overvoltage coefficient for CF_4 or input a plant-specific Tier 3 parameter, in (kg CF_4/tonne Al) per mV.
2. Column |CE|: aluminium production process current efficiency expressed in % (Equation 4.27 provides an example of 95 %).
3. Column |F|: select from the drop-down menu the default weight fraction of C_2F_6 per CF_4 or input a plant-specific Tier 3 parameter, in kg C_2F_6 per kg CF_4.

Example: **Tier 2/3 EFs (Parameters) input for aluminium production (overvoltage method) for PFCs**



CO2 Emissions from Aluminium Production | PFC Emissions from Aluminium Production | CO2 Emissions from Prebake Anode Consumption - Tier 2/3 | CO2 Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3
CO2 Emissions from Bake Furnace Packing Material (Prebake) - Tier 2/3 | CO2 Emissions from paste consumption (Søderberg) - Tier 2/3 | PFC Emissions from Aluminium production - Slope method - Tier 2/3
PFC Emissions from Aluminium production - Overvoltage method - Tier 2/3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.3 - Aluminium production
Sheet: PFC Emissions from Aluminium Production - Overvoltage method - Tier 2/3

Data
F-Gases Manager

Equation 4.27										
Subdivision	Type of Technology	Amount of Aluminium Production (tonne)	Anode effect overvoltage, AEO (mV)	Overvoltage coefficient for CF4, OVC ((kg CF4/tonne Al)/mV)	Aluminium production process current efficiency expressed, CE	CF4 emissions from aluminium production (kg CF4)	Weight fraction of C2F6/CF4 (kg C2F6/kg CF4)	C2F6 emissions from aluminium production (kg C2F6)	CF4 emissions from aluminium production (Gg CF4)	C2F6 emissions from aluminium production (Gg C2F6)
		MP	AEO	OVC	CE	ECF4 = OVC * AEO / (CE/100) * MP	F	EC2F6 = ECF4 * F	ECF4 / 1000000	EC2F6 / 1000000
ALUMICO	CWPB	5000	400	1.16	100	2320000	0.121	280720	2.32	0.28072
							0.121			
Total		5000				2320000		280720	2.32	0.28072

Results

CO_2 and PFC emissions from Aluminium Production are estimated in mass units (tonnes and Gg for CO_2 and kg and Gg for PFCs) by the *Software* in the following worksheets:

CO_2 emissions:

- ✓ **CO_2 emissions from Aluminium Production**
- ✓ **CO_2 emissions from Prebake Anode Consumption – Tier 2/3**
- ✓ **CO_2 emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3**
- ✓ **CO_2 emissions from Bake Furnace Packing Material (Prebake) – Tier 2/3**
- ✓ **CO_2 emissions from Paste Consumption (Soderberg) – Tier 2/3**

PFCs emissions:

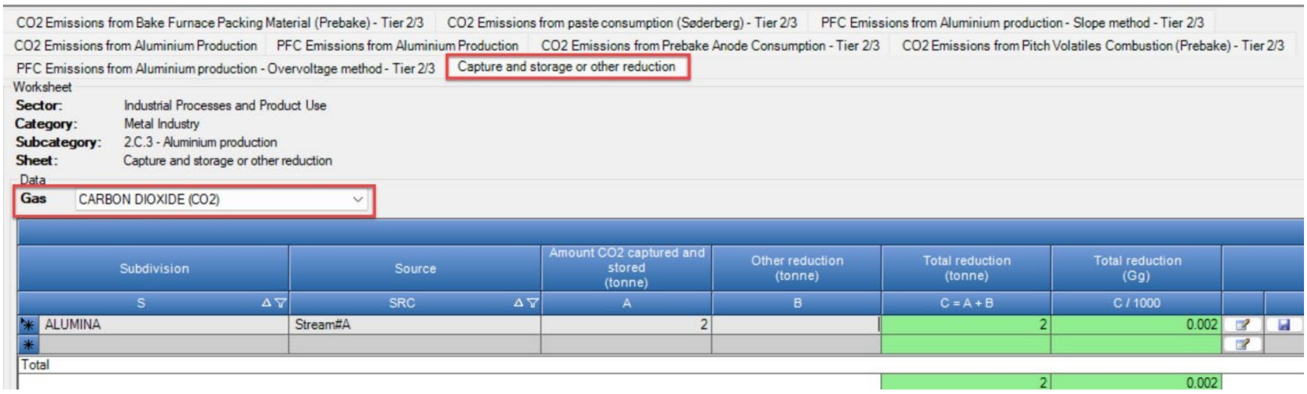
- ✓ **PFC Emissions from Aluminium Production**
- ✓ **PFC Emissions from Aluminium Production – Slope Method – Tier 2/3**
- ✓ **PFC Emissions from Aluminium Production – Overvoltage Method – Tier 2/3:**

Total CO_2 and PFC emissions from aluminium production is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the drop-down menu, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2 or PFC emissions, in tonnes.
   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



2.C.4 Magnesium Production

Information

The *2006 IPCC Guidelines* provide guidance for estimation of CO_2 and SF_6 emissions from Magnesium Production, nothing however that other possible GHG emissions include fluorinated ketone and various fluorinated decomposition products such as PFCs

For CO_2, the Tier 1 method is based on national production data on and default EFs, while the Tier 2 – EF method relies on company or plant-specific EFs. For SF_6, the Tier 1 is also based on national production data and default EFs while the Tier 2 relies on statistics national or sub- national consumption of SF_6 in the industry and default EFs. Tier 3 methods for both CO_2 and SF_6 are based on direct measurements.

GHGs

The *Software* allows for the estimation of the following GHGs for the Magnesium Production source category, noting that only methods for CO_2 and SF_6 are provided in the 2006 IPCC Guidelines.

Note that for users using the Software for reporting to the UNFCCC ETF Reporting Tool, the MPGs provide for reporting of all F-gases (except NF_3) for this category. Users may consider whether the methods for SF_6 may also be applicable for other fluorinated gases. All fluorinated gases can be reported in the Software.

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	--	--	X	X	X	X

IPCC Equations

GHG emissions from the Magnesium Production source category are estimated by applying the following IPCC equations (Chapter 4 Volume 3 of the *2006 IPCC Guidelines*):

For CO_2

- ✓ Tier 1: Equation 4.28
- ✓ Tier 2: Equation 4.29
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*; emissions based on direct measurement

For SF_6

- ✓ Tier 1: Equation 4.30
- ✓ Tier 2: Equation 4.31
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*; emissions based on direct measurement

As explained in section **1.1.3 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 CO_2 and F-gas emissions from the Magnesium Production source category using the following six worksheets:

CO_2 emissions:

- ✓ **CO_2 Emissions from Magnesium Production:** contains for each subdivision and each type of raw material used (e.g. dolomite, magnesite) information on the amount magnesium produced and default CO_2 EFs. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Magnesium Production – Tier 2:** contains for each subdivision information on the amount of magnesium produced and country/plant-specific CO_2 EFs. The worksheet calculates the associated CO_2 emissions for Tier 2.

F-gas emissions:

- ✓ **1.1.2 F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ✓ **F-gases from Magnesium Casting:** contains for each subdivision information on the amount of magnesium casting and corresponding default EF (SF_6 only). The worksheet calculates the associated emissions for Tier 1.
- ✓ **SF_6 emissions from Magnesium Casting – Tier 2:** contains for each subdivision information on the company/plant-specific consumption of the fluorinated gas. Emissions are equal to consumption.

Capture and storage or other reduction (CO_2 and F-gas):

- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2 and SF_6 not accounted previously in the worksheets for different Tiers.

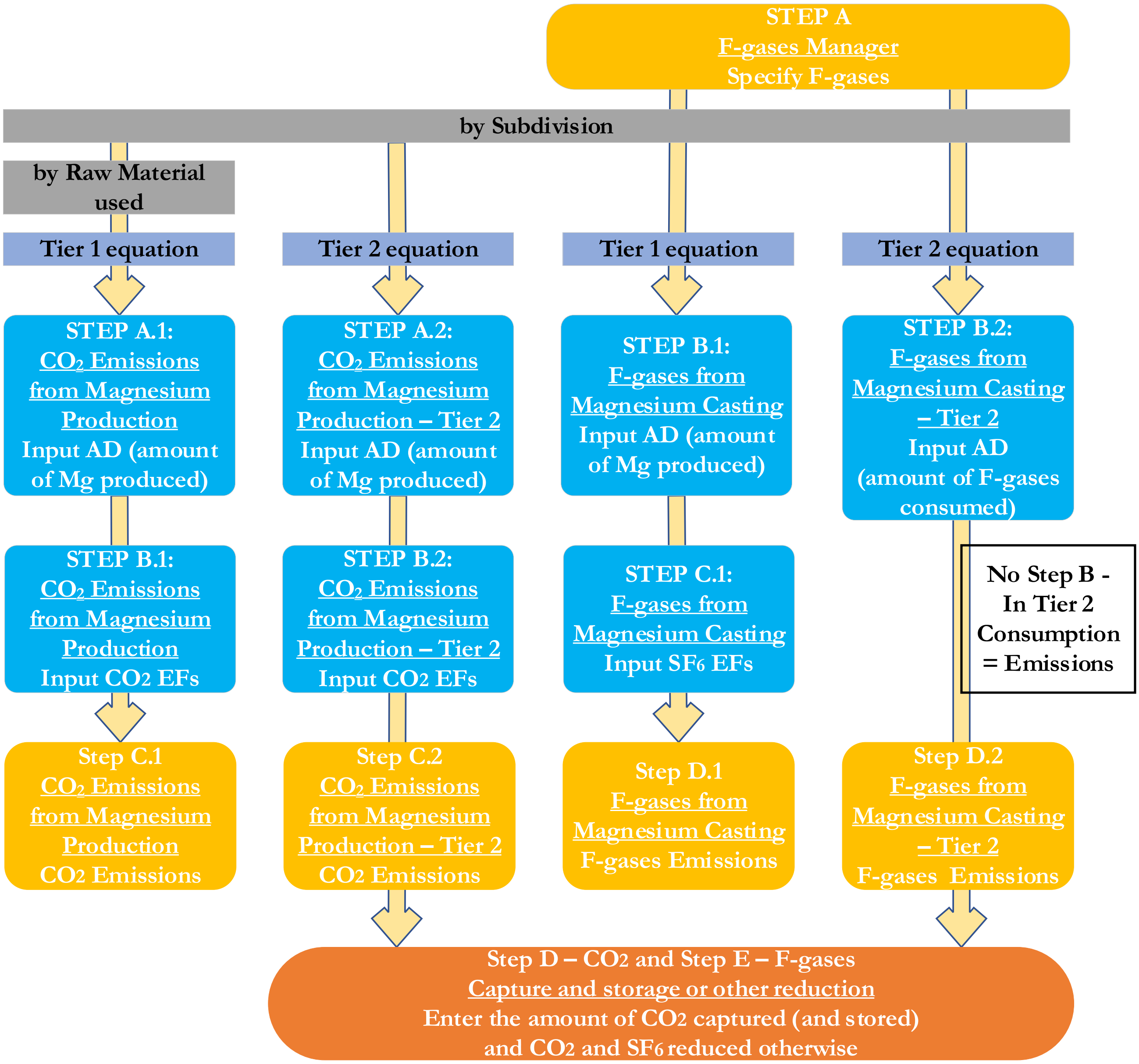
User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 4.13 (for CO_2) and Figure 4.14 (for SF_6) 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for the estimation of CO_2 and SF_6 emissions from magnesium production.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Magnesium Production – flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When Tier 1 Equations are applied:

i. CO_2 emissions

Step A.1, in the worksheet **CO_2 Emissions from Magnesium Production,** for each type of raw material used (e.g. dolomite, magnesite) users collect and input in the *Software* information on the amount of magnesium produced.

Step B.1, in the worksheet **CO_2 Emissions from Magnesium Production,** for each type of raw material used users input the respective CO_2 EFs.

Step C.1, in the worksheet **CO_2 Emissions from Magnesium Production** the *Software* calculates the associated emissions for each subdivision in mass units (tonnes and Gg). In addition, the total emissions of all subdivisions are shown.

ii. F-gas emissions

Step A, **1.1.2 F-gases Manager**, users ensure that all F-gases emitted for this source category have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Step B.1, in the worksheet **F-Gases from Magnesium Casting,** users collect and input in the *Software* information on the amount of magnesium casting or handling in the country, by casting system.

Step C.1, in the worksheet **F-Gases from Magnesium Casting**, users input respective EFs (default EF available for SF_6 only).

Step D.1, in the worksheet **F-Gases from Magnesium Casting**, the *Software* calculates the associated emissions for each subdivision in mass units (kg and Gg). In addition, the total emissions of all subdivisions are shown.

When Tier 2 Equations are applied:

i. CO_2 emissions

Step A.2, in the worksheet **CO_2 Emissions from Magnesium Production– Tier 2**, users collect and input in the *Software* information on the amount of primary magnesium produced at each plant.

Step B.2, in the worksheet **CO_2 Emissions from Magnesium Production – Tier 2**, users input country/plant-specific CO_2 EFs.

Step C.2, in the worksheet **CO_2 Emissions from Magnesium Production – Tier 2** the *Software* calculates the associated emissions for subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown in each worksheet.

ii. F-gas emissions

Step A, **1.1.2 F-gases Manager**, users ensure that all F-gases emitted for this source category have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Step B.2, in the worksheet **F-gases from Magnesium Casting – Tier 2**, users collect and input information on the amount of F-gases consumed in magnesium smelters and foundries.

Step C.2, in the worksheet **F-gases from Magnesium Casting – Tier 2**, the *Software* automatically calculates emissions as equal to consumption in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

Then, for each tier, as appropriate:

Step D (CO_2)/Step E (F-gases), in the worksheet **Capture and storage or other reduction,** if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) or other GHG, not otherwise captured in the worksheets above.

Activity data input

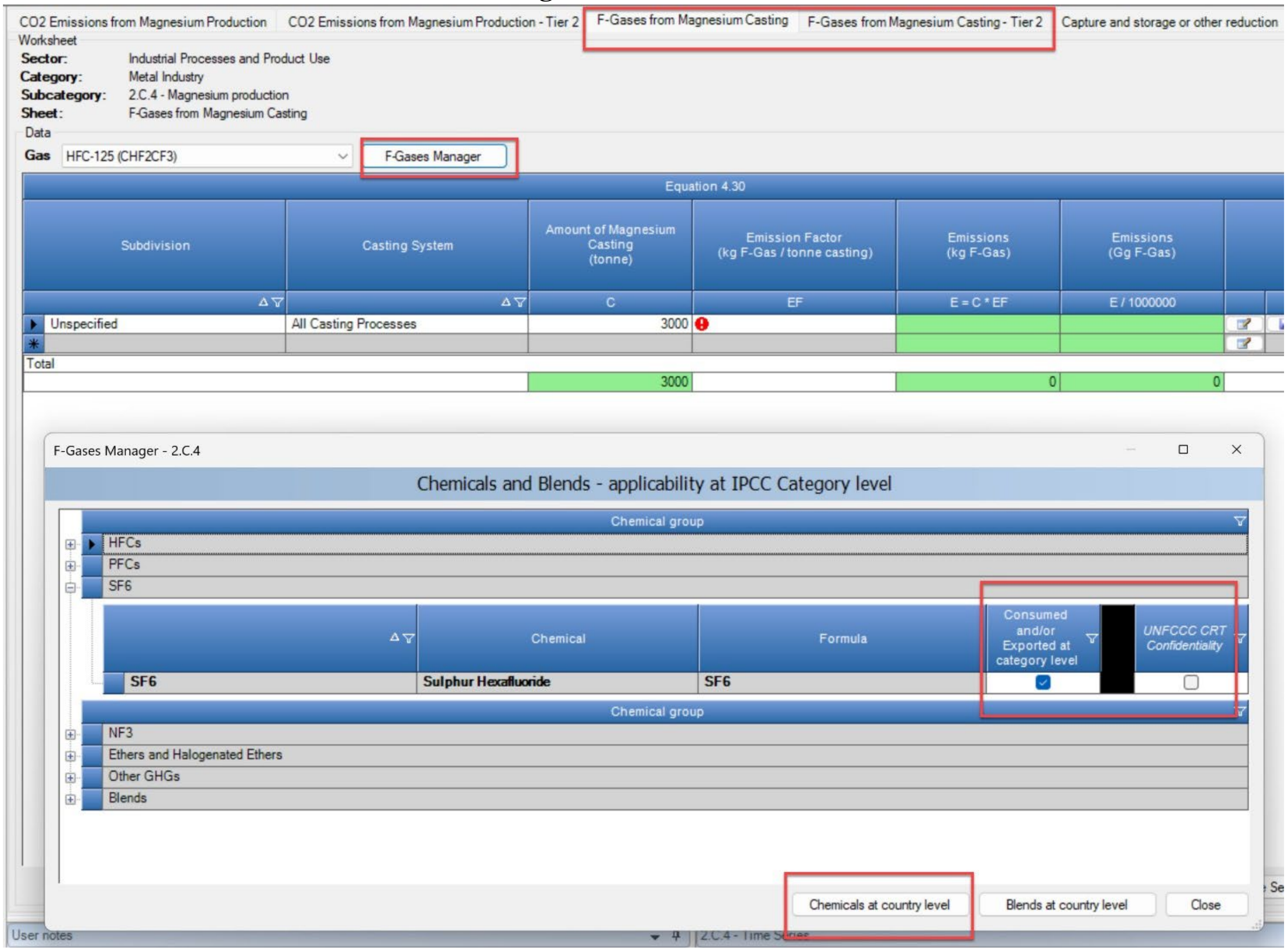
Section 4.5.2.3 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Magnesium Production.

As a **Starting step**, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases to be reported for the source category Magnesium Production.

Note that if relevant gases are not checked in the F-gases Manager, then it will not be possible to enter any data. If data entry is not possible, select the ***F-Gases Manager*** *from any tab for F-Gases from Magnesium Production. This will open the F-gases Manager – applicability at IPCC Category Level. Either select the relevant gases, or if none are available for selection, navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the* *country level- F-gases Manager to select the relevant gases. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager to indicate those gases used for Magnesium Production.*

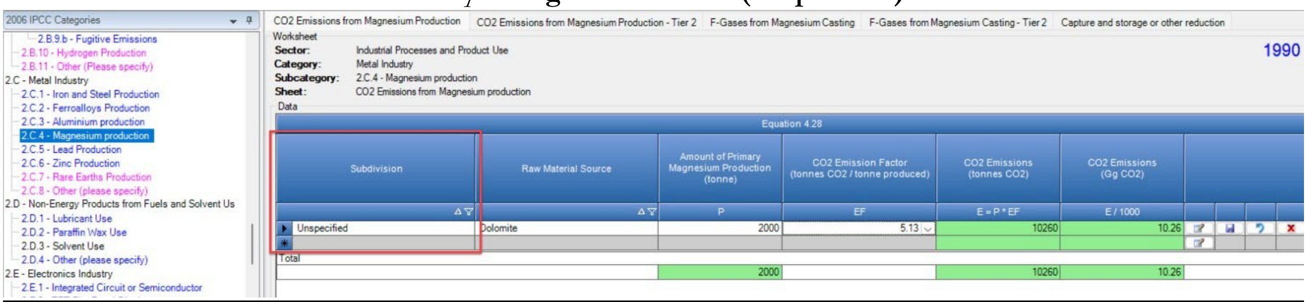
<u>For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool:</u> If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate.

Example: **Populating the F-gases manager and designating confidentiality for category: Magnesium Production**



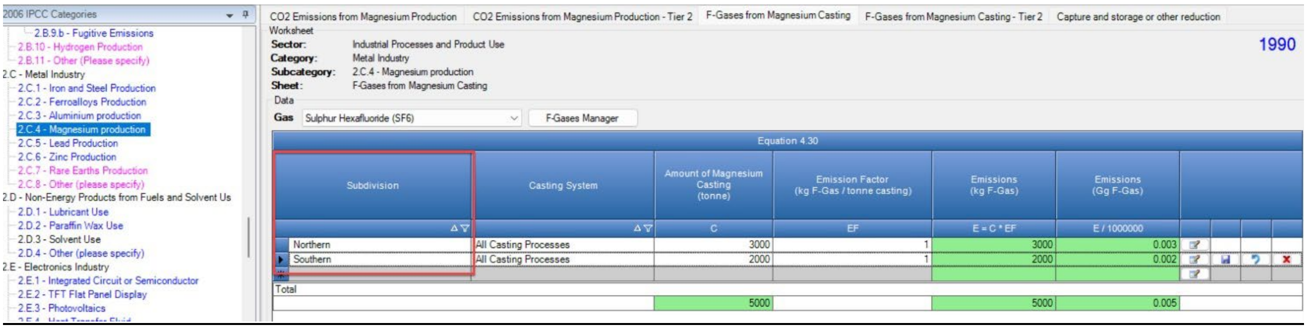
Second, input of AD for the Magnesium Production source category requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in <u>Column |Subdivision|</u> [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**

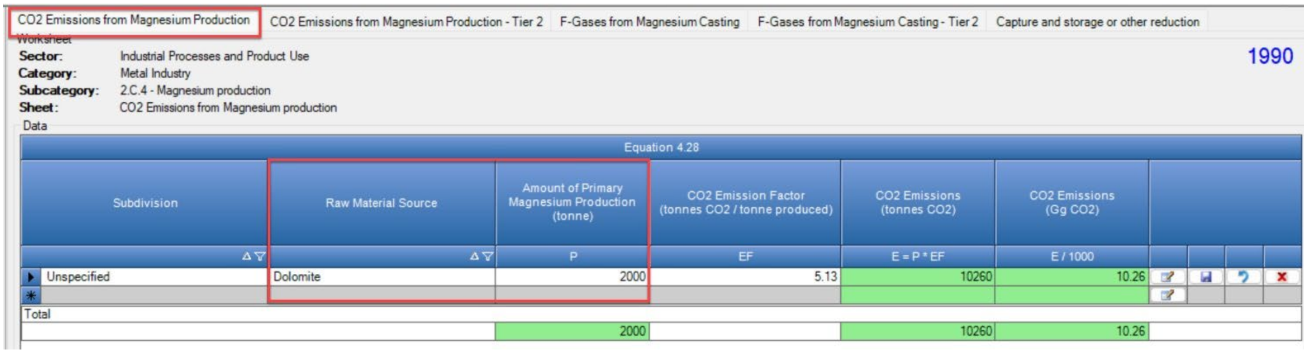


When Tier 1 Equations are applied

i.CO_2 emissions

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Magnesium Production** row by row, as follows:

1. Column |Raw Material Source|: input from the drop-down menu the default type of raw material used (dolomite or magnesite) or input manually the country-specific raw material used.
2. Column |P|: input the amount/mass of magnesium produced, in tonnes.

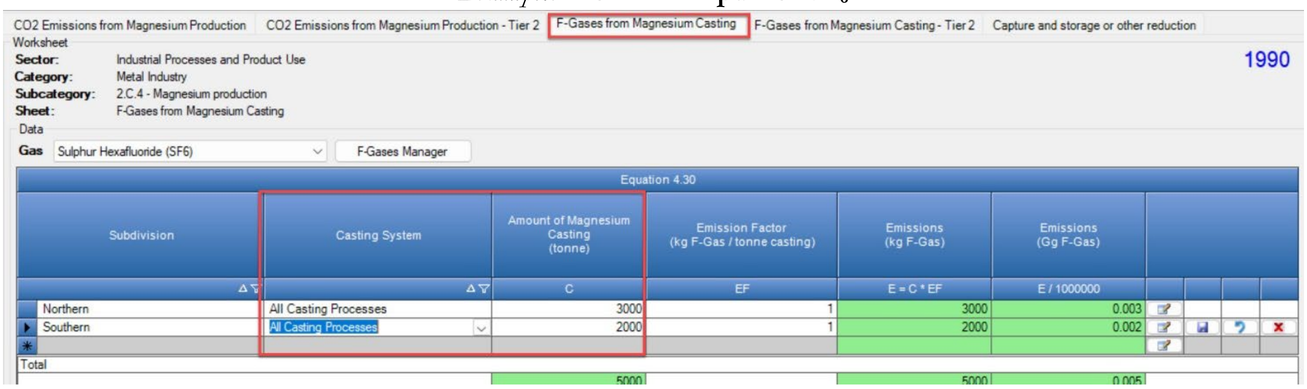


ii. F-gas emissions

For each subdivision in Column |Subdivision|, data are entered in worksheet **F-gases from Magnesium Casting** row by row, as follows:

1. Column |Casting system|: input from the drop-down menu the default type of casting system or input manually country-specific system.
2. Column |C|: input the amount/mass of magnesium casting, in tonnes.

Example: **Tier 1 AD input for SF_6**



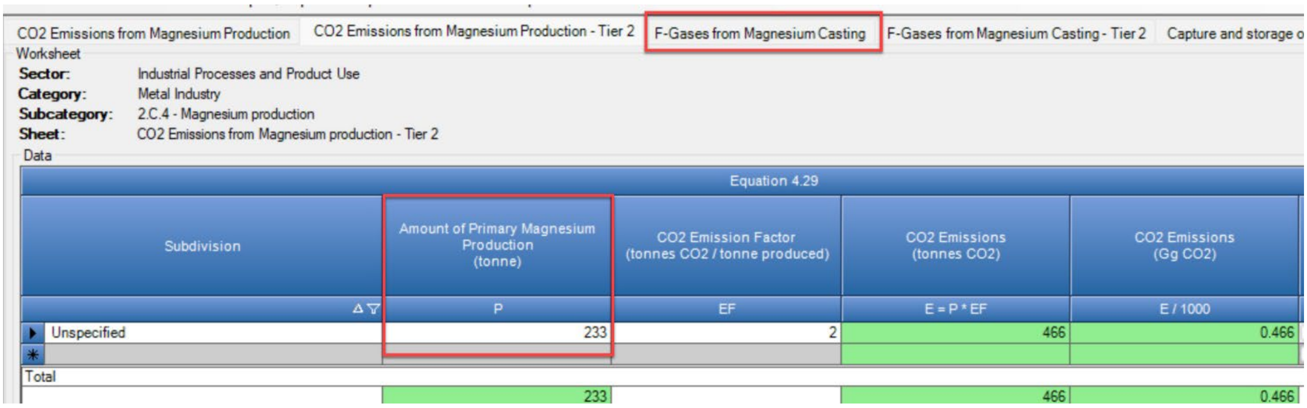
When Tier 2 Equations are applied

i.CO_2 emissions

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 emissions from Magnesium Production – Tier 2** row by row, as follows:

1. Column |P|: input the amount/mass of primary magnesium produced, in tonnes.

Example: **Tier 2 AD input for CO_2**

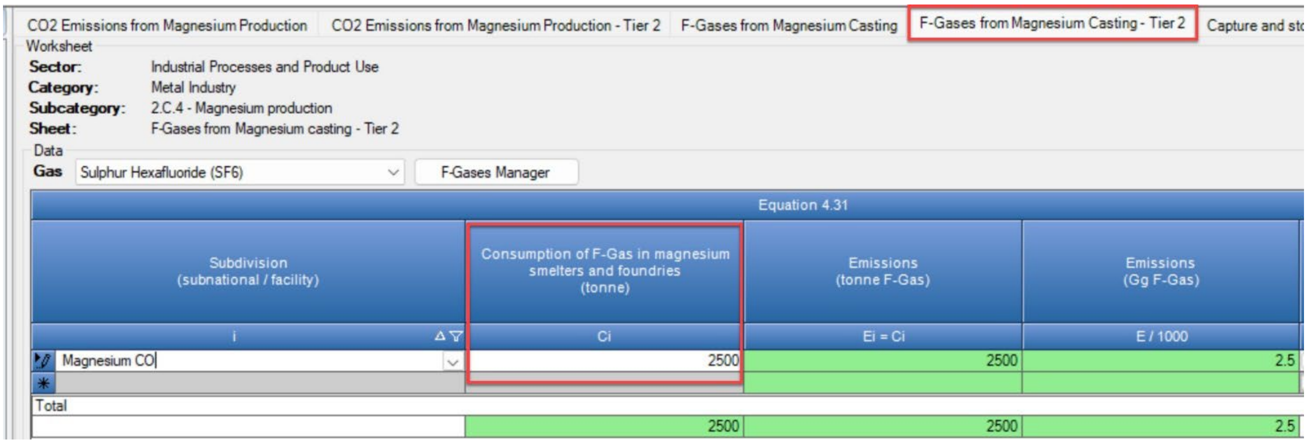


ii. F-gas emissions

For each subdivision in Column |Subdivision|, data are entered in worksheet **F-gases from Magnesium Casting – Tier 2** row by row, as follows:

1. Column |Ci|: input the amount of F-gas consumed in magnesium smelters and foundries, in tonnes.

Example: **Tier 2 AD for SF_{6f}**



Emission factor input

Section 4.5.2.2 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Magnesium Production. There are two sets of default EFs:

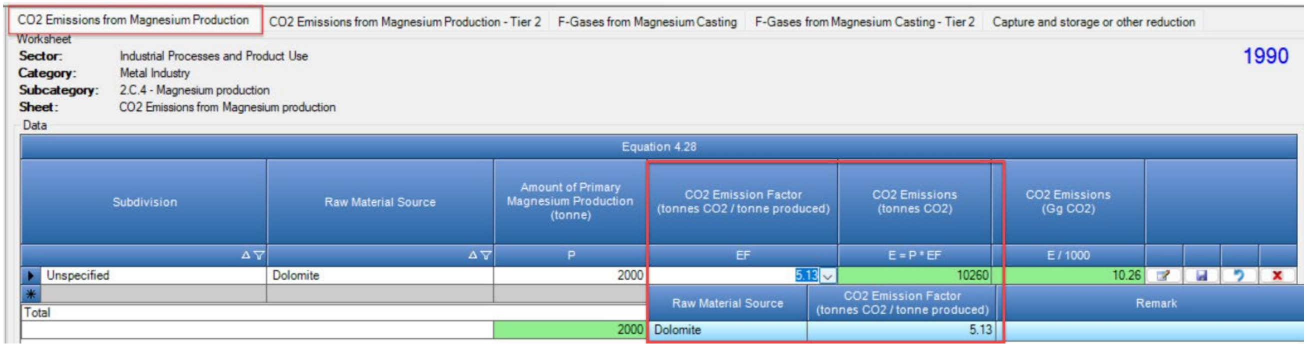
i) Tier 1 EFs for CO_2 (Table 4.19)
ii) Tier 1 EFs for SF_6 (Table 4.20)

When the Tier 1 Equations are applied:

<u>i. CO_2 emissions</u>

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions from Magnesium Production,** row by row in <u>Column |EF|</u>. The user selects either default CO_2 EFs from the drop-down menu or enters manually country-specific EFs, in tonne of CO_2 per tonne of magnesium produced.

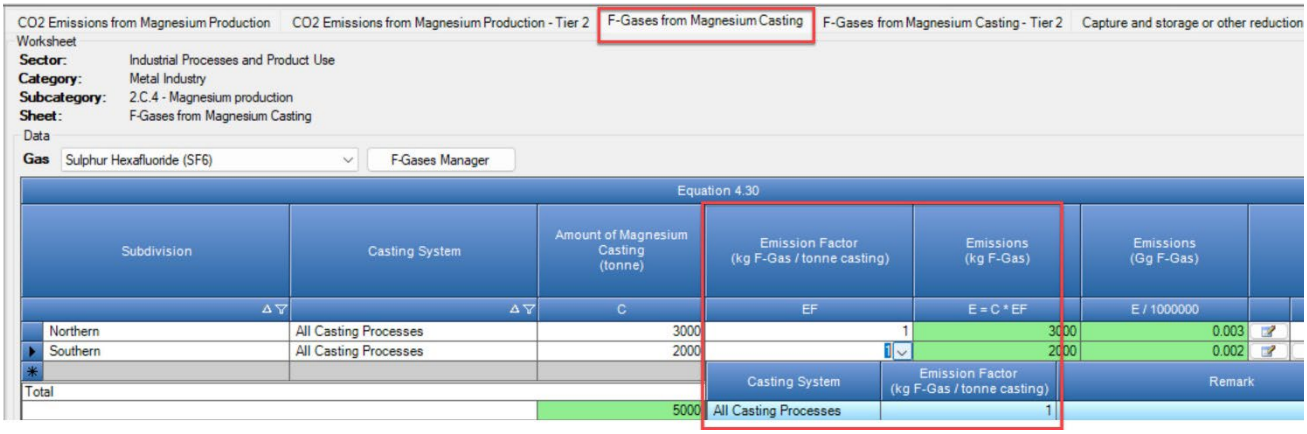
Example: **Tier 1 EFs for CO_2**



<u>ii. F-gas emissions</u>

For each gas and each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **F-Gases from Magnesium Casting,** row by row in <u>Column |EF|</u>. The user selects either default EFs from the drop-down menu (available for SF_6 only) or enters manually country-specific EFs, in kg F gas per tonne of magnesium casting. *<u>Note that</u> the user shall the relevant gas in the "Gas" bar at the top, to enter data for each F-gas one by one*

Example: **Tier 1 EFs for SF_6**



When Tier 2 Equations are applied:

<u>i. CO_2 emissions</u>

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions from Magnesium Production – Tier 2,** row by row in <u>Column |EF|</u>. For Tier 2, the user must input a company or plant-specific EF, in tonnes of CO_2 / tonne of magnesium produced.

<u>ii. F-gas emissions</u>

The Tier 2 approach for estimating F-gases assumes that consumption equals emissions. There is no user entry required.

Results

CO_2 and SF_6 emissions from Magnesium Production are estimated in mass units (tonnes/kg and Gg) by the *Software* in the following worksheets:

CO_2 emissions:

- ✓ **CO_2 Emissions from Magnesium Production**
- ✓ **CO_2 Emissions from Magnesium Production – Tier 2**

F-gases:

- ✓ **F-Gases from Magnesium Casting**
- ✓ **F-Gases from Magnesium Casting – Tier 2**

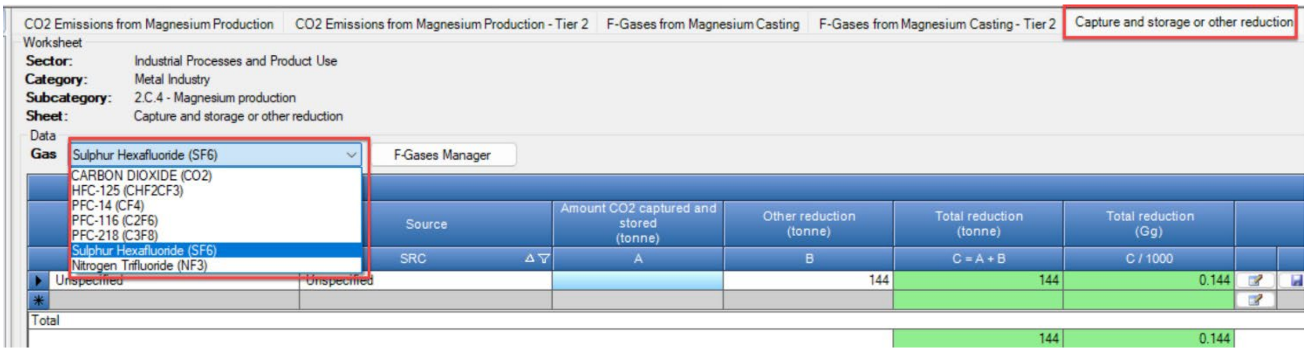
Total CO_2 and F-gas emissions from magnesium production is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: users either select from the drop-down menu, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2 or F-gas emissions, in tonnes.

   Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



2.C.5 Lead Production and 2.C.6 Zinc Production

Information

This section groups guidance for the following source categories according to their common methodological approaches applied in the *Software*:

- ✓ **2.C.5 Lead Production**
- ✓ **2.C.6 Zinc Production**

The *2006 IPCC Guidelines* provide three Tiers to estimate CO_2 emissions from these source categories.

Tier 1 is a simple method which multiplies default EFs by AD (lead production or zinc production). If information is known, production should be disaggregated by furnace type. Tier 2 recognizes that there are differences in CO_2 emissions for production of lead and zinc depending on the production methodology and the source of the raw materials, either from secondary sources (for example, such as recycled batteries for lead production), or, from primary production from ores. Emissions can be calculated using country-specific EFs based on the use of reducing agents, furnace types and other process materials of interest. Factors can be developed based on carbon contents applicable to those materials. Tier 3 is based on directly measured CO_2 emissions data available from lead and zinc facilities or plant-specific data on use of reducing agents and other process materials.

GHGs

The *Software* includes the following GHG for the Lead Production and Zinc Production source categories:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	--	--	--	--	--	--

IPCC Equations

- ✓ Tier 1: Equation 4.32 (Lead) and Equations 4.33 and 4.34 (Zinc)
- ✓ Tier 2: No Tier 2 Equation provided; the *Software* implements the description for Tier 2 in Section 4.6.2.1 (Lead) and Section 4.7.2.1 (Zinc) of Chapter 4 Volume 3 of the *2006 IPCC Guidelines*
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines*, emissions based on direct measurement or plant-specific data

As explained in section **1.1.3 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

CO_2 emissions from Lead Production source category are estimated using the following three worksheets:

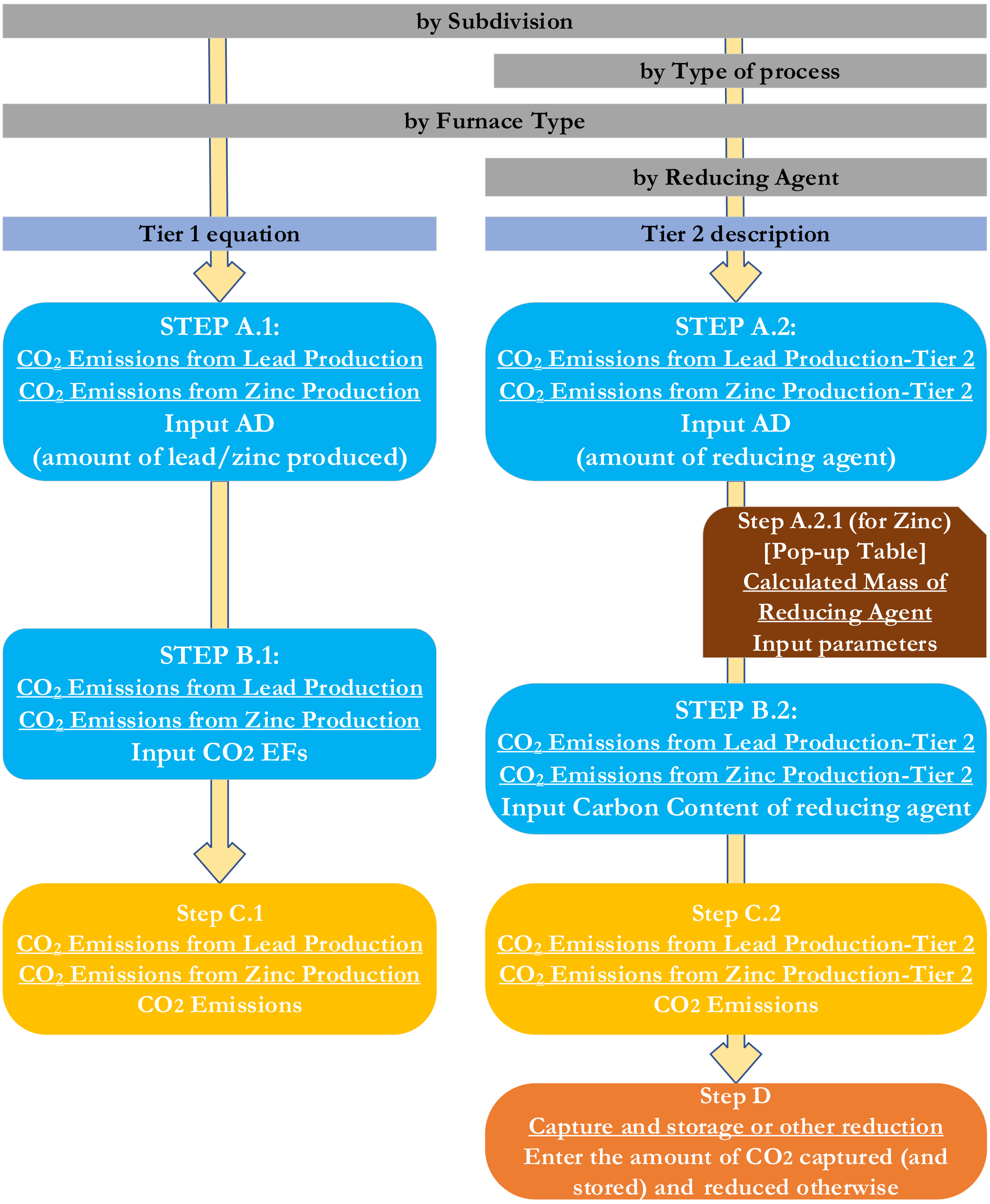
- ✓ **CO_2 Emissions from Lead Production** and **CO_2 Emissions from Zinc Production:** contains for each subdivision and each type of furnace/source/process, if known (e.g. direct smelting, imperial smelting furnace, from secondary materials, Waelz Kiln) information on the amount of lead or zinc produced and default CO_2 EFs. The worksheets calculate the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Lead Production- Tier 2** and **CO_2 Emissions from Zinc Production – Tier 2:** contains for each subdivision, type of production (primary or secondary) and type of furnace, information on the type, amount and carbon content of reducing agent or process input consumed. The worksheets calculate the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously in the worksheets for different Tiers.

User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 4.15 (Lead Production) and Figure 4.16 (Zinc Production) 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for the estimation of CO_2 emissions from lead production and from zinc production.

Lead Production and Zinc Production – flowchart



[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Thus, for the relevant source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step A.1, in the worksheet **CO_2 Emissions from Lead Production** or **CO_2 Emissions from Zinc Production,** for each type of furnace/source/process, if known, (e.g. direct smelting, imperial smelting furnace, from secondary materials, Waelz Kiln) users collect and input in the *Software* information on the amount of lead or zinc produced.

Step B.1, in the worksheet **CO_2 Emissions from Lead Production** or **CO_2 Emissions from Zinc Production,** for each type of furnace/source/process users input respective CO_2 EFs.

Step C.1, in the worksheet **CO_2 Emissions from Lead Production** or **CO_2 Emissions from Zinc Production**, the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

When the Tier 2 Equation is applied:

Step A.2, in the worksheet **CO_2 Emissions from Lead Production – Tier 2** or **CO_2 Emissions from Zinc Production – Tier 2,** for each type production (primary / secondary) and each furnace type, users collect and input in the *Software* information on the type and amount of reducing agent consumed (may be calculated through **Step A.2.1** for **Zinc Production**), and if reducing agent is of biogenic origin.

Step B.2, in the worksheet **CO_2 Emissions from Lead Production – Tier 2** or **CO_2 Emissions from Zinc Production – Tier 2,** for each type of production and furnace type, users input the carbon content(s) of reducing agent(s) or other process inputs consumed.

Step C.2, in the worksheet **CO_2 Emissions from Lead Production – Tier 2** or **CO_2 Emissions from Zinc Production – Tier 2**, the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

Then, for each tier, as appropriate:

Step D, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates), not otherwise captured in the worksheets above.

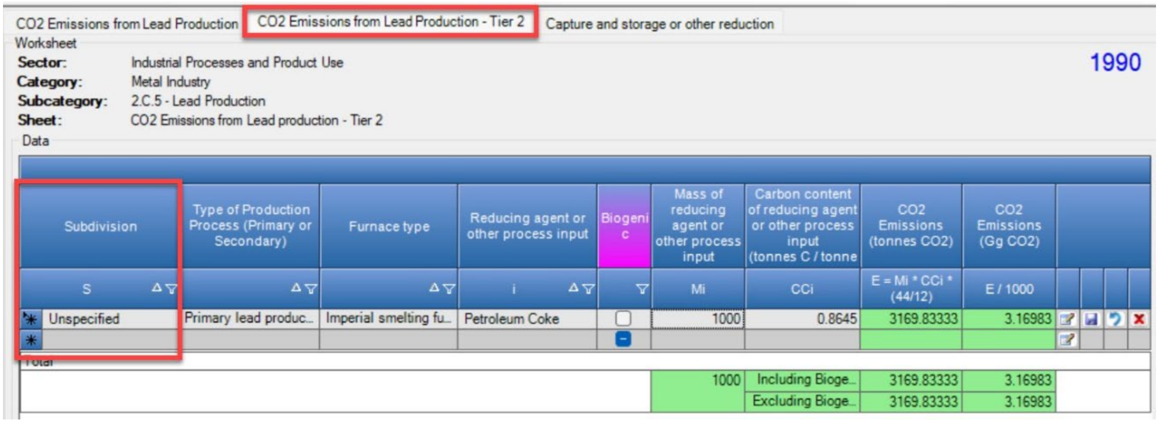
Activity data input

The following sections in Chapter 4, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of AD:

- ✓ Section 4.6.2.3 contains information on the choice of AD for Lead Production.
- ✓ Section 4.7.2.3 contains information on the choice of AD for Zinc Production.

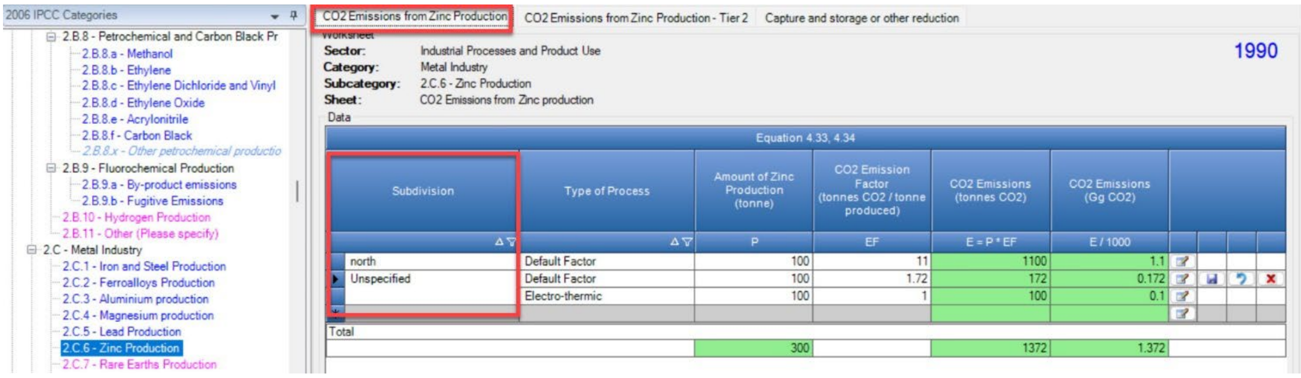
Input of AD for the Lead Production and Zinc Production source categories requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified) – lead production**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions – zinc production**



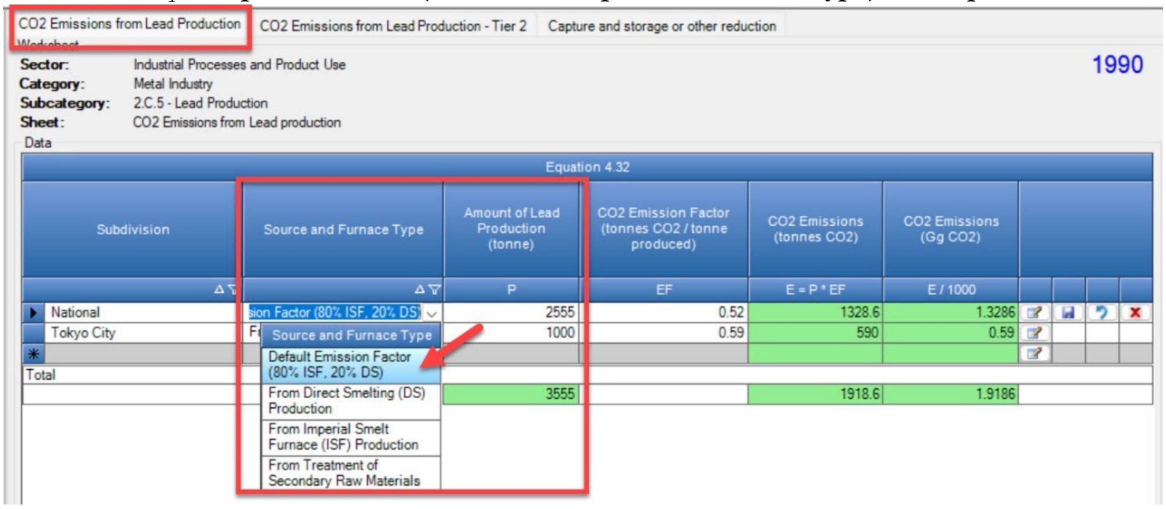
When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Lead Production,** or **CO_2 Emissions from Zinc Production** row by row, as follows:

1. Column |Source and Furnace Type|: input from the drop-down menu the type of furnace/source, if known (i.e. direct smelting, imperial smelting furnace, from secondary materials for lead production and electro-thermic distillation, pyrometallurgical or Waelz Kiln process for zinc production) or input manually a country-specific type of process.
   Note that if the type of furnace is unknown, select Default, which assumes the default allocation of 80% imperial smelting furnace and 20% direct smelting for lead production and 60% imperial smelting furnace and 40% Waelz Kiln for zinc production.

1. Column |P|: input the amount/mass of lead or zinc produced, in tonnes.

Example: **Input Tier 1 AD (default assumption for furnace type) – lead production**



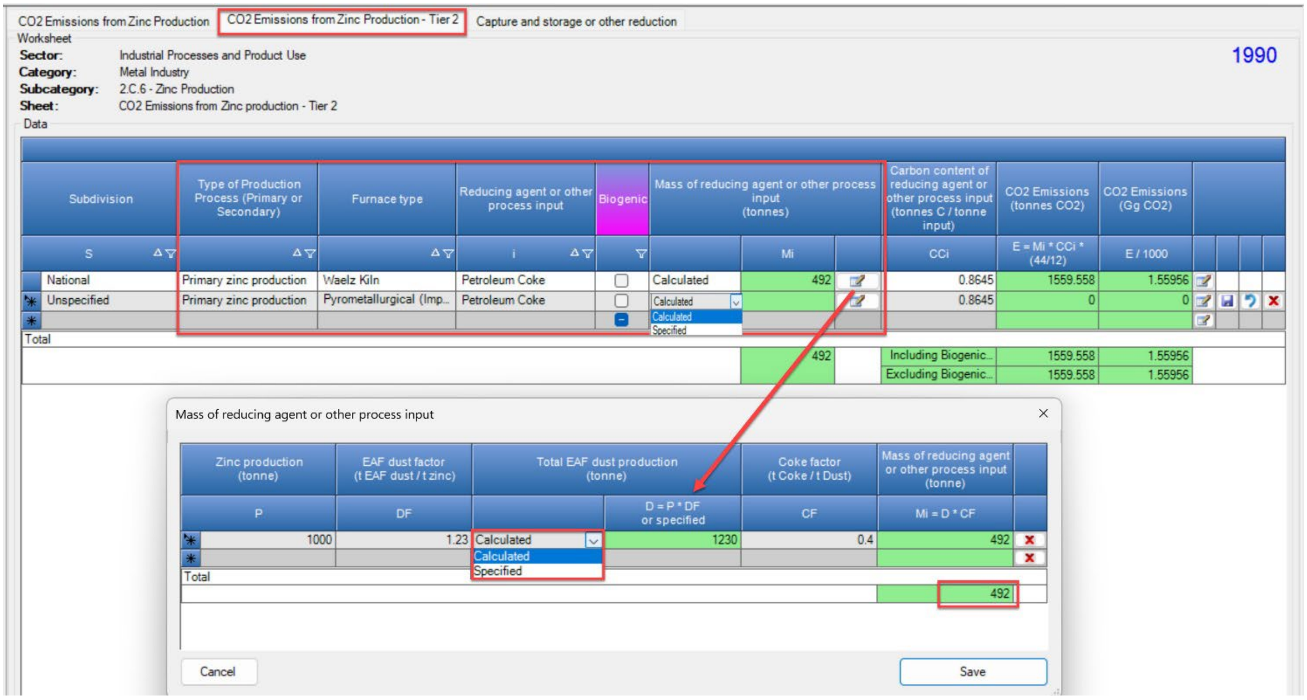
When the Tier 2 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions from Lead Production – Tier 2** or **CO_2 Emissions from Zinc Production – Tier 2,** row by row, as follows:

1. <u>Column |Type of Production|</u>: select from the drop-down menu whether emissions are estimated for primary production or secondary production.
2. <u>Column |Furnace type|</u>: select from the drop-down menu the default type of furnace or input manually a country-specific type of furnace.
3. <u>Column |i|</u>: select from the drop-down menu the default type of reducing agent or input manually a country-specific type of carbon input.
   <u>Note that</u> the selections in the drop-down menu are from the Fuel Manager. If the user selects a fuel from the Fuel Manager, the carbon content of that fuel will automatically be populated in <u>Column |CCi|</u>. If a user-specific reducing agent or process fuel is input, the user will be required to manually enter <u>Column |CCi|</u>. See section 1.1.1 Fuel **Manager** *for more information on how to populate the Fuel Manager.*
4. <u>Column |Biogenic|</u>: indicate with a check if the reducing agent or other process input is of biogenic origin.
5. <u>Column |Mi|</u>: input the amount/mass of reducing agent or other process input consumed, in tonnes.
   <u>Note that</u> for ***Zinc Production,*** *the user has the choice to* ***specify*** *directly the mass of reducing agent or other process input used (the same as lead production), or the user may* ***calculate*** *this value based on the amount of electric arc furnace dust produced.*

   To calculate the mass of reducing agent or other process input based on total EAF dust production, the user selects the pop-up table and then:
6. *<u>Column |D|:</u> the user first determines whether the total amount of EAF dust produced is to be Specified (thus input directly) or Calculated.*
   - *If <u>Column |D|</u> is Specified, <u>Column |P| and Column |DF|</u> are grayed out.*
   - *If <u>Column |D|</u> is Calculated, the user inputs the amount of zinc produced, in tonnes in <u>Column |P|</u>. A default EAF dust factor of 1.23 t EAF dust/t zinc will automatically populate In <u>Column |DF|</u>, or the user may manually enter in a country-specific value.*
7. *<u>Column |CF|:</u> A factor of 0.4 for the amount of coke used per tonne of dust produced is automatically populated ;or the user may manually enter in a country specific value.*

Example: **Input Tier 2 AD – zinc production**



Emission factor input

The following sections in Chapter 4, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of EFs:

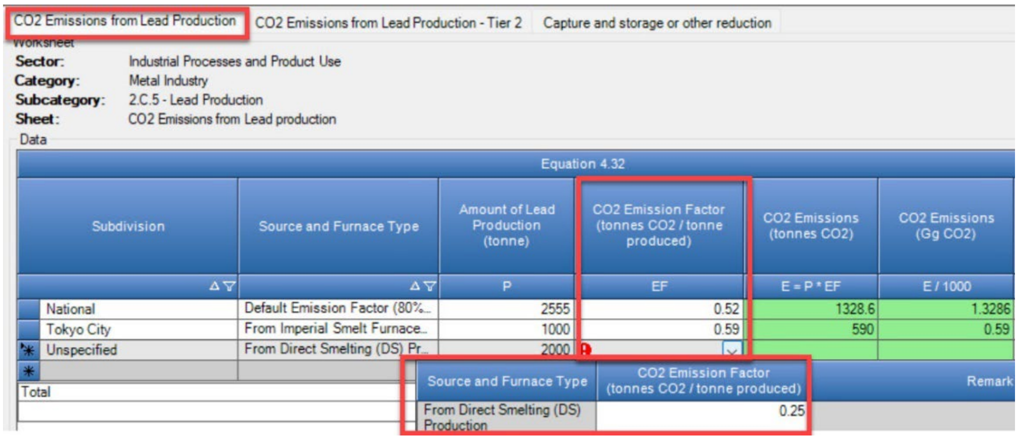
- ✓ Section 4.6.2.2 contains information on the choice of EFs for Lead Production. Tier 1 EFs for CO_2 are presented in Table 4.21. Tier 2 default carbon contents for input materials are presented in Table 4.22, but are to be used only if the compiler does not have country-specific information.
- ✓ Section 4.7.2.2 contains information on the choice of EFs for Zinc Production. Tier 1 EFs for CO_2 are presented in Table 4.24.

When the Tier 1 Equation is applied:

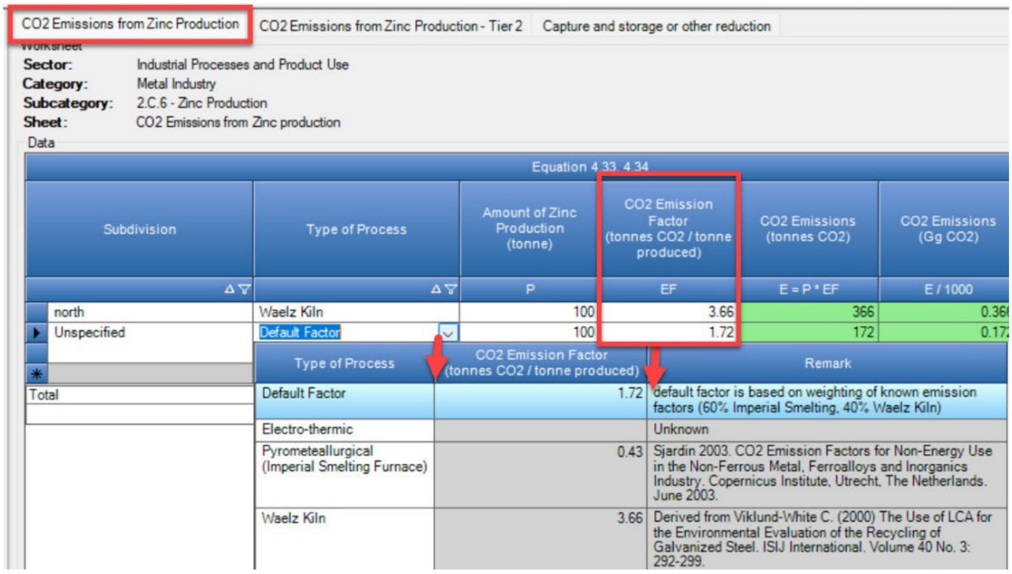
For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Lead Production or CO_2 Emissions from Zinc Production,** row by row, as follows:

1. Column |EF|: Select from the drop-down menu or manually overwrite the EFs with country-specific values.
   Note that: for Lead production, the user selection for the default in Column |EF| depends on the type of furnace in Column |Source and Furnace Type|. For zinc production, Column |EF| is automatically populated based on the selection in Column |Source and Furnace Type|.

Example: **Tier 1 EFs for CO_2 – lead production**



Example: **Tier 1 EFs for CO_2 –zinc production**



When the Tier 2 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Lead Production – Tier 2** or **CO_2 Emissions from Zinc Production – Tier 2,** row by row, in Column |CCi|. The default carbon content is automatically populated from the Fuel Manager if the user selects a reducing agent/process input from the drop-down menu in Column |CCi|. Users may manually over-write the carbon content with country-specific values.

Note that if the user changes from a pre-selected reducing agent / process input material from the drop-down menu and then decides to write in a user-defined reducing agent / process input, the value in Column |CCi| will not automatically change and the user-defined carbon content must be input.

Results

CO_2 emissions from Lead Production are estimated in mass units (tonnes and Gg) by the *Software* in the following worksheets:

- ✓ **CO_2 Emissions from Lead Production**
- ✓ **CO_2 Emissions from Lead Production – Tier 2**

CO_2 emissions from Zinc Production are estimated in mass units (tonnes and Gg) by the *Software* in the following worksheets:

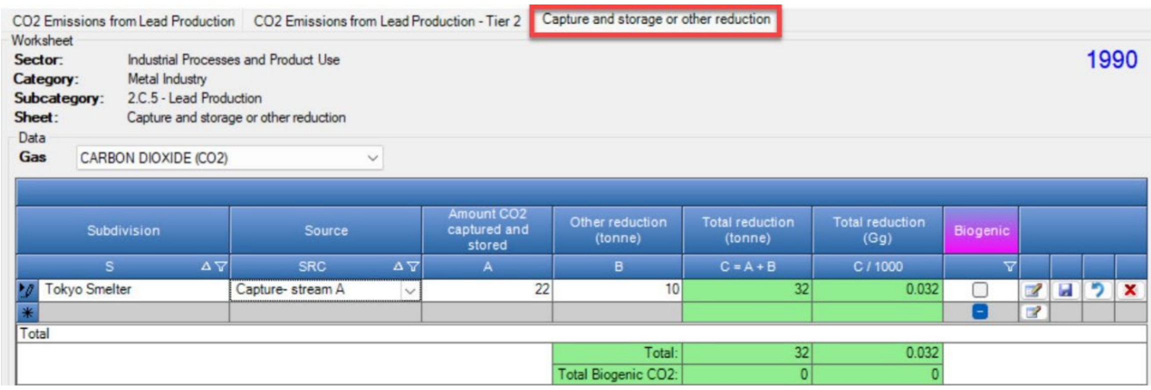
- ✓ **CO_2 Emissions from Zinc Production**
- ✓ **CO_2 Emissions from Zinc Production – Tier 2**

Total CO_2 from lead production and zinc production is the sum of all emissions in the above worksheets, respectively, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* for each source category to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. <u>Column |SRC|</u>: users either select from the drop-down menu, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. <u>Column |A|</u>: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. <u>Column |B|:</u> users collect and input information on any other long-term reduction of CO_2, in tonnes. *<u>Note that</u>: <u>Column |B|</u> may include short-term reductions only in cases where the subsequent CO_2 emissions from use are included elsewhere in the GHG inventory.*
4. <u>Column |Biogenic</u>|: indicate with a check if the reductant/process input material is of biogenic origin. *Note that consistent with Volume 2, Chapter 2 of the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.*

Example: **Capture and storage or other reduction- lead production**



2.C.7 Rare Earths Production

Information

Section 4.8 Chapter 4, Volume 3 of the *2019 IPCC Guidelines* provides methods to estimate CO2 and PFC emissions from Rare Earths Production.

There are two Tiers to estimate CO_2 emissions from primary production of rare earth (RE) metals and alloys. The Tier 1 method relies on production data for each type of RE metal or alloy multiplied by a default CO_2 EF. Since only a default CO_2 EF is available for neodymium (Nd), that EF is adjusted for production of other RE metals based on the relative atomic weight of that metal or alloy compared to Nd. The Tier 3 method is a mass balance approach, assuming the carbon content of net anode consumption is ultimately released to the atmosphere, taking into account any impurities in the anode. There is no Tier 2 method to estimate CO_2 emissions.

Tier 1 and Tier 3 methods are also provided to estimate PFC emissions (mainly CF_4 and C_2F_6, but also C_3F_8) released during the reaction of the carbon anode with a fluoride melt. Both methods employ EFs applied to metal production, and either default (Tier 1) or facility specific (Tier 3) EFs.

GHGs

The *Software* includes the following GHGs for the Rare Earths Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	--	--	--	X	--	--

IPCC Equations

GHG emissions from the Rare Earths Production source category are estimated by applying the following IPCC equations (Chapter 4 Volume 3 of the *2019 IPCC Refinement*):

For CO_2

- ✓ Tier 1: Equation 4.35 (NEW)
- ✓ Tier 3: Equation 4.36 (NEW)

For PFCs

- ✓ Tier 1: Equation 4.37 (NEW)
- ✓ Tier 3: Same equation as Tier 1, although with plant-specific EF information.

As explained in section **1.1.3 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 CO_2 and PFC emissions from Rare Earths Production using the following five worksheets:

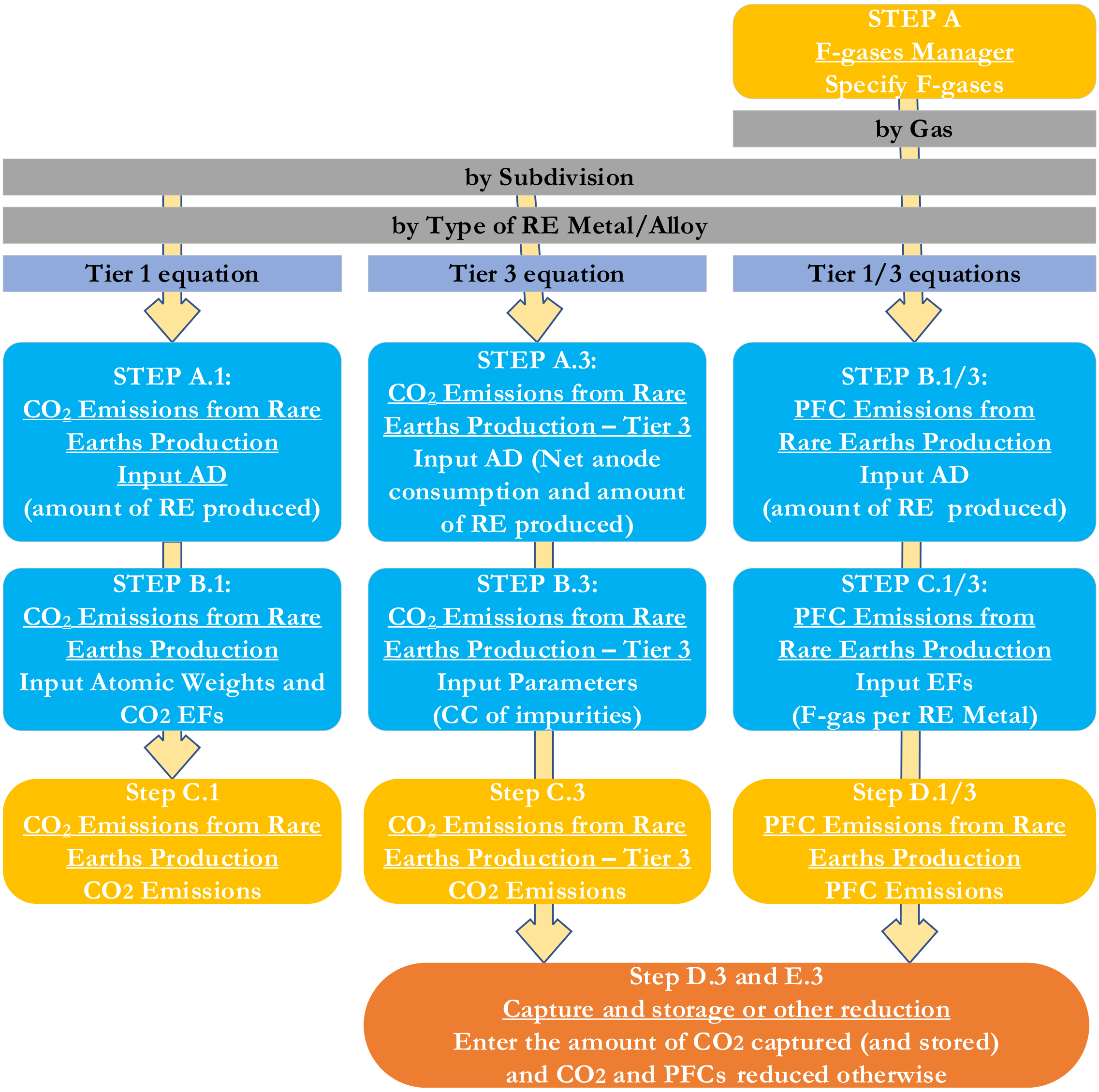
- ✓ **CO_2 Emissions from Rare Earths Production:** contains for each subdivision and each type of RE metal/alloy, information on the amount of the metal/alloy produced and default CO_2 EFs. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Rare Earths Production – Tier 3:** contains for each subdivision, facility and each type of RE metal/alloy, information on the amount of the metal/alloy produced and the total content of non-carbon impurities. The worksheet calculates the associated CO_2 emissions.
- ✓ **1.1.2 F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ✓ **PFC Emissions from Rare Earths Production:** contains for each subdivision and each type of RE metal/alloy, information on the amount of the metal/alloy produced and corresponding EFs. The worksheet calculates the associated PFC emissions.
- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2 and PFCs, not accounted previously in the worksheets for different Tiers.

User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 4.17 (NEW) (for CO_2) and Figure 4.18 (NEW) (for PFCs) of the *2019 Refinement*, 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[1] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for the estimation of CO_2 and PFC emissions from the Rare Earths Production source category

Rare Earths Production – CO_2 and F-gases– flowchart



Thus, for the source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Then, for each subdivision, if any:

i. CO_2 emissions

When the Tier 1 Equation is applied:

Step A.1, in the worksheet **CO_2 Emissions from Rare Earths Production**, users collect and input in the *Software* information on the type and amount of each RE metal/alloy produced.

Step B.1, in the worksheet **CO_2 Emissions from Rare Earths Production**, users collect and input CO_2 EFs for each type of RE metal/alloy, including the atomic weight of the RE metal/alloy as compared to the base case, Nd.

Step C.1, in the worksheet **CO_2 Emissions from Rare Earths Production,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

When the Tier 3 Equation is applied:

Step A.1, in the worksheet **CO_2 Emissions from Rare Earths Production- Tier 3**, users collect and input in the *Software* information on the type and amount of each RE metal/alloy produced and net anode consumption.

Step B.1, in the worksheet **CO_2 Emissions from Rare Earths Production- Tier 3**, users collect and input the total carbon content of non-carbon impurities.

Step C.1, in the worksheet **CO_2 Emissions from Rare Earths Production- Tier 3,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown.

ii. PFC emissions

Step A, **1.1.2 F-gases Manager**, users ensure that all F-gases emitted for this source category (in this case, PFCs) have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

When the Tier 1 Equation is applied:

Step B.1/3, in the worksheet **PFC Emissions from Rare Earths Production**, users collect and input in the *Software* information on the type and amount of each RE metal/alloy produced.

Step C.1/3, in the worksheet **PFC Emissions from Rare Earths Production**, users collect and input the EF for each F-gas.

Step D.1/3, in the worksheet **PFC Emissions from Rare Earths Production,** the *Software* calculates the associated PFC emissions for each subdivision in mass units (kg and Gg). In addition, the total emissions of all subdivisions are shown.

Then, for each tier, and each gas, as appropriate:

Step D.3/E.3, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) or other GHG, not otherwise captured in the worksheets above.

Activity data input

Section 4.8.2.5 in Chapter 4 Volume 3 of the *2019 Refinement* contains information on the choice of AD for Rare Earths Production.

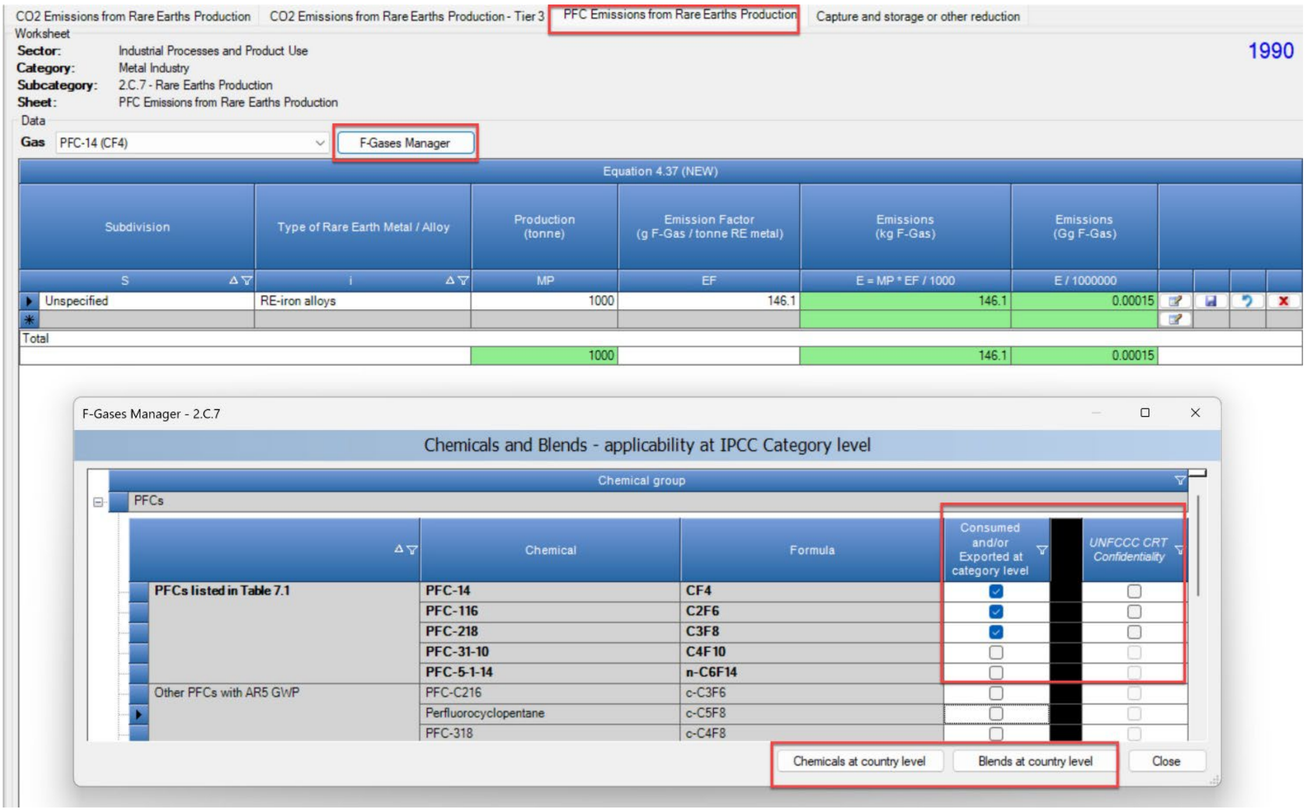
As a **Starting step**, users must ensure that the **1.1.2 F-gases Manager** has been populated for all F-gases to be reported for the source category Rare Earths Production.

*Note that if no PFCs are checked in the F-gases Manager, then it will not be possible to enter any data. If data entry is not possible, select the **F-Gases Manager** in worksheet **PFC Emissions from Rare Earths Production**. This will open the F-gases Manager – applicability at IPCC Category Level. Navigate to the bottom of the pop-up box and select Chemicals at country level. This will take the user back to the country level- F-gases Manager to check the relevant F-gases for this category. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager.*

The user then selects the relevant F-gases for this category in the Category-level F-gases Manager.

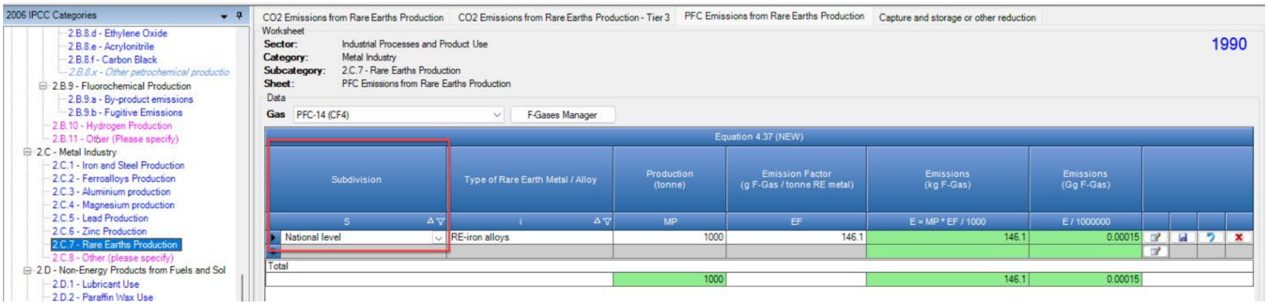
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT, as unspecified mix of HFCs and PFCs, in tonnes CO_2 equivalents.

Example: **Populating the F-gases manager and designating confidentiality for category: Rare Earths Production**



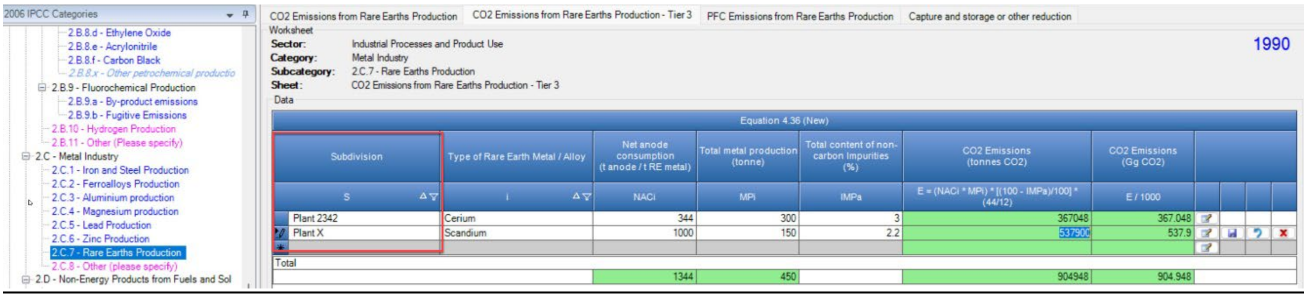
Second, input of AD for the Rare Earths Production source category requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |S| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision**



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**

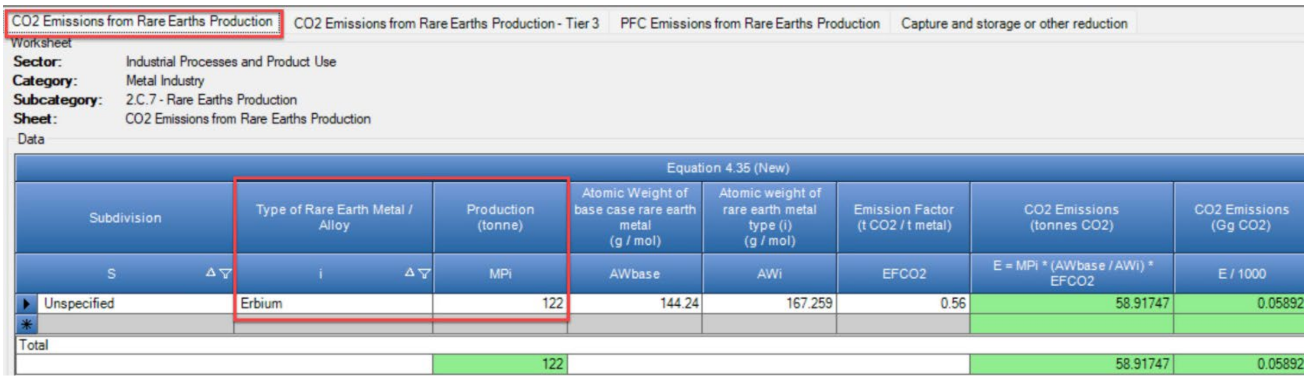


When the Tier 1 Equations are applied (CO_2 and PFCs):

For each subdivision in Column |S|, data are entered in worksheets **CO_2 Emissions from Rare Earths Production** and **PFC Emissions from Rare Earths Production,** row by row, as follows:

1. Column |i|: select from the drop-down menu the RE metal/alloy produced.
2. Column |MPi|: input the amount/mass of RE metal/alloy produced, in tonnes.

Example: **AD input for CO_2 – Tier 1**



When the Tier 3 Equation is applied (CO_2):

For each subdivision in Column |S|, data are entered in worksheet **CO_2 Emissions from Rare Earths Production – Tier 3,** row by row, as follows:

1. Column |i|: select from the drop-down menu the RE metal/alloy produced.
2. Column |NACi|: input facility-specific net anode consumption, in tonnes anode/t RE metal produced.
3. Column |MPi|: input the amount/mass of RE metal/alloy produced, in tonnes.

Example: **AD input for CO_2 – Tier 3**

CO2 Emissions from Rare Earths Production | CO2 Emissions from Rare Earths Production - Tier 3 | PFC Emissions from Rare Earths Production | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.7 - Rare Earths Production
Sheet: CO2 Emissions from Rare Earths Production - Tier 3
Data

Equation 4.36 (New)						
Subdivision	Type of Rare Earth Metal / Alloy	Net anode consumption (t anode / t RE metal)	Total metal production (tonne)	Total content of non-carbon Impurities (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
S	i	NACi	MPi	IMPa	E = (NACi * MPi) * [(100 - IMPa)/100] * (44/12)	E / 1000
Plant 2342	Cerium	344	300	3	367048	367.048
Plant X	Scandium	1000	150	2.2	537900	537.9
Total						
		1344	450		904948	904.948

Emission factor input

Sections 4.8.2.2 and 4.8.2.4 in Chapter 4 Volume 3 of the *2019 Refinements* contain information on the choice of CO_2 and PFC EFs, respectively, for Rare Earths Production; specifically:

i) Tier 1 EFs for CO_2 (Table 4.26 (NEW))
Note that: the CO_2 EF provided is for the RE metal Nd. For other RE metals/alloys, the user must scale the EF based on the atomic weight of the produced RE metal, as compared to Nd. This explanation is provided in Section 4.8.2.1.

ii) Tier 1 EFs for PFCs (Table 4.28 (NEW))

The default EFs are embedded in the *Software*. Users may manually over-write EFs with country-specific values. Tier 3 requires use of facility specific EFs.

When Tier 1 Equations are applied:

i. CO_2 Emissions

For each subdivision in Column |S|, in worksheet **CO_2 Emissions from Rare Earths Production**, the *Software* automatically populates the following columns after the user enters information in Column |i|:

1. Column |EF|: the *Software* automatically populates the default EF for Nd; the user may manually overwrite.
2. Column |AW_{base}|: the *Software* automatically populates the atomic weight of the base case RE metal, Nd; in g/mole.
3. Column |AW_i|: the *Software* automatically populates the atomic weight of the produced RE metal, i, in g/mole.

Example: **Tier 1 EFs for CO_2**

CO2 Emissions from Rare Earths Production | CO2 Emissions from Rare Earths Production - Tier 3 | PFC Emissions from Rare Earths Production | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.7 - Rare Earths Production
Sheet: CO2 Emissions from Rare Earths Production
Data

Equation 4.35 (New)							
Subdivision	Type of Rare Earth Metal / Alloy	Production (tonne)	Atomic Weight of base case rare earth metal (g / mol)	Atomic weight of rare earth metal type (i) (g / mol)	Emission Factor (t CO2 / t metal)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
S	i	MPi	AWbase	AWi	EFCO2	E = MPi * (AWbase / AWi) * EFCO2	E / 1000
Unspecified	Promethium	200	144.24	145	0.56	111.41297	0.11141
	Yttrium	1000	144.24	88.90585	0.56	908.53864	0.90854
Total							
		1200				1019.9516	1.01995

ii. PFC Emissions

For each subdivision in Column |S|, in worksheet **PFC Emissions from Rare Earths Production**, the *Software* automatically populates Column |EF| after the user enters information in Column |i|, with the IPCC default EF for the gas selected. For Tier 3, the user shall manually overwrite the EF with facility-specific values.
Note that the user shall select the relevant PFC in the "Gas" bar at the top, to enter data for each GHG one by one

Example: **EFs input for PFCs (Tiers 1 and 3)**

CO2 Emissions from Rare Earths Production | CO2 Emissions from Rare Earths Production - Tier 3 | PFC Emissions from Rare Earths Production | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.7 - Rare Earths Production
Sheet: PFC Emissions from Rare Earths Production

Data
Gas PFC-14 (CF4) | F-Gases Manager

Equation 4.37 (NEW)					
Subdivision	Type of Rare Earth Metal / Alloy	Production (tonne)	Emission Factor (g F-Gas / tonne RE metal)	Emissions (kg F-Gas)	Emissions (Gg F-Gas)
S	i	MP	EF	E = MP * EF / 1000	E / 1000000
National level	RE-iron alloys	1000	146.1	146.1	0.00015
Unspecified	RE-iron alloys	2000	146.1	292.2	0.00029
Total		3000		438.3	0.00044

When the Tier 3 Equation is applied:

For each subdivision in Column |S|, in worksheet **CO_2 Emissions from Rare Earths Production-Tier 3**, the user inputs the facility specific total content of non-carbon impurities (e.g. sulphur, ash, etc) in the based anodes in Column |IMPa|, in wt%.

Example: **EFs input for CO_2 (Tiers 3)**

CO2 Emissions from Rare Earths Production | CO2 Emissions from Rare Earths Production - Tier 3 | PFC Emissions from Rare Earths Production | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.7 - Rare Earths Production
Sheet: CO2 Emissions from Rare Earths Production - Tier 3

Data

Equation 4.36 (New)						
Subdivision	Type of Rare Earth Metal / Alloy	Net anode consumption (t anode / t RE metal)	Total metal production (tonne)	Total content of non-carbon Impurities (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
S	i	NACi	MPi	IMPa	E = (NACi * MPi) * [(100 - IMPa)/100] * (44/12)	E / 1000
Plant 2342	Cerium	344	300	3	367048	367.048
Plant X	Scandium	1000	150	2.2	537900	537.9
Total		1344	450		904948	904.948

Results

CO_2 and PFC emissions from Rare Earths Production are estimated in mass units (tonnes and Gg for CO_2 and kg and Gg for PFCs) by the *Software* in the following worksheets:

CO_2 emissions:

- ✓ **CO_2 Emissions from Rare Earths Production**
- ✓ **CO_2 Emissions from Rare Earths Production-Tier 3**

PFCs emissions:

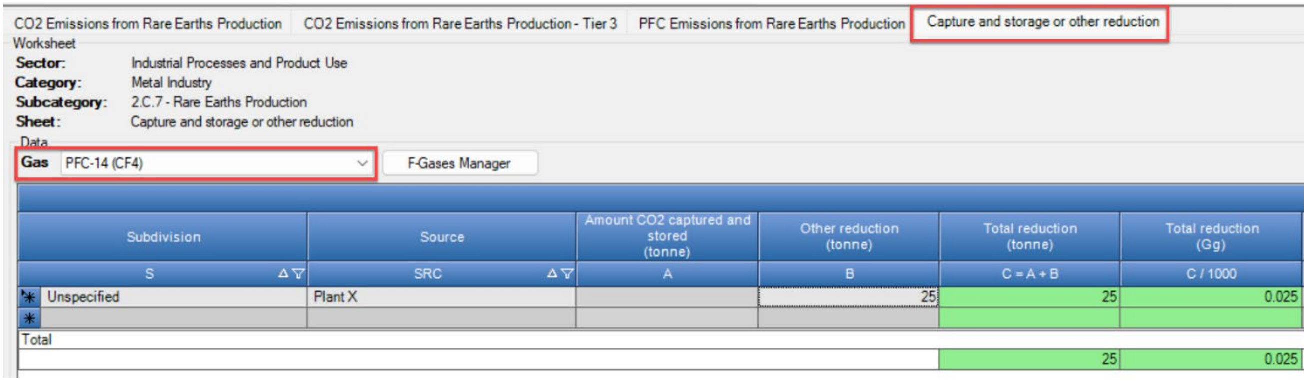
- ✓ **PFC Emissions from Rare Earths Production**

Total CO_2 and PFC emissions from rare earths production is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. <u>Column |SRC|</u>: users either select from the drop-down menu, or preferably, input information on the source where the capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. <u>Column |A|</u>: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. <u>Column |B|:</u> users collect and input information on any other long-term reduction of CO_2 or PFC emissions, in tonnes.
   <u>Note that</u>: <u>Column |B|</u> may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.

Example: **Capture and storage or other reduction**



2.C.8 Other

Information

This section describes calculation of other sources of emissions in the metal industry not included in source categories 2.C.1-2.C.7.

This category also allows for estimating of GHG emissions from categories for which specific methods are not provided in the *2006 IPCC Guidelines* or the *2019 Refinement*, but for which information is contained in the common reporting tables of the MPGs, specifically:

- ✓ F-gases used in Aluminium Foundries
- ✓ CH_4 and N_2O emissions from Rare Earths Production

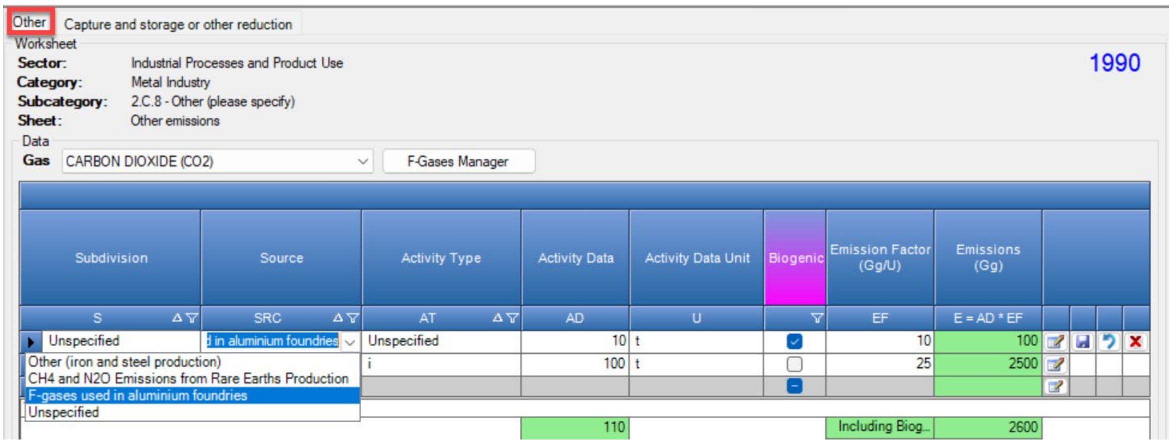
GHGs

Other emissions from the metal industry source category include the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X	X	X	X	X

For more information on **IPCC Equations, Software Worksheets, User's work Flowchart. Activity data input, Emission factor input** and **Results** refer to the corresponding information and figures in section 2.B.11 Other. The same information applies to filling in the worksheets for source category 2.C.8 Other (Metal Industry).

Example: **2.C.8 Other – Generic worksheet**



2.D Non-Energy Products from Fuels and Solvent Use

This section provides methods for estimating emissions from the first use of fossil fuels as a product for primary purposes other than i) combustion for energy purposes and ii) use as feedstock or reducing agent. Emissions from the latter two uses are accounted for by methods described in the **2.B Chemical Industry** and **2.C Metal Industry**.

The products covered here comprise lubricants, paraffin waxes, bitumen/asphalt, and solvents. Emissions from further uses or disposal of the products after first use (i.e., the combustion of waste oils such as used lubricants) are to be estimated and reported in the Waste Sector when incinerated or in the Energy Sector when energy. To illustrate the scope and allocation of GHG emissions from various uses of lubricants and waxes, refer to Figure 5.1 in Chapter 5 Volume 3 of the *2006 IPCC Guidelines*.

Note that the use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions to be reported in the IPPU Sector. However, in the case of 2-stroke engines, where the lubricant is mixed with another fuel and thus on purpose co-combusted in the engine, the emissions should be estimated and reported as part of the combustion emissions in the Energy Sector.

This chapters covers the following source categories:

- ✓ **2.D.1 and 2.D.2 Lubricant Use and Paraffin Wax Use**– description of the use of the *Software* for these two source categories is provided together owing to the common methodologies.
- ✓ **2.D.3 Solvent Use**- the *Software* does not contain calculation worksheets for this category as it is not a source of direct GHG emissions (category 2.D.3 is black in the navigation tree and cannot be selected). The common reporting tables of the MPGs include reporting of CO_2, CH_4 and N_2O emissions from this source category and thus use of the *Software* to estimate these emissions is described further below.
- ✓ **2.D.4 Other**– contains relevant information for use of the *Software* for other emissions from non-energy products from fuels and solvent use.

2.D.1 and 2.D.2 Lubricant Use and Paraffin Wax Use

Information

This section groups guidance for the following source categories according to their common methodological approaches applied in the *Software*:

- ✓ **2.D.1 Lubricant Use**
- ✓ **2.D.2 Paraffin Wax Use**

The *2006 IPCC Guidelines* provide two Tiers to estimate CO_2 emissions from these source categories. In Tier 1 – CO_2 emissions are calculated from data on the non-energy use of fuels for lubricants or paraffin waxes, the carbon content of that fuel, and a oxidised during use (ODU) factor that represents the fraction of fossil carbon oxidized during use. Tier 2 method relies on detailed data of the lubricants and greases consumed or paraffin waxes produced and country-specific EFs based on fuel type specific carbon content and ODU factors.

GHGs

The *Software* includes the following GHGs for the Lubricant Use and Paraffin Wax Use source categories:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	--	--	--	--	--	--

The *2006 IPCC Guidelines* do not contain methods for estimating CH_4 and N_2O emissions from Lubricant Use or Paraffin Wax Use, however for interoperability with the UNFCCC ETF Reporting Tool, the *Software* allows these emissions to be calculated in category **2.D.4 Other**. The sources "CH_4 and N_2O emissions from lubricant use" and "CH_4 and N_2O emissions from paraffin wax" are provided as a default options in the drop-down menu in Column |SRC|. For further information, see description under section **2.D.4 Other**.

IPCC Equations

CO_2 emissions from Lubricant Use source category for Tier 1 are estimated by applying Equations 5.2 and for Tier 2 – Equation 5.3 Chapter 5 Volume 3 of the 2006 IPCC Guidelines.

- ✓ Tier 1: Equation 5.2 (Lubricant Use), Equation 5.4 (Paraffin Wax Use)
- ✓ Tier 2: Equation 5.3 (Lubricant Use), Equation 5.5 (Paraffin Wax Use)
- ✓ Tier 3: no IPCC Tier 3 Equation provided in the *2006 IPCC Guidelines* for these source categories.

As explained in section **1.1.3 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

GHG emissions from each source category are estimated using the following worksheets:

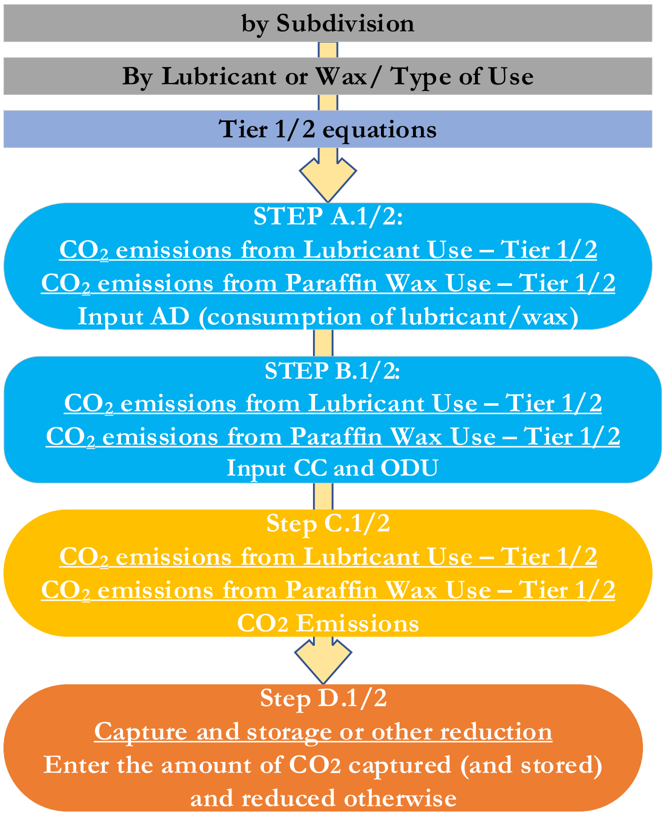
- ✓ **CO_2 emissions from Lubricant Use – Tier 1/2** or **CO_2 emissions from Paraffin Wax Use – Tier 1/2:** contains for each subdivision and each NEU product type/use (e.g. lubricating oil, grease, paraffin wax) information on the amount of lubricant/paraffin wax consumed, its carbon content and ODU factor. The worksheet calculates the associated CO_2 emissions.
- ✓ **Capture and storage or other reduction** contains information on CO_2 capture (with subsequent storage) and other reduction of CO_2, not accounted previously.

User's work Flowchart

Consistent with the key category analysis and the decision trees in Figure 5.2 (Lubricant Use) or Figure 5.3 (Paraffin Wax Use) of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier for each source category, or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements for that source category.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Nitric Acid Production.

Lubricant Use and Paraffin Wax Use – flowchart



Thus, for each relevant source-category:

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision, if any:

Step A.1/2, in the worksheet **CO_2 emissions from Lubricant Use – Tier 1/2** or **CO_2 emissions from Paraffin Wax Use – Tier 1/2,** for each subdivision and each type of use (lubricating oil, grease, paraffin wax) users collect and input in the *Software* information on the amount of lubricant or paraffin wax consumed.

Step B.1/2, in the worksheet **CO_2 emissions from Lubricant Use – Tier 1/2** or **CO_2 emissions from Paraffin Wax Use – Tier 1/2,** for each subdivision and each type of use, users input the carbon content and ODU factor.

Step C.1/2, in the worksheets **CO_2 emissions from Lubricant Use – Tier 1/2** or **CO_2 emissions from Paraffin Wax Use – Tier 1/2,** the *Software* calculates the associated CO_2 emissions for each subdivision in mass units (tonne and Gg). In addition, the total emissions of all subdivisions are shown in the worksheet.

[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Step D.1/2, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates).

Activity data input

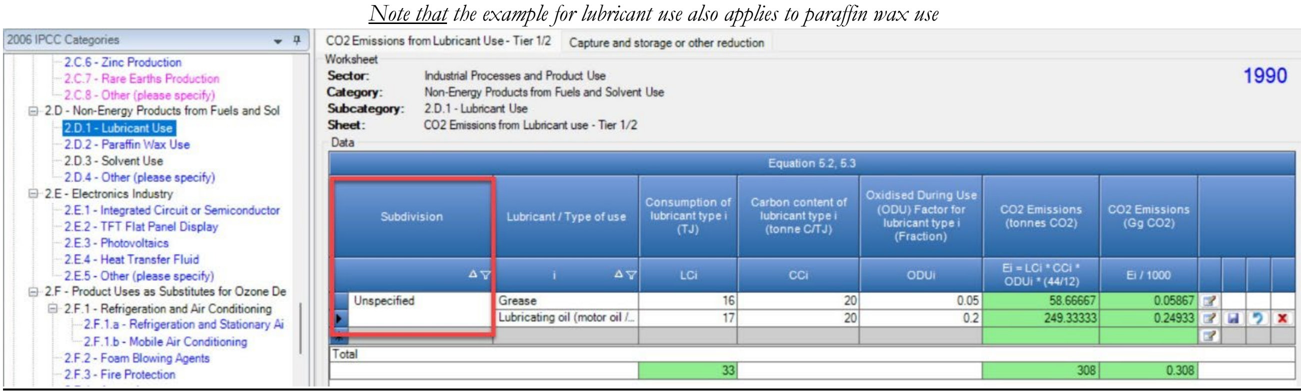
The following sections in Chapter 3, Volume 5 of the *2006 IPCC Guidelines* contain information on the choice of AD:

- ✓ Section 5.2.2.3 contains information on the choice of AD for Lubricant Use.
- ✓ Section 5.3.2.3 contains information on the choice of AD for Paraffin Wax Use.

Input of AD for the Lubricant Use and Paraffin Wax Use source categories requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu].

Example: **single subdivision (unspecified)**

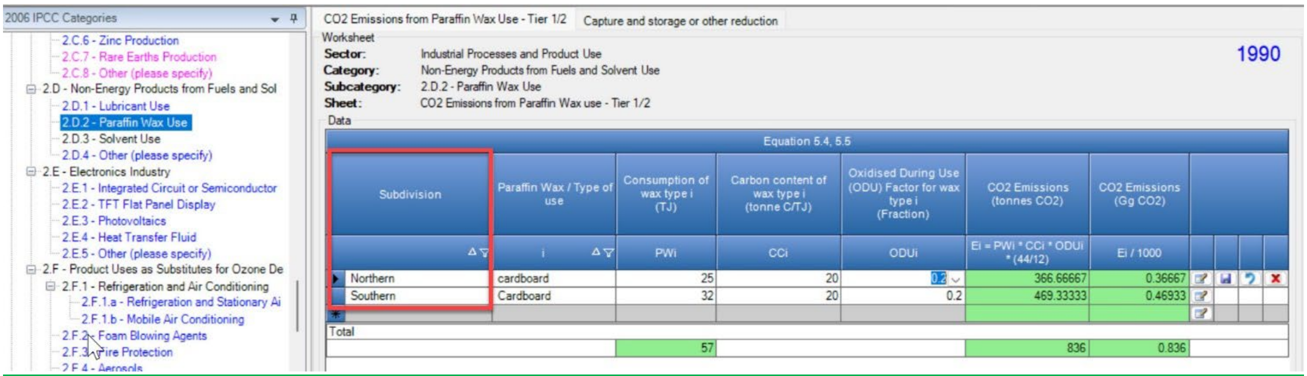
Note that the example for lubricant use also applies to paraffin wax use



Where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **multiple subdivisions**

Note that the example for paraffin wax use also applies to lubricant use



Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **CO_2 Emissions from Lubricant Use – Tier 1/2** or **CO_2 Emissions from Paraffin Wax Use – Tier 1/2,** row by row, as follows:

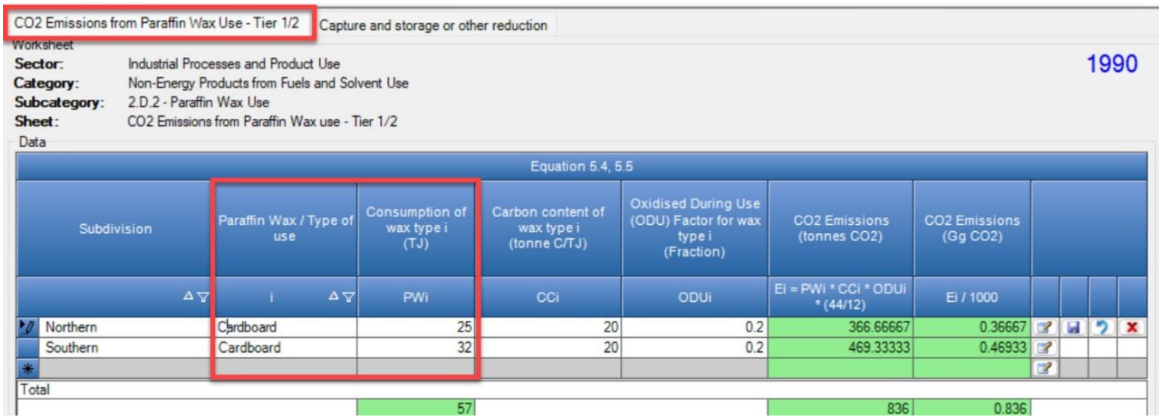
1. Column |i|: select from the drop-down menu (for lubricant use) the default lubricant/type of use (lubricating oil, grease) or input manually a country-specific lubricant. For paraffin wax use, input the type of paraffin wax consumed.
   Note that: for lubricant use, if information is not known on the types and quantities of different types of lubricants consumed, the user shall select "IPCC default for total lubricants".

Recall that the use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions to be reported in the IPPU Sector. However, in the case of 2-stroke engines, where the lubricant is mixed with another fuel and thus on purpose co-combusted in the engine, the emissions should be estimated and reported as part of the combustion emissions in the Energy Sector.

2. Column |LCi| (Lubricant Use): input the amount/mass of lubricant consumed in TJ.
3. Column |PWi| (Paraffin Wax Use): input the amount/mass of lubricant consumed in TJ.

Example: **AD input – Tier 1**

Note that the example for paraffin wax use also applies to lubricant use



Emission factor input

The following sections in Chapter 3, Volume 5 of the *2006 IPCC Guidelines* contain information on choice of EFs:

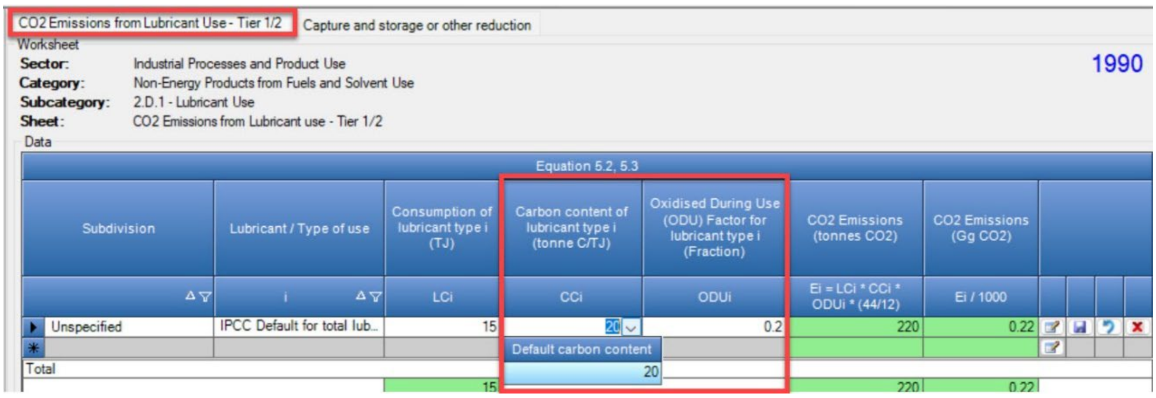
- ✓ Section 5.2.2.2 contains information on the choice of EF for Lubricant Use. Default values are presented in Table 5.2.
- ✓ Section 5.3.2.2 contains information on the choice of EF for Paraffin Wax Use.

For each combination of subdivision/ type of use in worksheet **CO_2 Emissions from Lubricant Use – Tier 1/2** or **CO_2 Emissions from Paraffin Wax Use – Tier 1/2:**

1. Column |CCi|: select from the drop-down menu, the IPCC default carbon content (20 tonnes C/TJ on a lower heating value basis) or manually enter in a user-specific value.
2. Column |ODUi|: select from the drop-down menu the IPCC default ODU, depending on the type of lubricant/paraffin wax used (lubricating oil - 0.2, grease – 0.05, IPCC default for all lubricants – 0.2, paraffin wax – 0.2) or manually enter in a user-specific value.

Example: **Tier 1/2 EFs for CO_2**

Note that the example for lubricant use also applies to paraffin wax



Results

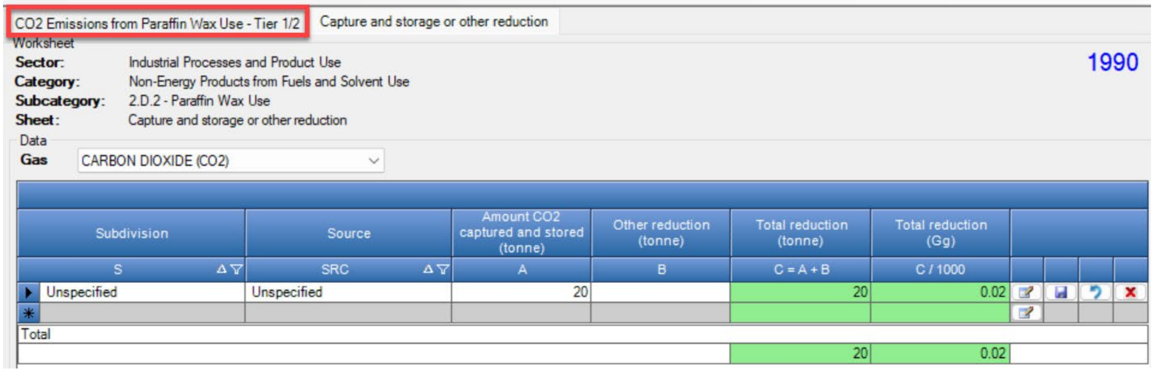
CO_2 emissions from Lubricant Use are estimated in mass units (tonnes and Gg) by each subdivision and total in the Software in the worksheets **CO_2 emissions from Lubricant Use – Tier 1/2** or **CO_2 Emissions from Paraffin Wax Use – Tier 1/2.**

Total CO_2 emissions from each source category is the sum of all subdivisions in the relevant worksheet above, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

In the worksheet **Capture and storage or other reduction** for each subdivision:

1. Column |SRC|: users either select from the dropdown, or preferably, input information on the source where CO_2 capture or other reduction occurs (e.g. the facility, stream, or other identifying information).
2. Column |A|: users collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: users collect and input information on any other long-term reduction of CO_2, in tonnes. *Note that: Column |B| may include short-term reductions only in cases where the subsequent GHG emissions from use are included elsewhere in the GHG inventory.*

Example: **Capture and storage or other reduction**



2.D.3 Solvent Use

Category 2.D.3 Solvent Use is not a source category that emits direct GHGs (CO_2, CH_4, N_2O or F-gases), therefore no methodological guidance (including worksheets) is provided in the *2006 IPCC Guidelines* for this source category. Solvent Use is one of the largest source categories of NMVOC emissions (such guidance on NMVOC emissions from Solvent Use was previously provided in the *Revised 1996 IPCC Guidelines*). The sectoral summary tables, and thus the *Software* allows for reporting of these precursor emissions from the main menu (tab **Reports – IPPU – Sectoral**).

Although the *Software* contains no worksheets for this source category in the category tree, the common reporting tables contained in the MPGs do include reporting of CO_2, CH_4 and N_2O emissions from CRT category 2.D.3.a Solvent use. Users using the *Software* for purposes of preparing a GHG inventory for upload to the UNFCCC ETF Reporting Tool may estimate GHG emissions Solvent use in the worksheets for IPCC Category **2.D.4 Other** (see next section).

2.D.4 Other

Information

This section describes calculation of other sources of emissions from Non-Energy Products from Fuels and Solvent Use not included in source categories 2.D.1 and 2.D.2.

This category also allows for estimating of GHG emissions from categories for which specific methods are not provided in the *2006 IPCC Guidelines* or the *2019 Refinement*, but for which information is contained in the common reporting tables of the MPGs, specifically:

- ✓ CH_4 and N_2O emissions from Lubricant Use
- ✓ CH_4 and N_2O emissions from Paraffin Wax Use
- ✓ CO_2, CH_4 and N_2O emissions from Solvent Use
- ✓ CO_2, CH_4 and N_2O emissions from Road Paving with Asphalt
- ✓ CO_2, CH_4 and N_2O emissions from Asphalt Roofing

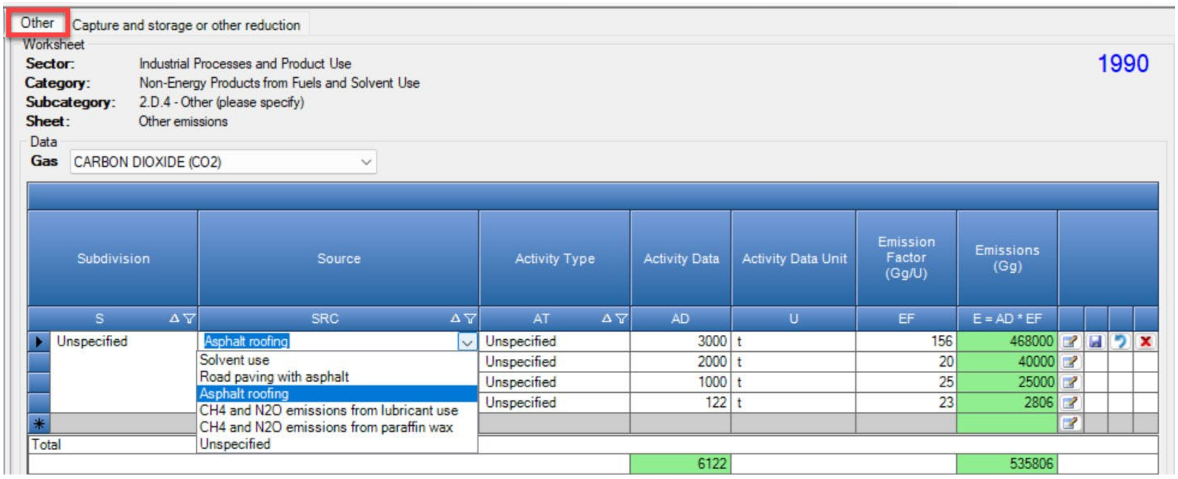
GHGs

Emissions from the Non-Energy Products from Fuels and Solvent Use source category include the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X	-	-	-	-

For more information on **IPCC Equations, Software Worksheets, User's work Flowchart. Activity data input, Emission factor input** and **Results** refer to the corresponding information and figures in section **2.A.5 Other**. The same information applies to filling in the worksheets for source category 2.D.4 Other.

Example: **2.D.4 Other – Generic worksheet**



2.F Product Uses as Substitutes for Ozone Depleting Substances (ODS)

2.F.1 and 2.F.3 Refrigeration and Air Conditioning, and Fire Protection

This section groups guidance for the following source categories according to their common methodological approaches applied in the *Software*:

- ✓ **2.F.1 Refrigeration and Air Conditioning**
  - **2.F.1.a Refrigeration and Stationary Air Conditioning**
  - **2.F.1.b Mobile Air Conditioning**
- ✓ **2.F.3 Fire Protection**

Section 7.5 in Chapter 7 Volume 3 of the *2006 IPCC Guidelines* provides single methodological guidance for all sub-applications (e.g., domestic, commercial, industrial, etc.) of source category 2.F.1 Refrigeration and Air Conditioning and divides them in two sub-categories: i) 2.F.1.a Refrigeration and Stationary Air Conditioning and ii) 2.F.1.b Mobile Air Conditioning. Please note that the sub-application "Transport refrigeration", which comprises equipment and systems used in refrigerated trucks, containers, reefers, and wagons, is included under sub-category 2.F.1.a. The sub-category 2.F.1.b is for the sub-application "Mobile air-conditioning" which comprises systems used in passenger cars, truck cabins, buses, and trains.

The guidance for Refrigeration and Air Conditioning has two Tiers (Tier 1 and Tier 2) with differentiation between Tier 2a (EF approach) and Tier 2b (mass-balance approach). Tier 1 is considered a mixed Tier 1 a/b method.

For source category 2.F.3 Fire Protection, the *Software* follows the Tier 1 method for Refrigeration and Air Conditioning, and thus these two source categories are presented together.

Information

The Tier 1 method estimates emissions from each of the source categories refrigeration and air conditioning and fire protection as a whole across the country (not by sub-application) and requires the following data input:

i) Year of introduction of the refrigerant (F-gas)
ii) Growth rate in sales of new equipment
iii) Assumed equipment lifetime
iv) EF from installed base
v) Fraction (%) of refrigerant destroyed at the end-of-life
vi) Production (sales) of refrigerant/fire protectant (i.e. agent) in the current reporting year
vii) Export of agent in the current reporting year
viii) Import of agent in the current reporting year

Then the Tier 1 method back-calculates the development of the bank of the agent from the current reporting year to the year of its introduction. The bank is the amount of agent stored in products. The *Software* then calculates emissions from the bank in the current reporting year plus emissions from the retired equipment in the current reporting year (if they happen, assuming the lifetime of equipment).

Tier 2 methods apply to the source category refrigeration and air conditioning only. Emissions can be estimated, by sub-application (e.g. commercial and domestic refrigeration are estimated separately), using a Tier 2a and/or Tier 2b method.

The Tier 2a method is an EF approach and requires the data input and respective EFs for each stage of operation:

i) Management of refrigerant containers
ii) Charge of refrigerant
iii) Operation and servicing of refrigerant systems (emissions from the bank)
iv) Disposal of refrigerant systems (end-of-life).

The Tier 2b method is a mass-balance approach for refrigeration across the whole country in the current reporting year and overall needs data to estimate the flow of refrigerants across the industry, including:

i) Annual sales of new refrigerant
ii) Total charge of new equipment
iii) Original total charge of retiring equipment
iv) Amount of refrigerant destroyed

GHGs

The *Software* includes the following GHGs for the Refrigeration and Air Conditioning and Fire Protection source categories:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

- ✓ Tier 1: Equation 7.1 and 7.2A/B (Refrigeration and Air Conditioning (RAC)), Equation 7.17 (Fire Protection)
- ✓ Tier 2a: Equations 7.10, 7.11, 7.12, 7.13 and 7.14 (RAC)
- ✓ Tier 2b: Equation 7.9 (RAC)

Software Worksheets

The *Software* calculates emissions of F-gases from **Refrigeration and Air Conditioning** (sub-category 2.F.1.a and 2.F.1.b) and **Fire Protection,** using the following worksheets as described:

- ✓ **1.1.2 F-gases Manager**: is applicable to both source categories and contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **F-gas Emissions** (RAC)/**Emissions from Fire Protection** (Fire Protection)**:** These worksheets are exactly the same and contain for each subdivision and each F-gas, information on the year of introduction, growth rate in sales of new equipment, assumed equipment lifetime, EF from installed base, fraction (%) of agent destroyed at the end-of-life, production, export and import. The worksheet calculates the associated F-gas emissions for Tier 1.
- ✓ **F-gas Parameters – Tier 2** (RAC only)**,** this worksheet is required for users applying either Tier 2a or Tier 2b, and allows input of necessary information: subdivisions, sub-applications, chemicals (i.e. gases) consumed and which Tier 2 method is applied for that subdivision/sub-application/F-gas (Tier 2a or 2b). Additional parameters are available for data input, depending on the method selected for each gas. These parameters are automatically transferred into the Tier 2a and/or Tier 2b worksheets for calculation of emissions. The user may also indicate in this worksheet if a specific combination of subdivision/sub-application/ F- gas is confidential.
- ✓ **F-gas Emissions – Tier 2a** (RAC only)**,** allows the user to enter in the relevant AD to estimate GHG emissions for each subdivision /sub-application / F-gas, based on the EFs and parameters entered in worksheet **F-gas Parameters- Tier 2** and using the Tier 2a method (EF approach).
- ✓ **F-gas Emissions – Tier 2b** (RAC only)**,** allows the user to enter in the relevant AD to estimate GHG emissions for each subdivision/sub-application/F-gas, based on the parameters entered in worksheet **F-gas Parameters- Tier 2** and using the Tier 2b method (mass balance approach).

User's work Flowchart

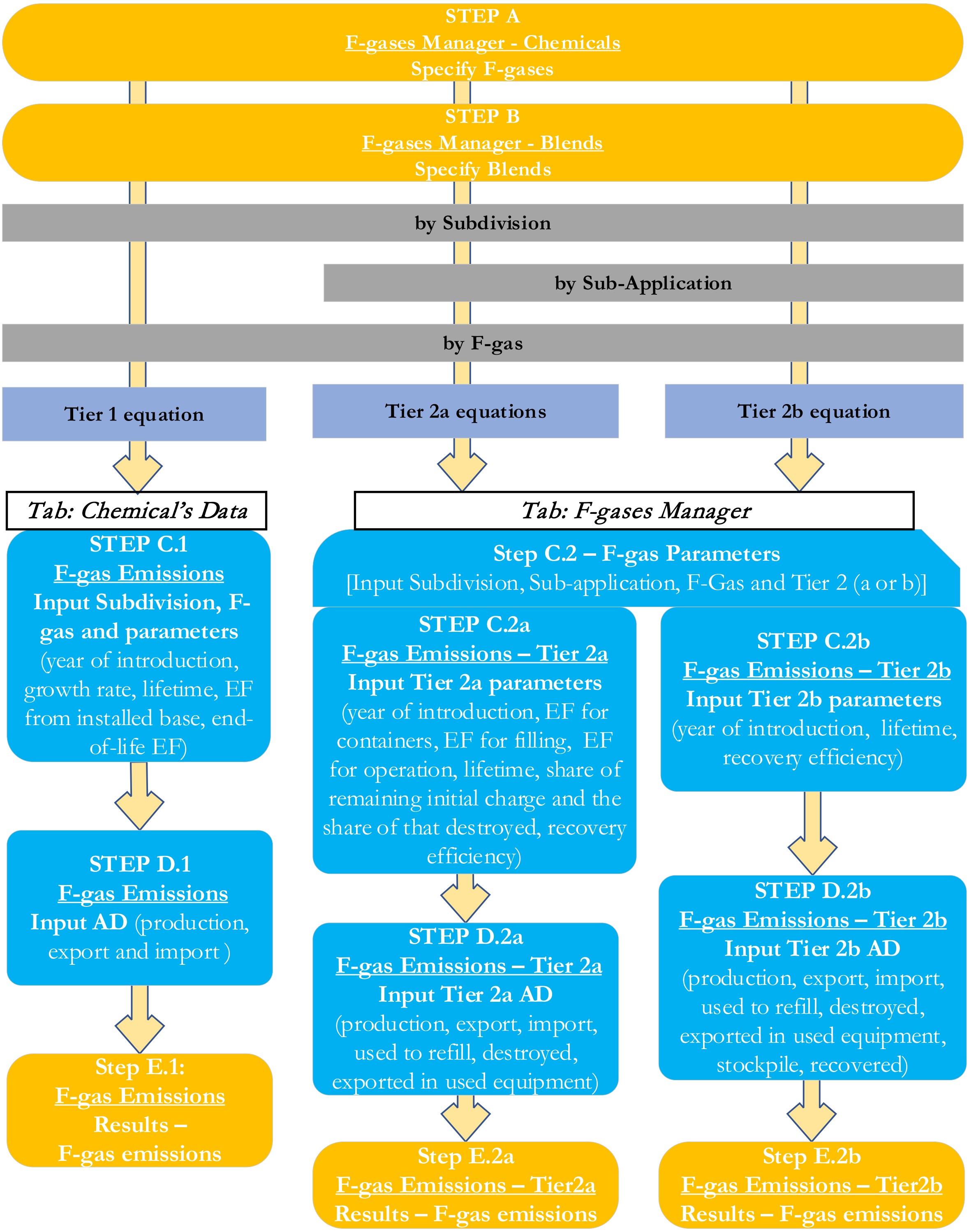
For Refrigeration and Air Conditioning, consistent with the key category analysis and the decision tree in Figure 7.6 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements.

For Fire Protection, GHG estimates are calculated following the decision tree in Figure 7.9.

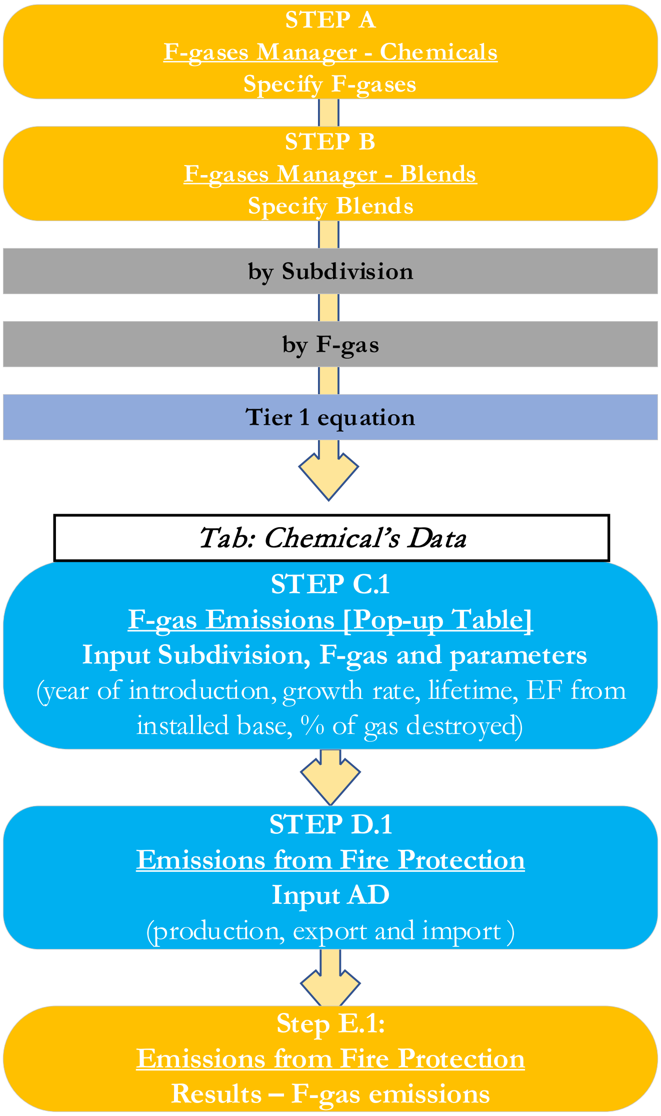
[1] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 subdivisions of country's X estimates, a Tier 2 methodological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

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowcharts for Refrigeration and Air Conditioning and Fire Protection, respectively.

Refrigeration and Air Conditioning– flowchart



Fire Protection – flowchart



Thus, for the relevant source-category:

Steps A and B, 1.1.2 F-gases Manager, users ensure that all F-gases/blends consumed (including imported for consumption) or produced and exported and related to each source category have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision:

Data may be entered as a single application (e.g. all mobile air conditioning or all fire protection equipment) as in **Step C.1** or, for refrigeration and air conditioning, in distinct sub-applications (e.g. domestic refrigeration is calculated separately from commercial refrigeration as in **Step C.2**). See the section below on EF/Parameter input to customize the *Software* to fit the users' needs to designate subdivisions, sub-applications and gases.

Then, for each subdivision/sub-application, if any:

When the Tier 1 Equation is applied:

Step C.1, in the worksheet **F-gas Emissions** or **Emissions from Fire Protection**, users collect and input in the tab **Chemical's Data** information on subdivision(s), relevant F-gases and their year of introduction, growth rate in sales of new equipment, assumed equipment lifetime, EF from installed base, and fraction (%) of refrigerant/fire protectant destroyed at the end-of-life.

Step D.1, in the worksheet **F-gas Emissions** or **Emissions from Fire Protection**, for each subdivision and each F-gas identified in **Step A** or blend identified in **Step B**, users collect and input information on the production, export and import of that gas in the current reporting year (the worksheet allows to enter such information for previous years as well).

Step E.1, in the worksheets **F-gas Emissions** or **Emissions from Fire Protection,** the *Software* calculates the associated emissions for each F-gas, in tonnes.

When Tier 2 Equations are applied (Refrigeration and Air Conditioning only)**:**

Step C.2, in the worksheet **F-gas Parameters – Tier 2**, users collect and input in the *Software* the information on subdivisions, sub-applications and Tier 2 methods (Tier 2a and/or Tier 2b). For Tier 2a, users collect and input the information on year of introduction, EF for containers, EF for filling, EF for operation, lifetime, share of remaining initial charge, the percent of that share that is destroyed and the recovery efficiency (**Step C.2a)**. For Tier 2b it contains information on year of introduction, lifetime, and recovery efficiency **(Step C.2.b)**.

Then for Tier 2a:

Step D.2a, in the worksheet **F-gas Emissions – Tier 2a**, for each subdivision/sub-application/F-gas, users collect and input information on the amount of F-gas produced domestically for refrigeration, imported and exported in bulk or equipment, the amount used to refill equipment, the amount destroyed, and exported in used equipment for subsequent use (for the current reporting year as well as it is possible to enter such information for previous years).

Step E.2a in the worksheet **F-gas Emissions – Tier 2a,** the *Software* calculates the associated emissions for each F-gas in kg and Gg.

Then for Tier 2b:

Step D.2b, in the worksheet **F-gas Emissions – Tier 2b,** for each subdivision/sub-application/F-gas/blend, users collect and input information on the amount of F-gas produced domestically, imported and exported in bulk or equipment, the amount used to fill equipment factory- and not-factory-charged, the amount stockpiled (i.e. not used in the inventory year), the amount recovered and recycled/reclaimed, the amount destroyed and the amount exported in used equipment (for the current reporting year as well as it is possible to enter such information for previous years).

Step E.2b, in the worksheets **F-gas Emissions – Tier 2b,** the *Software* calculates the associated emissions for each F-gas in kg and Gg.

Customizing the *Software* for Refrigeration and Air Conditioning and Fire Protection: subdivision/sub-application/F-gases/blends

For both the Tier 1 and Tier 2 methods, users must first identify the applicable subdivision/sub-application/F -gases/blends applicable to the chosen method that will be used to estimate GHG emissions.

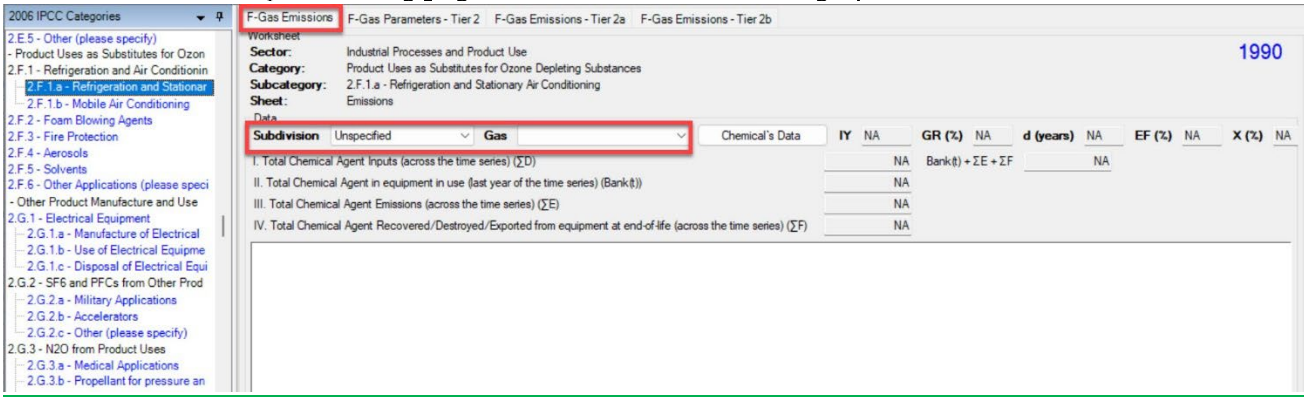
When the Tier 1 Equation is applied:

For the Tier 1 method, the user customizes the *Software* to identify the relevant subdivision and F-gases used. There are no sub-applications for the Tier 1 method for either Refrigeration and Air Conditioning or Fire Protection. By definition, Tier 1 estimates emissions from Refrigeration and Air Conditioning in two major applications: Refrigeration and Stationary Air Conditioning (2.F.1.a) and Mobile Air Conditioning (2.F.1.b) and Fire Protection is a single application.

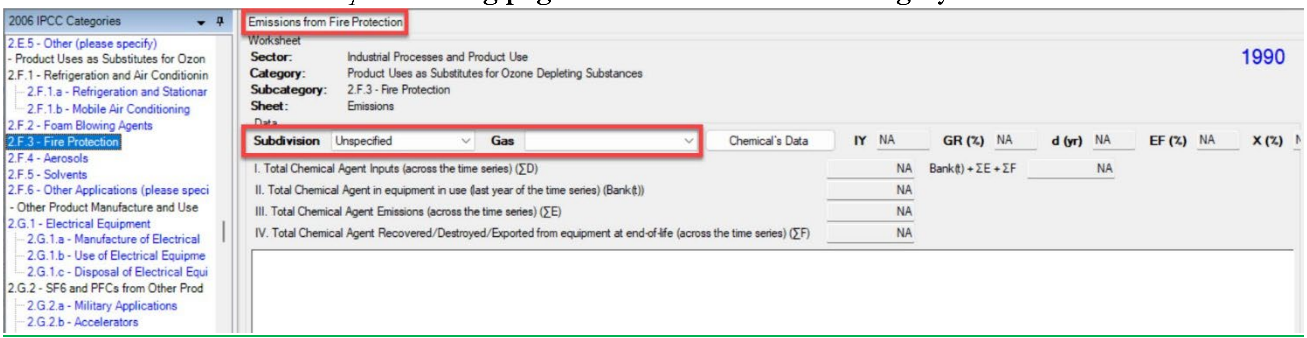
Note that for users that apply a Tier 1 method for Refrigeration and Stationary Air Conditioning (2.F.1.a) and intend to prepare a JSON file for submission of the GHG inventory into the UNFCCC ETF Reporting Tool all data will transfer to the UNFCCC as commercial refrigeration. This is because the structure of the CRT accommodates reporting at the sub-application level (i.e. Tier 2). Users reporting a Tier 1 method for Refrigeration and Air Conditioning should indicate that emissions from any other possible sub-application (domestic refrigeration, industrial refrigeration, etc) are "IE" (included elsewhere). See Annex I for further information.

Important: When the user first enters the *Software*, there is only a single subdivision (Unspecified) and no F-gases available for selection for data entry for these source categories. Thus, the user must identify subdivisions and enter the relevant F-gas(es)/blends to be able to enter data in the worksheet.

Example: **Landing page when user first enters category 2.F.1.a and 2.F.1.b**



Example: **Landing page when user first enters category 2.F.3**

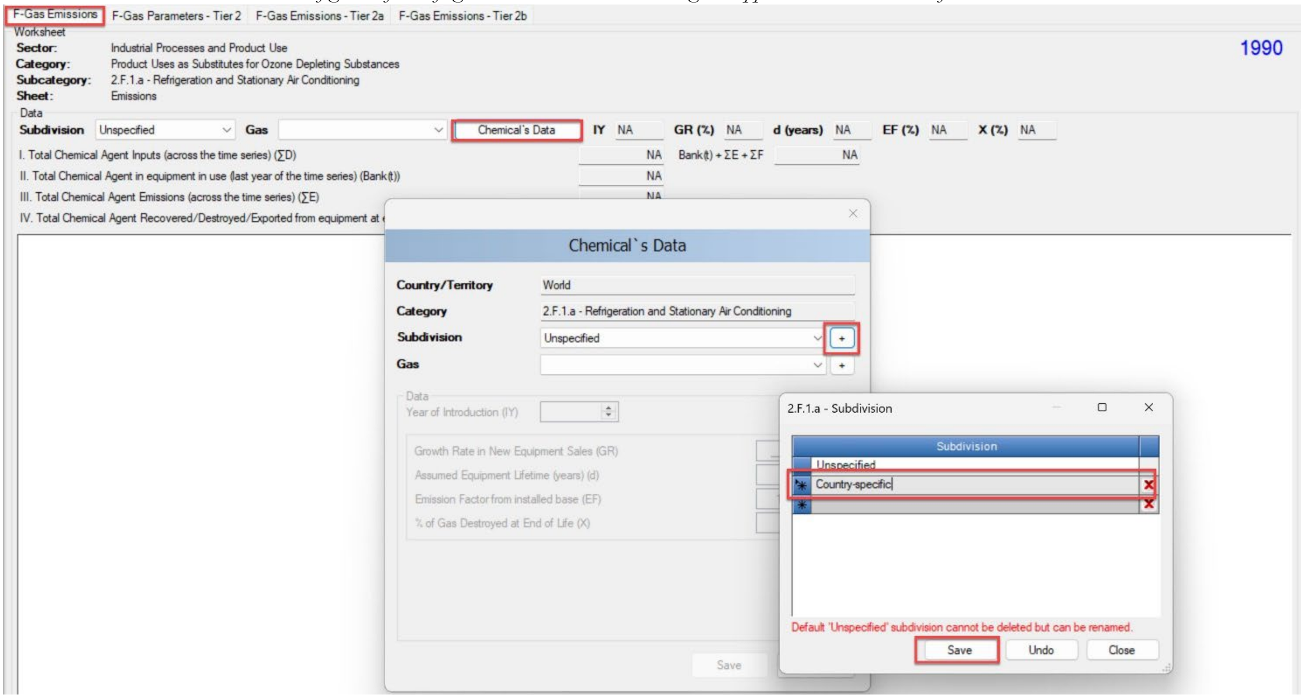


Entering subdivision(s)

1. If the user intends to apply a single subdivision (e.g. national) they may either leave as is (subdivision =Unspecified) or add its univocal name/code [e.g. "country name"].
2. To add a univocal name/code in worksheet **F-Gas Emissions** or **Emissions from Fire Protection,** users must click on the tab **Chemical's Data** to open a pop-up window and to enter a new subdivision(s).

Example: **Adding a subdivision for Tier 1**

<u>*Note that*</u> *this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.*



<u>Identifying relevant F-gases /blends at the IPCC category level</u>

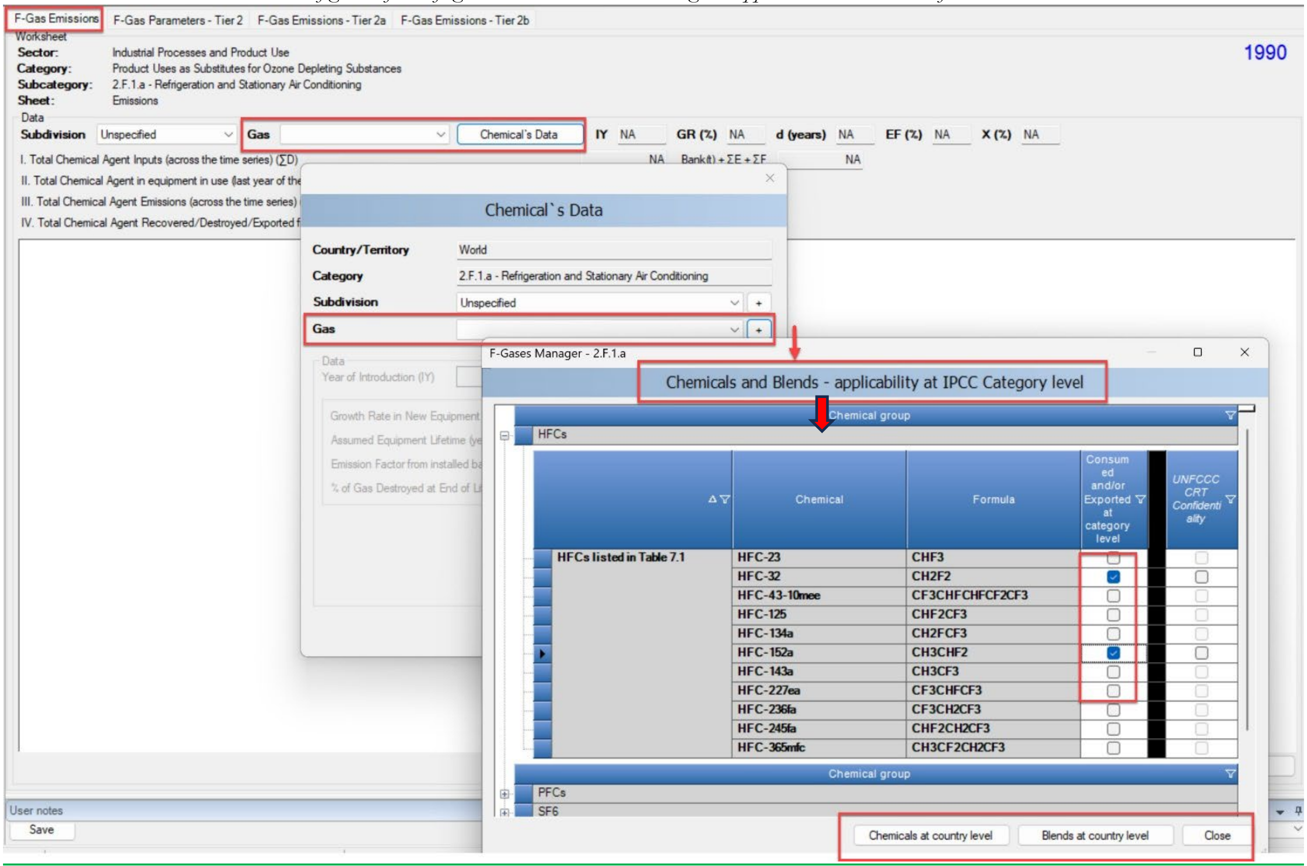
Upon first entering the *Software* and selecting **Gas** in the worksheet **F-Gas Emissions** or **Emissions from Fire Protection,** the user will not see any F-gases (or blends) pre-populated in the drop-down menu. This is because users must first identify the specific F-gases /blends consumed for each relevant source category; selected from all F-gases/blends that have already been identified by the user at the national level in the **1.1.2 F-gases Manager**.

To select the F-gases used in this IPCC category:

1. select **Chemical's Data**
2. select the [+] next to the drop-down menu for **Gas**
3. check all F-gas(es)/blends consumed for refrigeration and air conditioning and for fire protection.
   Note that: any F-gases/blends selected here will be available for all subdivisions in each source category. If a needed gas is not available for selection, it is because it has not been added at the national level as a gas produced/used in this country. To enter F-gases (or blends thereof) at the national level, select ***Chemicals at National Level*** *or* ***Blends at National Level*** *from the bottom of the screen.*
4. <u>For users intending to use the *Software* for reporting in the UNFCCC ETF Reporting Tool:</u> If AD and/or emissions for a particular F-gas consumed <u>in this category</u> are considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. If checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT. Further, all confidential emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate (for further information, see **Annex I: Mapping between the IPCC Inventory Software and the UNFCCC ETF Reporting Tool**).

Example: **Populating the F-gases manager and designating confidentiality for category: Refrigeration and Air Conditioning and Fire Protection – Tier 1**

Note that this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.



Once information on subdivisions and relevant F-gas(es) for category 2.F.1.a, 2.F.1.b and 2.F.3, as appropriate, have been identified, the user is ready to input relevant EF/parameters following the Tier 1 method.

When Tier 2 Equations are applied (Refrigeration and Air Conditioning only)**:**

Similar as for Tier 1, users must customize the *Software* to identify the relevant subdivision(s) and F-gas(es) used for Refrigeration and Air Conditioning following a Tier 2 method. In addition, the Tier 2 method requires information on sub-applications (e.g. commercial refrigeration is calculated separately from domestic).

The worksheet **F-Gas Parameters- Tier 2** is used to define subdivision(s), sub-application(s), and F-gases and/or blends used in the Tier 2a and Tier 2b methods, as well as additional parameters needed for these methods (input of additional parameters is described in the next section).

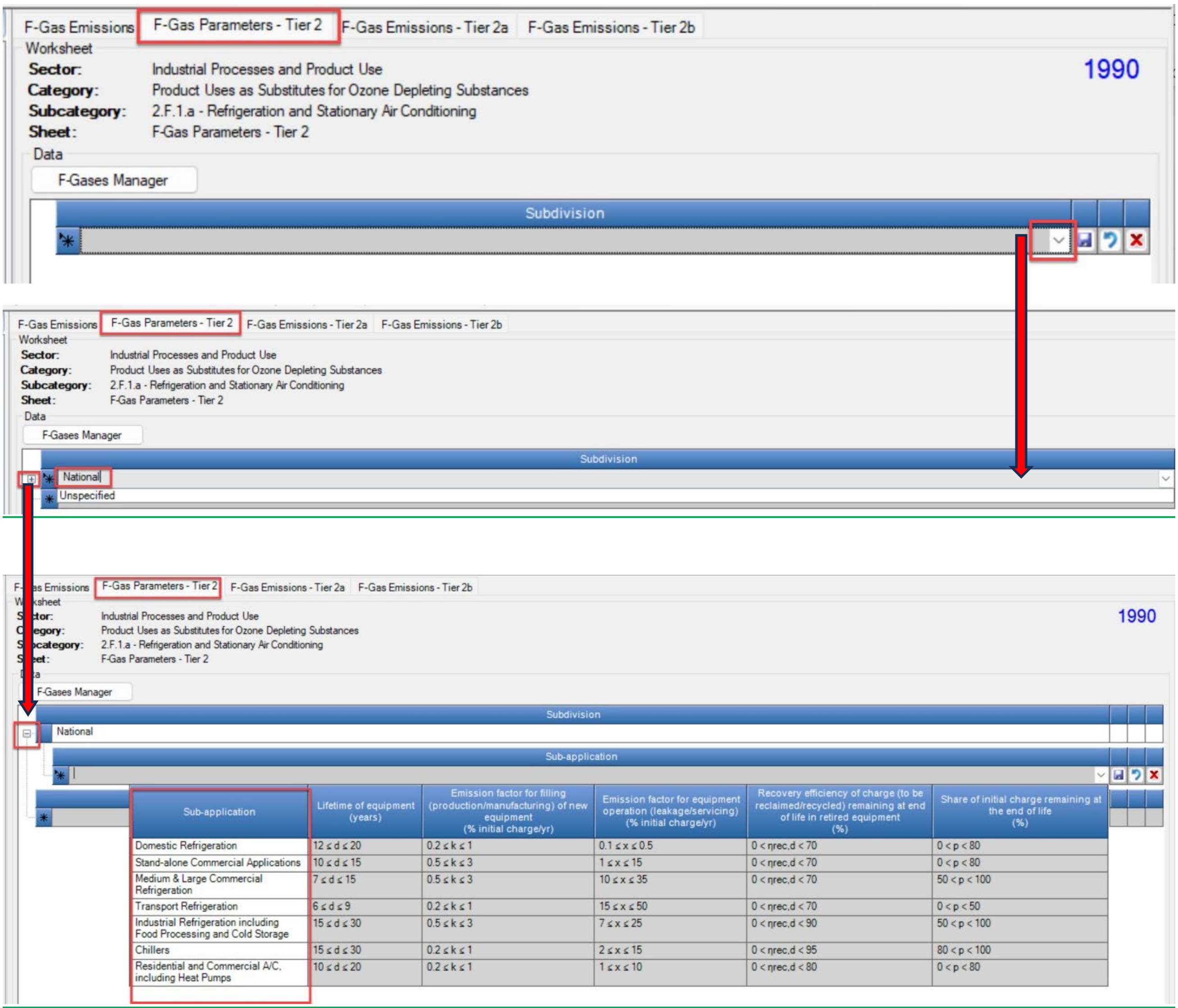
Entering subdivision(s) and sub-application(s)

At the beginning, the worksheet is empty and users need to input firstly subdivision(s) in the grey cell as follows.

1. Select the drop-down menu. If the user intends to apply a single subdivision (e.g. national) they may either leave as is (select subdivision =Unspecified) or add its univocal name/code [e.g. "country name"].
2. Then the *Software* introduces the expanding window below the entered subdivision, see [+] sign in below figure. By clicking on the [+] sign, the window explands and allows the user to enter sub-applications (domestic, commercial, etc.), which are available in the drop-down table. Users may enter country-specific sub-applications manually.

   For users intending to use the Software for reporting in the UNFCCC ETF Reporting Tool: The user should avoid changing the pre-defined sub-applications in the drop-down menu, as the existing naming convention has been used to map to the appropriate category in the UNFCCC CRT. Any additional sub-applications added by the user (or modifications of the names of existing sub-applications) will map to the source category stationary air conditioning in Table 2(II)B-Hs2 of the UNFCCC CRT.

Example: **Identifying subdivision(s)/ sub-application(s) – Tier 2**



<u>Identifying relevant F-gases/blends at the IPCC category level</u>

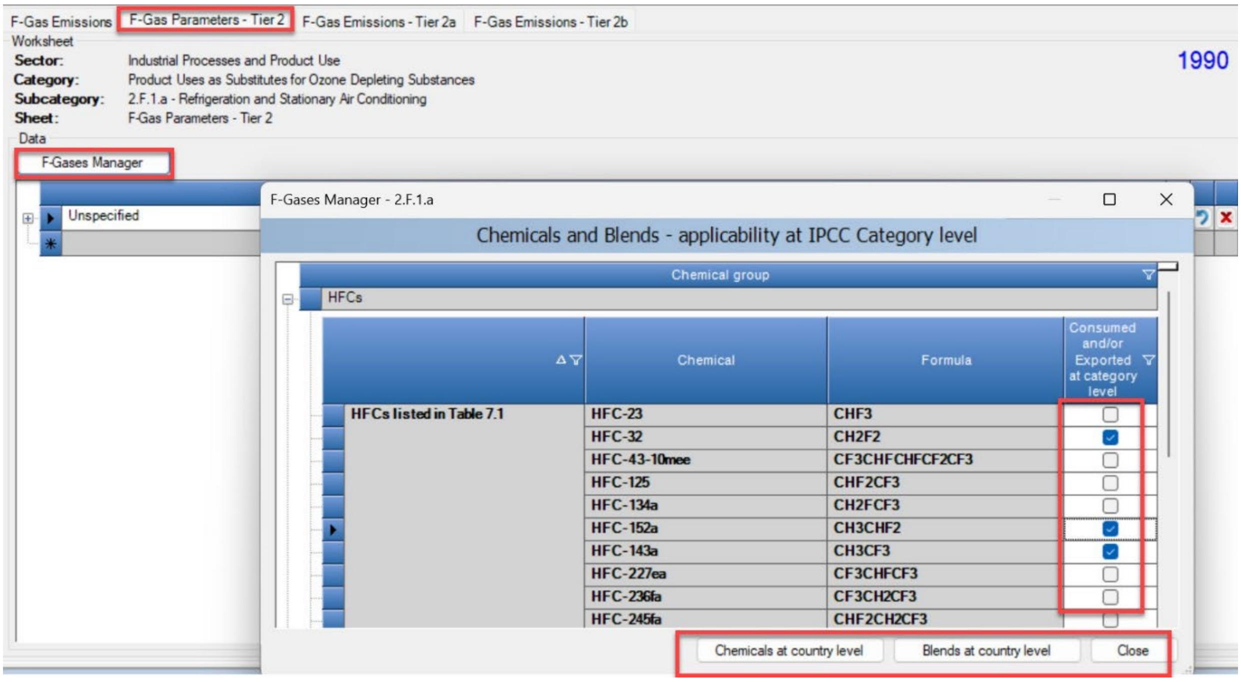
After identifying the subdivision(s) and sub-application(s), users must then identify the specific F-gases /blends consumed for Refrigeration and Air Conditioning; selected from all F-gases/blends that have already identified by the user at the national level in the **1.1.2 F-gases Manager**.

To select the F-gas(es)/blends used in this IPCC category:

1. For first time use of the *Software* it is necessary to enter F-gas(es)/blends consumed in the Refrigeration and Air Conditioning source category. To do this, select **F-Gases Manager** and check all F-gas(es)/blends consumed for refrigeration and air conditioning.
   <u>Note that</u>: the list of possible blends is also accessible in the drop-down menu, after Other GHGs.
   <u>Note that</u>: if a gas/blend is not available for selection, it is because it has not been added at the national level as a gas/blend produced/used in this country. To enter F-gases (or blends thereof) at the national level, select ***Chemicals at National Level*** *or* ***Blends at National Level*** *from the bottom.*

2. After identifying the subdivision, selecting a specific sub-application (e.g. Domestic Refrigeration in the image below), and ensuring the F-gases Manager includes all gases/blends consumed in the category, the user selects the [+] plus sign to select the F-gas(es)/blends for which emissions are to be calculated. Each F-gas /blend, is entered row by row in <u>Column |Chemical|</u>.
   <u>Note that:</u> the drop-down for chemical will be blank until a user identifies the specific F-gas(es) /blends used for the IPCC source category in previous step.

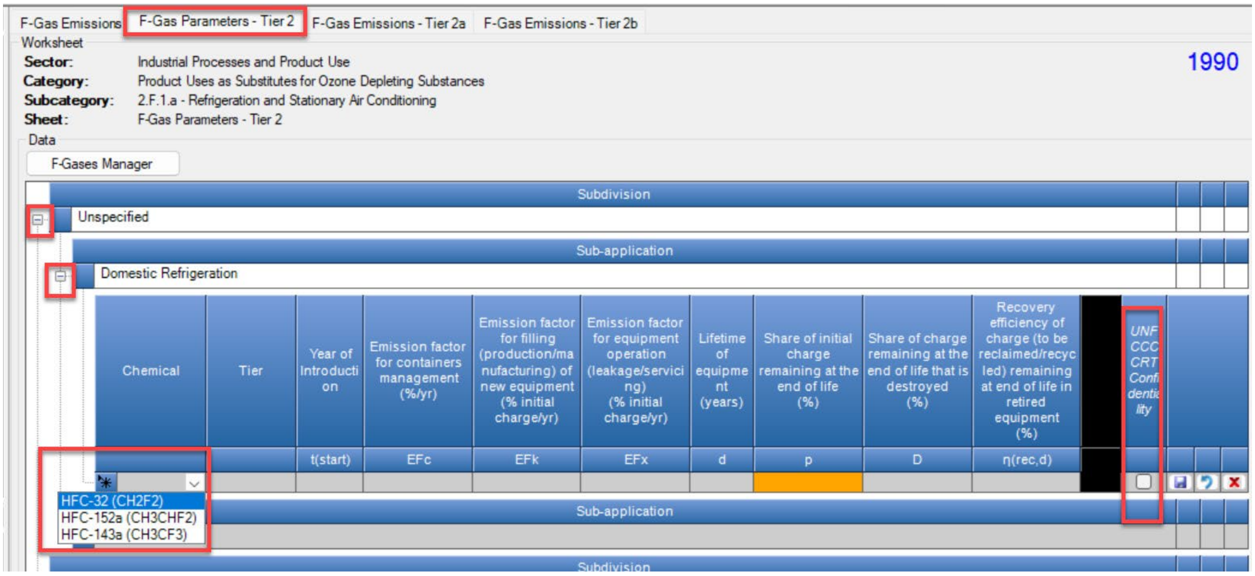
Example: **Adding F-gas(es)/blends for Tier 2**



3. For users intending to use the *Software* for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas consumed in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. For Tier 2, the designation of confidentiality occurs row by row, for each gas consumed in the subdivision/sub-application (see **Annex I: Mapping between the IPCC Inventory Software and the UNFCCC ETF Reporting Tool**).

   Note that: if checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate (for further information, see Annex I).

Example: **Populating the F-gases manager and designating confidentiality for category: refrigeration and air conditioning - Tier 2**



EF/parameters input[1]

The following sections in Chapter 7, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of EF/parameters:

- ✓ Section 7.5.2.2 contains information on the choice of EFs/parameters for Refrigeration and Air Conditioning.
- ✓ Section 7.6.2.2 contains information on the choice of EFs/parameters for Fire Protection.

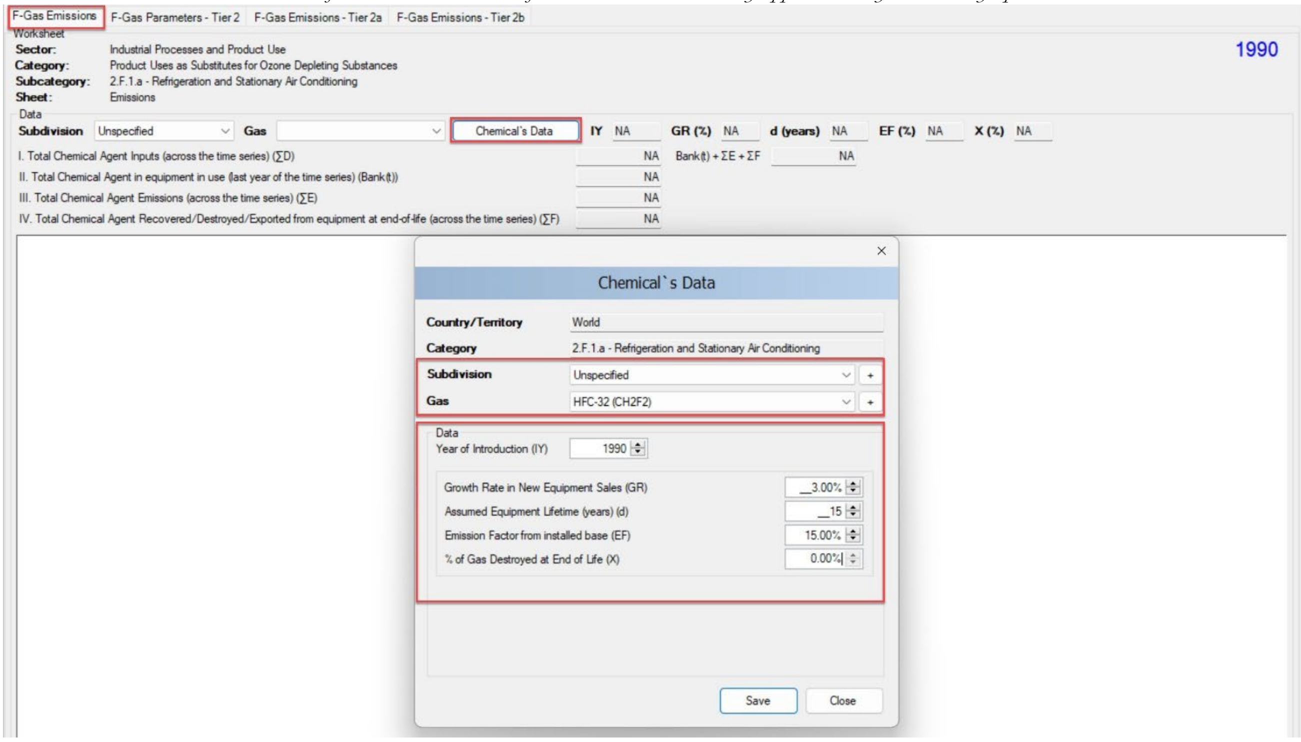
When the Tier 1 Equation is applied:

1. In worksheet **F-Gas Emissions** or **Emissions from Fire Protection,** users must click on the tab **Chemical's Data** to open a pop-up window and to enter the parameters and EFs needed for estimation of each F-gas/blend consumed in that subdivision.
2. **Gas:** user selects the relevant F-gas/blend from the drop-down menu (refer to previous section on customizing the *Software* if an additional F-gas or blend needs to be added to the drop-down menu).
3. Window |Year of Introduction|: year of introduction of the agent in the country for use in RAC (e.g., 1990).
4. Window |Growth Rate in New Equipment Sales|: growth rate in sales of new equipment, usually assumed linear across the period of assessment (e.g. 3%).
5. Window |Assumed Equipment Lifetime|: equipment lifetime - number of years:
   Note that: the average lifetime for refrigeration and air conditioning equipment is 15 years.
   Note that: for fire protection, the average lifetime is 15 years.
6. Window |Emission Factor from Installed Base|: EF from installed base or bank, in percent.
   Note that: the average EF from installed base for refrigeration and air conditioning equipment is 15 % annually.
   Note that: for fire protection, the average EF from installed base is 4% annually.
7. Window |% of Gas Destroyed at End-of-Life|: fraction of agent destroyed at the end-of-life, percent (the default assumption of 0% means no F-gas is destroyed at the end-of-life, thus all the amount in retired equipment is emitted).

[1] Unlike other source categories in the IPCC sector, this Users' Guidebook explains first the input of EF/parameter inputs, then AD inputs, due to the structure of the *Software*.

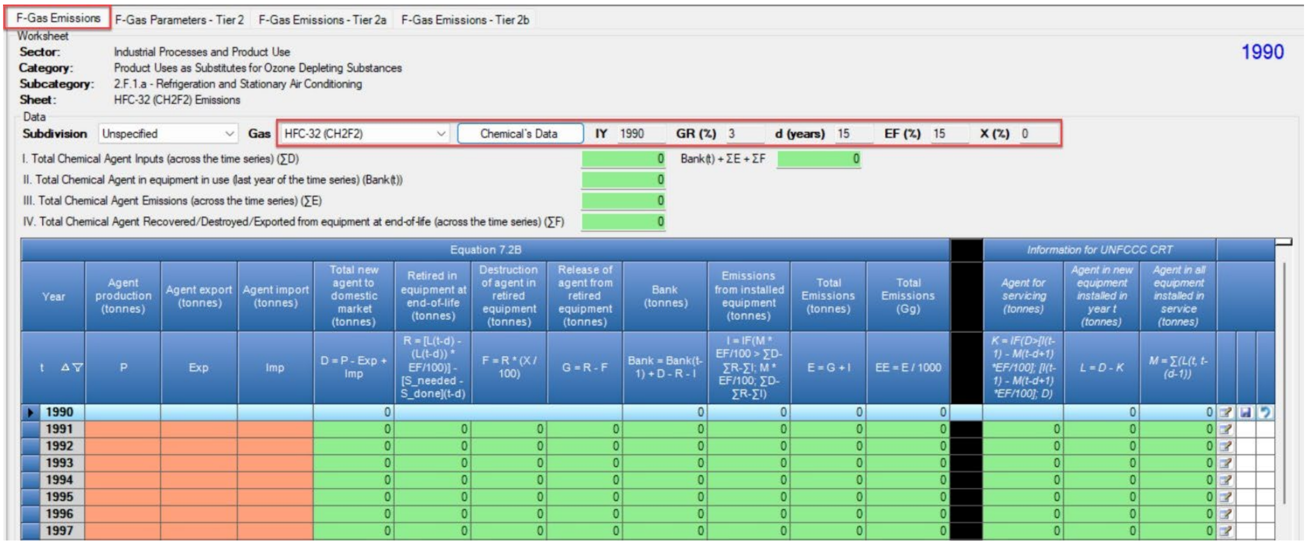
Example: **Entering EF/parameter information- Tier 1**

<u>Note that</u> this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet. The IPCC default values for Fire Protection, identified below, will automatically appear but may be manually updated.



8. Then, users need to **Save and Close** the pop-up window **Chemical's Data** to return to the worksheet and to enter agent production, export and import data. The user can see information entered in **Chemical's Data** tab in the main calculation window. In the image below, the gas consumed in the subdivision appears (i.e. HFC-32), and the parameters are visible. Input of AD (in red-orange cells) and the QA/QC check in the green cells of steps I-IV just below the gas and EF information, is explained in the next section.

Example: **Grid ready for entry of AD – Tier 1- refrigeration and air conditioning**



Example: **Grid ready for entry of AD – Tier 1- fire protection**

When Tier 2 Equations are applied (Refrigeration and Air Conditioning only)**:**

1. In worksheet **F-Gas Parameters-Tier 2,** users use the [+] plus sign to allow data entry for each subdivision/ sub-application.
2. Column |Chemical|: user selects the relevant F-gas/blend from the drop-down menu (refer to previous section on customizing the *Software* if an additional F-gas or blend needs to be added to the drop-down menu).
3. Column |Tier|: After selecting the F-gas/blend, the specific Tier 2 method applied (i.e. either Tier 2a or Tier 2b) should be selected.

Then, for different Tiers (Tier 2a and/or Tier 2b) users input the following EFs/parameters (consult Table 7.9 Chapter 7 Volume 3 of the *2006 IPCC Guidelines* for IPCC default values, if needed).

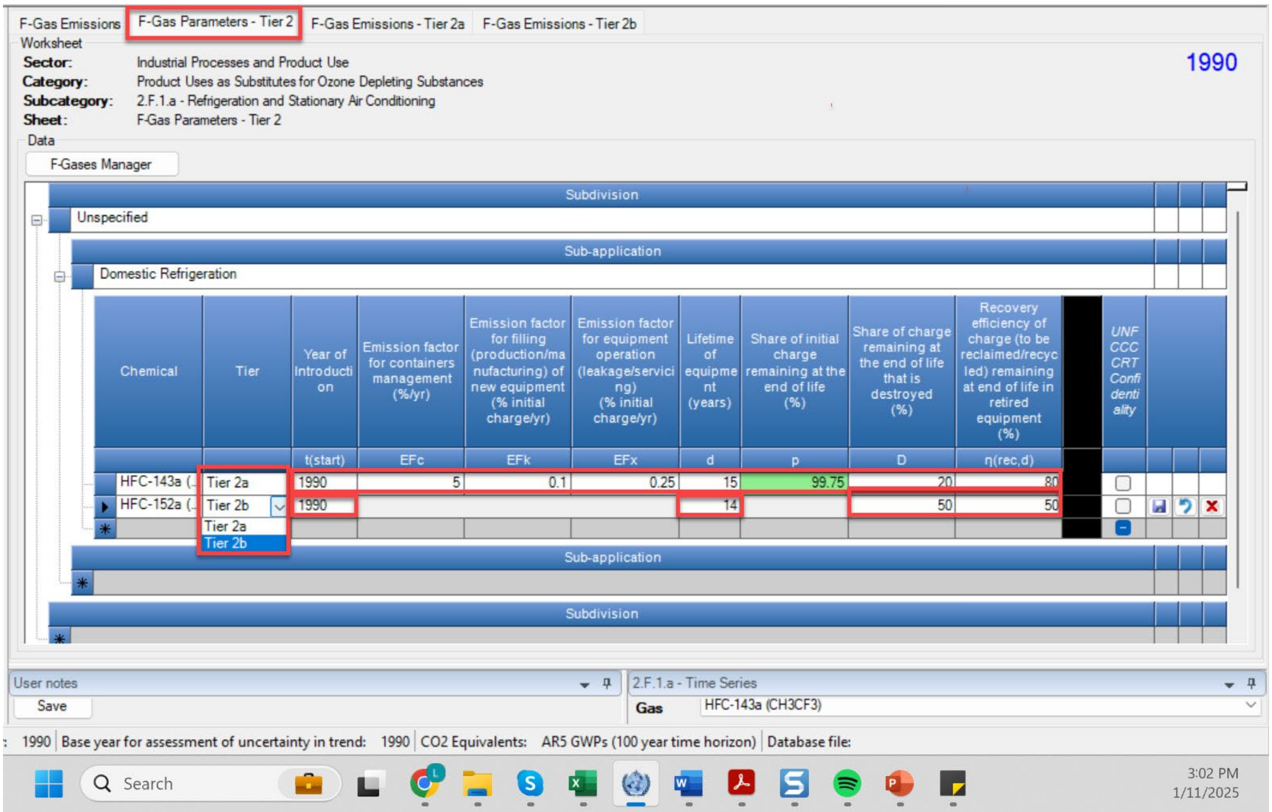
4. For Tier 2a, for each subdivision, sub-application and each F-gas/blend, enter the following information:
   a. Column |t (start)|: the year of introduction of refrigerant (F-gas/blend).
   b. Column |EFc|: EF for containers management (percent per year).
   c. Column |EFk|: EF for filling new equipment (percent of initial charge per year).
   d. Column |EFx|: EF for equipment operation (percent of initial charge per year).
   e. Column |d|: lifetime of equipment, years.
   f. Column |p|: share of initial (full) charge remaining at end-of-life, percent. *Note that: this cell requires direct entry. By default, the user should enter into this cell the value that is equal to 1-EFx. Since the annual operation EFs assume full charge, at the end of the year, the assumption is that the emissions remaining are equal to full charge minus annual operating emissions in that year. When a value equal to 1-EFx is entered into this cell, it will turn green. Additional values may be possible to account for country specific circumstances (and note the range of default p value in Table 7.9 may differ). But if alternative data are entered, the cell will turn either orange or red. An orange colour means that p estimates a quantity of charge that is less than the initial charge minus all annual losses across the period d-1, under the assumption of full servicing. A red colour means that p estimates a quantity of charge that is larger than the initial charge minus all annual losses across the period d-1, under the assumption of full servicing. If this cell turns a colour, the user should ensure that mass conservation of the gases is ensured at the end of the calculations (see discussion of the QA/QC check in the AD section below).*
   g. Column |D|: share of charge remaining at the end of life that is destroyed, percent.
   h. Column |η (rec,d)|: recovery efficiency of charge to be reclaimed/recycled, percent. *Note that: the sum of Column |D| + Column |η (rec,d)| must be ≤ 100* because gas is either emitted, destroyed or reclaimed/recycled.

5. Tier 2b: for each sub-division, sub-application and each F-gas/blend, enter the following information:
   1. Column |t (start)|: year of introduction of refrigerant (F-gas/blend).
   2. Column |d|: lifetime of equipment, years.
   3. Column |D|: share of charge remaining at the end of life that is destroyed, percent.

4. Column |η (rec,d)|: recovery efficiency at disposal, which is the ratio of recovered HFC referred to the HFC contained in the system, percent.
Note that: the sum of Column |D| + Column |η (rec,d)| must be ≤ *100* because gas is either emitted, destroyed or reclaimed/recycled.

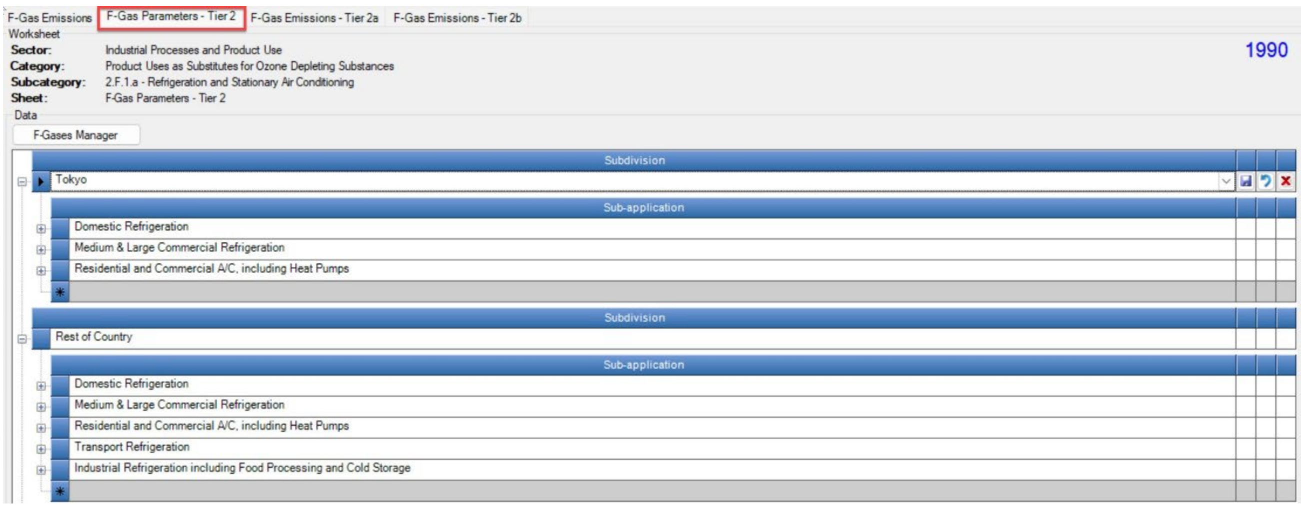
Please note that EFs are based on the initial (full) charge.

Example: **Entering EF/parameter information- Tier 2**



5. The same procedure is to be applied for all subdivisions/sub-applications.

Example: **Subdivisions and sub-applications entered for the entire category 2.F.1.a**
Note that the same table structure applies to category 2.F.1.b

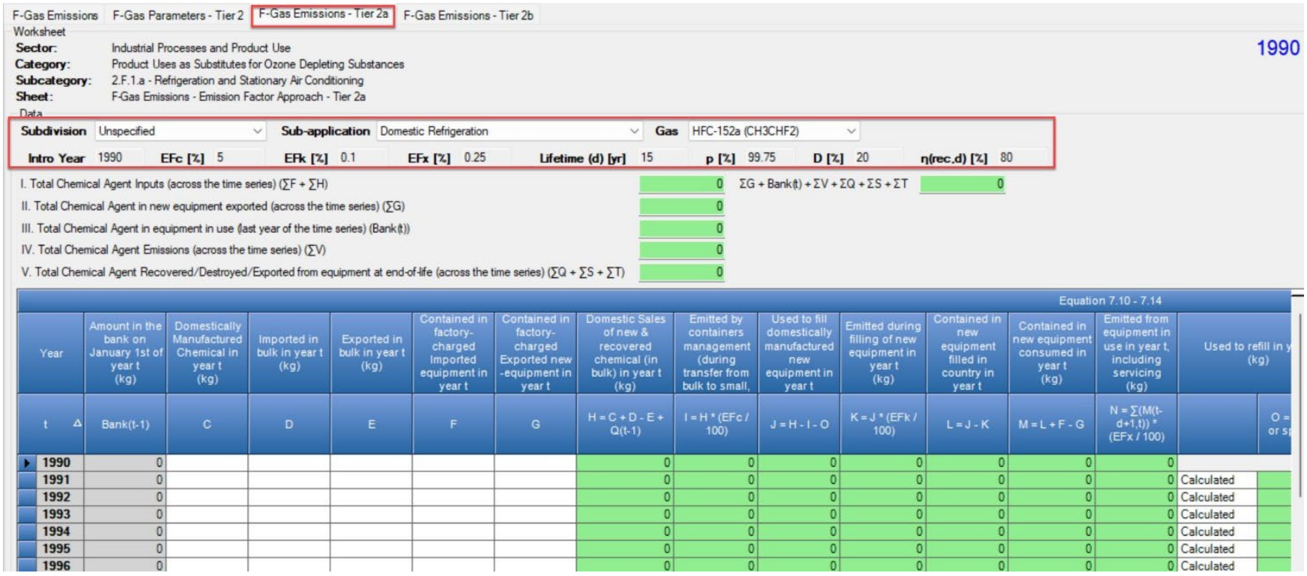


6. After EF and parameter information is entered for all subdivisions /sub-applications/ F-gases/blends, the user navigates to the worksheet **F-Gas Emissions – Tier 2a** and/or **F-Gas Emissions – Tier 2b** and

enters the corresponding AD. The user can see information entered in the **F-Gas Parameters-Tier 2** tab in the main calculation window of those worksheets. Input of AD (white cells) and the QA/QC check in green below the EFs/parameters is explained in the next section.

Note that: worksheets may be for individual F-gas species, or blends. The figure below illustrates entry of information for a blend. The blend will be disaggregated to individual F-gas species for reporting, including when preparing a JSON file for reporting to the UNFCCC ETF Reporting Tool.

Example: **Grid for ready for entry of AD – Tier 2a- refrigeration and air conditioning**



Activity data input

The following sections in Chapter 7, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of AD:

- ✓ Sections 7.5.2.3 contains information on the choice of AD for Refrigeration and Air Conditioning.
- ✓ Sections 7.6.2.3 contains information on the choice of AD for Fire Protection.

Important to highlight for data entry is the need to avoid double counting of F-gas consumption. The possibility of double counting can be mitigated in two ways:

1. **Ensure that consumption of a unique quantity of F-gases is not counted simultaneously in multiple applications**, both within Refrigeration and Air Conditioning (e.g. the same quantity of HFC-134a should not be added into worksheets for both domestic and commercial refrigeration) or across sub-categories (e.g. the same quantity should not be included in both Refrigeration and Air Conditioning (2.F.1) and Foams (2.F.2) or Fire Protection (2.F.3)). AD entered in each worksheet should be unique to that subdivision/application/sub-application.
2. **Do not count for both consumption of an F-gas species as well as the consumption of a blend that is then produced from that same quantify of F-gases.** Possible double counting can be mitigated where data are entered all as individual F-gases, or all as blends. Where both are available, care should be taken not to include the same quantity of F-gases twice in the AD.

In addition, the *Software* contains a check for categories 2.F.1, 2.F.2, 2.F.3 and 2.F. 6 (contained applications) to ensure that the data input is consistent with the fundamental principle of mass conservation of the gases. This QA/QC check appears just below the EFs/input parameters and will be discussed below after describing input of AD.

The *Software* will be updated in the future to include a validation check to indicate if the total consumption of F gases across all source categories and applications/sub-applications is equal to or less than the total supply of that F-gas, calculated as *Production of the gas + imports (bulk and equipment)+ amount recycled – exports (bulk and in equipment)– F-gases used to produce blends.*

Input of AD requires the following steps for different Tiers for both Refrigeration and Air Conditioning and Fire Protection.

When the Tier 1 Equation is applied:

As noted in the section **EF/parameters** above, parameters from the tab **Chemical's Data** will be visible in the worksheet **F-Gas Emissions** or **Emissions from Fire Protection**. Next, users need to enter the AD in the red-orange cells, by subdivision/gas, and for each year, as follows:

1. Column |t|: year t (from the year of introduction of agent to the last inventory year). This column is automatically populated based on the year of introduction of the agent in **Chemical's Data** tab.
2. Column |P|: enter the amount of the respective chemical identified in **Gas** produced for consumption in the designated subdivision. For RAC, the amount for category 2.F.1.a should be entered separately from the amount used for 2.F.1.b.
3. Column|Exp|: if applicable, enter the amount of the respective chemical identified in **Gas** that was produced for consumption in the designated subdivision, but exported, in tonnes. This amount should not be considered in the calculation of emissions.
   Note that: exports must be equal to or less than the amount produced plus imported for a given year.
4. Column|Imp|: enter the amount of the respective chemical identified in **Gas** that was imported for consumption in the designated subdivision, in tonnes.
   Note that: data on production, export and import of the agent (F-gas/blends) should be entered for the reporting (inventory) year in Column|t| and all other year(s) for which data are known and available. The Software will fill in the gaps to complete the time series, as described below.

Once known AD are input, the *Software* makes several calculations:

1. The *Software* back-calculates production, export and import back to the year of introduction, or interpolates between two known years for which data are known .
   *Note that this cell is based on the assumed parameters entered in the tab **Chemical's Data** (specifically the equipment growth rate).*
2. Column|D|: The total new agent to the market each year is estimated. A fraction of this is assumed to be used for servicing existing equipment (Column|K|) and a fraction for newly installed equipment ((Column|L|).
   Note that, if the total new agent to the market is greater than the previous year's emissions, the new agent is assumed to replace gas in equipment to compensate for all of the previous year's emissions, with any remainder used to fill new equipment. If the total new agent is less than that required to replace the previous year's emissions, all of the new agent is assumed to be used for servicing.
   Note that: information in Column|K| and Column|L| will be included in the JSON file for upload to the UNFCCC ETF Reporting Tool.
3. Column|R|: The *Software* tracks the amount of agent in retired equipment.
   Note that: following the assumption that equipment is serviced to full charge every year (see step 2), this is equal to the full initial charge of the equipment, minus operational emissions from the current year. However, in cases where the total new agent to the market is not sufficient for full servicing of emissions from the previous year (S_needed), equipment may only be partially serviced (referred to as S_done), and thus the amount in the retired equipment may be less than full charge. The Software calculates the difference between "S_needed" and "S-done" and subtracts this from the full charge less annual emissions, to calculate the amount in the retired equipment.

Example: **Calculation of S-needed and S-done for source categories 2.F.1 and 2.F.3**

N	O	P	Q	R	S	T	U	V	W
Information for CRT				HIDDEN CALCULATION					
K	L	M			N		O		P
agent for servicing	agent in new equipment installed in year t	agent in all equipment installed		needed agent across lifetime		actual agent used across time			
(tonnes)	(tonnes)	(tonnes)							
K=IF(D>$I_{(t-1)}$,$I_{(t-1)}$, D)	L=D-K	$M = \sum_{t-(d-1)}^{t} (L)$			S_neeeded				S_done
NO	D	L			NO		NO		NO
IF(D>$I_{(t-1)}$,$I_{(t-1)}$,D)	D-K	SUM($L_{t-(d-1)}$:L_t)		for equipment	L_{t-1}*(d-1)*EF/100		equal to K	for equipment X installed in a year Y	SUM(K_d) for X_{t-Y}
NO	1,000.000	1,000.000		installed in year t-13	450.000	year t-13	NO	installed in year t-13	100.000
50.000	950.000	1,950.000		installed in year t-12	427.500	year t-12	50.000	installed in year t-12	47.500
0.000	0.000	1,950.000		installed in year t-11	0.000	year t-11	0.000	installed in year t-11	0.000
97.500	902.500	2,852.500		installed in year t-10	406.125	year t-10	97.500	installed in year t-10	0.000
0.000	0.000	2,852.500		installed in year t-9	0.000	year t-9	0.000	installed in year t-9	0.000
0.000	0.000	2,852.500		installed in year t-8	0.000	year t-8	0.000	installed in year t-8	0.000
0.000	0.000	2,852.500		installed in year t-7	0.000	year t-7	0.000	installed in year t-7	0.000
0.000	0.000	2,852.500		installed in year t-6	0.000	year t-6	0.000	installed in year t-6	0.000
0.000	0.000	2,852.500		installed in year t-5	0.000	year t-5	0.000	installed in year t-5	0.000
0.000	0.000	2,852.500		installed in year t-4	0.000	year t-4	0.000	installed in year t-4	0.000
0.000	0.000	1,852.500		installed in year t-3	0.000	year t-3	0.000	installed in year t-3	0.000
0.000	0.000	902.500		installed in year t-2	0.000	year t-2	0.000	installed in year t-2	0.000
0.000	0.000	902.500		installed in year t-1	0.000	year t-1	0.000	installed in year t-1	0.000
0.000	0.000	0.000							
negative values not allowed				negative values not allowed servicing occurs across lifetime from year after installation to the end of lifetime year (so for a period					
amount of total net chemical input in year t that is used for servicing	amount of total net chemical input in year t that is used for new equpment	cumulated amount of chemical input in year t that has not reached endlife yet			cumulated amount of chemical to be serviced across lifetime of equipment X installed in the relevant year Y based on information in column L		amount of chemical serviced in a year t		cumulated amount of chemical actually serviced across lifetime of equipment X installed in the relevant year Y

Each cell calculated as: if amount needed for servicing of equipment installed in previous year is less than the agent available for servicing, then there is full servicing. If the amount of agent available for servicing is less that is needed (S_needed) then this cell is equal to the amount of agent available for servicing.

X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
to calculate actual servicing occurred in each year subsequent to the installation of the equipment installed in a year Y													
	installed in year t-13	*installed in year t-12*	*installed in year t-11*	*installed in year t-10*	*installed in year t-9*	*installed in year t-8*	*installed in year t-7*	*installed in year t-6*	*installed in year t-5*	*installed in year t-4*	*installed in year t-3*	*installed in year t-2*	*installed in year t-1*
	100.000	**47.500**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
year t-12	50.000												
year t-11	0.000	0.000											
year t-10	50.000	47.500	0.000										
year t-9	0.000	0.000	0.000	0.000									
year t-8	0.000	0.000	0.000	0.000	0.000								
year t-7	0.000	0.000	0.000	0.000	0.000	0.000							
year t-6	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
year t-5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000					
year t-4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
year t-3		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
year t-2			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
year t-1				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
					0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

4. Column|F| is the amount of agent in the retired equipment destroyed in the year of retirement. *Note that the % destroyed was added in **Chemical's Data** tab.*
5. Column|G| is the total amount of agent retired in the year, minus the amount destroyed.
6. Column|Bank|: the *Software* back-calculates the development of the bank of the agent from the current reporting year to the year of its introduction .
   *Note that the bank for a given year (t) is calculated as the sum of the bank at the end of the previous year (t-1) plus total new agent to the market in year (t), minus the amount in retired equipment in year (t), minus emissions from all installed equipment (calculated based on the lifetime entered in **Chemical's Data** tab and the amount in installed equipment).*
7. Column|I|: contains emissions from installed equipment in year t.
8. Column|E|: total emissions are calculated, in tonnes.
   Note that total emissions are calculated as emissions from installed equipment plus emissions from retired equipment.

9. Column|EE|: total emissions are calculated, in Gg.

Green cells are estimated by the *Software* and cannot be modified. Cell calculations are provided below the column header.

Ensuring mass conservation of gases

A QA/QC check has been introduced into the worksheets for categories 2.F.1, 2.F.2, 2.F.3 and 2.F.6 (contained applications only) to ensure that the data, EFs and parameters entered by the users ensure conservation of mass of gases over time.

To ensure mass conservation, the *Software* tracks and visually presents the inputs and outputs over time as follows:

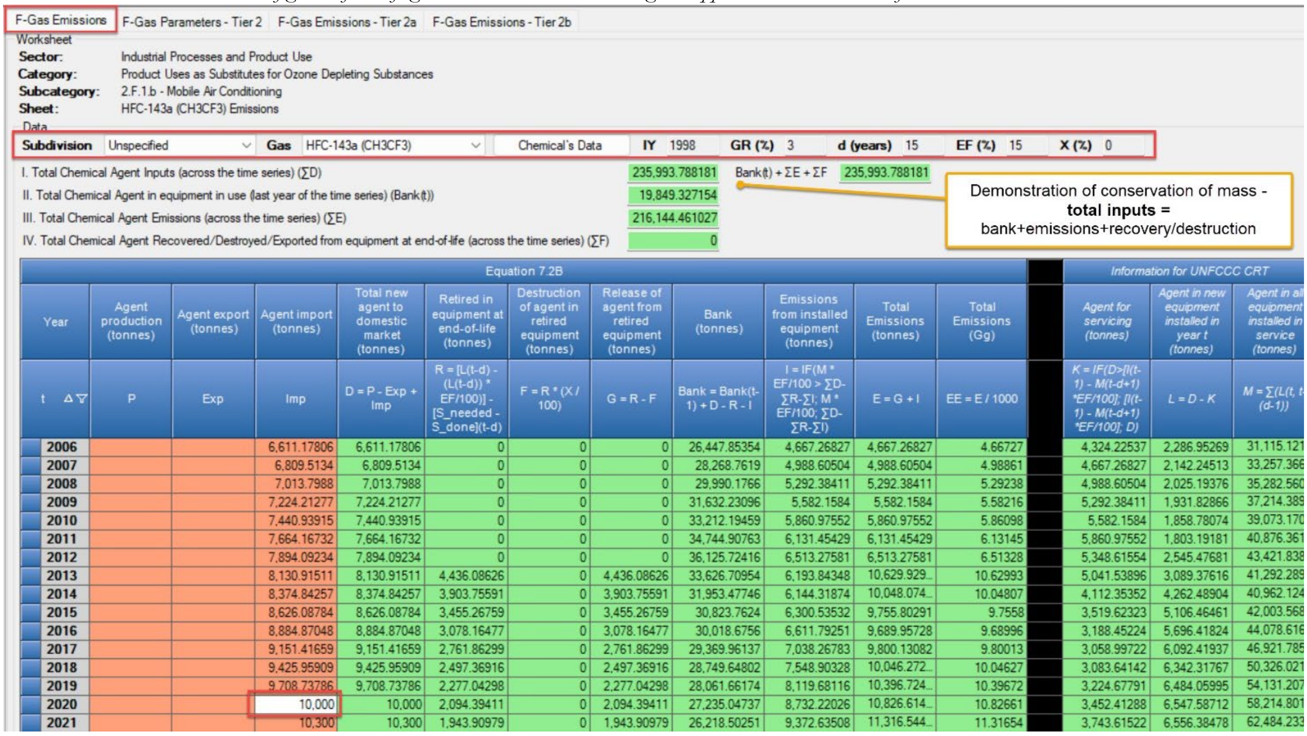
I. Total chemical agent inputs, across time (∑D)
II. Total chemical agent in equipment in use (Bank(t))
III. Total chemical agent emissions, across time (∑E)
IV. Total chemical agent recovered/destroyed/exported in equipment at end-of-life(∑F)

For Tier 1, mass conservation has been ensured if:

$$\sum D = Bank(t) + \sum E + \sum F$$

Example #1: **Import – 10 000 tonnes of HFC-143a for mobile air conditioning, no production and export in the current year 2020 (only one entry, year of introduction – 1998)**

Note that this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.


F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet
Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.b - Mobile Air Conditioning
Sheet: HFC-143a (CH3CF3) Emissions

Data
Subdivision Unspecified **Gas** HFC-143a (CH3CF3) Chemical's Data **IY** 1998 **GR (%)** 3 **d (years)** 15 **EF (%)** 15 **X (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑D) 235,993.788181 Bank(t) + ΣE + ΣF 235,993.788181
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 19,849.327154
III. Total Chemical Agent Emissions (across the time series) (∑E) 216,144.461027
IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑F) 0

Equation 7.2B												Information for UNFCCC CRT		
Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	*Agent for servicing (tonnes)*	*Agent in new equipment installed in year t (tonnes)*	*Agent in all equipment installed in service (tonnes)*
t	P	Exp	Imp	D = P - Exp + Imp	R = [L(t-d) - (L(t-d)) * EF/100)] - [S_needed - S_done](t-d)	F = R * (X / 100)	G = R - F	Bank = Bank(t-1) + D - R - I	I = IF(M * EF/100 > ∑D-∑R-∑I; M * EF/100; ∑D-∑R-∑I)	E = G + I	EE = E / 1000	*K = IF(D>[I(t-1) - M(t-d+1) *EF/100]; [I(t-1) - M(t-d+1) *EF/100]; D)*	*L = D - K*	*M = ∑(L(t, t-(d-1))*
2006			6,611.17806	6,611.17806	0	0	0	26,447.85354	4,667.26827	4,667.26827	4.66727	4,324.22537	2,286.95269	31,115.121
2007			6,809.5134	6,809.5134	0	0	0	28,268.7619	4,988.60504	4,988.60504	4.98861	4,667.26827	2,142.24513	33,257.366
2008			7,013.7988	7,013.7988	0	0	0	29,990.1766	5,292.38411	5,292.38411	5.29238	4,988.60504	2,025.19376	35,282.560
2009			7,224.21277	7,224.21277	0	0	0	31,632.23096	5,582.1584	5,582.1584	5.58216	5,292.38411	1,931.82866	37,214.389
2010			7,440.93915	7,440.93915	0	0	0	33,212.19459	5,860.97552	5,860.97552	5.86098	5,582.1584	1,858.78074	39,073.170
2011			7,664.16732	7,664.16732	0	0	0	34,744.90763	6,131.45429	6,131.45429	6.13145	5,860.97552	1,803.19181	40,876.361
2012			7,894.09234	7,894.09234	0	0	0	36,125.72416	6,513.27581	6,513.27581	6.51328	5,348.61554	2,545.47681	43,421.838
2013			8,130.91511	8,130.91511	4,436.08626	0	4,436.08626	33,626.70954	6,193.84348	10,629.929...	10.62993	5,041.53896	3,089.37616	41,292.289
2014			8,374.84257	8,374.84257	3,903.75591	0	3,903.75591	31,953.47746	6,144.31874	10,048.074...	10.04807	4,112.35352	4,262.48904	40,962.124
2015			8,626.08784	8,626.08784	3,455.26759	0	3,455.26759	30,823.7624	6,300.53532	9,755.80291	9.7558	3,519.62323	5,106.46461	42,003.568
2016			8,884.87048	8,884.87048	3,078.16477	0	3,078.16477	30,018.6756	6,611.79251	9,689.95728	9.68996	3,188.45224	5,696.41824	44,078.616
2017			9,151.41659	9,151.41659	2,761.86299	0	2,761.86299	29,369.96137	7,038.26783	9,800.13082	9.80013	3,058.99722	6,092.41937	46,921.785
2018			9,425.95909	9,425.95909	2,497.36916	0	2,497.36916	28,749.64802	7,548.90328	10,046.272...	10.04627	3,083.64142	6,342.31767	50,326.021
2019			9,708.73786	9,708.73786	2,277.04298	0	2,277.04298	28,061.66174	8,119.68116	10,396.724...	10.39672	3,224.67791	6,484.05995	54,131.207
2020			10,000	10,000	2,094.39411	0	2,094.39411	27,235.04737	8,732.22026	10,826.614...	10.82661	3,452.41288	6,547.58712	58,214.801
2021			10,300	10,300	1,943.90979	0	1,943.90979	26,218.50251	9,372.63508	11,316.544...	11.31654	3,743.61522	6,556.38478	62,484.233

Note that:

1. White cells show where data were entered manually.
2. In the red-orange cells the *Software* interpolates or back-calculates the input. The user should use caution in modifying any red-orange cells, unless data are known. If data are manually entered in an interim year, the *Software* will recalculate the trend between the two known data entry points. **DO NOT ADD ZERO** unless "0" is the known value, as the *Software* will interpolate values assuming the zero. To delete an incorrect entry, instead of using zero, simply delete/clear the value from the cell.
3. Green cells are calculated by the *Software* – they cannot be modified.
4. Note conservation of mass, 235,993 tonnes of HFC-143a were input into mobile refrigeration and air conditioning and the same amount either remains in equipment, was emitted, or is destroyed/recovered/exported in equipment.

Example #2: **AD available only for four years – 2005, 2010, 2015 and 2020 (year of introduction – 1998, current reporting year – 2020)**

<u>Note that</u> this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.

F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.b - Mobile Air Conditioning
Sheet: HFC-143a (CH3CF3) Emissions

Data

Subdivision Unspecified **Gas** HFC-143a (CH3CF3) Chemical's Data **IY** 1998 **GR (%)** 3 **d (years)** 15 **EF (%)** 15 **X (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑D) 150,470.046241 Bank(t) + ΣE + ΣF 150,470.046241
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 40,408.788799
III. Total Chemical Agent Emissions (across the time series) (∑E) 110,061.257442
IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑F) 0

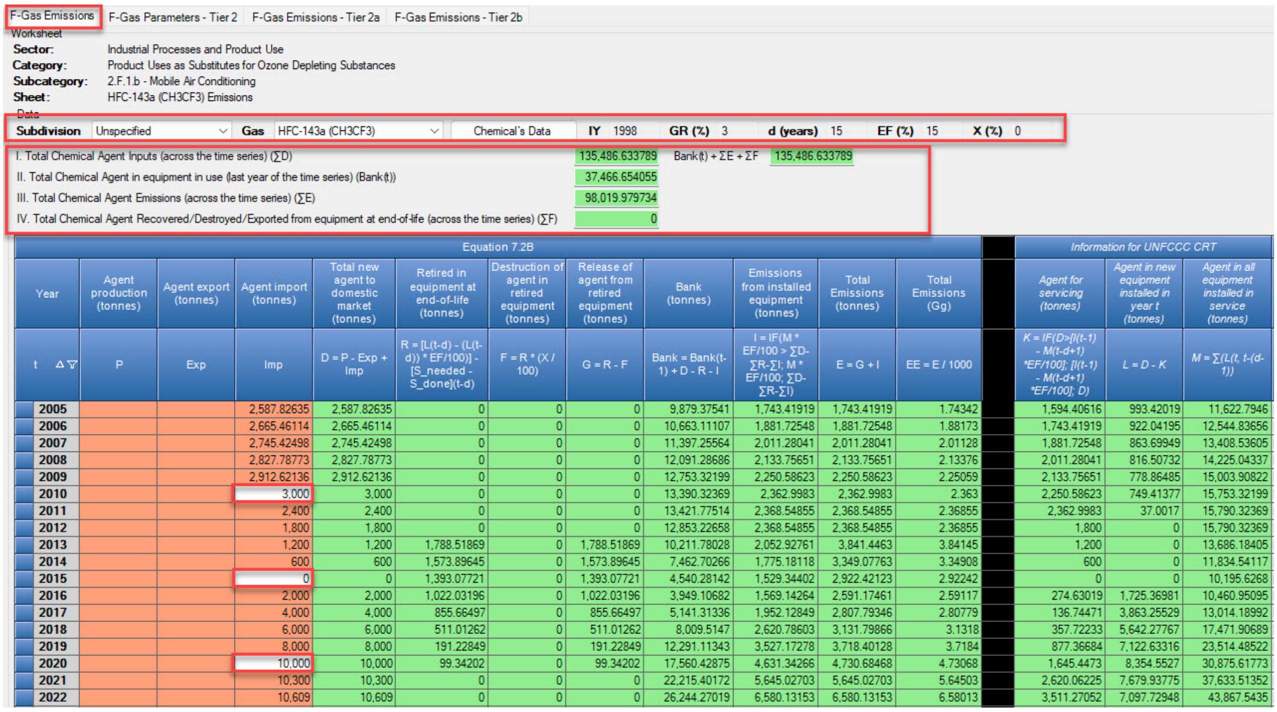
Equation 7.2B												Information for UNFCCC CRT		
Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	Agent for servicing (tonnes)	Agent in new equipment installed in year t (tonnes)	Agent in all equipment installed in service (tonnes)
t	P	Exp	Imp	D = P - Exp + Imp	R = [L(t-d) - (L(t-d)) * EF/100)] - [S_needed - S_done](t-d)	F = R * (X / 100)	G = R - F	Bank = Bank(t-1) + D - R - I	I = IF(M * EF/100 > ∑D-∑R-∑I; M * EF/100; ∑D-∑R-∑I)	E = G + I	EE = E / 1000	K = IF(D>[I(t-1) - M(t-d+1) *EF/100]; [I(t-1) - M(t-d+1) *EF/100]; D)	L = D - K	M = ∑(L(t, t-(d-1))
2000			1,293.91318	1,293.91318	0	0	0	2,756.4595	486.43403	486.43403	0.48643	343.93771	949.97547	3,242.89353
2001			1,332.73057	1,332.73057	0	0	0	3,475.81156	613.37851	613.37851	0.61338	486.43403	846.29654	4,089.19007
2002			1,372.71249	1,372.71249	0	0	0	4,121.24544	727.27861	727.27861	0.72728	613.37851	759.33398	4,848.52405
2003			1,413.89386	1,413.89386	0	0	0	4,704.86841	830.2709	830.2709	0.83027	727.27861	686.61526	5,535.13931
2004			1,456.31068	1,456.31068	0	0	0	5,237.00223	924.17686	924.17686	0.92418	830.2709	626.03978	6,161.17909
2005			1,500	1,500	0	0	0	5,726.45189	1,010.55033	1,010.55033	1.01055	924.17686	575.82314	6,737.00223
2006			1,800	1,800	0	0	0	6,397.48411	1,128.96778	1,128.96778	1.12897	1,010.55033	789.44967	7,526.45189
2007			2,100	2,100	0	0	0	7,222.86149	1,274.62262	1,274.62262	1.27462	1,128.96778	971.03222	8,497.48411
2008			2,400	2,400	0	0	0	8,179.43227	1,443.42922	1,443.42922	1.44343	1,274.62262	1,125.37738	9,622.86149
2009			2,700	2,700	0	0	0	9,247.51743	1,631.91484	1,631.91484	1.63191	1,443.42922	1,256.57078	10,879.432...
2010			3,000	3,000	0	0	0	10,410.38981	1,837.12761	1,837.12761	1.83713	1,631.91484	1,368.08516	12,247.517...
2011			3,400	3,400	0	0	0	11,738.83134	2,071.55847	2,071.55847	2.07156	1,837.12761	1,562.87239	13,810.389...
2012			3,800	3,800	0	0	0	13,180.5648	2,358.26654	2,358.26654	2.35827	1,888.61288	1,911.38712	15,721.776...
2013			4,200	4,200	1,036.69168	0	1,036.69168	13,840.7015	2,503.17163	3,539.8633	3.53986	2,014.32883	2,185.67117	16,687.810...
2014			4,600	4,600	912.28868	0	912.28868	14,798.74396	2,729.66887	3,641.95754	3.64196	2,016.7376	2,583.2624	18,197.792...
2015			5,000	5,000	807.47915	0	807.47915	15,971.53582	3,019.72899	3,827.20814	3.82721	2,116.29036	2,883.70964	20,131.526...
2016			6,000	6,000	719.35206	0	719.35206	17,803.2668	3,448.91695	4,168.26901	4.16827	2,292.45039	3,707.54961	22,992.779...
2017			7,000	7,000	645.43388	0	645.43388	20,165.61297	3,992.21995	4,637.65383	4.63765	2,618.64606	4,381.35394	26,614.799...
2018			8,000	8,000	583.62297	0	583.62297	22,952.96881	4,629.0212	5,212.64417	5.21264	3,068.04308	4,931.95692	30,860.141...
2019			9,000	9,000	532.13382	0	532.13382	26,078.49039	5,342.3446	5,874.47842	5.87448	3,618.47086	5,381.52914	35,615.630...
2020			10,000	10,000	489.44967	0	489.44967	29,465.07612	6,123.96461	6,613.41427	6.61341	4,213.37682	5,786.62318	40,826.430...
2021			10,300	10,300	671.03222	0	671.03222	32,270.89804	6,823.14586	7,494.17807	7.49418	4,849.34199	5,450.65801	45,487.639...

Note that:

1. As noted above, only enter 0 for a cell if this is the known value (for production, export and import).
2. If zero is entered, the *Software* understands that in that year there was no production/export/import and the *Software* back-calculates the data assuming zero production/export/import. It will be a white cell.
3. If nothing is entered for a given year, the cell remains red-orange and the *Software* interpolates that cell assuming inputs in other years.
4. Note conservation of mass, 150,470 tonnes of HFC-143a were input into mobile refrigeration and air conditioning and the same amount either remains in equipment, was emitted, or is destroyed/recovered/exported in equipment.

Example #3: **AD for 2020 and 2010, zero AD (2015) and user AD removed (2005)**

Note that this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.



F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.b - Mobile Air Conditioning
Sheet: HFC-143a (CH3CF3) Emissions

Data

Subdivision Unspecified **Gas** HFC-143a (CH3CF3) Chemical's Data **IY** 1998 **GR (%)** 3 **d (years)** 15 **EF (%)** 15 **X (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑D) 135,486.633789 Bank(t) + ΣE + ΣF 135,486.633789
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 37,466.654055
III. Total Chemical Agent Emissions (across the time series) (∑E) 98,019.979734
IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑F) 0

Equation 7.2B												Information for UNFCCC CRT		
Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	Agent for servicing (tonnes)	Agent in new equipment installed in year t (tonnes)	Agent in all equipment installed in service (tonnes)
t	P	Exp	Imp	D = P - Exp + Imp	R = [L(t-d) - (L(t-d)) * EF/100)] - [S_needed - S_done](t-d)	F = R * (X / 100)	G = R - F	Bank = Bank(t-1) + D - R - I	I = IF(M * EF/100 > ∑D-∑R-∑I; M * EF/100; ∑D-∑R-∑I)	E = G + I	EE = E / 1000	K = IF(D>[I(t-1) - M(t-d+1) *EF/100]; [I(t-1) - M(t-d+1) *EF/100]; D)	L = D - K	M = ∑(L(t, t-(d-1))
2005			2,587.82635	2,587.82635	0	0	0	9,879.37541	1,743.41919	1,743.41919	1.74342	1,594.40616	993.42019	11,622.7946
2006			2,665.46114	2,665.46114	0	0	0	10,663.11107	1,881.72548	1,881.72548	1.88173	1,743.41919	922.04195	12,544.83656
2007			2,745.42498	2,745.42498	0	0	0	11,397.25564	2,011.28041	2,011.28041	2.01128	1,881.72548	863.69949	13,408.53605
2008			2,827.78773	2,827.78773	0	0	0	12,091.28686	2,133.75651	2,133.75651	2.13376	2,011.28041	816.50732	14,225.04337
2009			2,912.62136	2,912.62136	0	0	0	12,753.32199	2,250.58623	2,250.58623	2.25059	2,133.75651	778.86485	15,003.90822
2010			3,000	3,000	0	0	0	13,390.32369	2,362.9983	2,362.9983	2.363	2,250.58623	749.41377	15,753.32199
2011			2,400	2,400	0	0	0	13,421.77514	2,368.54855	2,368.54855	2.36855	2,362.9983	37.0017	15,790.32369
2012			1,800	1,800	0	0	0	12,853.22658	2,368.54855	2,368.54855	2.36855	1,800	0	15,790.32369
2013			1,200	1,200	1,788.51869	0	1,788.51869	10,211.78028	2,052.92761	3,841.4463	3.84145	1,200	0	13,686.18405
2014			600	600	1,573.89645	0	1,573.89645	7,462.70266	1,775.18118	3,349.07763	3.34908	600	0	11,834.54117
2015			0	0	1,393.07721	0	1,393.07721	4,540.28142	1,529.34402	2,922.42123	2.92242	0	0	10,195.6268
2016			2,000	2,000	1,022.03196	0	1,022.03196	3,949.10682	1,569.14264	2,591.17461	2.59117	274.63019	1,725.36981	10,460.95095
2017			4,000	4,000	855.66497	0	855.66497	5,141.31336	1,952.12849	2,807.79346	2.80779	136.74471	3,863.25529	13,014.18992
2018			6,000	6,000	511.01262	0	511.01262	8,009.5147	2,620.78603	3,131.79866	3.1318	357.72233	5,642.27767	17,471.90689
2019			8,000	8,000	191.22849	0	191.22849	12,291.11343	3,527.17278	3,718.40128	3.7184	877.36684	7,122.63316	23,514.48522
2020			10,000	10,000	99.34202	0	99.34202	17,560.42875	4,631.34266	4,730.68468	4.73068	1,645.4473	8,354.5527	30,875.61773
2021			10,300	10,300	0	0	0	22,215.40172	5,645.02703	5,645.02703	5.64503	2,620.06225	7,679.93775	37,633.51352
2022			10,609	10,609	0	0	0	26,244.27019	6,580.13153	6,580.13153	6.58013	3,511.27052	7,097.72948	43,867.5435

In the above example, user-specific import information has been added for 2010 (3,000 tonnes), 2015 (0 tonnes) and 2020 (10,000 tonnes). The *Software* understands that AD are available for three years 2020, 2015 and 2010 and interpolates data between 2020 and 2015 from 10000 tonnes to 0 and between 2015 and 2010 from 0 to 3000 tonnes. From 2010 back to 1998 (the year of introduction) the *Software* extrapolates backwards based on the data entered in 2010 and the provided growth rate of new equipment (3%).

When Tier 2 Equations are applied (Refrigeration and Air Conditioning only)**:**

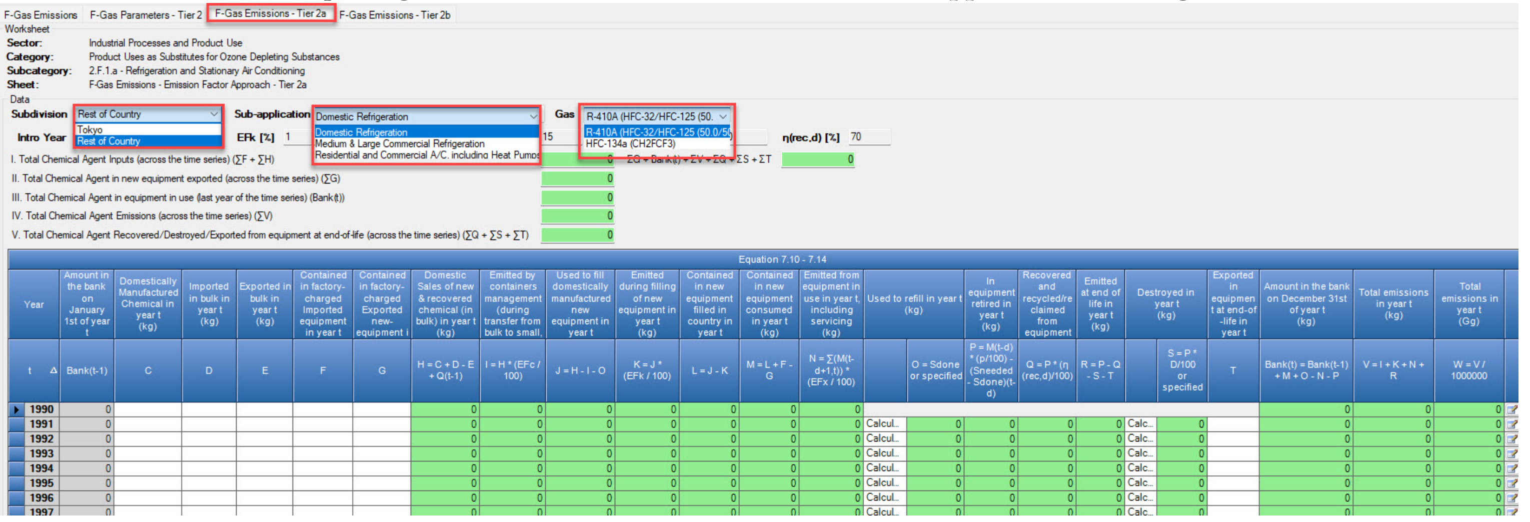
As noted in the section **EF/parameters** above, parameters from the tab **F-Gas Parameters – Tier 2** will be visible in the worksheets **F-Gas Emissions – Tier 2a** and **F-Gas Emissions – Tier 2b**. Next, users need to enter the AD in the white cells of these worksheets for each year, as applicable.

Tier 2a:

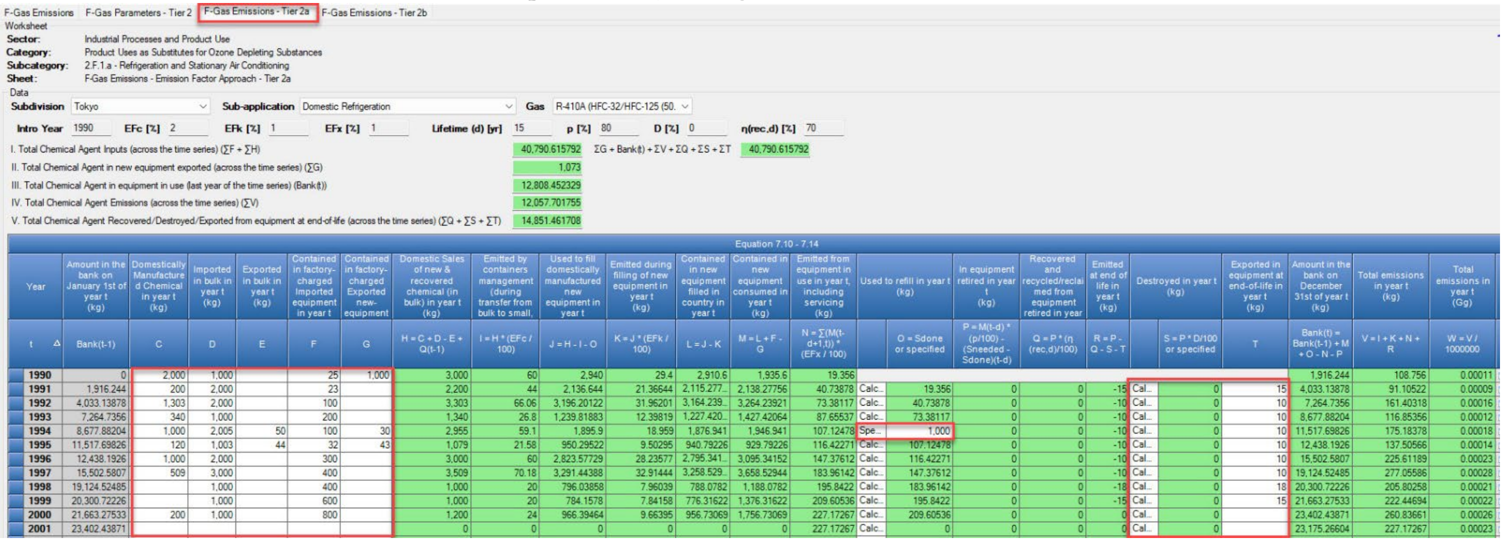
If Tier 2a was specified in the worksheet **F-Gas Parameters – Tier 2**, then the worksheet **F-gas Emissions – Tier 2a** will be active, so that users can select subdivisions, sub-applications and F-gases/blends and estimate emissions. Data are entered as follows:

1. Users first need to select subdivision, then sub-application and F-gas/blend for which AD are to be entered. *Note that if a subdivision/sub-application/F-gas / blend is not available for selection, the user should refer back to the description for Tier 2 in Customizing the Software for Refrigeration and Air Conditioning: subdivision/sub-application/F-gases*
2. Then for each subdivision, sub-application and F-gas/blend for which Tier 2a was specified in the worksheet **F-Gas Parameters – Tier 2**, users need to populate AD in the white cells of worksheet **F-gas Emissions – Tier 2a**.

Example: **F-gas Emissions – Tier 2a (subdivisions, sub-applications and F-gases)**



Example: **AD Input: F-gas Emissions – Tier 2a**



AD are entered for each subdivision/sub-application/ F gas/blend, and for each year (based on the year of introduction of the refrigerant) in worksheet **F-Gas Emissions – Tier 2a,** as follows:

Note that: the Tier 2a worksheet requires AD entry for each year, it does not interpolate data as in Tier 1. If there is a need to apply IPCC splicing techniques to fill data gaps, this should be done outside the Software, and the results manually input.

1. Column |C|: amount of domestically manufactured F-gas/blend used in that subdivision/sub-application, in year t, kg
2. Column |D|: amount imported in bulk in year t, kg
3. Column |E|: amount exported in bulk in year t, kg
   Note that: bulk exports must be equal to or less than the amount produced plus imported for a given year, otherwise the QA/QC check that appears below the EF/parameters will turn orange, indicating that mass of F-gases is not conserved (see discussion below Ensuring mass conservation of gases).
4. Column |F|: amount contained in factory-charged imported equipment in year t, kg
5. Column |G|: amount contained in factory-charged exported new-equipment in year t, kg.
6. Column |O|: amount used to refill equipment in year t, kg. In Column |O| there is a drop-down menu for two options:
   a. *Calculated* (green cell) – the *Software* estimates the amount of gas available for refill of operating equipment. The *Software* calculates the amount for servicing as equal to the losses from operating equipment in the previous year, plus any additional servicing needs for operating equipment that could not be met by gas sales in previous years (i.e. if servicing needs in a previous year could not be met by new gas sales in that year, there is a deficit and the new sales in the current year are used to meet that deficit).
      - If domestic sales for the year (Column |H|) are equal to or greater than the servicing needs, the full service needs are met, and any remaining gas is used to fill domestically sold equipment in the current year (Column |J|).
      - If domestic sales for that year (Column |H|) are less than the servicing needs, all domestic sales are used to refill equipment and no gas is used to fill domestically sold equipment in the current year (Column |J|).
   b. *Specified* (white cell) – users enter country-specific AD manually.
7. Column |S|: amount destroyed in year t, kg. In Column |S| there is a drop-down menu for two options:
   a. *Calculated* (green cell) – the *Software* estimates the amount of gas destroyed in year t. The *Software* calculates the amount destroyed as equal to the amount of gas contained in the retired equipment, Column |P| (taking into account whether that equipment was fully serviced up to the time of retirement), and the share of the remaining charge that is entered by the user (D) in the worksheet **F-Gas Parameters – Tier 2.**
   b. *Specified* (white cell) – users enter country-specific AD manually.
8. Column |T|: amount exported in used equipment in year t, kg.

Once AD are input, the *Software* makes several calculations in green cells (these cannot be modified):

9. Column |Bank $_{(t-1)}$|: amount in the bank (i.e. the amount of refrigerant stored in products) on January 1st of year t, kg.
   Note that this column is automatically calculated and is equal to the bank at the end of the previous year.
10. Column |H|: domestic sales of new chemical (in bulk) in year t, kg.
    Note that this cell is calculated as total domestic manufactured F-gas/blend, plus import (bulk), minus exports (bulk), plus any refrigerant recovered and recycled/reclaimed from the previous year.
11. Column |I|: emitted by containers management (during transfer from bulk to small, and as leftover if not recovered), kg.
    *Note that this cell is calculated as the total amount of domestic sales in year (t) multiplied by the EF for containers |EFc|, as indicated in worksheet **F-Gas Parameters- Tier 2** (2% in this example).*
12. Column |J|: amount used to fill domestically manufactured new equipment in year t, kg.
    Note that this cell is calculated as the total domestic sales in year (t) minus any emissions from filling of containers, minus the amount used to service/refill other equipment.
13. Column |K|: emitted during filling of new equipment in year t, kg.
    *Note that this cell is calculated as the amount in Column |J| multiplied by the EF for filling |EFk|, as indicated in worksheet **F-Gas Parameters- Tier 2** (1% in this example).*
14. Column |L|: amount contained in new equipment filled in country in year t, kg.
    Note that this cell is calculated as the total amount used to fill new equipment minus emissions from filling.

15. Column |M|: amount contained in new equipment consumed in year t (i.e. going to the bank), kg.
Note that this cell is calculated as the amount in new equipment, plus gas contained in imports of new equipment, minus agent exported in new equipment.
16. Column |N|: amount emitted from equipment in use in year t, kg.
*Note that this cell is calculated as the sum of agent in all equipment in use, based on the lifetime selected in worksheet **F-Gas Parameters- Tier 2** (15 years in this example), and EF |EFx| for equipment operation in the same worksheet (1% in the example).*
17. Column |P|: amount in equipment retired in year t, kg.
*Note that this cell is calculated based on the amount of agent in equipment reaching the end of its lifetime, based on the lifetime added in worksheet **F-Gas Parameters- Tier 2,** and the share of initial charge remaining in the equipment provided in that same worksheet |p| (80% in this example), taking into account whether there was sufficient agent to fully service the equipment.*
18. Column |Q|: amount recovered and recycled/reclaimed from equipment retired in year t, kg.
*Note that this cell is calculated based on the agent in equipment reaching the end of its lifetime Column |P| and the percentage of that which is recycled/reclaimed |η (rec,d)|, provided by the user in worksheet **F-Gas Parameters- Tier 2,** (70% in this example).*
19. Column |R|: amount emitted at end of life in year t, kg.
Note that this cell is calculated as the total amount in the retired equipment, less any agent recovered/recycled, destroyed, or exported in equipment to another country.
20. Column |$Bank_{(t)}$|: amount in the bank on December 31st of year t, kg.
Note that this cell is calculated as the bank in the beginning of the year plus the amount contained in new equipment going to the bank in that year, plus the amount used to refill/service existing equipment, minus emissions from equipment in use during the year, minus the amount in retired equipment.
21. Column |V|: total emissions in year t, kg.
Note that this cell is calculated as the sum of emissions from containers, equipment filling, equipment in use, and at end of life.
22. Column |W|: total emissions in year t, Gg

Ensuring mass conservation of gases in Tier 2a

A QA/QC check has been introduced into the worksheets for categories 2.F.1, 2.F.2, 2.F.3 and 2.F.6 (contained applications only) to ensure that the data, EFs and parameters entered by the users ensure conservation of mass of gases over time.

To ensure mass conservation, the *Software* tracks and visually presents the inputs and outputs over time as follows:

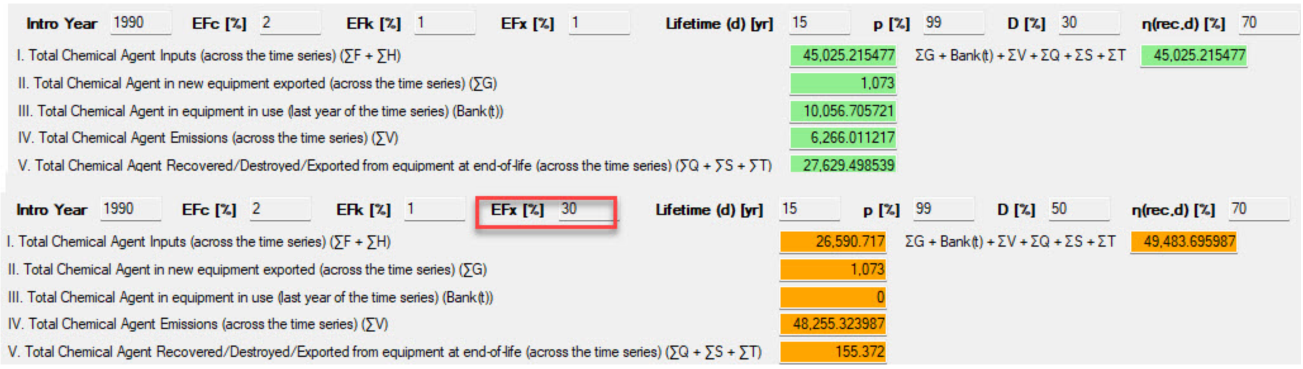
I. Total chemical agent inputs, across time (∑F+∑H)
II. Total chemical agent in new equipment exported, across time (∑G)
III. Total chemical agent in equipment in use, (last year of the time series) (Bank(t))
IV. Total chemical agent emissions, across time (∑V)
V. Total chemical agent recovered/destroyed/exported in equipment at the end of life (∑Q+∑S+∑T)

In the case of Tier 2a, mass conservation has been ensured if:

$$\sum F+\sum H = \sum G + Bank(t) + \sum V + \sum Q+\sum S+\sum T$$

If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading, refer back to worksheet F-Gas Parameters to ensure that all parameters are coherent.

Example: **Demonstration of mass conservation – Tier 2a**
Note that the change of EFx from 1 to 30 results in incoherent inputs and outputs greater than inputs, thus the check became orange.

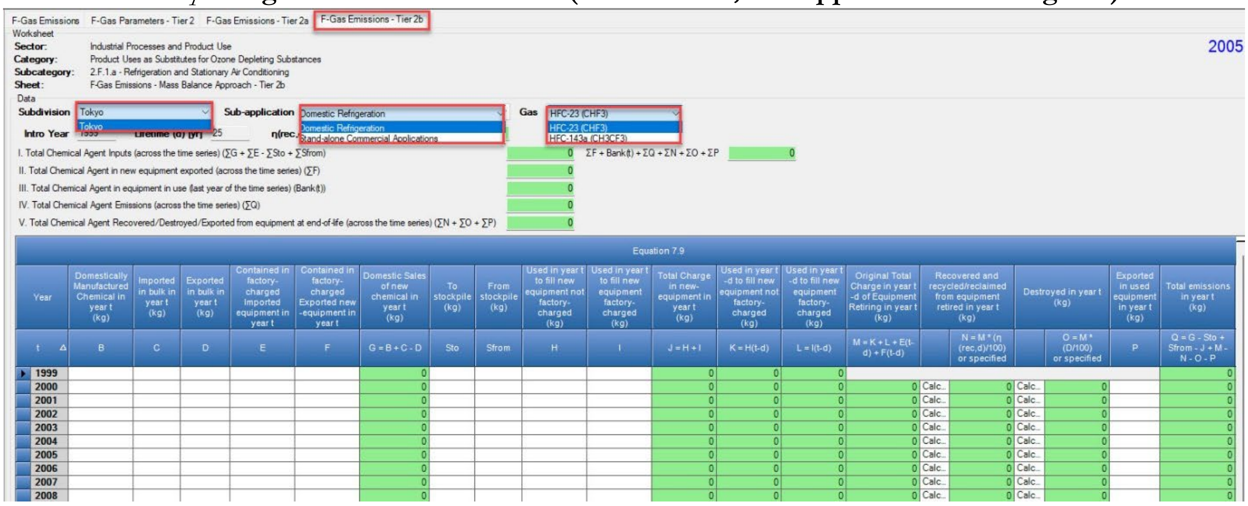


Tier 2b:

If Tier 2b was specified in the worksheet **F-Gas Parameters – Tier 2**, then worksheet **F-gas Emissions – Tier 2b** becomes active so users can select subdivisions, sub-applications and F-gases/blends and respective parameters. Data are entered, row by row, for each subdivision/sub-application/F-gas/blend, as follows:

1. Users first need to select subdivision, then sub-application and F-gas/blend for which AD are to be entered. *Note that if a subdivision/sub-application/F-gas / blend is not available for selection, the user should refer back to the description for Tier 2 in Customizing the Software for Refrigeration and Air Conditioning: subdivision/sub-application/F-gases*
2. Then for each subdivision, sub-application and F-gas/blend for which Tier 2b was specified in the worksheet **F-Gas Parameters – Tier 2**, users must populate AD in the white cells of worksheet **F-gas Emissions – Tier 2b**.

Example: **F-gas Emissions – Tier 2b (subdivisions, sub-applications and F-gases)**



Then AD are entered for each subdivision/sub-application/ F gas/blend, and for each year (based on the year of introduction of the refrigerant), in worksheet **F-Gas Emissions – Tier 2b,** as follows:

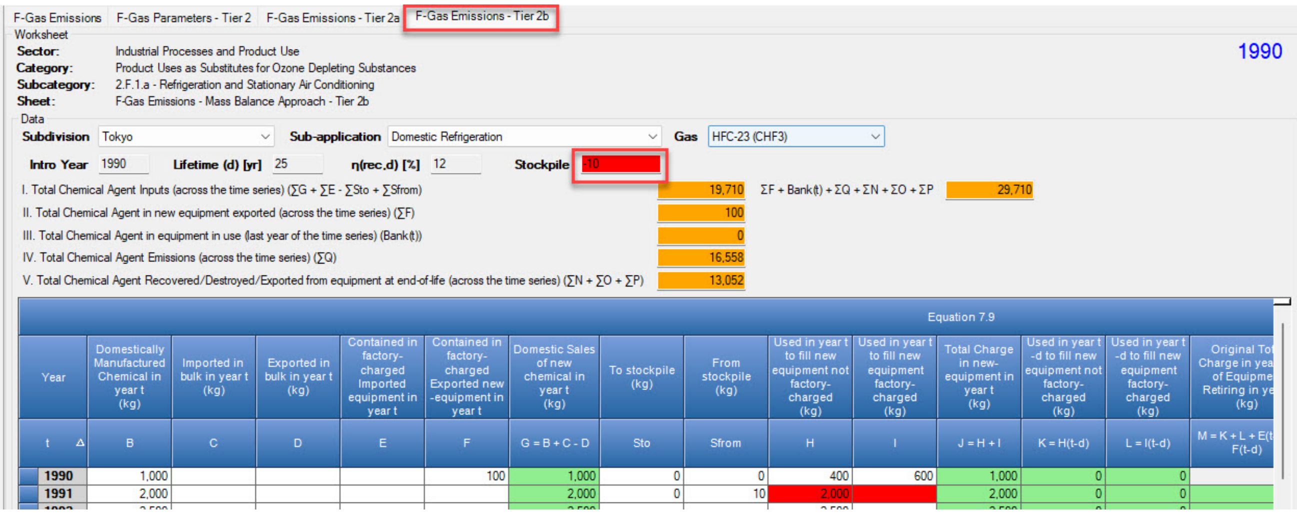
Note that: the Tier 2b worksheet requires AD entry for each year, it does not interpolate data as in Tier 1. If there is a need to apply IPCC splicing techniques to fill data gaps, this should be done outside the Software, and the results manually input.

1. Column |B|: amount of domestically manufactured F-gas/blend in year t, kg
2. Column |C|: amount imported in bulk in year t, kg
3. Column |D|: amount exported in bulk in year t, kg
   Note that bulk exports must be equal to or less than the amount produced plus imported for a given year, otherwise the QA/QC check that appears below the EF/parameters will turn orange, indicating that mass of F-gases is not conserved (see discussion below Ensuring mass conservation of gases).
4. Column |E|: amount contained in factory-charged imported equipment in year t, kg
5. Column |F|: among contained in factory-charged exported new-equipment in year t, kg
   Note that exports of gas contained in factory charged new equipment must be equal to or less than the amount produced plus imported in bulk for a given year, otherwise the QA/QC check that appears below the EF/parameters will turn orange, indicating that mass of F-gases is not conserved (see discussion below Ensuring mass conservation of gases).

6. Column |S_{to}|: amount of F-gas/blend available (from production or import) but not used in year (t), i.e. stockpiled.
7. Column |S_{from}|: amount of F-gas/blend removed from the stockpile in year (t).
   Note that the Software contains a check for the user of the cumulative amount of the stockpile. The cumulated stockpile should always be positive. If the available stockpile turns negative owing to user entry, the cell will become red (see image below where the stockpile turned negative owing to values entered for 1991).
8. Column |H|: amount of F-gas/blend used to fill new equipment not factory-charged in year t, kg
   Note that this column, as well as the subsequent Column |I| will turn red or orange immediately upon entering any information in columns B, C, D, E or F. These are QA/QC checks to alert the user that inconsistent information has been entered. Specifically, all domestic sales of a gas/blend must have a fate, and either be used to fill new equipment (Columns H and or I) or be added to the stockpile. Any exports from the system in a given year, must be equal to or less than the amount produced/imported. A red cell means that the chemical agent has entered the system (e.g. via import) and has not yet been allocated to use. If the cells turn orange, this means that exports from the system are greater than the chemical input. The user must ensure that these cells turn to white.
9. Column |I|: amount of F-gas/blend used to fill equipment factory-charged in year t, kg (see note above on Column |H|.

Example: **Indicator that stockpile should be reviewed**

Note that the negative stockpile has resulted in overall QA/QC for mass conservation to turn orange.



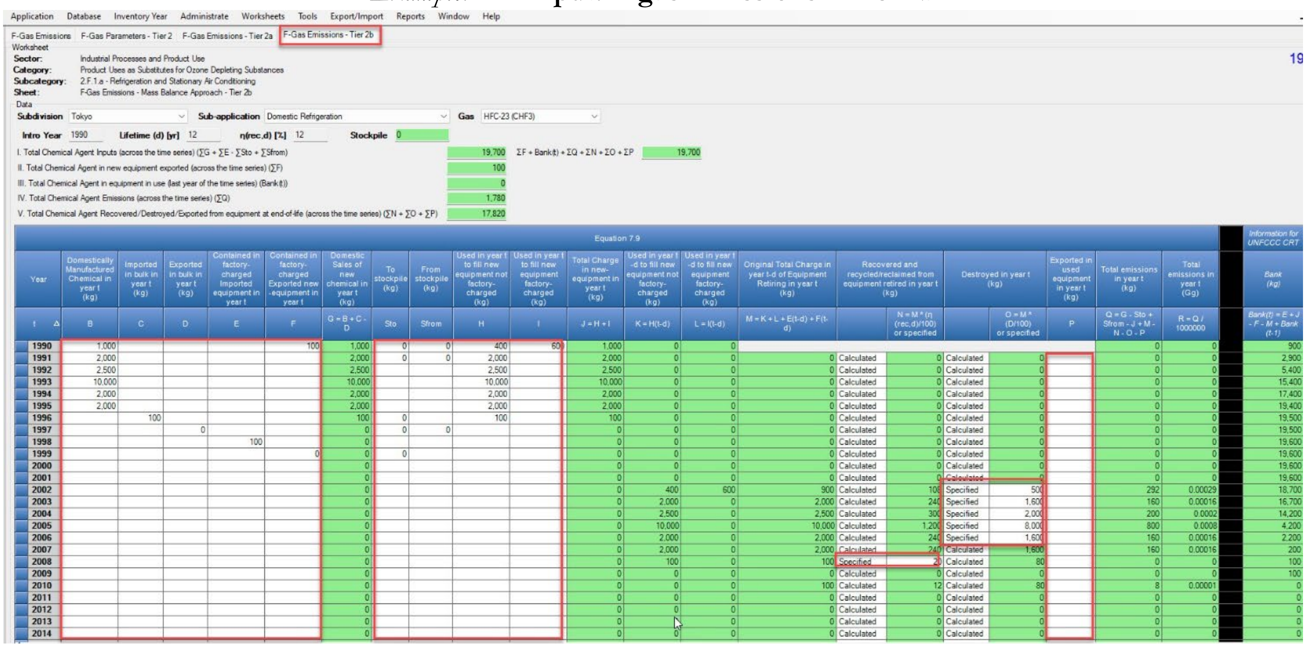
10. Column |N|: amount recovered and recycled/reclaimed from equipment retired in year t, kg. In Column |N| there is a drop-down menu for two options:
    a. Calculated (green cell) – the *Software* estimates the amount of gas recovered and recycled/reclaimed in year t. The *Software* calculates the amount as equal to the amount of gas contained in the retired equipment Column |M| multiplied by the percentage share of that amount that was indicated by the user as recovered/reclaimed (η (rec,d)) in worksheet **F-Gas Parameters – Tier 2**.
    b. *Specified* (white cell) – users enter country-specific AD manually.
       Note that the amount recovered and recycled/reclaimed plus any values entered in Column |O| plus Column |P| must be equal to or less than the total chemical agent in retired equipment (Column |M|). If the value is Columns N+O+P is greater than the amount in Column |M|, then the QA/QC check will change to orange and the user should check the values entered.
11. Column |O|: amount destroyed in year t, kg. In Column |O| there is a drop-down menu for two options:
    a. Calculated (green cell) – the *Software* estimates the amount of gas destroyed in year t. The *Software* calculates the amount destroyed as equal to the amount of gas contained in the retired equipment, Column |M| multiplied by the share of that amount that was indicated by the user as destroyed (D) in the worksheet **F-Gas Parameters – Tier 2**.
    b. Specified (white cell) – users need to enter country-specific AD manually.
       Note that the amount destroyed plus any values entered in Column |N| plus Column |P| must be equal to or less than the total chemical agent in retired equipment (Column |M|). If the value is Columns N+O+P is greater than the amount in Column |M|, then the QA/QC check will change to orange and the user should check the values entered.

12. Column |P|: amount exported in used equipment in year t, kg.
Note that the amount exported plus any values entered in Column |N| plus Column |O| must be equal to or less than the total chemical agent in retired equipment (Column |M|). If the value is Columns N+O+P is greater than the amount in Column |M|, then the QA/QC check will change to orange and the user should check the values entered.

Once AD are input, the *Software* makes several calculations in green cells (these cannot be modified):

9. Column |G|: domestic sales of new chemical in year t, kg.
Note that this cell is calculated as the total domestic manufactured F-gas/blend, plus bulk import minus bulk export.
10. Column |J|: total charge in new equipment in year t, kg.
Note that this cell is calculated as the sum of the amount used to fill new equipment not factory-charged plus the amount used to fill new equipment factory-charged.
11. Column |K|: amount used in the year t-d to fill new equipment not factory-charged, kg.
*Note that this cell is calculated based on the lifetime entered in worksheet **F-Gas Parameters- Tier 2** and is used to estimate the original charge in retired equipment. For example, in the year 1990 it was 20 kg, so after 15 years, in the year 2005, it will be 20 kg).*
12. Column |L|: amount used in the year t-d to fill new equipment factory-charged, kg.
*Note that this cell is calculated based on the lifetime entered in worksheet **F-Gas Parameters- Tier 2** and is used to estimate the original charge in retired equipment. For example, in the year 1992 it was 25 kg, so after 15 years, in the year 2007, it will be 25 kg).*
13. Column |M|: the original total charge in year t-d of equipment retiring in year t, kg.
Note that this cell is calculated as information entered in Column |K| plus Column |L| plus the amount of agent that was imported contained in factory-charged imported equipment in the year t-d and subtracting any agent that was contained in factory-charged new equipment in year t-d.
14. Column |Q|: Total emissions in year t, kg.
Note that this cell is calculated as the sum of domestic sales plus the total agent in retired equipment in the year plus any agent withdrawn from the stockpile (these are the total possible emissions), and subtracting the sum of any agent added to the stockpile, the amount in all new equipment, and any agent recovered/reclaimed/destroyed or exported in equipment at the end of life.
15. Column |R|: Total emissions in year t, Gg
16. Column |Bank$_{(t)}$|: This column is applicable for users intending to use the *Software* for reporting in the UNFCCC ETF Reporting Tool and calculates the bank (i.e. the amount of refrigerant stored in products) in year (t).
*Note that this cell is the total charge of equipment operating within its lifetime, as determined based on the lifetime added in worksheet **F-Gas Parameters – Tier 2.** The value is calculated as the total amount imported in equipment or added to new equipment in the country in that year, plus the bank of all agent in currently operating equipment, minus the sum of any agent exported in new equipment in that year and the original charge of equipment retired in that year.*

Example: **AD Input: F-gas Emissions – Tier 2b**



Ensuring mass conservation of gases in Tier 2b

A QA/QC check has been introduced into the worksheets for categories 2.F.1, 2.F.2, 2.F.3 and 2.F.6 (contained applications only) to ensure that the data, EFs and parameters entered by the users ensure conservation of mass of gases over time.

To ensure mass conservation, the *Software* tracks and visually presents the inputs and outputs over time as follows:

I. Total chemical agent inputs, across time ($\sum G+\sum E + \sum S_{to} + \sum S_{from}$)
II. Total chemical agent in new equipment exported, across time ($\sum F$)
III. Total chemical agent in equipment in use (last year of the time series) (Bank(t))
IV. Total chemical agent emissions, across time ($\sum Q$)
V. Total chemical agent recovered/destroyed/exported in equipment at the end of life ($\sum N+\sum O+\sum P$)

In the case of Tier 2b, mass conservation has been ensured if:

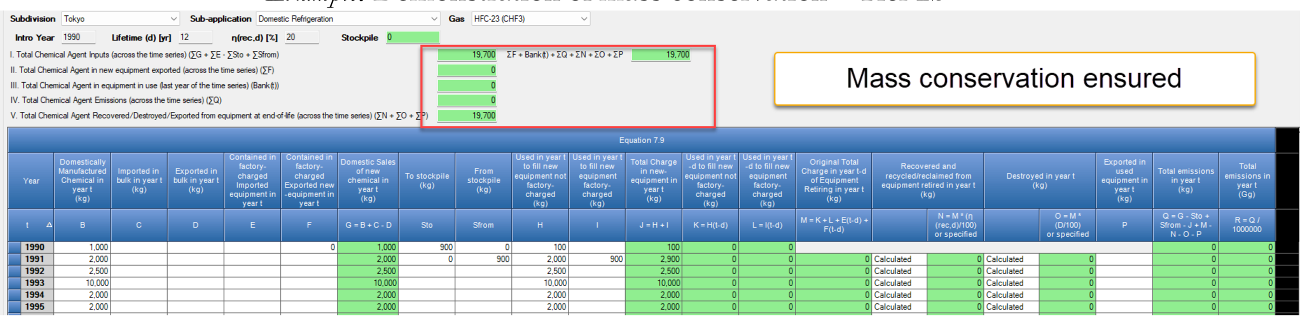
$$\sum G+\sum E + \sum S_{to} + \sum S_{from} = \sum F + Bank(t) + \sum Q + \sum N+\sum O+\sum P$$

If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading, refer back to worksheet F-Gas Parameters to ensure that all parameters are coherent.

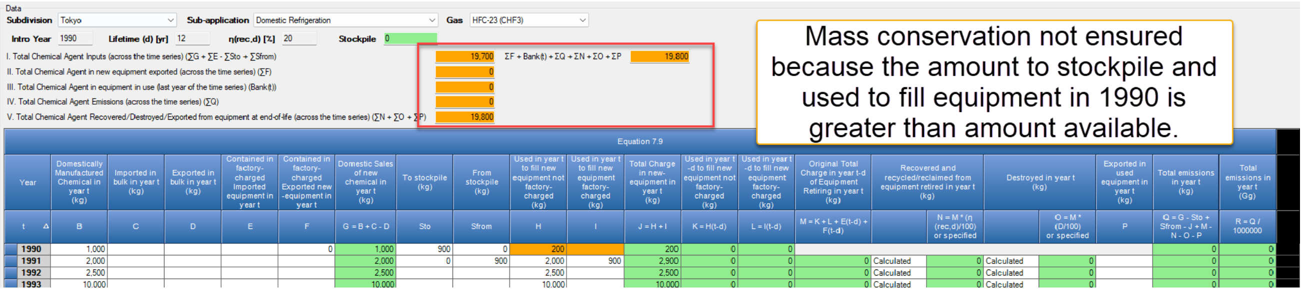
Some common scenarios leading to orange cells (chemical stored in the system and subsequent emissions are greater than inputs) include:

- Agent going to the stockpile (Column S_{to}) for a given year is also included in Column H and/or I as being used to fill new equipment.
- The amount used to fill new equipment (factory charged and non-factory charged) (Columns H and I) is greater than the amount available from domestic sales (Column G) and stockpile withdraw (S_{from}).
- The sum of the amount recovered/recycled/reclaimed/destroyed/exported in equipment in year t (Columns $\sum N+\sum O+\sum P$) is greater than the original total charge in year t-d of equipment retiring in the current year (Column M).
- In worksheet **F-Gas Parameters- Tier 2,** the share of charge remaining at the end of life that is destroyed (D) plus the recovery efficiency of charged to be reclaimed/recycled)(η(rec,d))must be ≤ 1, if greater than 1 this is not possible and more gas is estimated to be destroyed/reclaimed/recovered than available.

Example: **Demonstration of mass conservation – Tier 2b**



Example: **Mass not conserved over time– Tier 2b**



Data

Subdivision Tokyo **Sub-application** Domestic Refrigeration **Gas** HFC-23 (CHF3)

Intro Year 1990 **Lifetime (d) [yr]** 12 **η(rec,d) [%]** 20 **Stockpile** 0

I. Total Chemical Agent Inputs (across the time series) (∑G + ∑E - ∑Sto + ∑Sfrom) 19,700 ΣF + Bank(t) + ΣQ + ΣN + ΣO + ΣP 19,800

II. Total Chemical Agent in new equipment exported (across the time series) (∑F) 0

III. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 0

IV. Total Chemical Agent Emissions (across the time series) (∑Q) 0

V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑N + ∑O + ∑P) 19,800

Equation 7.9

Year	Domestically Manufactured Chemical in year t (kg)	Imported in bulk in year t (kg)	Exported in bulk in year t (kg)	Contained in factory-charged Imported equipment in year t	Contained in factory-charged Exported new-equipment in year t	Domestic Sales of new chemical in year t (kg)	To stockpile (kg)	From stockpile (kg)	Used in year t to fill new equipment not factory-charged (kg)	Used in year t to fill new equipment factory-charged (kg)	Total Charge in new-equipment in year t (kg)	Used in year t-d to fill new equipment not factory-charged (kg)	Used in year t-d to fill new equipment factory-charged (kg)	Original Total Charge in year t-d of Equipment Retiring in year t (kg)	Recovered and recycled/reclaimed from equipment retired in year t (kg)		Destroyed in year t (kg)		Exported in used equipment in year t (kg)	Total emissions in year t (kg)	Total emissions in year t (Gg)
t	B	C	D	E	F	G = B + C - D	Sto	Sfrom	H	I	J = H + I	K = H(t-d)	L = I(t-d)	M = K + L + E(t-d) + F(t-d)		N = M * (η (rec,d)/100) or specified		O = M * (D/100) or specified	P	Q = G - Sto + Sfrom - J + M - N - O - P	R = Q / 1000000
1990	1,000				0	1,000	900	0	200		200	0	0							0	0
1991	2,000					2,000	0	900	2,000	900	2,900	0	0	0	Calculated	0	Calculated	0		0	0
1992	2,500					2,500			2,500		2,500	0	0	0	Calculated	0	Calculated	0		0	0
1993	10,000					10,000			10,000		10,000	0	0	0	Calculated	0	Calculated	0		0	0

Results

GHG emissions from Refrigeration and Air Conditioning are estimated one row for each year of the time series, in the following worksheets:

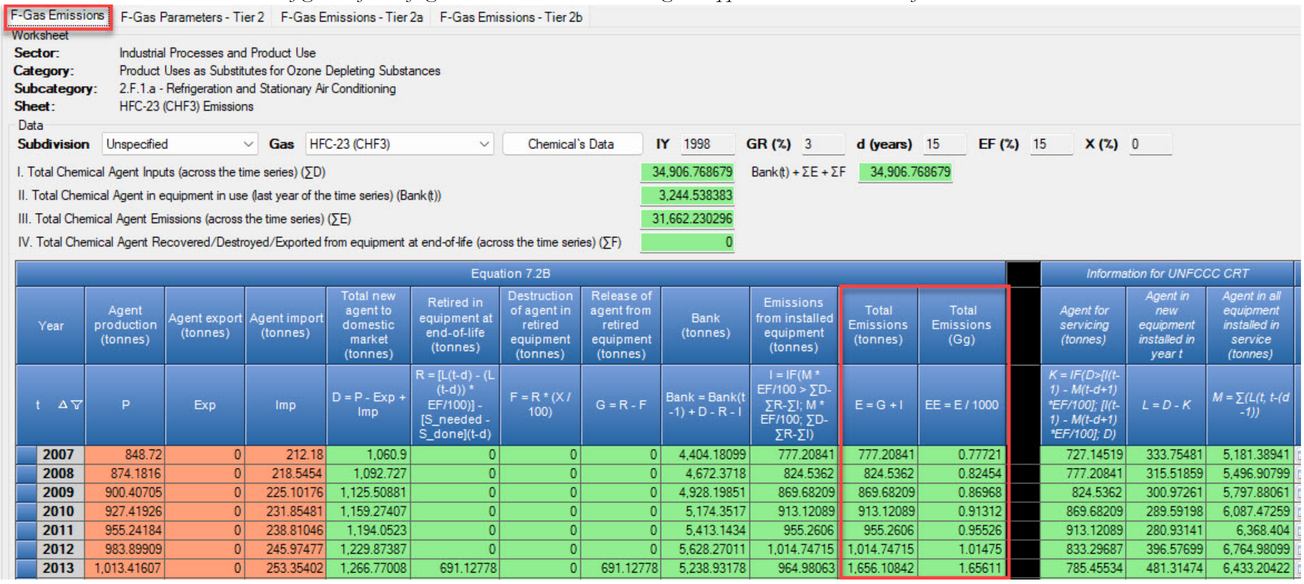
- ✓ **F-Gas Emissions**
- ✓ **F-Gas Emissions – Tier 2a**
- ✓ **F-Gas Emissions – Tier 2b**

Total F-gas emissions from refrigeration and air conditioning is the sum of all emissions from all subdivisions in the above worksheets. The *Software* calculates the associated emissions for each F-Gas/blend in the following units: Tier 1 – metric tonnes; Tier 2 – kg and Gg. The full time series of emissions estimates will appear in the worksheets for each year (e.g. in the image below for Tier 1, the user is in the 1990 inventory year worksheet but is able to view the entire time series of emissions estimates for F gases/blends. Please see the examples of worksheets below with final estimates/results for different Tiers.

The user will note that Refrigeration and Air Conditioning is one of the few categories in the IPPU sector of the *Software* that does not contain a worksheet for **Capture and storage or other reduction.** This is because all capture and other reductions are already accounted for in the worksheets noted above.

Example: **Results: F-Gas Emissions – Tier 1**

<u>Note that</u> this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.



F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: HFC-23 (CHF3) Emissions

Data

Subdivision Unspecified **Gas** HFC-23 (CHF3) Chemical's Data **IY** 1998 **GR (%)** 3 **d (years)** 15 **EF (%)** 15 **X (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑D) 34,906.768679 Bank(t) + ΣE + ΣF 34,906.768679

II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 3,244.538383

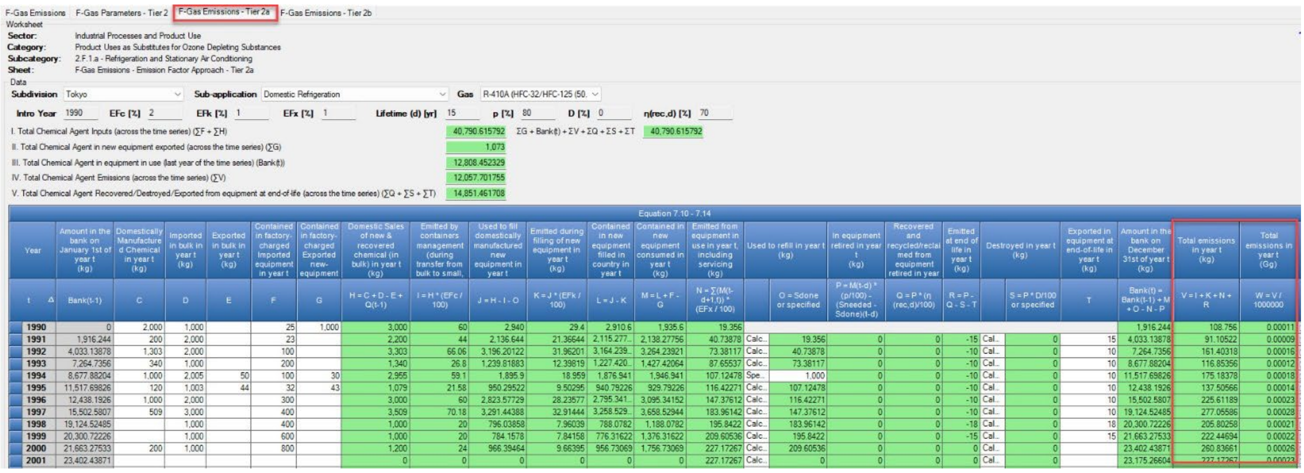
III. Total Chemical Agent Emissions (across the time series) (∑E) 31,662.230296

IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑F) 0

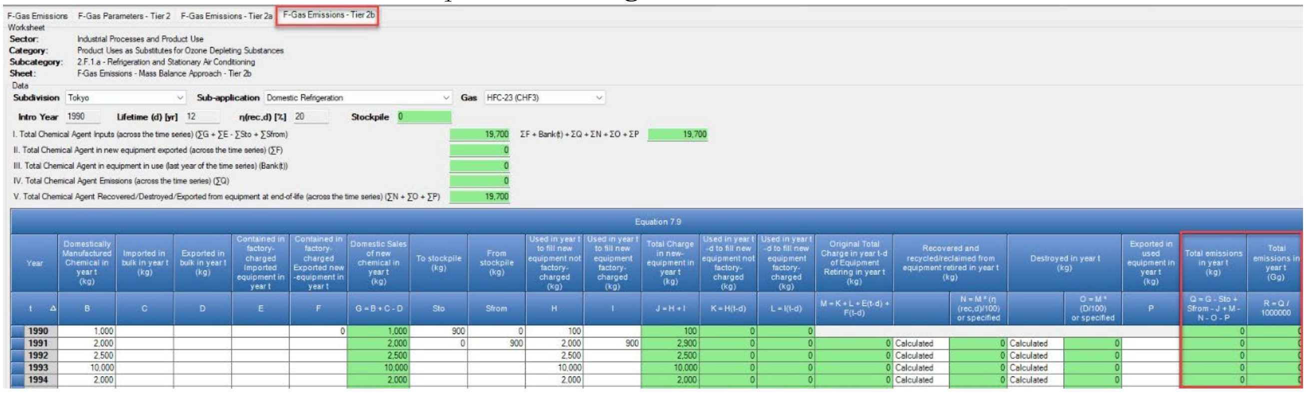
Equation 7.2B / Information for UNFCCC CRT

Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	*Agent for servicing (tonnes)*	*Agent in new equipment installed in year t*	*Agent in all equipment installed in service (tonnes)*
t	P	Exp	Imp	D = P - Exp + Imp	R = [L(t-d) - (L(t-d)) * EF/100)] - [S_needed - S_done](t-d)	F = R * (X / 100)	G = R - F	Bank = Bank(t-1) + D - R - I	I = IF(M * EF/100 > ∑D-∑R-∑I; M * EF/100; ∑D-∑R-∑I)	E = G + I	EE = E / 1000	*K = IF(D>[I(t-1) - M(t-d+1) *EF/100]; [I(t-1) - M(t-d+1) *EF/100]; D)*	*L = D - K*	*M = ∑(L(t, t-(d-1))*
2007	848.72	0	212.18	1,060.9	0	0	0	4,404.18099	777.20841	777.20841	0.77721	727.14519	333.75481	5,181.38941
2008	874.1816	0	218.5454	1,092.727	0	0	0	4,672.3718	824.5362	824.5362	0.82454	777.20841	315.51859	5,496.90799
2009	900.40705	0	225.10176	1,125.50881	0	0	0	4,928.19851	869.68209	869.68209	0.86968	824.5362	300.97261	5,797.88061
2010	927.41926	0	231.85481	1,159.27407	0	0	0	5,174.3517	913.12089	913.12089	0.91312	869.68209	289.59198	6,087.47259
2011	955.24184	0	238.81046	1,194.0523	0	0	0	5,413.1434	955.2606	955.2606	0.95526	913.12089	280.93141	6,368.404
2012	983.89909	0	245.97477	1,229.87387	0	0	0	5,628.27011	1,014.74715	1,014.74715	1.01475	833.29687	396.57699	6,764.98099
2013	1,013.41607	0	253.35402	1,266.77008	691.12778	0	691.12778	5,238.93178	964.98063	1,656.10842	1.65611	785.45534	481.31474	6,433.20422

Example: **Results: F-gas Emissions – Tier 2a**



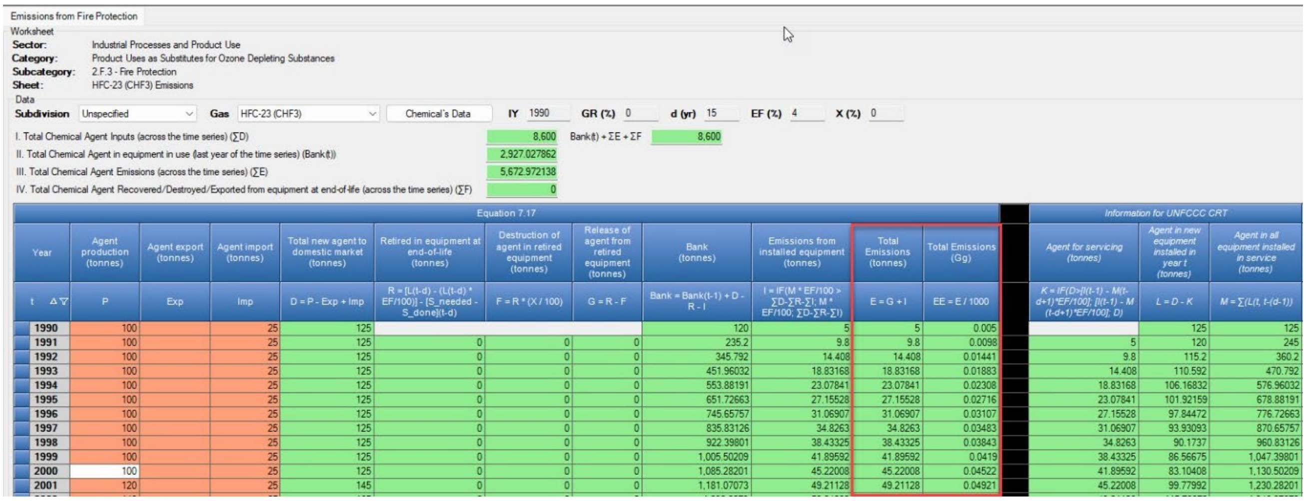
Example: **Results: F-gas Emissions – Tier 2b**



GHG emissions from Fire Protection are estimated in a similar fashion as described above for worksheet **F-Gas Emissions,** but in the following worksheet of source category 2.F.3:

- ✓ **Emissions from Fire Protection**

Example: **Results: Fire protection – All tiers**



2.F.2 Foam Blowing Agents

Information

The *2006 IPCC Guidelines* differentiate open-cell foams and closed-cell foams, each type of foam can then be broken down into further sub-applications (i.e. types of foam), see Table 7.4 in Chapter 7 Volume 3.

The division of foams into open-cell or closed-cell relates to the way in which blowing agent is lost from the products. For open-cell foam, emissions (typically HFCs) are used as blowing agents and are likely to occur during the manufacturing process and shortly thereafter. In closed-cell foam, only a minority of emissions occur during manufacturing. For closed cell foams, emissions extend into the in-use phase, with most of the emission not occurring until end-of-life (decommissioning losses).

The *2006 IPCC Guidelines* provide two Tiers for estimation of GHG emissions from Foam Blowing Agents:

- Tier 1 is based on known consumption data for a foam blowing agent and default EFs for the first-year loss and annual loss.
- Tier 2 is a more data demanding method and requires data on production, import, export of a foam blowing agent, EFs for the first-year loss, annual losses and for the end-of-life (decommissioning and recovery).

For open-cell foams – the basic assumption (Tier 1) is that all HFCs are released immediately and the emissions will occur in the country of manufacture. The difference in Tier 2 for closed cell and open cell foams is that Tier 2 for closed cell foams estimate end-of-life emissions including estimates for the decommissioned bank and emissions from it.

GHGs

The *Software* includes the following GHGs for the Foam Blowing Agents source category, although emissions are predominantly HFCs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

- ✓ Tier 1: Equation 7.7 (generic equation for both Closed Cell and Open Cell Foams), Equation 7.8 (Open Cell Foams) at the application level
- ✓ Tier 2a: Box 7.2 (sub-application level)
- ✓ Tier 3: No IPCC Tier 3 equation provided in the *2006 IPCC Guidelines*

Software Worksheets

GHG emissions from the Foam Blowing Agents source category are estimated using the following worksheet for all Foam Blowing Agents:

- ✓ **1.1.2 F-gases Manager**: is applicable to both open and closed cell fomas and contains data on F-gases used (including imported) and/or produced and exported in country.

Then, for:

Closed Cell Foams:

- ✓ **F-gas Emissions – Closed Cell Foams:** contains for each subdivision and each F-gas (at the application level) information on the year of introduction, product lifetime, EF for the first-year loss and EF for annual loss as well as the growth rate and known consumption of the F-gas. Users may also add information on agent recovery and destruction; but this type of information is not typically available for Tier 1. The worksheet calculates the associated F-gas emissions for closed cell foams for Tier 1.

- ✓ **F-gas Parameters – Closed Cell Foams – Tier 2:** allows for input of necessary information: subdivisions, sub-applications and chemicals (i.e. gases) consumed. For each gas, additional parameters are available for data input; information on the year of introduction of each foam blowing agent, growth rate, product lifetime, EFs for the first-year loss and for maximum potential end-of-life loss, EFs for decommissioning, recovery and destruction, and annual rate loss for the decommissioned bank. These parameters are automatically transferred into the calculation of emissions in worksheet **F-Gas Emissions- Closed Cell Foams- Tier 2.**
- ✓ **F-Gas Emissions- Closed Cell Foams- Tier 2:** contains for each subdivision/sub-application/F-gas, information on the amount of F-gas produced domestically, imported and exported. Based on these data, and parameters entered above, the worksheet calculates the associated F-gas emissions for closed cell foams for Tier 2.

Open Cell Foams:

- ✓ **F-gas Emissions – Open Cell Foams:** contains for each subdivision and each F-gas (at the application level) information on the year of introduction and the growth rate for the use of agent. The worksheet calculates the associated F-gas emissions for open cell foams for Tier 1 (consumption = emissions).
- ✓ **F-gas Parameters – Open Cell Foams – Tier 2:** allows for input of necessary information: subdivisions, sub-applications and chemicals (i.e. gases) consumed. For each gas, additional parameters are available for data input; information on the year of introduction of each foam blowing agent, growth rate, product lifetime, EFs for the first-year loss and annual loss, the maximum potential end-of-life loss, the rate of loss at decommissioning, recovery and destruction rate and the rate of loss from any decommissioned bank, if applicable. These parameters are automatically transferred into the calculation of emissions in worksheet **F-Gas Emissions- Open Cell Foams- Tier 2.**
- ✓ **F-gas Emissions – Open Cell Foams – Tier 2:** contains for each subdivision/sub-application/F-gas information on the amount of F-gas produced domestically, imported and exported. The worksheet calculates the associated F-gas emissions for open cell foams for Tier 2.

User's work Flowchart

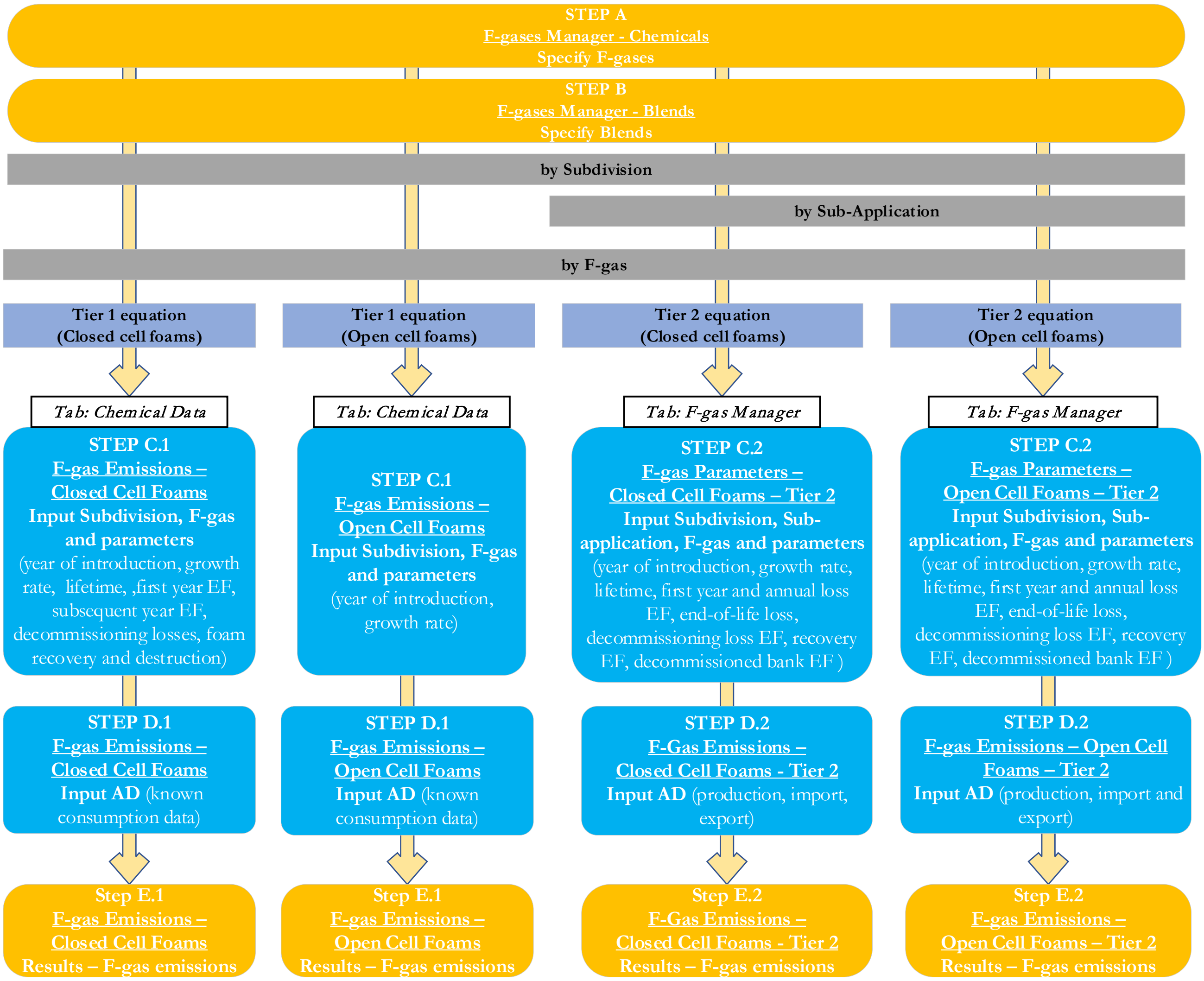
For Foam Blowing Agents, consistent with the key category analysis and the decision tree in Figure 7.4 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[40] EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowchart for Foam Blowing Agents.

[40] Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 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 country-specific EF.

Foam Blowing Agents– flowchart

(Closed cell foams and Open cell Foams)



Thus, for the source-category:

Steps A and B, **1.1.2 F-gases Manager**, users ensure that all F-gases/blends consumed (including imported for consumption) or produced and exported and related to open and closed cell foams have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager.

Data can be input as a single total (e.g. national level) or stratified, where AD are available, in subdivisions (e.g. states, regions, provinces; or single facilities or companies).

Then, for each subdivision:

Data may be entered separately for closed cell foams and open cells foams as a single application (i.e. all closed cell foams separate from all open cell foams), as in **Step C.1** or in distinct sub-applications (e.g. flexible foam is calculated separately from other open cell foams as in **Step C.2**). See the section below on EF/Parameter input to customize the *Software* to fit the users' needs to designate subdivisions, sub-applications and gases.

Then, for each subdivision/sub-application, if any:

When the Tier 1 Equation is applied:

<u>**Closed Cell Foams**</u>

Step C.1, in the worksheet **F-gas Emissions – Closed Cell Foams**, users collect and input in the Tab "Chemical Data" information for each subdivision and F-gas on year of introduction, growth rate, product lifetime, EF for the first-year loss, EF for annual loss, decommissioning loss and foam recovery and destruction.

Step D.1, in the worksheet **F-gas Emissions – Closed Cell Foams**, for each subdivision and each F-gas users collect and input information on known consumption of F-gas for closed cell foams in the current reporting year (the worksheet allows to enter such information for previous years as well).

Step E.1 in the worksheet **F-gas Emissions – Closed Cell Foams** the *Software* calculates the associated emissions for each F-gas, in tonnes.

<u>**Open Cell Foams**</u>

Step C.1, in the worksheet **F-gas Emissions – Open Cell Foams**, users collect and input in the Tab "Chemical Data" information on F-gases, subdivisions, year of introduction and growth rate.

Step D.1, in the worksheet **F-gas Emissions – Open Cell Foams**, for each subdivision and each F-gas users collect and input information on as known consumption of F-gas for open cell foams in the current reporting year (the worksheet allows to enter such information for previous years as well).

Step E.1, in the worksheet **F-gas Emissions – Open Cell Foams,** the *Software* calculates the associated emissions for each F-gas, in tonnes.

When the Tier 2 Equation is applied:

<u>**Closed Cell Foams:**</u>

Step C.2, in the worksheet **F-gas Parameters – Closed Cell Foams – Tier 2**, users collect and input in the *Software* information for each subdivision, sub-application, and F-gas on year of introduction, growth rate, product lifetime, EFs for the first-year loss, annual loss and for maximum potential end-of-life loss (all based on initial charge), EFs for decommissioning, recovery and destruction, and annual rate loss for the decommissioned bank.

Step D.2, in the worksheet **F-gas Emissions – Closed Cell Foams – Tier 2**, for each subdivision and each F-gas, users collect and input information on the amount of F-gas produced for closed cell foams domestically, imported and exported (the worksheet allows to enter such information for previous years as well).

Step E.2, in the worksheets **F-gas Emissions – Closed Cell Foams – Tier 2,** the *Software* calculates the associated emissions for each F-gas, in tonnes and Gg.

Open Cell Foams:

Step C.2, in the worksheet **F-gas Emissions – Open Cell Foams – Tier 2**, users collect and input in the *Software* information for each subdivision, sub-application, and F-gas on year of introduction, growth rate, product lifetime, EFs for the first-year loss, annual loss and for maximum potential end-of-life loss (all based on initial charge), EFs for decommissioning, recovery and destruction, and annual rate loss for the decommissioned bank.

Step D.2, in the worksheet **F-gas Emissions – Open Cell Foams – Tier 2**, for each subdivision and each F-gas users collect and input information on the amount of F-gas produced for open cell foams domestically, imported and exported in the current reporting year (the worksheet allows to enter such information for previous years as well).

Step E.2, in the worksheet **F-gas Emissions – Open Cell Foams – Tier 2,** the *Software* calculates the associated emissions for each F-gas, in tonnes and Gg.

Customizing the *Software* for Foam Blowing Agents: subdivision/sub-application/F-gases/blends

For both the Tier 1 and Tier 2 methods, users must first identify the applicable subdivision/sub-application/F - gases/blends applicable to the chosen method that will be used to estimate GHG emissions.

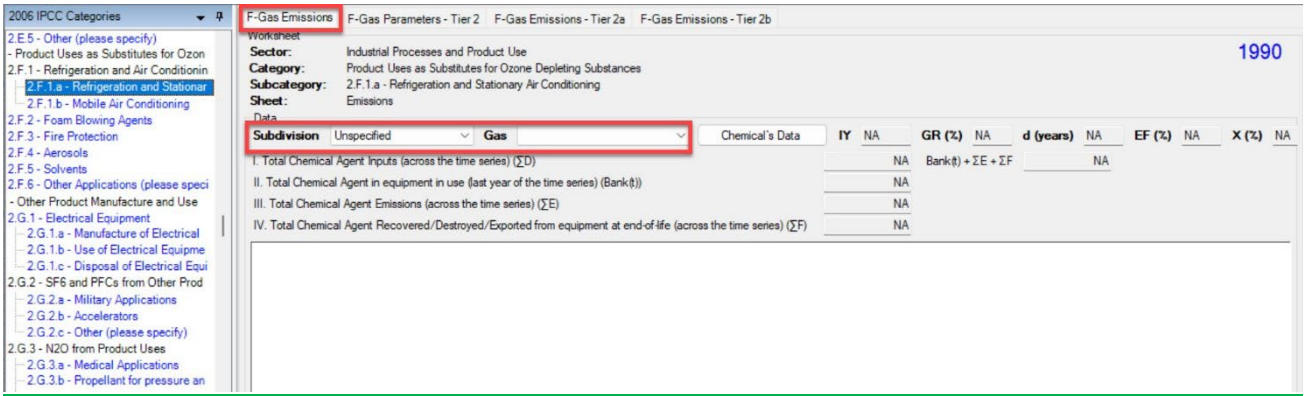
When the Tier 1 Equation is applied:

For the Tier 1 method, the user customizes the *Software* to identify the relevant subdivision and F-gases used. There are no sub-applications for the Tier 1 method for either open or closed cell foams.

Important: When the user first enters the *Software* for Tier 1 for closed and open cell foams, there is only a single subdivision (Unspecified) and no F-gases available for selection for data entry for Foam Blowing Agents. The user must identify subdivisions and enter the relevant F-gas(es)/blends to be able to enter data in the worksheets.

Example: **Landing page when user first enters category 2.F.2 – Tier 1**

Note that the example is for closed cell foams, but also applies to open cells foams



Entering subdivision(s)

For worksheets **F-gas Emissions-Closed Cell Foams** and **F-gas Emissions Open Cell Foams**, entering of subdivisions takes place in **Chemical's Data** tab, following the same procedure as outlined for Tier 1 in the source category 2.F.1 Refrigeration and Air Conditioning **above.**

Identifying relevant F-gases /blends at the IPCC category level

For worksheets **F-gas Emissions-Closed Cell Foams** and **F-gas Emissions Open Cell Foams**, entering of F-gases /blends takes place in **Chemical's Data** tab following the same procedure as outlined for Tier 1 in the source category 2.F.1 Refrigeration and Air Conditioning **above,** with one exception and that is related to where the user identifies if a particular gas used in closed cell or open cell foams is confidential (this is applicable only for those wishing to use the *Software* for reporting to the UNFCCC ETF Inventory Reporting Tool). For Tier 1, the user may designate a gas used in closed cell foams or open cell foams as confidential in the main tab of Chemical's Data (illustrated in EF/parameters input **below.**).

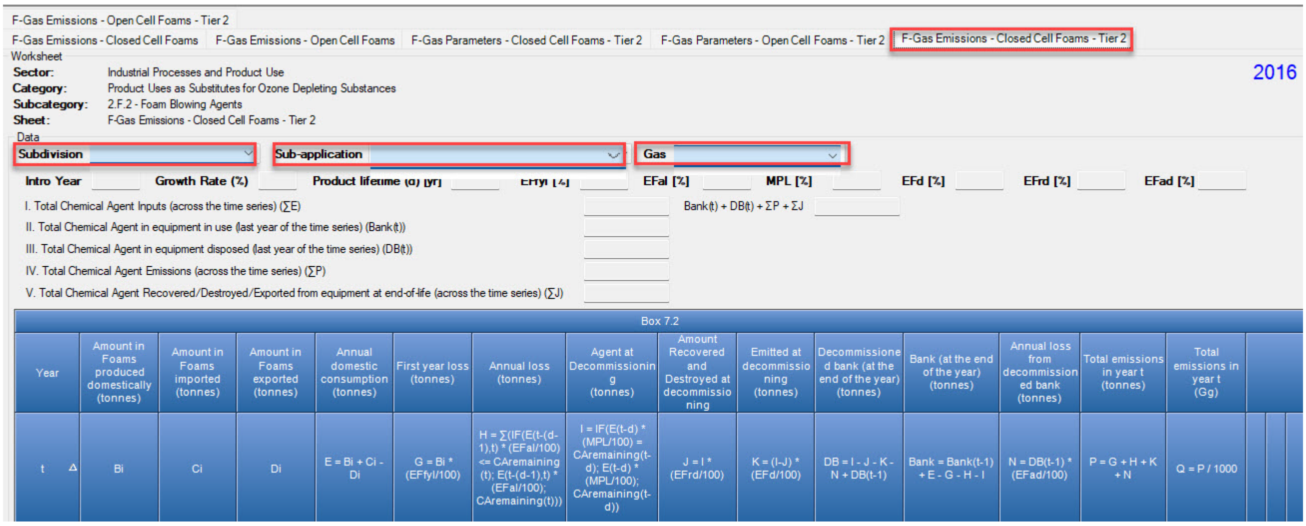
When the Tier 2 equation is applied:

Similar to Tier 1, users must customize the *Software* to identify the relevant subdivision(s) and F-gas(es) used for open and closed cell foams following a Tier 2 method. In addition, the Tier 2 method requires information on sub-applications (e.g. specific type of open or closed cell foam produced).

Important: When the user first enters the *Software* for Tier 2 in worksheet **F-Gas Parameters- Closed Cell Foams-Tier 2** and **F-Gas Parameters- Open Cell Foams- Tier 2**, there is only a single subdivision (Unspecified) and no F-gases available for selection for data entry for Foam Blowing Agents. The user must identify subdivisions and enter the relevant F-gas(es)/blends to be able to enter data in the worksheet.

Example: **Landing page when user first enters category 2.F.2 – Foams – Tier 2**

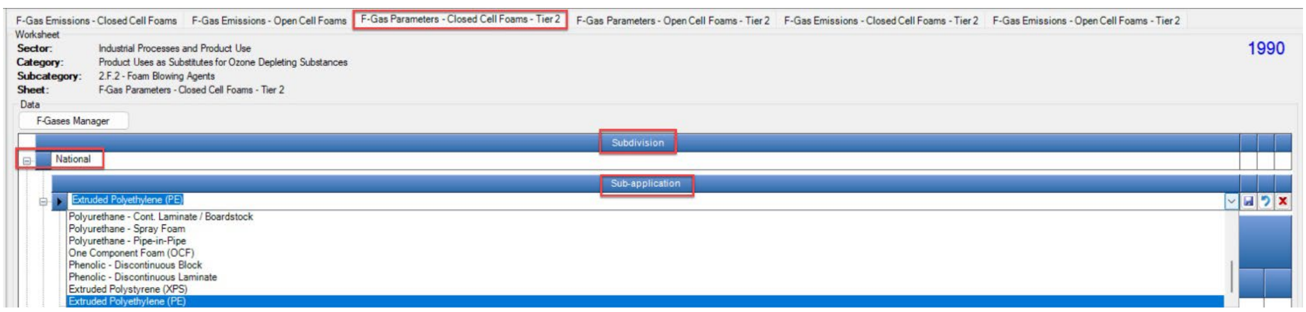
Note that the example is for closed cell foams, but also applies to open cells foams



Entering subdivision(s) and sub-application(s)

For worksheets **F-Gas Parameters- Closed Cell Foams-Tier 2** and **F-Gas Parameters- Open Cell Foams-Tier 2** entering of subdivisions takes place following the same procedure as outlined for Tier 2 in the source category 2.F.1 Refrigeration and Air Conditioning **above**, but selecting the relevant sub-applications for foams.

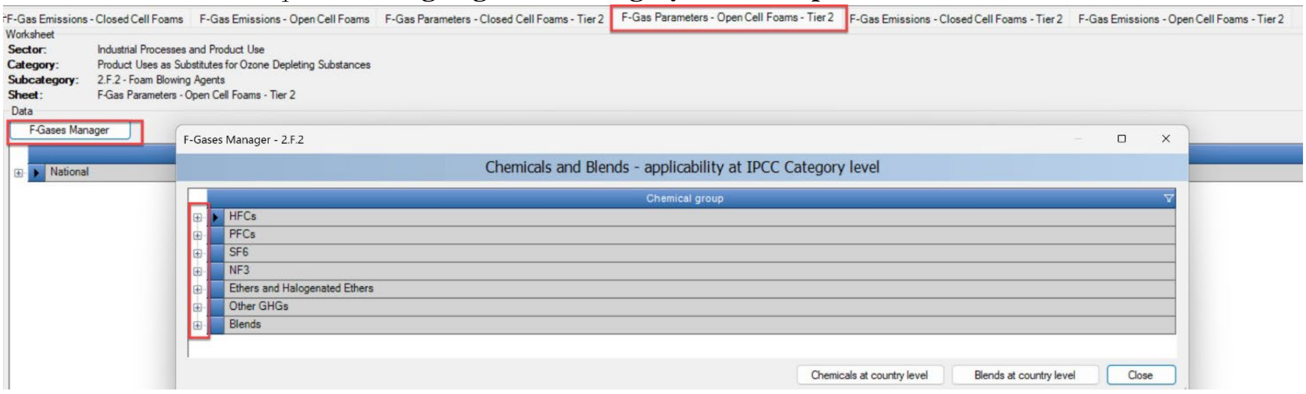
Example: **Entering subdivision/sub-application for closed cell foams– Tier 2**



Identifying relevant F-gases/blends at the IPCC category level

For worksheets **F-Gas Parameters- Closed Cell Foams-Tier 2** and **F-Gas Parameters- Open Cell Foams-Tier 2** entering of relevant F-gases/blends takes place, following the same procedure as outlined for Tier 2 in the source category 2.F.1 Refrigeration and Air Conditioning **above**.

Example: **Entering F-gases at category level for open cell foams– Tier 2**



EF/parameters input

The following sections in Chapter 7, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of EF/parameters:

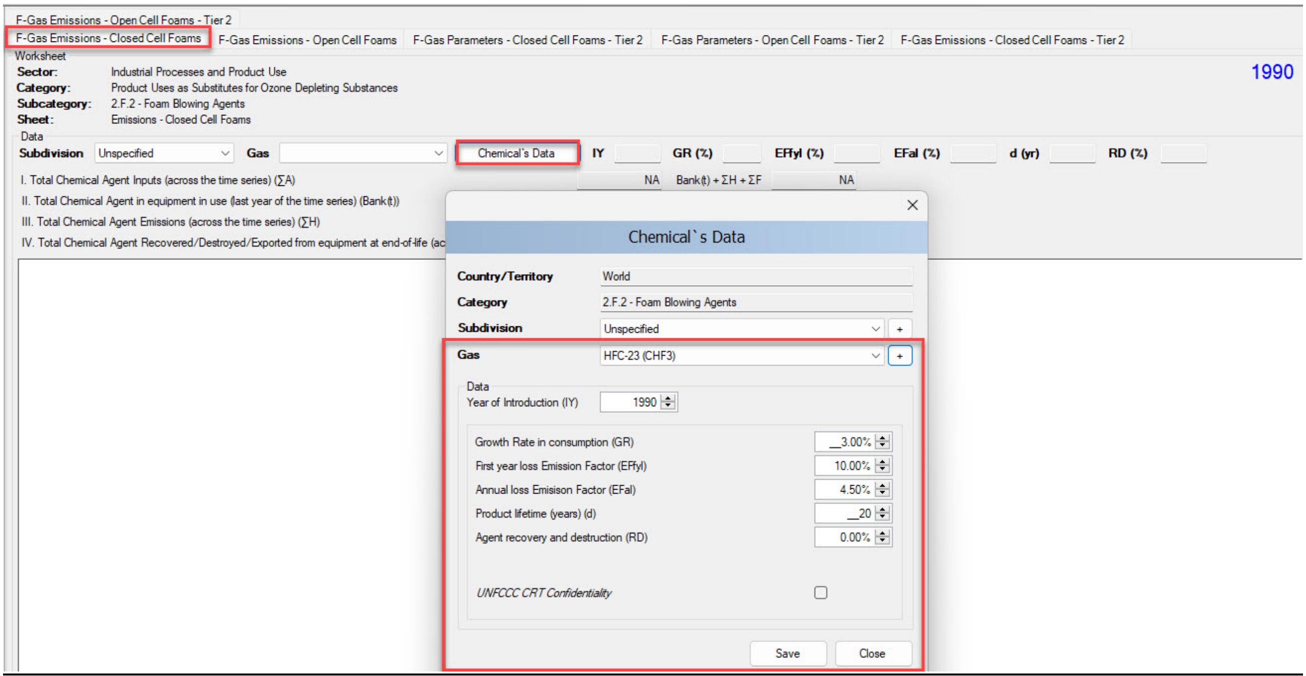
- ✓ Table 7.5 provides default EF for Tier 1(closed cell foams).
- ✓ Section 7.4.2 describes that for Tier 1 (open cell foams) the first -year loss is typically 100%.
- ✓ Section 7.4.2.2 (Tables 7.6 and 7.7) contains information on the choice of EFs/parameters for Tier 2.

When the Tier 1 Equation is applied:

Closed Cell Foams:

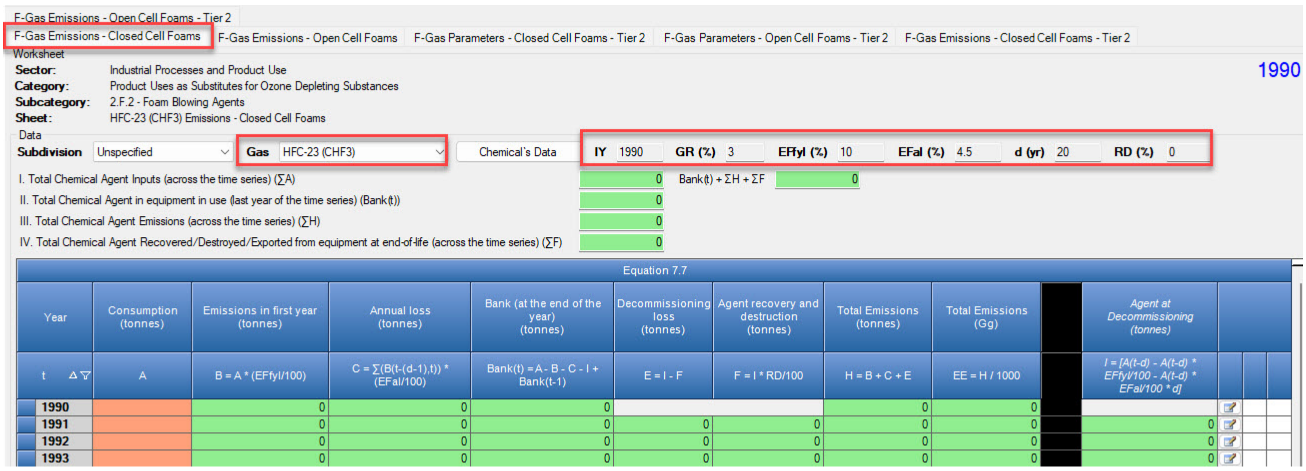
1. In worksheet **F-Gas Emissions- Closed Cell Foams**, users must click on the tab **Chemical's Data** to open a pop-up window and to enter the parameters and EFs needed for estimation of each F-gas/blend consumed in that subdivision.
2. **Gas:** user selects the relevant F-gas/blend from the drop-down menu (refer to previous section on customizing the *Software* if an additional F-gas or blend needs to be added to the drop-down menu).
3. Window |Year of Introduction|: year of introduction of the agent in the country for use in foam blowing (closed cells) (e.g., 1990).
4. Window |Growth Rate in consumption|: growth rate in consumption, usually assumed linear across the period of assessment, in %.
5. Window |First year loss Emission Factor|: EF for the first-year loss in percent of the original charge (IPCC default =10% of the original charge/year.
   Note that: according to Table 7.5, the value could drop to 5% if significant recycling takes place during manufacturing.
6. Window |Annual loss Emission Factor|: EF for annual loss in percent of the original charge (IPCC default = 4.5% of the original charge/year).
7. Window |Product lifetime|: product lifetime, in years (IPCC default =20 years).
8. Window |Agent recovery and destruction|: The percent of blowing agent recovered and destroyed from foams at the end of life. In the absence of country specific information this is assumed to be zero.
9. Window |Confidentiality|: If AD and/or emissions for a particular F-gas consumed in closed cell foams is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas.
   Note that: if checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate (for further information, see Annex I).

Example: **Entering EFs, parameters information and confidentiality for closed cell foams– Tier 1**



10. Then, users need to **Save and Close** the pop-up window **Chemical's Data** to return to the worksheet and enter agent consumption for closed cell foams. The user can see information entered in **Chemical's Data** tab in the main calculation window. In the image below, the gas consumed in the subdivision appears (i.e. HFC-23), and the parameters are visible. Input of AD (in red-orange cells) is explained in the next section.

Example: **Grid ready for entry of AD for closed cell foams – Tier 1**

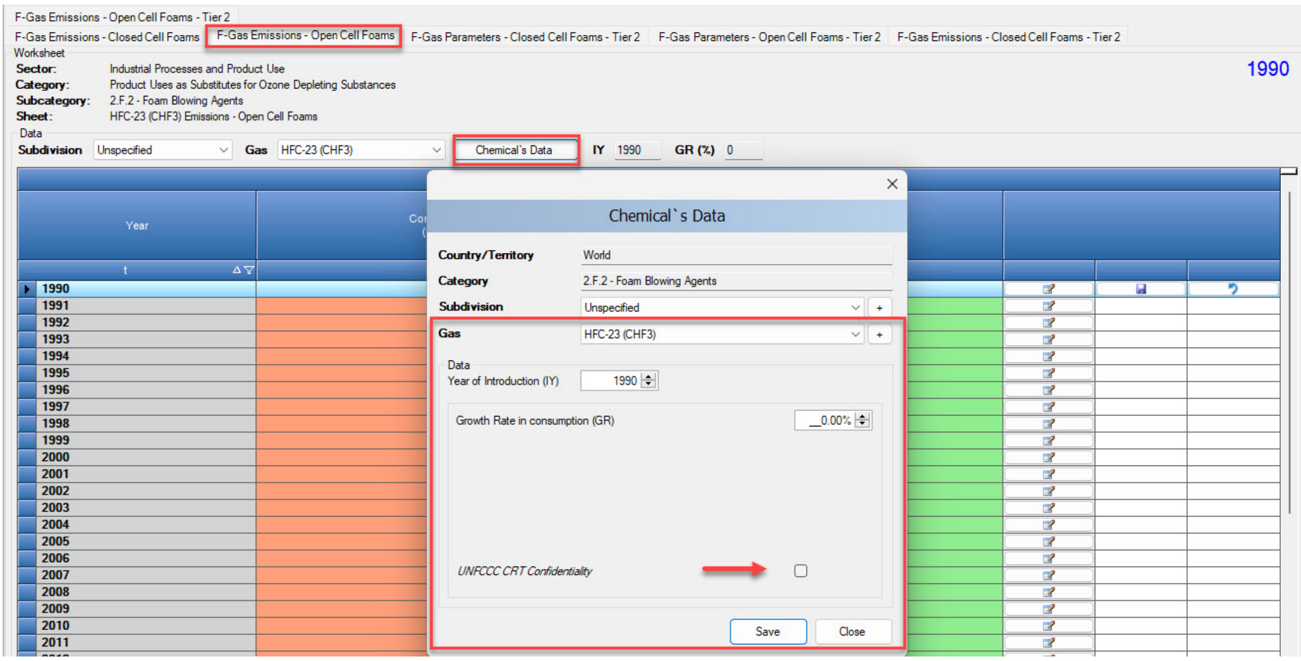


<u>Open Cell Foams:</u>

1. In worksheet **F-Gas Emissions- Open Cell Foams**, users must click on the tab **Chemical's Data** to open a pop-up window and to enter the parameters and EFs needed for estimation of each F-gas/blend consumed in that subdivision.
2. **Gas:** user selects the relevant F-gas/blend from the drop-down menu (refer to previous section on customizing the *Software* if an additional F-gas or blend needs to be added to the drop-down menu).
3. <u>Window |Year of Introduction|</u>: year of introduction of the agent in the country for use in foam blowing (open cells) (e.g., 1990).

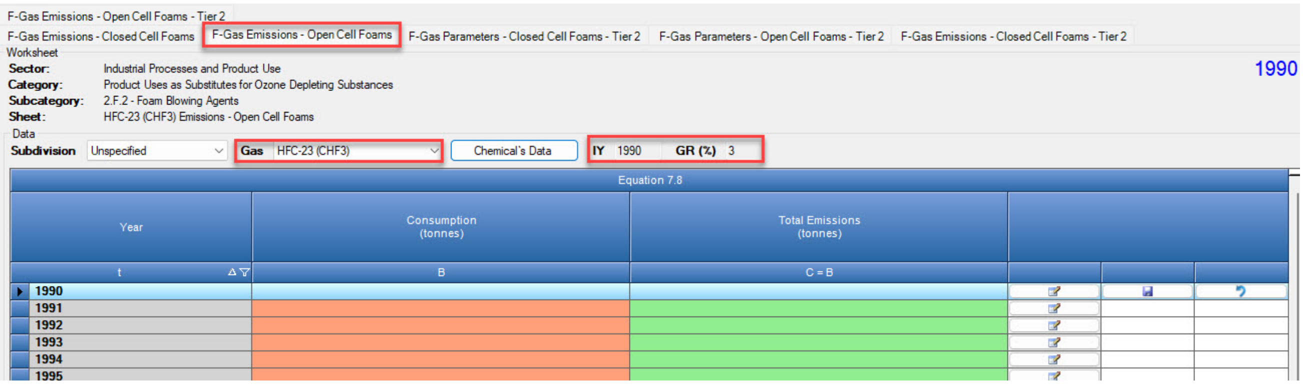
4. Window |Growth Rate in consumption|: growth rate in consumption, usually assumed linear across the period of assessment, in %.
5. Window |Confidentiality|: If AD and/or emissions for a particular F-gas consumed in open cell foams is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. *Note that: if checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate (for further information, see Annex I).*

Example: **Entering EFs, parameters information and confidentiality for open cell foams– Tier 1**



6. Then, users need to **Save and Close** the pop-up window **Chemical's Data** to return to the worksheet and enter agent consumption for open cell foams. The user can see information entered in **Chemical's Data** tab in the main calculation window. In the image below, the gas consumed in the subdivision appears (i.e. HFC-23), and the parameters are visible. Input of AD (in red-orange cells) is explained in the next section.

Example: **Grid ready for entry of AD for open cell foams – Tier 1**



When the Tier 2 Equation is applied

Closed Cell Foams

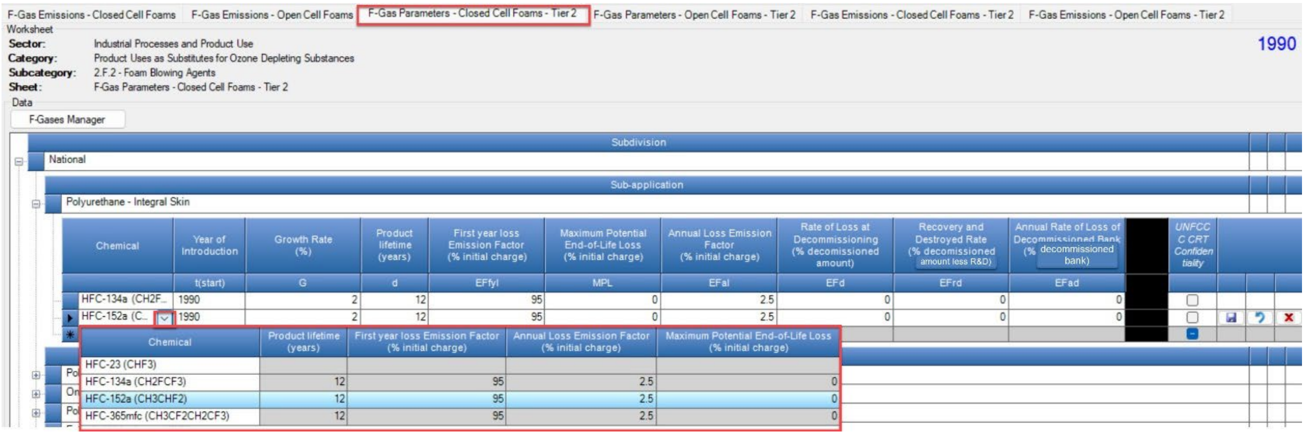
Open Cell Foams

Entry of EFs and parameters in worksheets **F-Gas Parameters- Closed Cell Foams-Tier 2** and **F-Gas Parameters- Open Cell Foams- Tier 2** is identical. For each subdivision/ sub-application in the respective worksheet, the user enters the following information:

1. Column |Chemical|: user selects the relevant F-gas/blend from the drop-down menu (refer to previous section on customizing the *Software* if an additional F-gas or blend needs to be added to the drop-down menu).
   Note that for Closed Cell Foams: for gases for which there are default parameters in Tables 7.6 and 7.7, values for product lifetime, first year losses and annual loss EF will automatically populate (they may be overwritten with country-specific values). For other gases, the user must impact these factors directly. Users should be careful if they change the type of sub-application type after entering the chemical information (e.g. change from integral skin to continuous panel), as the parameter information will not automatically update. The user should delete the row for that chemical and re-enter it, so that the updated parameters are populated.
2. Column |t (start)|: year of introduction of F-gas/blend for closed cell foams.
3. Window |G|: growth rate in consumption, usually assumed linear across the period of assessment, in %.
4. Column |d|: product lifetime, years.
   Note that for Closed Cell Foams: this column is automatically populated for HFC-134a, 152a, 245fa, 365mfc, and 227ea; the user may manually overwrite the default value.
   Note that for Open Cell Foams: a product lifetime of 1 year is automatically populated because the default assumption is that all emissions occur in the year of manufacturing.
5. Column |EFfyl|: EF for first year loss (% of initial charge).
   Note that for Closed Cell Foams: this column is automatically populated for HFC-134a, 152a, 245fa, 365mfc, and 227ea; the user may manually overwrite the default value.
   Note that for Open Cell Foams: an EFfyl of 100 is automatically populated because the default assumption is that all emissions occur in the year of manufacturing.
6. Column |MPL|: EF for maximum potential end-of-life loss (% of initial charge).
   Note that: this column is automatically populated for HFC-134a, 152a, 245fa, 365mfc, and 227ea for Closed Cell Foams; the user may manually overwrite the default values. For both Closed and Open Cell Foams, the Software tracks the chemical remaining over time. The MPL is only used in calculations when it is consistent with the factors selected for first year and annual losses. In cases where the chemical agent remaining is less than the MPL, the value for the chemical agent, and not the MPL, will be used.
7. Column |EFal|: EF for annual loss (% of initial charge).
   Note that for Closed Cell Foams: this column is automatically populated for HFC-134a, 152a, 245fa, 365mfc, and 227ea; the user may manually overwrite the default value.
   Note that for Open Cell Foams: an EFal of 0 is automatically populated because the default assumption is that all emissions occur in the year of manufacturing and there are no annual losses.
8. Column |EFd|: EF for decommissioning losses (% of decommissioned amount less the amount recovered/destroyed).
   Note that: decommissioning losses are those at the end of service life that occur when the product/equipment is scrapped. This factor is applied to the total agent at decommissioning, less any agent that has been recovered/destroyed.
   Note that: inventory compilers should be careful to research decommissioning practices and any recovery and destruction practices within their country closely. If it is not possible to collect data for potential losses upon decommissioning, it should be assumed that all chemical not emitted in manufacturing is emitted over the lifetime of the foam. At the same time, methods should typically assume complete release of blowing agent at decommissioning only where there is definite evidence to support this and should normally attribute emissions to subsequent years based on a more appropriate release function.
9. Column |EFrd|: EF for recovery and destruction rate (% of decommissioned amount).
   Note that: If it is not possible to collect data on recovery and destruction, it should be assumed that 0% is recovered and destroyed. This practice is likely more applicable to closed cell foams than open cell foams.
10. Column |EFad|: EF for losses from the decommissioned bank (% of the decommissioned bank).
11. Column |Confidentiality|: If AD and/or emissions for a particular F-gas consumed in closed or open cell foams is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas.
   Note that: if checked, "C" will be reported for AD and "IE" for emissions in the JSON file generated for the CRT; and all emissions will be reported in category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate (for further information, see Annex I).

Example: **Entering EFs, parameters information and confidentiality for closed cell foams– Tier 2**

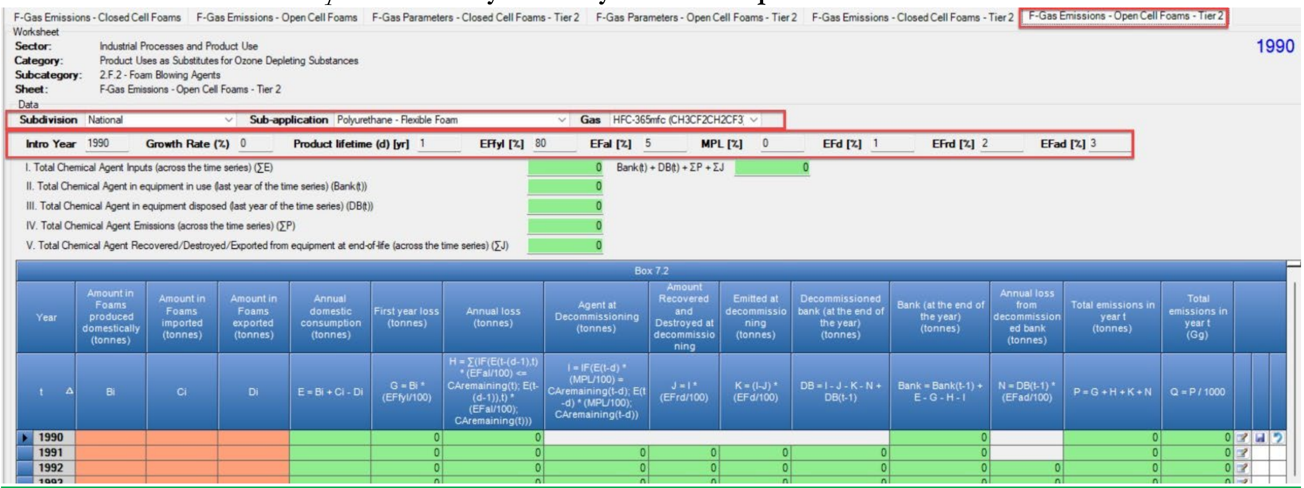
<u>Note that</u> example is for closed cell foams, but column headings the same for Open Cell Foams



12. The user can see information entered in **F-Gas Parameters – Closed Cell Foams- Tier 2** and **F-Gas Parameters – Open Cell Foams- Tier 1** tabs in the main calculation window for closed and open cell foams, respectively. In the image below, the gas consumed in the subdivision /sub-application appears (i.e. HFC-134a), and the parameters are visible. Input of AD for closed and open cell foams is explained in the next section.

Example: **Grid ready for entry of AD for closed cell foams – Tier 2**

Example: **Grid ready for entry of AD for open cell foams – Tier 2**



Activity data input

Sections 7.4.2.3 in Chapter 7 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for 2.F.2 Foam Blowing Agents source category.

Important to highlight for data entry is the need to avoid double counting of F-gas consumption. The possibility of double counting can be mitigated in two ways:

1. **Ensure that consumption of a unique quantity of F-gases is not counted simultaneously in multiple applications**, both within Foam Blowing Agents (e.g. the same quantity of HFC-134a should not be added into worksheets for both open and closed cell foams) or across sub-categories (e.g. the same quantity should not be included in both Refrigeration and Air Conditioning (2.F.1) and Foams (2.F.2)). AD entered in each worksheet should be unique to that subdivision/application/sub-application.
2. **Do not count for both consumption of an F-gas species as well as the consumption of a blend that is then produced from that same quantify of F-gases.** Possible double counting can be mitigated where data are entered all as individual F-gases, or all as blends. Where both are available, care should be taken not to include the same quantity of F-gases twice in the AD.

In addition, the *Software* contains a check for categories 2.F.1, 2.F.2, 2.F.3 and 2.F. 6 (contained applications) to ensure that the data input is consistent with the fundamental principle of mass conservation of the gases. This QA/QC check appears just below the EFs/input parameters and will be discussed below after describing input of AD.

The *Software* will be updated in the future to include a validation check to indicate if the total consumption of F gases across all source categories and applications/sub-applications is equal to or less than the total supply of that F-gas, calculated as *Production of the gas + imports (bulk and equipment)+ amount recycled – exports (bulk and in equipment)– F-gases used to produce blends.*

Input of AD requires the following steps for different Tiers for Foam Blowing Agents

When the Tier 1 Equation is applied:

Closed Cell Foams:

As noted in the section **EF/parameters** above, parameters from the tab **Chemical's Data** will be visible in the worksheet **F-Gas Emissions- Closed Cell Foams**. Next, users need to enter the AD in the red-orange cells, by subdivision/gas, and for each year, as follows:

1. Column |A|: The user should enter all known consumption for each subdivision/gas for closed cell foams in this column, in tonnes. Only those years for which data are known should be entered. Data entered, along

with the growth rate entered in the **Chemical's Data** tab, will be used to interpolate a full, consistent time series of AD. Do not add "0" for years unknown as the 0 will be read as zero consumption, impacting the interpolation of the time series.

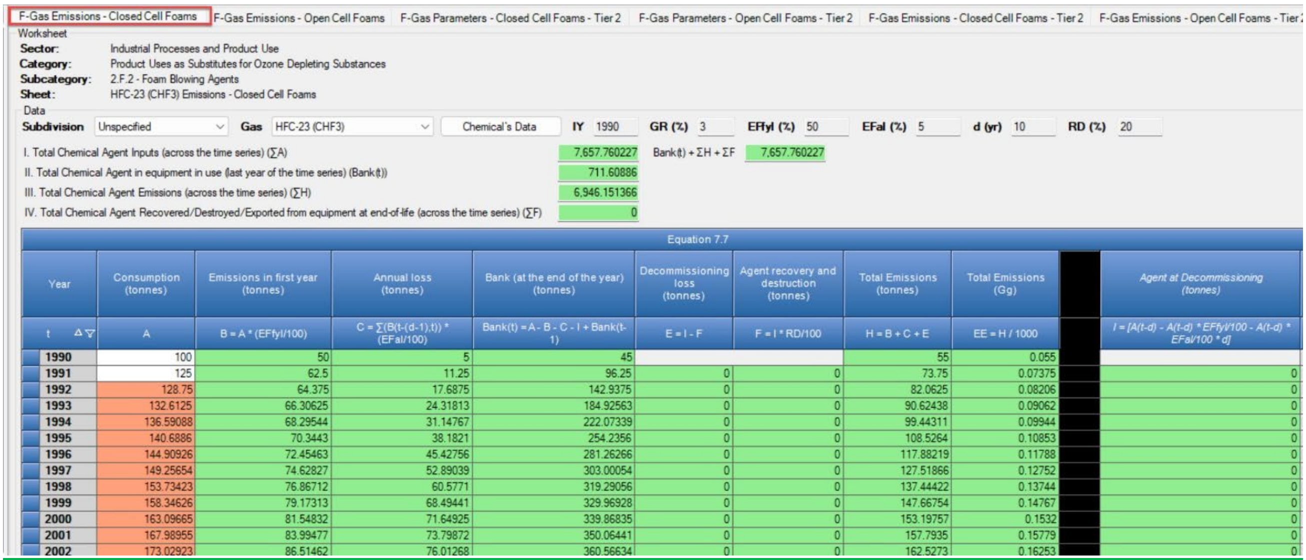
<u>Note that,</u> unlike many categories in IPPU, AD entry worksheets for source category 2.F.2 (along with 2.F.1 and 2.F.3) are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

Once known AD are input, the *Software* makes several calculations based on the factors added in the Chemical's Data tab:

2. <u>Column |B|</u>: calculates emissions in the first year based on, in tonnes.
   *<u>Note that</u> this cell is calculated based on the total consumption in that year and the first-year loss EF entered in the tab **Chemical's Data** tab.*
3. <u>Column |C|</u>: calculates annual emissions from the bank, in tonnes.
   *<u>Note that</u> this cell is calculated based on the development of the bank over the lifetime of currently used closed cell foams, and the annual loss EF entered in the tab **Chemical's Data** tab.*
4. <u>Column |$Bank_{(t)}$|</u>: calculates the bank for the current year, in tonnes.
   <u>Note that</u> this cell is calculated as the bank from the previous year plus consumption for the current year, minus first- year losses, minus annual emissions from the bank, minus amount of agent in decommissioned equipment (<u>Column |I|</u>).
5. <u>Column |E|</u>: calculates the decommissioning losses, in tonnes.
   Based on the amount of agent at decommissioning in <u>(Column |I|</u>) minus the amount in <u>Column |F|</u> that is determined to be recovered/destroyed.
6. <u>Column |F|</u>: calculates emissions prevented by recovery and destruction of foams and their blowing agent, in tonnes.
   *<u>Note that</u> this cell is calculated as the total agent at decommissioning <u>(Column |I|</u>) multiplied by the foam recovery and destruction factor enter in the **Chemical's Data** tab.*
7. <u>Column |H|</u>: calculates total emissions, in tonnes.
   <u>Note that</u> this cell is calculated as the sum of emissions in first year, plus emissions from the bank, plus emissions from decommissioning.
8. <u>Column |I|</u>: The amount of agent at decommissioning is shown separately and in italics, as this amount is calculated for the purposes of reporting to the UNFCCC ETF reporting tool. This is the total amount of agent that is to be decommissioned in a given year (based on the lifetime of the foam).
   <u>Note that</u> this cell is calculated based on the amount consumed in year (t minus the lifetime), minus the first-year losses during manufacturing in that year, minus the sum of the annual losses across the lifetime of the foam and subtracting any first year and annual losses.

Green cells are estimated by the *Software* and cannot be modified. Cell calculations are provided below the column header.

Example: **AD input – closed cell foams-Tier 1**



F-Gas Emissions - Closed Cell Foams | F-Gas Emissions - Open Cell Foams | F-Gas Parameters - Closed Cell Foams - Tier 2 | F-Gas Parameters - Open Cell Foams - Tier 2 | F-Gas Emissions - Closed Cell Foams - Tier 2 | F-Gas Emissions - Open Cell Foams - Tier

Worksheet
Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.2 - Foam Blowing Agents
Sheet: HFC-23 (CHF3) Emissions - Closed Cell Foams

Data
Subdivision Unspecified **Gas** HFC-23 (CHF3) Chemical's Data **IY** 1990 **GR (%)** 3 **EFfyl (%)** 50 **EFal (%)** 5 **d (yr)** 10 **RD (%)** 20

I. Total Chemical Agent Inputs (across the time series) (∑A) 7,657.760227 Bank(t) + ∑H + ∑F 7,657.760227
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 711.60886
III. Total Chemical Agent Emissions (across the time series) (∑H) 6,946.151366
IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑F) 0

Equation 7.7

Year	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Bank (at the end of the year) (tonnes)	Decommissioning loss (tonnes)	Agent recovery and destruction (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	*Agent at Decommissioning (tonnes)*
t	A	B = A * (EFfyl/100)	C = ∑(B(t-(d-1),t)) * (EFal/100)	Bank(t) = A - B - C - I + Bank(t-1)	E = I - F	F = I * RD/100	H = B + C + E	EE = H / 1000	*I = [A(t-d) - A(t-d) * EFfyl/100 - A(t-d) * EFal/100 * d]*
1990	100	50	5	45			55	0.055	
1991	125	62.5	11.25	96.25	0	0	73.75	0.07375	0
1992	128.75	64.375	17.6875	142.9375	0	0	82.0625	0.08206	0
1993	132.6125	66.30625	24.31813	184.92563	0	0	90.62438	0.09062	0
1994	136.59088	68.29544	31.14767	222.07339	0	0	99.44311	0.09944	0
1995	140.6886	70.3443	38.1821	254.2356	0	0	108.5264	0.10853	0
1996	144.90926	72.45463	45.42756	281.26266	0	0	117.88219	0.11788	0
1997	149.25654	74.62827	52.89039	303.00054	0	0	127.51866	0.12752	0
1998	153.73423	76.86712	60.5771	319.29056	0	0	137.44422	0.13744	0
1999	158.34626	79.17313	68.49441	329.96928	0	0	147.66754	0.14767	0
2000	163.09665	81.54832	71.64925	339.86835	0	0	153.19757	0.1532	0
2001	167.98955	83.99477	73.79872	350.06441	0	0	157.7935	0.15779	0
2002	173.02923	86.51462	76.01268	360.56634	0	0	162.5273	0.16253	0

Note that:

1. White cells show where data were entered manually.

2. In the red-orange cells the *Software* interpolates or back-calculates the input. The user should use caution in modifying any red-orange cells, unless data are known. If data are manually entered in an interim year, the *Software* will recalculate the trend between the two known data entry points. **DO NOT ADD ZERO** unless "0" is the known value, as the *Software* will interpolate values assuming the zero. To delete an incorrect entry, instead of using zero, simply delete/clear the value from the cell.
3. Absent historic consumption data, the *Software* back-calculates consumption based on the growth rate.
4. The *Software* calculates emissions from first and annual losses based on EFs from the initial charge.

Ensuring mass conservation of gases

A QA/QC check has been introduced into the worksheets for categories 2.F.1, 2.F.2, 2.F.3 and 2.F.6 (contained applications only) to ensure that the data, EFs and parameters entered by the users ensure conservation of mass of gases over time.

To ensure mass conservation, the *Software* tracks and visually presents the inputs and outputs over time as follows:

I. Total chemical agent inputs, across time ($\sum A$)
II. Total chemical agent in equipment in use (Bank(t))
III. Total chemical agent emissions, across time ($\sum H$)
IV. Total chemical agent recovered/destroyed ($\sum F$)

For Tier 1, mass conservation has been ensured if:

$$\sum A = Bank(t) + \sum H + \sum F$$

If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading you should review data input to ensure that all parameters are coherent.

Some common scenarios leading to orange cells (chemical stored in the system and subsequent emissions are greater than inputs) include:

- First year losses plus annual losses in the first year cannot be greater than 100%, check that $EF_{FYL} + EF_{AL}$ is ≤1.
- Annual losses, summed over the lifetime, cannot be greater than 100%. Check that the EF_{AL} * lifetime ≤1

Example: **Demonstration of mass conservation – Tier 1**

Example: **Mass not conserved over time – Tier 1**

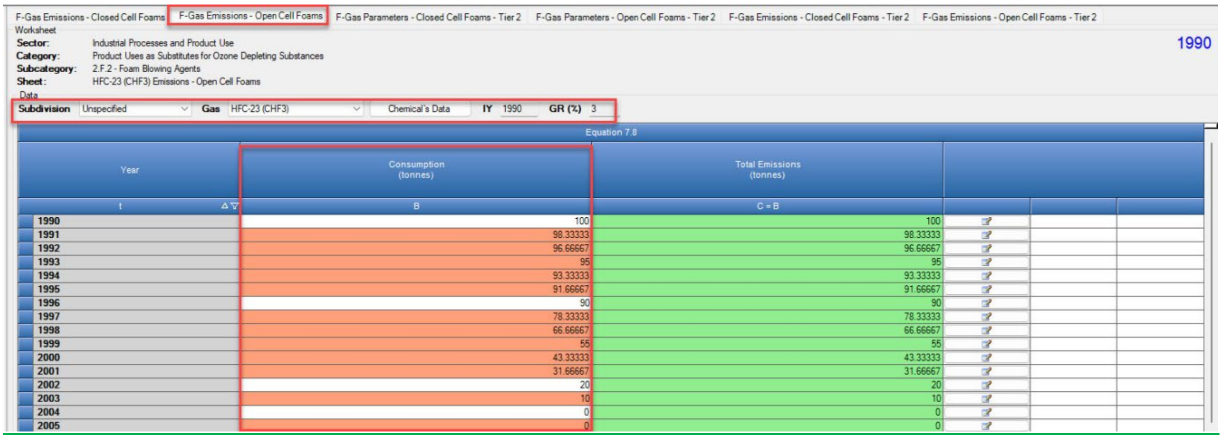
Open Cell Foams:

As noted in the section **EF/parameters** above, parameters from the tab **Chemical's Data** will be visible in the worksheet **F-Gas Emissions- Open Cell Foams**. Next, users need to enter the AD in the red-orange cells, by subdivision/gas, and for each year, as follows:

1. Column |B|: The user should enter all known consumption for each subdivision/gas for open cell foams in this column, in tonnes. Only those years for which data are known should be entered. Data entered, along with the growth rate entered in the **Chemical's Data** tab, will be used to interpolate a full, consistent time series of AD. Do not add "0" for years unknown as the 0 will be read as zero consumption, impacting the calculation of the interpolation of the time series.
   Note that, unlike many categories in IPPU, AD entry worksheets for source category 2.F.2 (along with 2.F.1 and 2.F.3) are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

Once known AD are input, the *Software* calculates total emissions in Column |C| as equal to the consumption in Column |B|, in tonnes, consistent with Equation 7.8 in the *2006 IPCC Guidelines.*

Example: **AD input – open cell foams - Tier 1**



Note that:

1. White cells show where data were entered manually.

2. In the red-orange cells the *Software* interpolates or back-calculates the input. The user should use caution in modifying any red-orange cells, unless data are known. If data are manually entered in an interim year, the *Software* will recalculate the trend between the two known data entry points. **DO NOT ADD ZERO** unless "0" is the known value, as the *Software* will interpolate/extrapolate values assuming the zero (see for example 2004/2005 above). To delete an incorrect entry, instead of using zero, simply delete/clear the value from the cell.
3. Absent historic consumption data, the *Software* back-calculates consumption based on the growth rate.

When the Tier 2 Equation is applied

<u>Closed Cell Foams</u>

<u>Open Cell Foams</u>

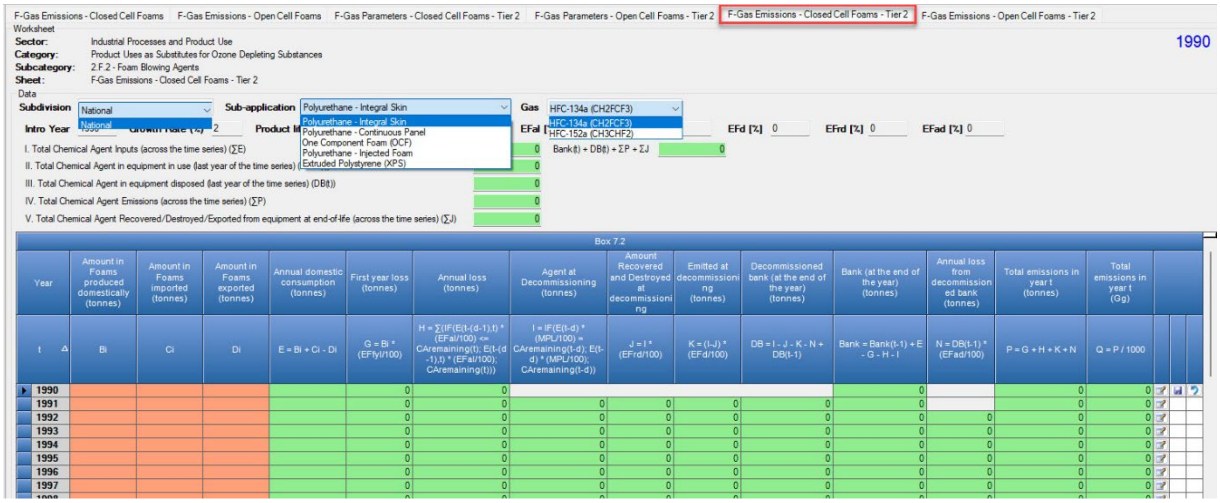
Entry of AD in worksheets **F-Gas Emissions- Closed Cell Foams-Tier 2** and **F-Gas Emissions- Open Cell Foams- Tier 2** is identical.

As noted in the section **EF/parameters** above, parameters from the tab **F-Gas Parameters – Closed Cell Foams-Tier 2** and **F-gas Parameters- Open Cell Foams** will be visible in worksheets **F-Gas Emissions – Closed Cell Foams – Tier 2** and **F-Gas Emissions- Open Cell Foams – Tier** 2, respectively, and the worksheets active so users can select subdivisions, sub-applications and F-gases/blends and estimate emissions.

1. Users first need to select subdivision, then sub-application and F-gas/blend for which AD are to be entered. *<u>Note that</u> if a subdivision/sub-application/F-gas / blend is not available for selection, the user should refer back to the description for Tier 2 in Customizing the Software for Foam Blowing Agents: subdivision/sub-application/F-gases.*
2. Then for each subdivision, sub-application and F-gas/blend users need to populate AD in the white cells of worksheet **F-gas Emissions – Closed Cell Foams- Tier 2** and/or **F-gas Emissions – Open Cell Foams- Tier 2.**

Example: **F-gas Emissions – Closed Cell Foams - Tier 2 (subdivisions, sub-applications and F-gases)**

<u>Note that</u> example is for closed cell foams, but same grid structure (but different sub-applications) applies to Open Cell Foams



AD are entered for each subdivision/sub-application/ F gas/blend, and for each year (based on the year of introduction of the foam blowing agent) in worksheet **F-Gas Emissions – Closed Cell Foams - Tier 2** and/or worksheet **F-Gas Emissions – Open Cell Foams - Tier 2,** as follows:

<u>Note that,</u> unlike many categories in IPPU, AD entry worksheets for source category 2.F.2 (along with 2.F.1 and 2.F.3) are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

1. <u>Column |Bi|</u>: enter the amount of F gases/blends produced domestically, in tonnes.
   <u>Note that:</u> the user should insert values only for the years known. The Software will interpolate/extrapolate missing values. Insert "0" only if zero is the true value otherwise it impacts the interpolation/extrapolation.

2. Column |Ci|: enter the amount of F-gas/blend imported, in tonnes.
Note that: the user should insert values only for the years known. The Software will interpolate/extrapolate missing values. Insert "0" only if zero is the true value otherwise it impacts the interpolation/extrapolation.
3. Column |Di|: enter the amount of F-gas/blend exported, in tonnes.
Note that: the user should insert values only for the years known. The Software will interpolate/extrapolate missing values. Insert "0" only if zero is the true value otherwise it impacts the interpolation/extrapolation.

Once known AD are input, the *Software* makes several calculations based on the factors added in the F-Gas Parameters – Closed Cell Foams- Tier 2 and/or F-Gas Parameters – Open Cell Foams- Tier 2 tabs:

4. Column |E|: total amount of F-gas/blend consumed domestically in year t, in tonnes
Note that this cell is calculated as the sum of production (Column |Bi|) plus imports (Column |Ci|) minus exports (Column |Di|).
5. Column |G|: amount of F-gas/blend lost (emitted) in the first year during manufacture or installation, in tonnes
*Note that this cell is calculated by multiplying the amount of agent used in foams produced domestically in the year by the EF for first year losses (EFfyl) entered in the respective worksheet **F-Gas Parameters- [Closed][Open] Cell Foams-Tier 2**. It is assumed all first-year losses occur in the country of production.*
6. Column |H|: amount of F-gases/blends emitted annually from the bank, in tonnes.
*Note that this cell is calculated by multiplying the amount of agent in the bank by the EF for annual losses (EFal) entered in worksheet **F-Gas Parameters- [Closed][Open] Cell Foams-Tier 2**. The calculation in this column has been constrained to ensure that the annual losses estimated are not greater than the chemical agent remaining in the system (CA remaining) and thus mass is conserved. CA remaining is calculated as the initial charge of the foam, minus first year losses minus annual losses * years of the lifetime reported between the year of introduction of the foam and the current year. If the annual losses estimated are greater than CA remaining, CA remaining is reported in this column.*
7. Column |I|: amount of F-gas/blend remaining at decommissioning in year t, in tonnes.
*Note that this cell is calculated by multiplying the total annual consumption in foams available for decommissioning based on the lifetime by the maximum potential amount of agent in the foam at end of life (MPL) entered in worksheet **F-Gas Parameters- [Closed][Open] Cell Foams-Tier 2**. The calculation in this column has been constrained to ensure that the amount of agent at decommissioning calculated based on the MPL entered by the user is not greater than the chemical agent remaining in the system (CA remaining) and thus mass is conserved. CA remaining is calculated as the initial charge of the foam, minus first year losses minus annual losses multiplied by years of the lifetime reported between the year of introduction of the foam and the current year. If the agent at decommissioning calculated from the MPL is greater than possible chemical agent remaining in the system, then CA remaining is reported in this column.*
8. Column |J|: amount of F-gas/blend recovered and destroyed, in tonnes.
*Note that this cell is calculated by multiplying the amount for decommissioning in Column |I| by the recovery and destroyed rate (EFrd), calculated as a % of decommissioned amount and entered in worksheet **F-Gas Parameters- [Closed][Open] Cell Foams-Tier 2**.*
9. Column |K|: amount of F-gas/blend emitted at decommissioning in year t, in tonnes.
*Note that this cell is calculated by multiplying the amount for decommissioning in Column |I|, less the amount of agent recovered/destroyed, multiplied by the rate of loss at decommissioning (EFd), as entered in worksheet **F-Gas Parameters- [Closed][Open] Cell Foams-Tier 2**.*
10. Column |DB|: decommissioned bank is the quantity of F gas/blend that remains in foams after decommissioning, and will continue to emit, in tonnes.
Note that this cell is calculated as the amount of F-gas/blend in the decommissioned bank from the previous year, t-1, plus amount decommissioned in year t, minus recovery/destruction amount minus current year decommissioning emissions and emissions from the decommissioned bank.
11. Column |$Bank_{(t)}$|: the bank at the end of the year t, in tonnes.
Calculated as the amount of F-gas of the bank from the previous year t-1 plus the amount consumed domestically in year t minus first-year and annual emissions minus decommissioned amount, in tonnes.
12. Column |N|: annual loss from decommissioned bank, in tonnes.
*Calculated as the decommissioned bank multiplied by the annual rate of loss of the decommissioned bank (EFad), entered in worksheet **F-Gas Parameters- [Closed][Open] Cell Foams-Tier 2**.*
13. Column |P|: total emissions in year t, in tonnes
14. Column |Q|: total emissions in year t, in Gg

Example: **AD input for closed and open cell foams- Tier 2**

<u>Note that</u> although example applies to closed cell foams, the data entry grid for open cell foams is exactly the same

F-Gas Emissions - Closed Cell Foams | F-Gas Emissions - Open Cell Foams | F-Gas Parameters - Closed Cell Foams - Tier 2 | F-Gas Parameters - Open Cell Foams - Tier 2 | F-Gas Emissions - Closed Cell Foams - Tier 2 | F-Gas Emissions - Open Cell Foams - Tier 2

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.2 - Foam Blowing Agents
Sheet: F-Gas Emissions - Closed Cell Foams - Tier 2

Data

Subdivision National **Sub-application** Polyurethane - Integral Skin **Gas** HFC-134a (CH2FCF3)

Intro Year 1990 **Growth Rate (%)** 3 **Product lifetime (d) [yr]** 50 **EFfyl [%]** 10 **EFal [%]** 0.5 **MPL [%]** 65 **EFd [%]** 50 **EFrd [%]** 0 **EFad [%]** 50

I. Total Chemical Agent Inputs (across the time series) (∑E) 409,786.382237 Bank(t) + DB(t) + ΣP + ΣJ 409,786.382237
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 376,691.139172
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t)) 0
IV. Total Chemical Agent Emissions (across the time series) (∑P) 33,095.243065
V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑J) 0

Box 7.2

Year	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes)	First year loss (tonnes)	Annual loss (tonnes)	Agent at Decommissioning (tonnes)	Amount Recovered and Destroyed at decommissioning (tonnes)	Emitted at decommissioning (tonnes)	Decommissioned bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss from decommissioned bank (tonnes)	Total emissions in year t (tonnes)	Total emissions in year t (Gg)
t	Bi	Ci	Di	E = Bi + Ci - Di	G = Bi * (EFfyl/100)	H = ∑(IF(E(t-(d-1),t) * (EFal/100) <= CAremaining(t); E(t-(d-1),t) * (EFal/100); CAremaining(t)))	I = IF(E(t-d) * (MPL/100) = CAremaining(t-d); E(t-d) * (MPL/100); CAremaining(t-d))	J = I * (EFrd/100)	K = (I-J) * (EFd/100)	DB = I - J - K - N + DB(t-1)	Bank = Bank(t-1) + E - G - H - I	N = DB(t-1) * (EFad/100)	P = G + H + K + N	Q = P / 1000
1996	106.61845	7,379.00605	0	7,485.62449	10.66184	240.18343	0	0	0	0	47,035.91011	0	250.84527	0.25085
1997	109.817	7,600.37623	0	7,710.19323	10.9817	278.73439	0	0	0	0	54,456.38724	0	289.71609	0.28972
1998	113.11151	7,828.38751	0	7,941.49902	11.31115	318.44189	0	0	0	0	62,068.13323	0	329.75304	0.32975
1999	116.50485	8,063.23914	0	8,179.74399	11.65049	359.34061	0	0	0	0	69,876.88612	0	370.99109	0.37099
2000	120	8,305.13631	0	8,425.13631	12	401.46629	0	0	0	0	77,888.55615	0	413.46629	0.41347
2001	178	8,554.2904	0	8,732.2904	17.8	445.12774	0	0	0	0	86,157.91881	0	462.92774	0.46293
2002	236	8,810.91911	0	9,046.91911	23.6	490.36234	0	0	0	0	94,690.87558	0	513.96234	0.51396
2003	294	9,075.24669	4.16667	9,365.08002	29.4	537.18774	0	0	0	0	103,489.36787	0	566.58774	0.56659
2004	352	9,347.50409	8.33333	9,691.17075	35.2	585.64359	0	0	0	0	112,559.69503	0	620.84359	0.62084
2005	410	9,627.92921	12.5	10,025.42921	41	635.77074	0	0	0	0	121,908.35351	0	676.77074	0.67677
2006	468	9,916.76709	16.66667	10,368.10042	46.8	687.61124	0	0	0	0	131,542.04269	0	734.41124	0.73441
2007	526	10,214.2701	20.83333	10,719.43677	52.6	741.20842	0	0	0	0	141,467.67103	0	793.80842	0.79381
2008	584	10,520.6982	25	11,079.6982	58.4	796.60691	0	0	0	0	151,692.36232	0	855.00691	0.85501
2009	642	10,836.31915	29.16667	11,449.15248	64.2	853.85268	0	0	0	0	162,223.46212	0	918.05268	0.91805
2010	700	11,161.40872	33.33333	11,828.07539	70	912.99305	0	0	0	0	173,068.54446	0	982.99305	0.98299
2011	730	11,496.25099	37.5	12,188.75099	73	973.93681	0	0	0	0	184,210.35864	0	1,046.93681	1.04694
2012	760	11,841.13851	41.66667	12,559.47185	76	1,036.73417	0	0	0	0	195,657.09632	0	1,112.73417	1.11273
2013	790	12,196.37267	45.83333	12,940.53934	79	1,101.43686	0	0	0	0	207,417.19879	0	1,180.43686	1.18044
2014	820	12,562.26385	50	13,332.26385	82	1,168.09818	0	0	0	0	219,499.36445	0	1,250.09818	1.2501
2015	850	12,939.13177	50	13,739.13177	85	1,236.79384	0	0	0	0	231,916.70238	0	1,321.79384	1.32179
2016	880	13,327.30572	50	14,157.30572	88	1,307.58037	0	0	0	0	244,678.42773	0	1,395.58037	1.39558
2017	910	13,727.12489	50	14,587.12489	91	1,380.516	0	0	0	0	257,794.03662	0	1,471.516	1.47152
2018	940	14,138.93864	50	15,028.93864	94	1,455.66069	0	0	0	0	271,273.31457	0	1,549.66069	1.54966
2019	970	14,563.1068	50	15,483.1068	97	1,533.07622	0	0	0	0	285,126.34514	0	1,630.07622	1.63008
2020	1,000	15,000	50	15,950	100	1,612.82622	0	0	0	0	299,363.51892	0	1,712.82622	1.71283

Note that:

1. White cells show where data were entered manually.
2. In the red-orange cells the *Software* interpolates or back-calculates the input. Interpolation takes place between two specified values, e.g. 120 in 2000 and 700 in 2010 and 1000 in 2020. Absent historic consumption data, the Software back-calculates consumption based on the growth rate (see years prior to 2020 in column Ci).
3. Green cells in columns from E to Q are estimates and they cannot be modified manually.

<u>Ensuring mass conservation of gases in Closed and Open Cell Foams- Tier 2</u>

A QA/QC check has been introduced into the worksheets for categories 2.F.1, 2.F.2, 2.F.3 and 2.F.6 (contained applications only) to ensure that the data, EFs and parameters entered by the users ensure conservation of mass of gases over time.

To ensure mass conservation, the *Software* tracks and visually presents the inputs and outputs over time as follows:

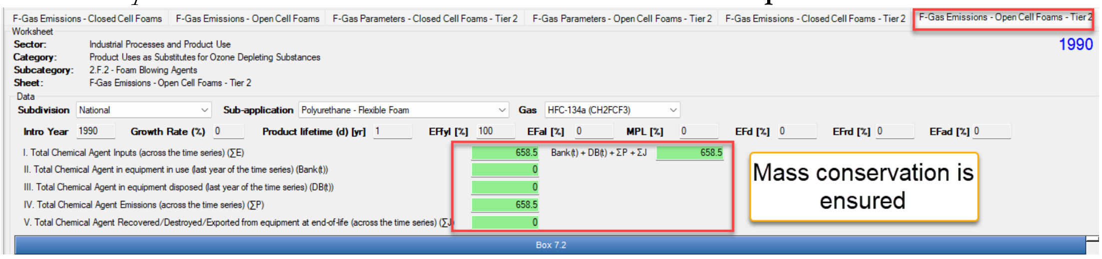
I. Total chemical agent inputs, across time ($\sum E$)
II. Total chemical agent in equipment in use ($\sum Bank_{(t)}$)
III. Total chemical agent in equipment disposed (last year of the time series) ($DB_{(t)}$)
IV. Total chemical agent emissions, across time ($\sum P$)
V. Total chemical agent recovered/destroyed ($\sum J$)

In the case of Tier 2, mass conservation has been ensured if:

$$\sum E = Bank(t) + DB_{(t)} + \sum P + \sum J$$

If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading, refer back to worksheet F-Gas Parameters to ensure that all parameters are coherent.

Example: **Demonstration of mass conservation – Tier 2 Open Cell Foams**



Results

GHG emissions from Foam Blowing Agents are estimated one row for each year of the time series, in the following worksheets:

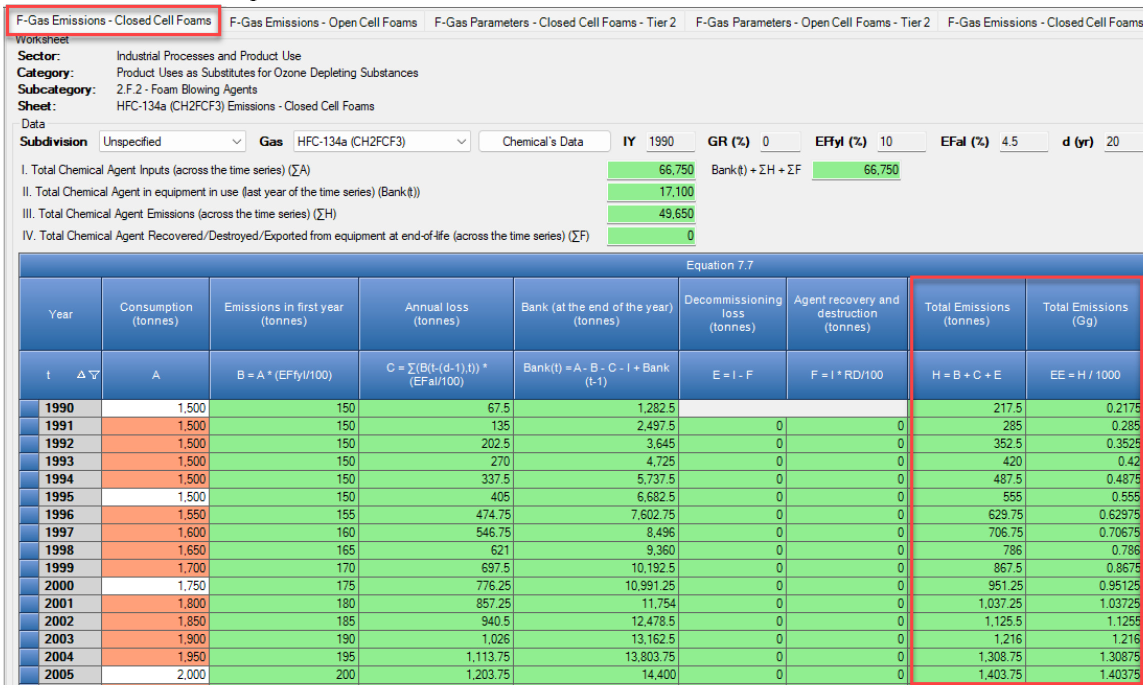
- ✓ **F-Gas Emissions – Closed Cell Foams**
- ✓ **F-Gas Emissions – Open Cell Foams**
- ✓ **F-Gas Emissions – Closed Cell Foams – Tier 2**
- ✓ **F-Gas Emissions – Open Cell Foams – Tier 2**

Total F-gas emissions from foam blowing agents is the sum of all emissions in the above worksheets. For users reporting to the UNFCCC ETF reporting tool, emissions totals will be reported separately for closed cells foams and open cell foams. The *Software* calculates the associated emissions for each F-Gas/blend in the following units: Tier 1 – metric tonnes; Tier 2 – metric tonnes and Gg.

The user will note that Foam Blowing Agents is one of the few categories in the IPPU sector of the *Software* that does not contain a worksheet for **Capture and storage or other reduction.** This is because all capture and other reductions are already accounted for in the worksheets noted above.

Results – emissions in the current inventory year, e.g. in this example 1000 tonnes of HFC-245fa in the year 2020 (equal to the known consumption data in this year)

Example: **Results: F-Gas Emissions – Closed Cell Foams Tier 1**



Year	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Bank (at the end of the year) (tonnes)	Decommissioning loss (tonnes)	Agent recovery and destruction (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)
t	A	B = A * (EFfyl/100)	C = ∑(B(t-(d-1),t)) * (EFal/100)	Bank(t) = A - B - C - I + Bank (t-1)	E = I - F	F = I * RD/100	H = B + C + E	EE = H / 1000
1990	1,500	150	67.5	1,282.5			217.5	0.2175
1991	1,500	150	135	2,497.5	0	0	285	0.285
1992	1,500	150	202.5	3,645	0	0	352.5	0.3525
1993	1,500	150	270	4,725	0	0	420	0.42
1994	1,500	150	337.5	5,737.5	0	0	487.5	0.4875
1995	1,500	150	405	6,682.5	0	0	555	0.555
1996	1,550	155	474.75	7,602.75	0	0	629.75	0.62975
1997	1,600	160	546.75	8,496	0	0	706.75	0.70675
1998	1,650	165	621	9,360	0	0	786	0.786
1999	1,700	170	697.5	10,192.5	0	0	867.5	0.8675
2000	1,750	175	776.25	10,991.25	0	0	951.25	0.95125
2001	1,800	180	857.25	11,754	0	0	1,037.25	1.03725
2002	1,850	185	940.5	12,478.5	0	0	1,125.5	1.1255
2003	1,900	190	1,026	13,162.5	0	0	1,216	1.216
2004	1,950	195	1,113.75	13,803.75	0	0	1,308.75	1.30875
2005	2,000	200	1,203.75	14,400	0	0	1,403.75	1.40375

Example: **Results: F-Gas Emissions – Open Cell Foams- Tier 2**

F-Gas Emissions - Closed Cell Foams | F-Gas Emissions - Open Cell Foams | F-Gas Parameters - Closed Cell Foams - Tier 2 | F-Gas Parameters - Open Cell Foams - Tier 2 | F-Gas Emissions - Closed Cell Foams - Tier 2 | F-Gas Emissions - Open Cell Foams - Tier 2

Worksheet

Sector: Industrial Processes and Product Use

Category: Product Uses as Substitutes for Ozone Depleting Substances

Subcategory: 2.F.2 - Foam Blowing Agents

Sheet: F-Gas Emissions - Open Cell Foams - Tier 2

1990

Data

Subdivision National **Sub-application** Polyurethane - Flexible Foam **Gas** HFC-134a (CH2FCF3)

Intro Year 1990 **Growth Rate (%)** 0 **Product lifetime (d) [yr]** 1 **EFfyl [%]** 100 **EFal [%]** 0 **MPL [%]** 0 **EFd [%]** 0 **EFrd [%]** 0 **EFad [%]** 0

I. Total Chemical Agent Inputs (across the time series) (∑E)	765.5	Bank(t) + DB(t) + ΣP + ΣJ	765.5
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t))	426		
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t))	0		
IV. Total Chemical Agent Emissions (across the time series) (∑P)	339.5		
V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑J)	0		

Box 7.2

Year	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes)	First year loss (tonnes)	Annual loss (tonnes)	Agent at Decommissioning (tonnes)
t	Bi	Ci	Di	E = Bi + Ci - Di	G = Bi * (EFfyl/100)	H = ∑(IF(E(t-(d-1),t) * (EFal/100) <= CAremaining (t); E(t-(d-1)),t) * (EFal/100); CAremaining(t)))	I = IF(E(t-d) * (MPL/100) = CAremaining(t-d); E(t-d) * (MPL/100); CAremaining(t-d))
1990	100	10	0	110	100	0	
1991	102	10	0	112	102	0	0
1992	50	10	0	60	50	0	0
1993	25	12	0	37	25	0	0
1994	20.83333	12	0	32.83333	20.83333	0	0
1995	16.66667	12	0	28.66667	16.66667	0	0
1996	12.5	12	0	24.5	12.5	0	0
1997	8.33333	12	0	20.33333	8.33333	0	0
1998	4.16667	12	0	16.16667	4.16667	0	0
1999	0	12	0	12	0	0	0
2000	0	12	0	12	0	0	0
2001	0	12	0	12	0	0	0
2002	0	12	0	12	0	0	0

Year	Amount Recovered and Destroyed at decommissioning	Emitted at decommissioning (tonnes)	Decommissioned bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss from decommissioned bank (tonnes)	Total emissions in year t (tonnes)	Total emissions in year t (Gg)
t	J = I * (EFrd/100)	K = (I-J) * (EFd/100)	DB = I - J - K - N + DB(t-1)	Bank = Bank(t-1) + E - G - H - I	N = DB(t-1) * (EFad/100)	P = G + H + K + N	Q = P / 1000
1990				10		100	0.1
1991	0	0	0	20		102	0.102
1992	0	0	0	30	0	50	0.05
1993	0	0	0	42	0	25	0.025
1994	0	0	0	54	0	20.83333	0.02083
1995	0	0	0	66	0	16.66667	0.01667
1996	0	0	0	78	0	12.5	0.0125
1997	0	0	0	90	0	8.33333	0.00833
1998	0	0	0	102	0	4.16667	0.00417
1999	0	0	0	114	0	0	0
2000	0	0	0	126	0	0	0
2001	0	0	0	138	0	0	0
2002	0	0	0	150	0	0	0

2.F.3 Fire Protection

Guidance for the use of the *Software* for source category 2.F.3 Fire Protection is provided above in the section **2.F.1 and 2.F.3 Refrigeration and Air Conditioning, and Fire Protection**. Procedures for entering data and information in the *Software* for Fire Protection follows the description for the Tier 1 equations for Refrigeration and Air Conditioning.

2.H Other

Information

This section groups guidance for the following source categories according to their common methodological approaches applied in the *Software*:

- ✓ **2.H.1 Pulp and Paper Industry**
- ✓ **2.H.2 Food and Beverages Industry**
- ✓ **2.H.3 Other**

The *2006 IPCC Guidelines* do not provide methodological guidance for estimating GHG emissions from these source categories (including worksheets). Rather, a generic worksheet is provided using the Tier 2 Basic Equation(AD x EF), the same worksheet used for Other categories, such as described above for **2.A.5 Other** and **2.B.11 Other**.

GHGs

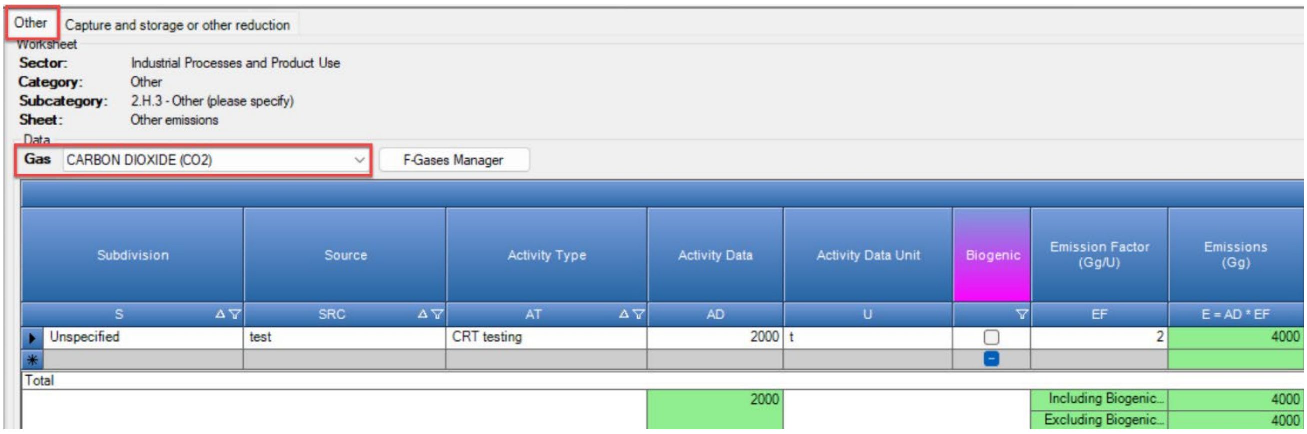
Emissions from the Other (IPPU) source category include the following GHGs (HFCs, PFCs, SF_6 and NF_3 for category 2.H.3 only):

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X	X	X	X	X

For more information on **IPCC Equations, Software Worksheets, User's work Flowchart. Activity data input, Emission factor input** and **Results** refer to the corresponding information and figures in section **2.A.5 Other** for source categories 2.H.1 and 2.H.2 and section **2.B.11 Other** for source category 2.H.3.

Example: **2.H.3 Other – Generic worksheet**

Note that the example for 2.H.3 also applies to 2.H.1 and 2.H.2 except the biogenic indicator



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,* and in limited cases where needed for reporting to the United Nations Framework Convention on Climate Change (UNFCCC), the *2019 Refinement to 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 ETF 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, through a separate UNFCCC platform and with proper credentials, be uploaded and further processed for transfer to the UNFCCC.

Preparing a JSON file that can be imported into the UNFCCC ETF Reporting Tool required a cell-by-cell mapping to identify where AD and GHG emissions estimates contained in each worksheet of the *Software* reside in the CRT.

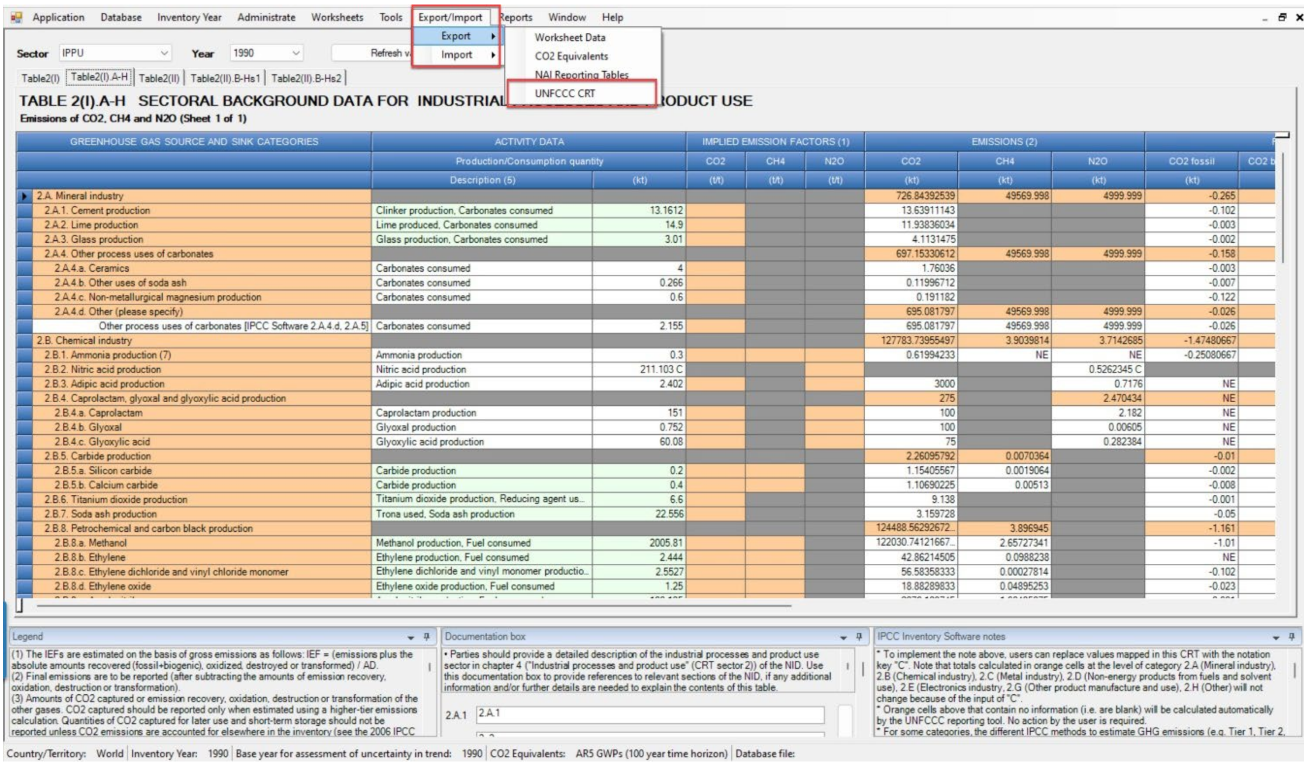
This annex contains detailed information to illustrate the mapping of categories and gases between the *Software* and the CRT for reporting of emissions from the IPPU sector and is supplemental to the general information provided in the UNFCCC Interoperability – CRT Export Quick Start Guide.

CRT visualization tables in the IPCC Inventory Software

The mappings between the *Software* and the CRT are visualized in the *Software* to allow the user to properly understand (thus enhancing transparency) and keep for internal use the results of the conversion of IPCC category GHG estimates into UNFCCC NGHGI categories.

To generate the visualization tables, select from the main ribbon "Export/Import" and then "UNFCCC CRT". For complete guidance on how to produce a CRT data set and compile data from the underlying worksheets of the *Software* into the CRT data set, refer to the **IPCC Inventory Software -UNFCCC Interoperability – CRT Export Quick Start Guide**. The result of the generated tables is presented below for the IPPU sector.

Example: **Generating visualized CRT for the IPPU sector**



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 the case of short-lived climate forcer emissions, data in the sector summary tables of the CRT are mapped from the IPCC sectoral reporting table.

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 of the *Software*.
2. The tab in that worksheet that contains the relevant information.
3. The gas of interest.
4. The column that contains the relevant information (AD, parameter on emissions), 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 CO_2 emissions cement production 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, after import of the JSON file.

The mapping example for CO_2 emissions from cement production below is a good example to highlight some relatively common occurrences in the IPPU sector:

- The *2006 IPCC Guidelines* contain multiple tiers to estimate emissions, and due to the nature of the differing methods, they are implemented through different worksheets in the *Software*. Thus, the mapping instructions must guide the user to different cells in different worksheets. In the example below, there is reference to the worksheet "**Cement production (2/2)**", "**Clinker production = Tier 2**" and "**CO_2 Emissions Summary- Tier 3 (4/4)**" referring to worksheets for the Tier 1, Tier 2 and Tier 3 methods, respectively. This issue is expanded further below, following the example.
- In accordance with the agreed CRTs, final emissions in the IPPU sector are reported after subtracting the amounts of emission recovery, oxidation, destruction or transformation, thus there is typically a parameter to subtract any such reduction (e.g. below there is a subtraction for any CO_2 capture reported in the worksheet **Capture and storage or other reduction.**

The following recurrent key instructions in the mapping are:

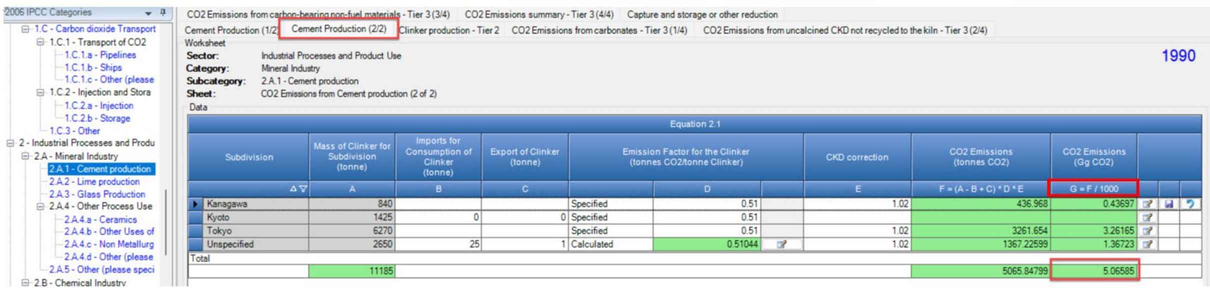
- ✓ The sign **"SUM"** indicates a summatory of information (numerical or alphabetical) contained across the column/row to which applies.
- ✓ The sign **"-SUM"** indicates that the result of the summatory is to be reported as a negative value.
- ✓ The sign **"AND"** indicates an additional element for 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 sign **"EXCEPT"** indicates all elements for mapping to be included except the listed element, because this element (e.g. category) is already included elsewhere.
- ✓ The signs "**MULTIPLY BY"** and **"DIVIDE BY"** indicate the corresponding mathematical operation to be applied to information sourced from the *Software*.
- ✓ The sign "**ISNOT"** means $\neq$
- ✓ The text **"IF"** and **"IF NOT"** explain a condition for mapping of information to the cell. IF no condition applies based on information populated by user in the *Software*, automatically insert "NE", unless otherwise specified.

Example: How to read mapping between the *Software* and the UNFCCC CRT

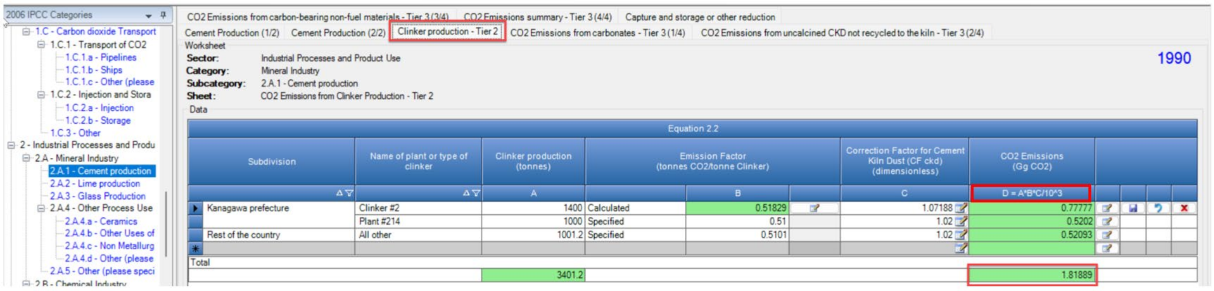
UNFCCC CRT

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2
2.A. Mineral industry	SUM (H11:H14)
2.A.1. Cement production	IPCC 2.A.1 <Cement Production (2/2)> SUM of values in column G **PLUS** IPCC 2.A.1 <Clinker production - Tier 2> SUM of values in column D **PLUS** IPCC 2.A.1 <CO2 Emissions summary - Tier 3 (4/4)> SUM of values in column E /1,000 **MINUS** IPCC 2.A.1 <Capture and storage or other reduction> SUM of values in column C / 1,000.

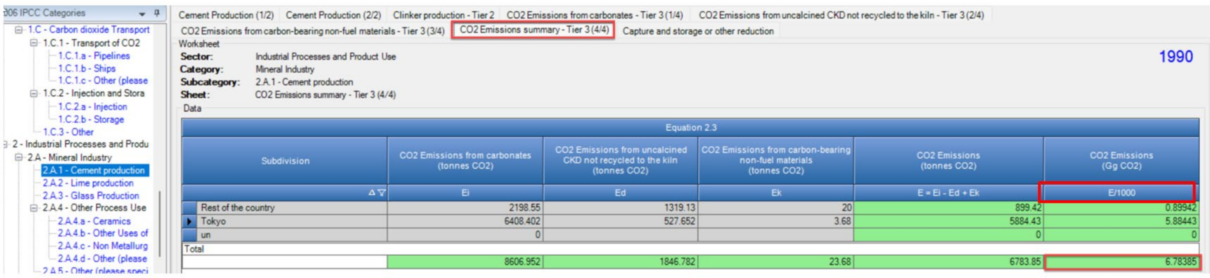
IPCC Inventory Software



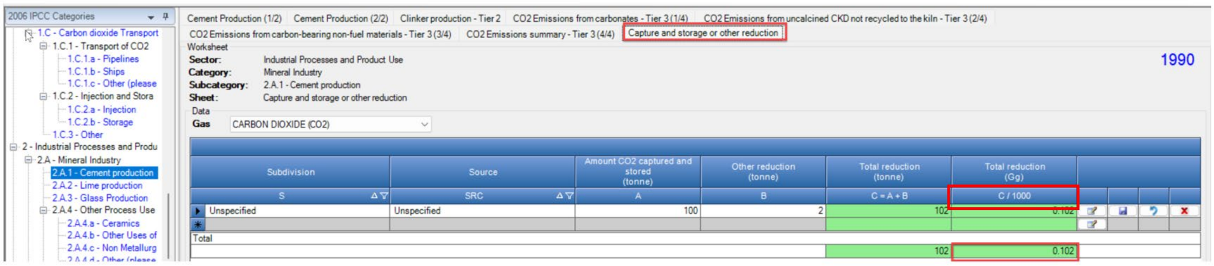
PLUS



PLUS



MINUS



There are several elements for the mapping of IPPU sector emissions relevant to highlight for users:

1. **Adding dis-similar types of AD (e.g. production and consumption):**
   Often, in the IPPU sector, different Tier methods require different types of AD. For example, for cement production (category 2.A.1), Tier 1 and Tier 2 rely on the amount of clinker produced, while Tier 3 emissions estimates are based on the type and amount of carbonates consumed. In the case of HFC-23 emissions from HCFC-22 production (category 2.B.9a), Tier 1 and Tier 2 estimates are based on the amount of HCFC-22 produced, while Tier 3 is a direct measurement method and thus does not have AD.

   Users may want to apply different Tier methods in different subdivisions, and in fact this may be desirable if it is possible to use a higher tier for a subset of the GHG inventory, but not the entire inventory. It would not be meaningful, however, to add different types of AD for the purposes of reporting to the CRT. This is because AD, in addition to providing information on how much of some product is produced or consumed, are also used to calculate an implied emission factor (equal to emissions/AD) which is a common metric that can be used to compare information across Parties.

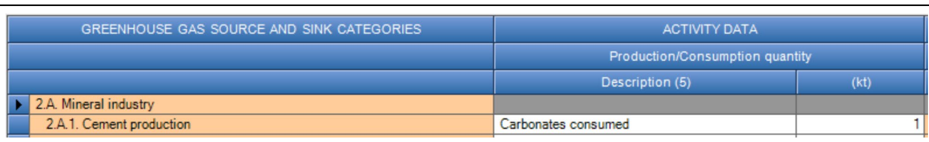
   To address this issue, and with a view to enhancing transparency and comparability, AD are aggregated in the visualized CRT, and transferred in the JSON file to the UNFCCC, as follows (see accompanying figure):

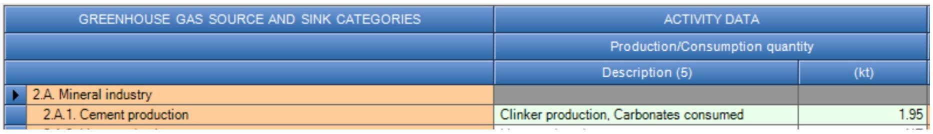
   ✓ If all the same type of AD is used for the user's selected Tiers, these AD values are combined and appear in the visualized CRT (scenario #1 below). In the cement example, if a user applies all Tier 1 and/or Tier 2 methods, the total amount of clinker production is aggregated and the visualized CRT 2(I).A-H reports AD as "Clinker production" and the total amount of clinker. Similarly, if all Tier 3 is applied (Scenario #2 below), the AD reported are for the amount of "Carbonates consumed" and the AD are summed accordingly.

   ✓ If the AD differ, as in the case of scenario #3, the cells for description and AD are pale green, and the user can see under **Description** a comma separated list of the types of AD used (e.g. "Clinker production, Carbonates consumed"). This is a signal to the user that the underlying methods applied by the user cannot be simply aggregated. In column (kt) the *Software* provides <u>only the value of the AD for the Tier 1 method (and Tier 2 when the method relies on the same AD, as is the case for cement production)</u>. If the user takes no action, he/she would be submitting incomplete AD in the JSON file, representing only that portion of the GHG Inventory covered by the Tier 1 and Tier 2 methods.
   Note that: the categories for which it is possible to have different types of AD when using different Tiers are indicated by "T1" in the mapping file linking the Software and the CRT. For further information, see ***Table 3.***

   The issue described above affects only AD; in all three scenarios, GHG emissions are the same and reflect total national GHG emissions.

Example: **Aggregating AD: cement production example**

Scenario	How AD are aggregated in visualized CRT
#1: User applies all Tier 1 and/or Tier 2 methods	
#2: User applies all Tier 3 methods	

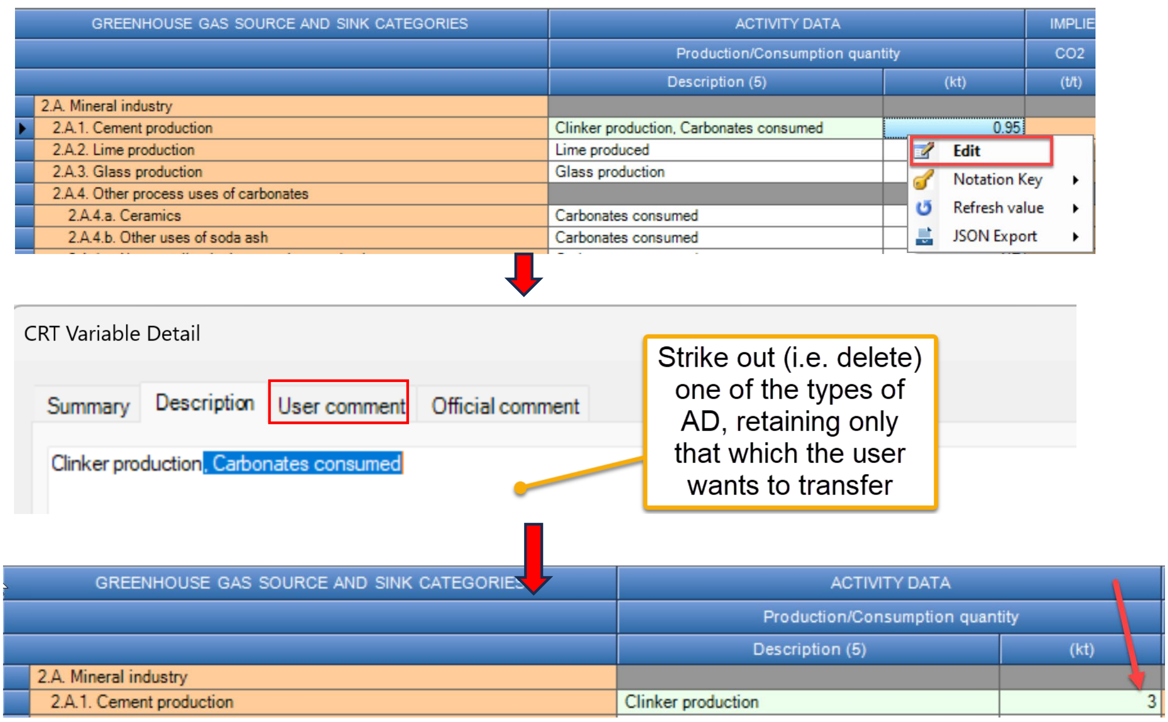
#3: User applies combination of Tier 1/2 and 3 methods	

- ✓ To transfer complete and meaningful AD, the pale green cells are editable and should be updated to ensure that that the AD reflect the entire inventory. To update the information, the user shall:
  1. Right click on the value of the AD and select **Edit**
  2. Select **Description** from the pop-up box. The user will see the comma separated list of AD used in the methods. Select the description that reflects the type of AD the user intends to use for reporting, and for which total national AD are available. In the example below, for instance, the user may delete "Carbonates consumed" if he/she wishes to report total national clinker production. **It is important that the user ONLY deletes one of the choices and does not to make any other changes to the text, otherwise the description will not transfer to the CRT.**

     > **Important:** Note that the UNFCCC ETF Reporting Tool is not currently reading any descriptions for the IPPU sector, as of January 2025 this information must be entered directly in the ETF Reporting Tool. The user is encouraged nevertheless to enter information as described above in the visualized CRT, for ease of future reporting. The updated value, described in step 3 below will be read and must be updated for accurate reporting.

  3. With the description change to Clinker production, now **manually edit the value in Column |kt|**: to equal total national amount of clinker produced (0.95 was updated to 3 in the example below).

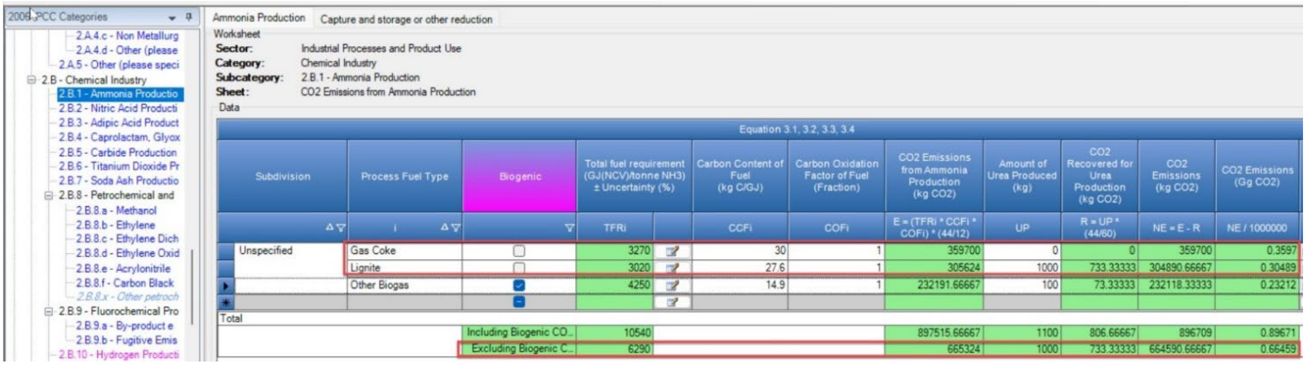
Example: **Updating AD when multiple Tiers are used**



2. **Calculation of CO_2 emissions from biogenic feedstocks in IPPU:**

The *Software* allows the user to designate through a checkbox if a feedstock/reductant is of biogenic nature (e.g. biochar in the iron and steel industry). The *Software* then calculates GHG emissions for a category / sector/ national total with and without biogenic CO_2. Biogenic emissions from the IPPU sector are not reported in the UNFCCC ETF Reporting Tool, although the capture of CO_2 emissions of a biogenic origin are included, and thus reflected in the net CO_2 emissions reported for a category, if applicable. This principle is reflected in the mapping.

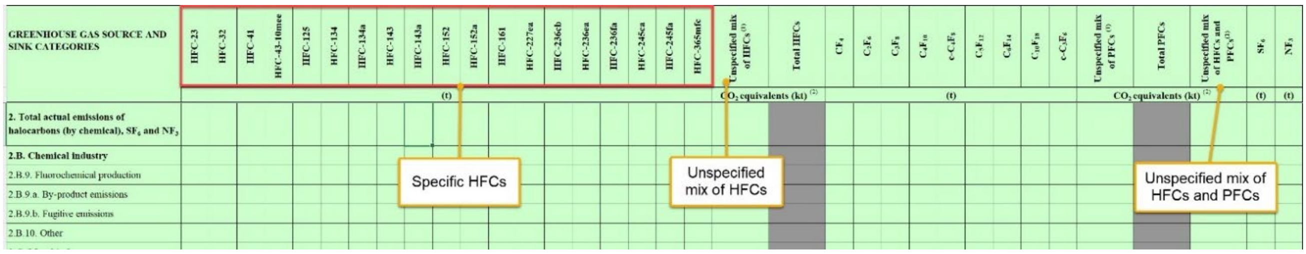
Example: CO_2 emissions mapped to the CRT is the total, excluding biogenic CO_2. Any capture of biogenic CO_2 would be included as a reduction from CO_2 emissions from ammonia production



3. **Reporting emissions from "Unspecified mix of…." HFCs and/or PFCs.**

The UNFCCC ETF Reporting Tool does not allow users to separately report all F-gases for which there is a GWP in the AR5; rather the tool requires the user to report these other emissions combined, under "Unspecified mix of HFCs", "Unspecified mix of PFCs" and/or "Unspecified mix of HFCs and PFCs". However, when calculating emissions in the *IPCC Inventory Software*, the user enters all individual gases, and the *Software* assigns the appropriate AR5 GWP. When mapping to the CRT, all F-gases not represented in a separate column of Table 2(II) of the CRT are combined as "Unspecified mix…" , and reported in $GgCO_2$ eq (e.g. either unspecified mix of HFCs, or unspecified mix of HFCs and PFCs, depending on the category).

Example: **Mapping of individual specifies of F-gases to Table 2(II) of the CRT**



4. **Reporting emissions from consumption of blends of refrigerants.**

The *Software* allows the user to input, and estimate GHG emissions from, the use of refrigerant blends. For reporting, the total emissions of the refrigerant (e.g. R-401A) will be separated into its constituent parts. For example, for R-401A, 13% of the refrigerant is composed of HFC-152a, thus 13% of the emissions from consumption of the refrigerant blend will be mapped to HFC-152a emissions from refrigeration and air conditioning in the *Software* and the UNFCCC ETF Reporting Tool. Other constituents that are covered by the Montreal Protocol and thus not reported under the UNFCCC (e.g. HCFC-22) are not included in the *Software* or the JSON file for transfer to the UNFCCC. For a list of the refrigerants included in the *Software,* refer to the **F-Gases Manager-blends.**

5. Confidentiality.

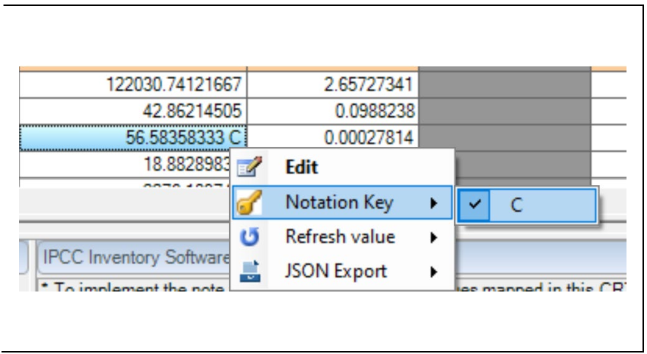
The UNFCCC ETF Reporting Tool allows Parties to claim information as "C", noting that some level of aggregation may be needed to mask confidential information. Confidential emissions must still be included in totals for a complete GHG inventory. If necessary, users of the *Software* may claim AD or emissions as confidential in the visualized CRT. Cells designated with a "C" (Confidential) will not be included in the JSON file. It is the user's responsibility to understand how confidentiality works, and ensure they understand what is contained in the IPCC JSON file for upload to the UNFCCC ETF Reporting Tool.

There are two different ways of handling confidentiality in the *Software*; one or non-F-gases (i.e. in CRT 2(I)A-H) and another way for F-gases (CRT 2(II)B-Hs1 and CRT 2(II)B-Hs2).

<u>Designating AD and emissions confidential in CRT 2(I)A-H</u>

Users are allowed to change values in white cells of the visualized CRT to "C". To do this, the user:

1. right clicks on the cell and selects **Edit**
2. selects **Notation Key**
3. checks the **"C"**
4. The value will still appear in the visualized CRT, with a "C" at the end. The value will not be included in the JSON file. Only a "C" will transfer.



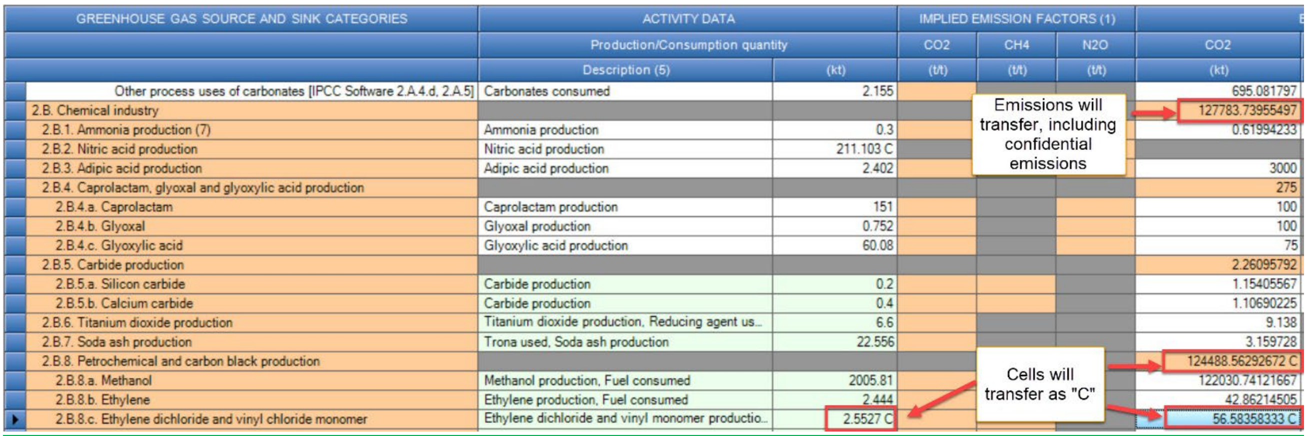
For this CRT, the steps above ensure that the AD are "C", and since there are no aggregations of data in CRT 2(I)A-H, the confidential AD cannot be back-calculated. Typically, emissions are not considered confidential. However, efforts have been made to allow a user to designate emissions as confidential, if necessary, while ensuring that total emissions still include the confidential emissions, to ensure a complete GHG inventory.

For CO_2, CH_4 and N_2O emissions, if a user designates a white cell as "C", and there is only one or two categories as "C" it is possible that the confidential emissions could be back-calculated or known. Thus, users may change orange cells to "C" up to a certain category level in each visualization table. At some levels it is not possible to change a value to "C" because to do so would result in no emissions transferring to the UNFCCC in a category. Confidential emissions must still be included in the national inventory.

In the example below, all AD and emissions labelled as "C" for the petrochemical industry will transfer as "C".

Typically, concerns around confidentiality are about AD, not emissions. In the example below, there is no aggregation of AD. The "C" for category 2.B.8.c will transfer and AD will remain fully masked in the transfer.

Example: **Designating AD and emissions confidential in CRT 2(I).A-H**



GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS (1)			
	Production/Consumption quantity		CO2	CH4	N2O	CO2
	Description (5)	(kt)	(t/t)	(t/t)	(t/t)	(kt)
Other process uses of carbonates [IPCC Software 2.A.4.d, 2.A.5]	Carbonates consumed	2.155				695.081797
2.B. Chemical industry						127783.73955497
2.B.1. Ammonia production (7)	Ammonia production	0.3				0.61994233
2.B.2. Nitric acid production	Nitric acid production	211.103 C				
2.B.3. Adipic acid production	Adipic acid production	2.402				3000
2.B.4. Caprolactam, glyoxal and glyoxylic acid production						275
2.B.4.a. Caprolactam	Caprolactam production	151				100
2.B.4.b. Glyoxal	Glyoxal production	0.752				100
2.B.4.c. Glyoxylic acid	Glyoxylic acid production	60.08				75
2.B.5. Carbide production						2.26095792
2.B.5.a. Silicon carbide	Carbide production	0.2				1.15405567
2.B.5.b. Calcium carbide	Carbide production	0.4				1.10690225
2.B.6. Titanium dioxide production	Titanium dioxide production, Reducing agent us...	6.6				9.138
2.B.7. Soda ash production	Trona used, Soda ash production	22.556				3.159728
2.B.8. Petrochemical and carbon black production						124488.56292672 C
2.B.8.a. Methanol	Methanol production, Fuel consumed	2005.81				122030.74121667
2.B.8.b. Ethylene	Ethylene production, Fuel consumed	2.444				42.86214505
2.B.8.c. Ethylene dichloride and vinyl chloride monomer	Ethylene dichloride and vinyl monomer productio...	2.5527 C				56.58358333 C

The user cannot change the following rows to "C" in the visualization tables (references to "row" refers to the row in the mapping tables appended to this guidebook).

- ✓ Row 10 -category 2.A. Mineral industry
- ✓ Row 20- category 2.B. Chemical industry
- ✓ Row 50- category 2.C. Metal industry
- ✓ Row 69- category 2.D. Non-energy products from fuels and solvent use
- ✓ Row 80- category 2.E. Electronics industry
- ✓ Row 87- category 2.G. Other product manufacture and use
- ✓ Row 97- category 2.H. Other

Designating AD and emissions confidential in 2(II)B-Hs1 and 2(II)B-Hs2

The structure of UNFCCC reporting tables for F-gases is different than that for non-F gases in table 2(I)A-H. Specifically, there are no aggregations of emissions (or AD) in these tables. This necessitates a different approach for allowing the user to designate F-gases as confidential.

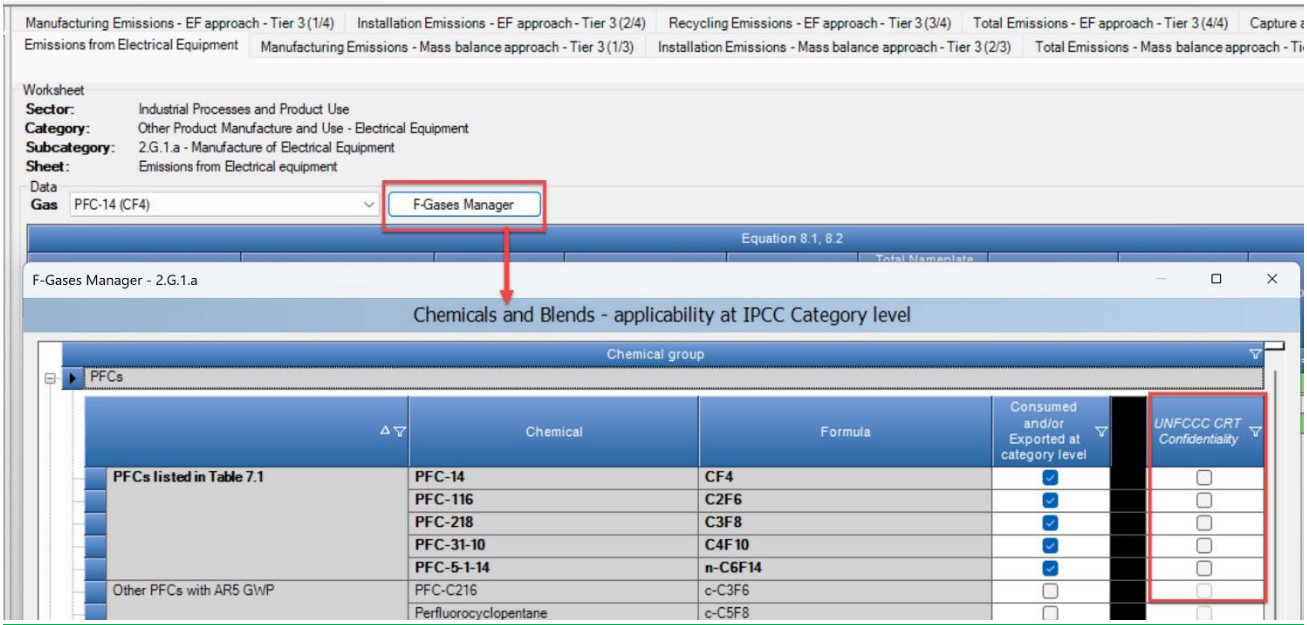
Designation of a gas as confidential is made by the user, category by category, generally (but not always) at the point where the user indicates which F-gases/blend are relevant for the category (i.e. in the F-gases Manager at the category level).

To access the category level F-gases Manager the user shall:

- ✓ select **F-Gases Manager** to open the IPCC category level manager.
- ✓ check the box(es) for the gas(es) or blends that are confidential

Examples are provided below to show how/where to designate a gas as confidential.

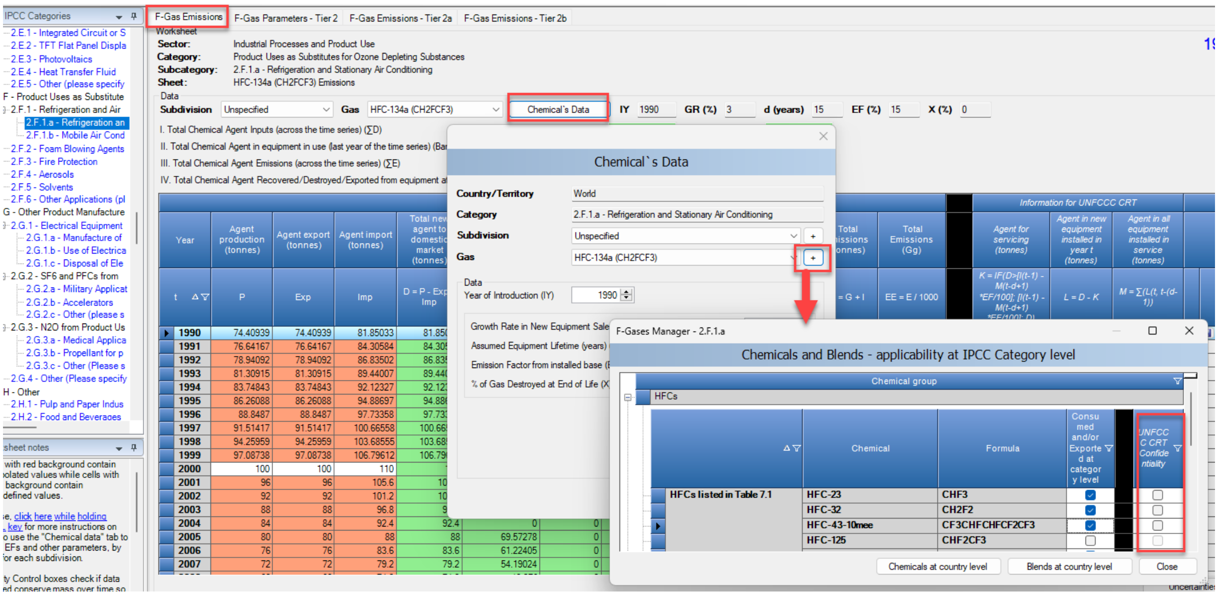
Example: **Designating a gas/category combination as confidential for F-gases: most categories**



Due to the structure of the *Software* and the mapping to the CRT, the user will find the designation of confidentiality differs from the explanation above, as follows:

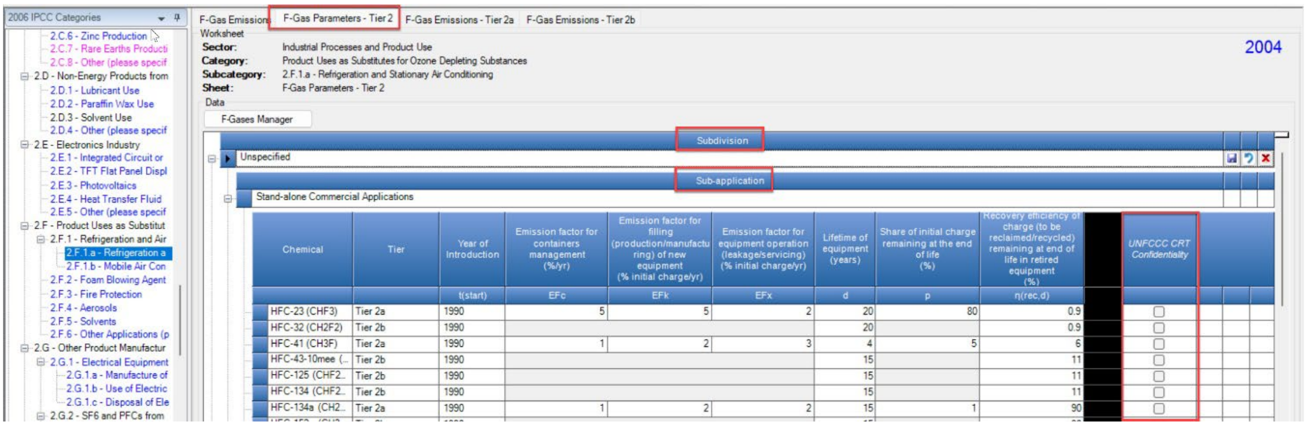
1. For 2.F.1, worksheet **F-Gas Emissions** and 2.F.3, worksheet **Emissions from Fire Protection**, the designation of confidentiality can be found in the **Chemical's Data** tab

Example: **Designating a gas/category combination as confidential: 2.F.1 (tier 1 only) and 2.F.3**



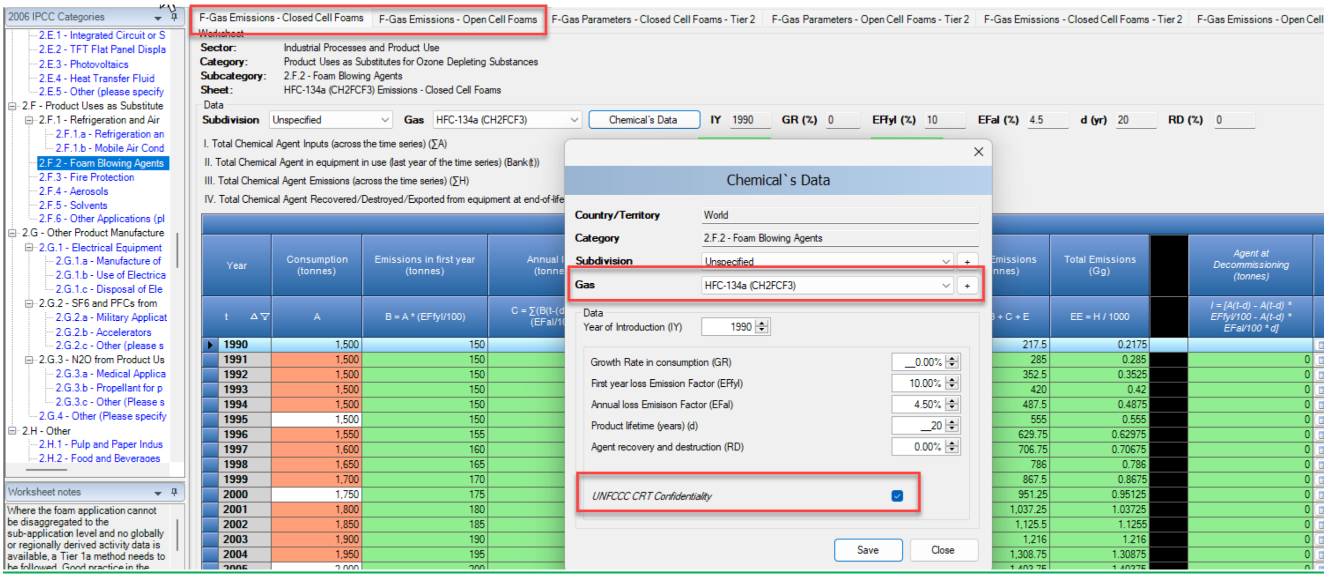
2. For 2.F.1**,** worksheet **F-Gas Parameters- Tier 2** and 2.F.2, worksheets **F-Gas Parameters- Open cell foams- Tier 2** and **F-Gas Parameters- closed cell foams- Tier 2**, the gases may go to multiple applications, so confidentiality is designated at the level gases are added to a sub-application.

Example: **Designating a gas/category combination as confidential: 2.F.1 and 2.F.2** (both Tier 2)



3. For 2.F.2, worksheets **F-Gas Emissions- Closed Cell Foams** and **F-Gas Emissions – Open Cell Foams** designation of confidentiality occurs in the **Chemical's Data** tab, at the bottom of the pop-up box for each selected gas. In this example, the user would first select the [+] plus sign to select the relevant gas(es) and then at the bottom of the box, designate that gas as confidential.

Example: **Designating a gas/category combination as confidential: 2.F.2** (both Tier 1)



In all cases, where F-gases are designated as confidential, the AD will not be included in the JSON file for transfer to the UNFCCC CRT. Emissions of F-gases will all be reported, combined as "from stocks", in unspecified mix of HFCs and PFCs, and/or SF_6 and/or NF_3 in category 2.H, in tCO_2 eq.

Example: **F-gases designated as confidential reported, together, under 2.H, stocks**

Sector IPPU Year 1990 Refresh values

Table2(I) | Table2(I).A-H | Table2(II) | Table2(II).B-Hs1 | Table2(II).B-Hs2

TABLE 2(II).B-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE

Sources of fluorinated substances (Sheet 2 of 2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA Amount			IMPLIED EMISSION FACTORS (1)			EMISSIONS (2)		
	Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	From manufacturing	From stocks	From disposal
	(t)	(t)	(t)	%	%	%	(t)	(t)	(t)
SF6	11229.8	300	333.3				7154.72	145.4	70451.636
2.G.2. SF6 and PFCs from other product use (12)									
2.G.2.a. Military applications									
Unspecified mix of PFCs	IE	22	IE				IE	-1296518.74	IE
SF6	IE	22	IE				IE	185.293	IE
2.G.2.b. Accelerators									
Unspecified mix of PFCs	IE	0.14428	IE				IE	-19533741.66331	IE
SF6	IE	198.9332	IE				IE	33.335183	IE
2.G.2.c. Soundproof windows									
SF6	2	NE	NE				0.66	NE	NE
2.G.2.d. Adiabatic properties: shoes and tyres									
Unspecified mix of PFCs	NE	NE	NE				NO	NE	NO
SF6	IE	2	IE				IE	2	IE
2.G.2.e. Other									
2.G.2.e.i. Waterproofing electronic circuits									
CF4	NE	NE	NE				NE	NE	NE
C2F6	NE	NE	NE				NE	NE	NE
Unspecified mix of PFCs	NE	NE	NE				NO	NE	NO
2.G.2.e.ii. Other (please specify)									
Other prompt emissive applications [IPCC Software 2.G.2.c]									
Unspecified mix of PFCs	IE	8	NA				IE	53040	NA
SF6	NO	NE	NA				NO	NE	NA
2.G.4. Other (please specify)									
Other product manufacture and use [IPCC Software 2.G.4]									
Unspecified mix of HFCs and PFCs	IE	125	IE				IE	12431250000	IE
SF6	NO	NE	NO				NO	NE	NO
NF3	NO	NE	NO				NO	NE	NO
2.H. Other (please specify)									
2.H.3. Other (please specify)									
Other industrial processes and product use [IPCC Software]									
Unspecified mix of HFCs and PFCs	IE	0	IE				IE	1138753684241.99	IE
SF6	IE	0	IE				IE	5992000	IE
NF3	IE	0	IE				IE	19990000	IE

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.

Notation keys are automatically populated in some cells of the visualized CRT for the IPPU sector. In some cases, these are automatically populated for all users (e.g. recovery of biogenic CO_2 from the mineral industry is automatically populated as "NA" for all users as it is not applicable). In some cases, certain notation keys will be populated depending on user choices (for example, if the user applies Tier 1 for refrigeration and air conditioning, all emissions are reported under commercial refrigeration in the CRT, and other sub-applications (except mobile air conditioning) are reported as "IE".

Table 4 explains the use of notation keys for each table relevant for reporting of GHG emissions from the IPPU sector. If appropriate for national circumstances, the user may change the type of notation key populated prior to generating the JSON file (e.g. if a category labelled as "IE" or "NA" is really not occurring in the country the user may change the notation key to "NO"). Recall that for reporting in the CRTs, Parties should provide the necessary explanations for the use of the notation keys "NE" and "IE". Refer to the UNFCCC Interoperability-CRT Export Quick Start Guide for more information on how to change notation keys and enter notation key explanations.

Note that the information included in Table 4 is in addition to the automatic population of notation keys if a user does not include any information for a category/gas. These rules can be found in the top of the columns for each table of the CRT (see the mapping files attached to this Guidebook for the specific rules for each column header).

Table 4. Automatic Reporting of Notation Keys in the IPPU Sector of the CRT

CRT Table	CRT category (ies)	Parameter/Gas	Automatic mapping	Explanation
2(I)A-H	2.A.1, 2.A.2 2.A.3, 2.A.4 (all)	CO_2 biogenic recovery /capture	NA	Any CO_2 recovery here is of process-related CO_2; so biogenic CO_2 is not applicable. All recovery is reported under CO_2 fossil.
2(I)A-H	2.B.7, 2.C.3 2.C.4, 2.C.7.a 2.D.1, 2.D.2 2.D.3 (all), 2.G.4, 2.H.1, 2.H.2	CO_2 biogenic recovery /capture	NA	Any CO_2 recovery here is of process-related CO_2; so biogenic CO_2 is not applicable. All recovery is reported under CO_2 fossil.
2(I)A-H	2.D.3.d. Other -Urea-based catalysts	CH_4 and N_2O (emissions and recovery)	NA	This category is from IPCC *Software* category 1.A.3.b.vi – Urea-based catalysts, which only estimates CO_2 emissions. Thus, CH_4 and N_2O emissions and removals are not applicable.
2(I)A-H	2.G.4 2.H.3	AD	NA	AD are automatically reported in the CRT as "NA." Given the large number of possible activities a user may choose to report here, the AD have not been aggregated. The user should describe the nature and quantity of these AD in the documentation box and/or NID.
2(I)A-H	2.H.1 2.H.2	AD	NA	AD are automatically reported in the CRT as "NA" because the user has a choice to report information based on production or consumption. The user may update these pale green cells (both for description and the amount of AD) to reflect the actual reporting.
Table 2(II).B-Hs2	2.F.1.b, 2.F.1.c, 2.F.1.d, 2.F.1.f	Emissions	IE	If in IPCC category 2.F.1, the user applies the Tier 1 method only (i.e. completes worksheet **F-gas Emissions**), all emissions are reported under CRT category 2.F.1.a commercial refrigeration, and the other sub-applications are reported as "IE". The Tier 1 method does not break consumption down into sub-applications, as shown in the CRT and a decision had to be made into which sub-application emissions would be reported.
Table 2(II).B-Hs2	2.F (all)	AD/ Emissions	NE	The *Software* automatically inserts an "NE" in cases where the result in a cell is zero or blank AND the gas is listed as in table 7.1 of the 2006 IPCC Guidelines (Volume 3, chapter 7) as a common gas for that application. If the activity and/or gas does not occur in the country, the user should change the "NE" to an "NO".
Table 2(II).B-Hs2	2.F.3, 2.F.4.a, 2.F.4.b, 2.F.6.a, 2.G.2.(all), 2.G.4, 2.H.3	Emissions from manufacturing	IE	If a user reports any emissions from stocks, then emissions from manufacturing are reported as "IE" and included in stocks. Otherwise, "NE" or "NO" is reported.
Table 2(II).B-Hs2	2.G.2.a, 2.G.2.b, 2.G.2.d,	Emissions from disposal	IE	If a user reports any emissions from stocks, then emissions from disposal are reported as "IE" and included in stocks. Otherwise, "NE" or "NO" is reported.

	2.G.2.e, 2.G.4, 2.H.3			
Table 2(II).B-Hs2	2.G.2.a.ii	Emissions from disposal	NA	This category is "other prompt emissive applications"; Since prompt emissions do not have disposal, this is automatically reported as "NA".
2(II)B-Hs1 and 2(II)B-Hs2	All	AD and emissions	C	If the user reports any F-gas as confidential, "C" will appear in the reporting table for AD and emissions for that category. All F-gases will be reported as stocks under 2.H.3, in tCO_2 eq.