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IPPU SECTOR USERS' GUIDEBOOK

IPCC Inventory Software, version 2.98

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

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
FC	fluorinated compound
F-gases	fluorinated gases
Gg	gigagram
GHG	greenhouse gas
GJ	gigajoule
GWP	global warming potential
HFC	hydrofluorocarbon
HTF	heat transfer fluid
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LCD	liquid crystal display
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
PV	photovoltaic
RAC	refrigeration and air conditioning
RE	rare earth
s	second
SF_6	sulphur hexafluoride
TFT-FPD	thin-film-transistor flat panel display
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

This 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).

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, to the extent consistent with the *2006 IPCC Guidelines*. 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), 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.

A word on selection of Tiers.

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

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

  Furthermore, recognizing that the *2006 IPCC Guidelines* allow reporting estimates produced with a Tier 3 user-specific[3] 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.

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[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.

[3] User-specific methodologies need to be in accordance with IPCC good practice to satisfy the transparency, completeness, consistency, accuracy and thus comparability reporting principles.

- ✓ **IPCC Tier 2 refers to:**
  - either 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[1] of variables[2] 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 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[3] while all remaining are reported within a single aggregation[4], as e.g. *unspecified*[5].

However, the *Software* allows the user to enter each combination of variables, e.g. subdivision/product type/process type in the case of ethylene dichloride and vinyl chloride monomer production, only once. To further disaggregate such a combination across the time series, a user may modify 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 ⊟ and a drop-down menu appears.

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.[6] In practice, this means that users of the *Software* can estimate GHG emissions and GHG reductions for categories and gases that are required to be reported pursuant to the UNFCCC CRT. Once data are entered into the *Software*, users wishing to use these data to facilitate reporting to the UNFCCC must generate a file in the *Software* (in JSON format) that may then subsequently, through a separate UNFCCC platform, be uploaded and further processed through the UNFCCC ETF Reporting Tool.

A separate Guidebook, titled **UNFCCC CRT Export 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.

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1 The larger the number of strata, the more accurate and precise the estimates are.
2 Stratification is the act of sorting data into distinct groups or layers.
3 By applying a higher tier method
4 By applying a lower tier method
5 This does not apply to variables required by IPCC Tier 1 method.
6 As requested by Parties in decision 5/CMA.3, paragraphs 19 and 20.

- 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) between the *Software* and the CRT generated by the UNFCCC ETF Reporting Tool.

- 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 individual category descriptions of the Guidebook below and 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 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 GHGs 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 GHGs 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. Users may click on the category name to navigate to the relevant section 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)	*Note that guidance for entering information for microelectromechanical systems (MEMS) is included here.*
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.
2.G.3 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)	

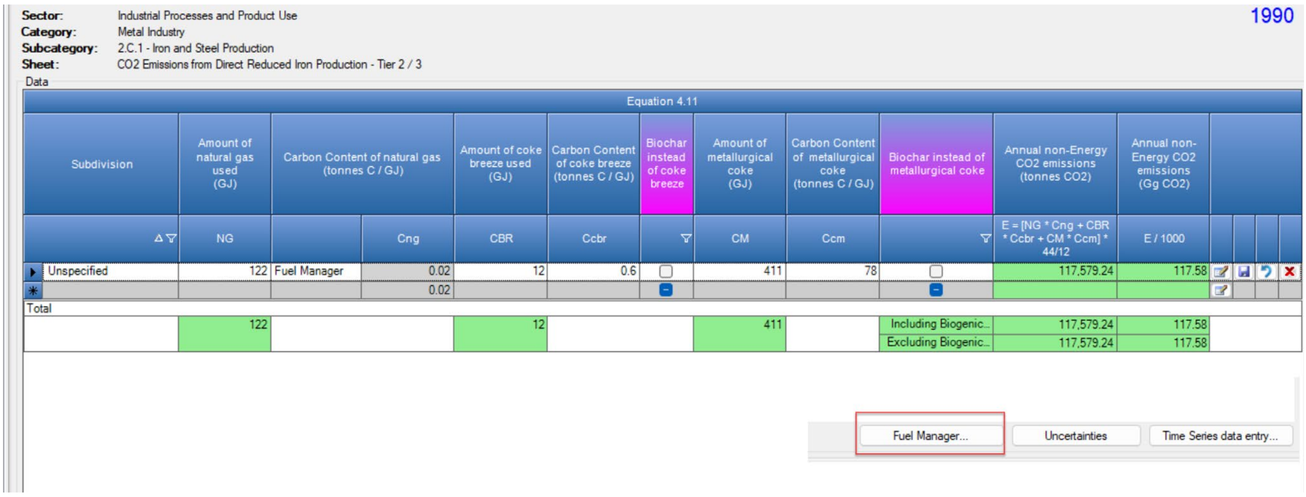
Note: The category tree in the *Software* reflects the categories included in the *2006 IPCC Guidelines*, as refined by the *2019 Refinement* for those categories relevant for interoperability with the UNFCCC ETF Reporting Tool, plus those added by the *Wetlands Supplement*. Categories from the *2019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

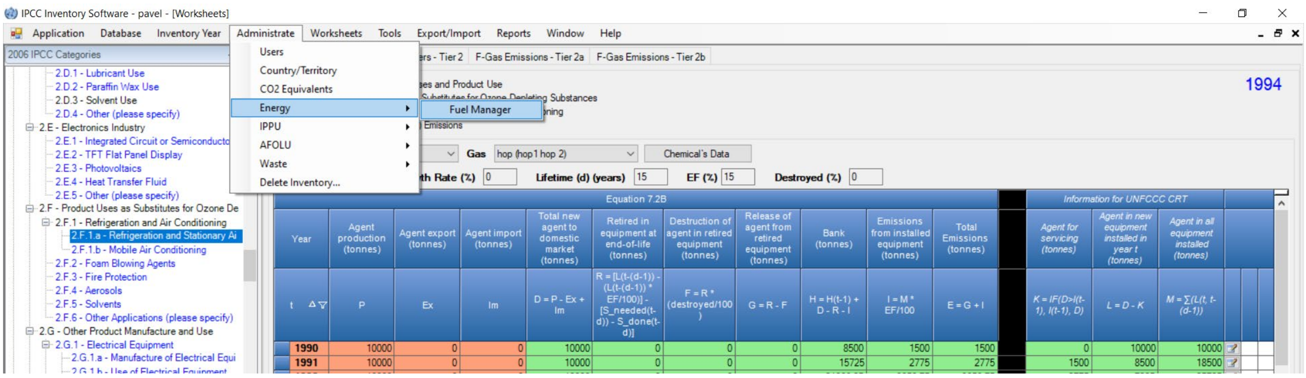


Before inputting data in the Energy and IPPU worksheets, the Fuel Manager shall be populated with all relevant fuels used, and corresponding information. The Fuel Manager contains information on carbon content and calorific value for each fuel type used in the country. All IPCC default fuels are included here. Users may 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).*

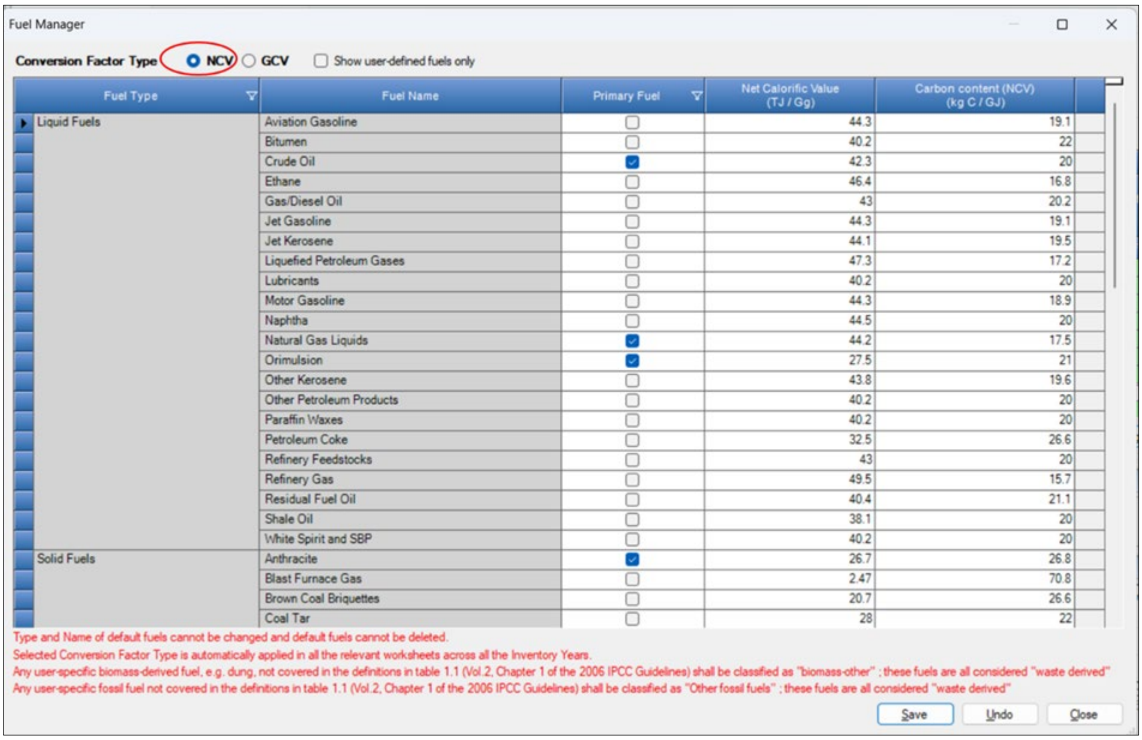


2. In the top of the window select either **NCV** (net calorific value) or **GCV** (gross calorific value) for the **Conversion Factor Type**. Note that:
   - ✓ For each IPCC default fuel, when NCV is selected, the **Calorific Value** and the **Carbon Content** are pre-filled with IPCC defaults for each 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**.

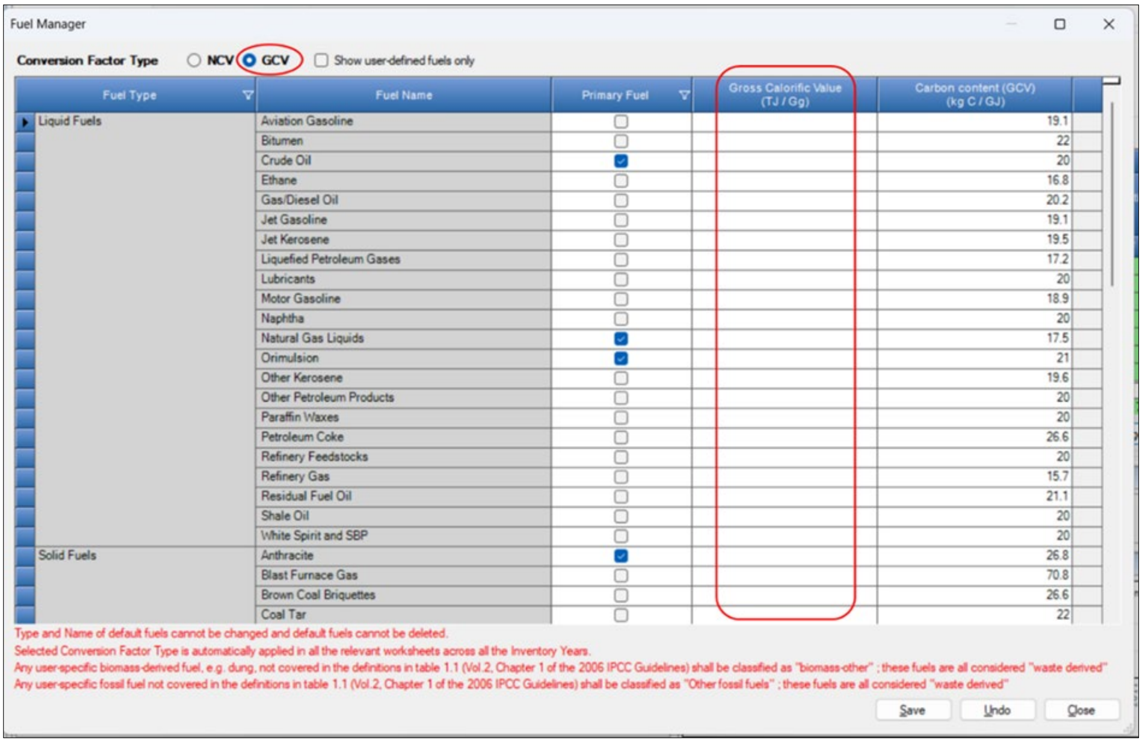
- ✓ Indicate (checkbox) if it is a **primary fuel**[1] or not.
- ✓ Enter its **calorific value** in TJ/Gg, (either *NCV* or *GCV* according to the selection made for the entire Fuel Manager).
- ✓ Enter the **carbon content** in kg C/GJ.

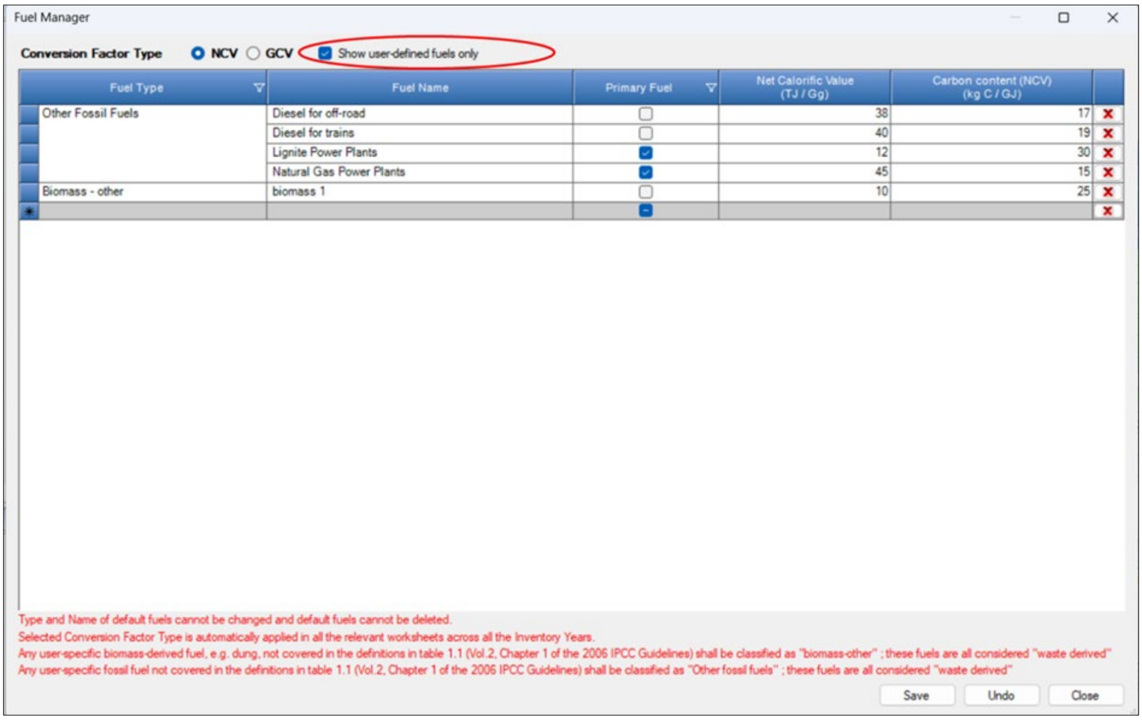
To see listed the user-defined fuels only, check the corresponding box on the top of the window.

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.



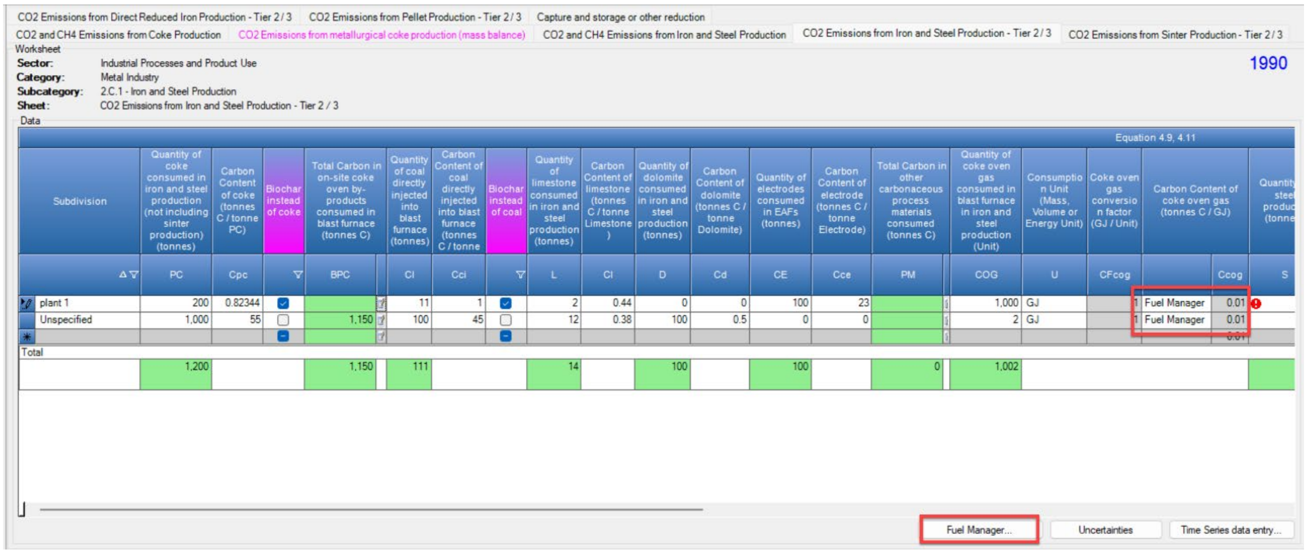
[1] Primary fuels are fuels found in nature such as coal, crude oil, and natural gas, while secondary fuels or fuel products are derived from primary fuels, such as gasoline and lubricants. A complete list of fuels is provided in Section 1.4.1.1 of the *2006 IPCC Guidelines*.





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.

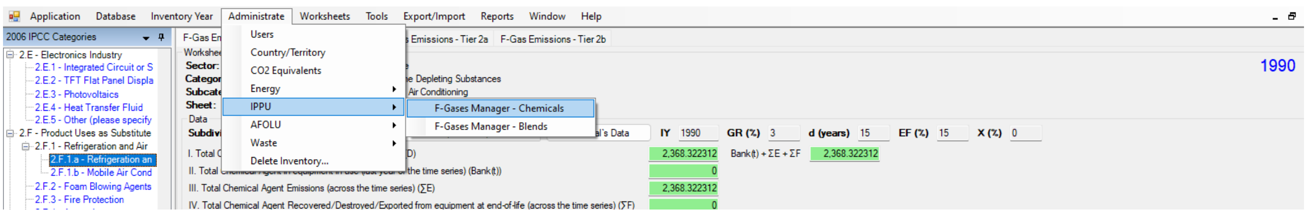
The overall approach to use of the F-Gases Manager is that the user must first specify which of the F-gases/ blends are either produced or consumed at the national level. Only the selected list of F-gases/blends will be available for emission calculations at an individual IPCC category (i.e. worksheet)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

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

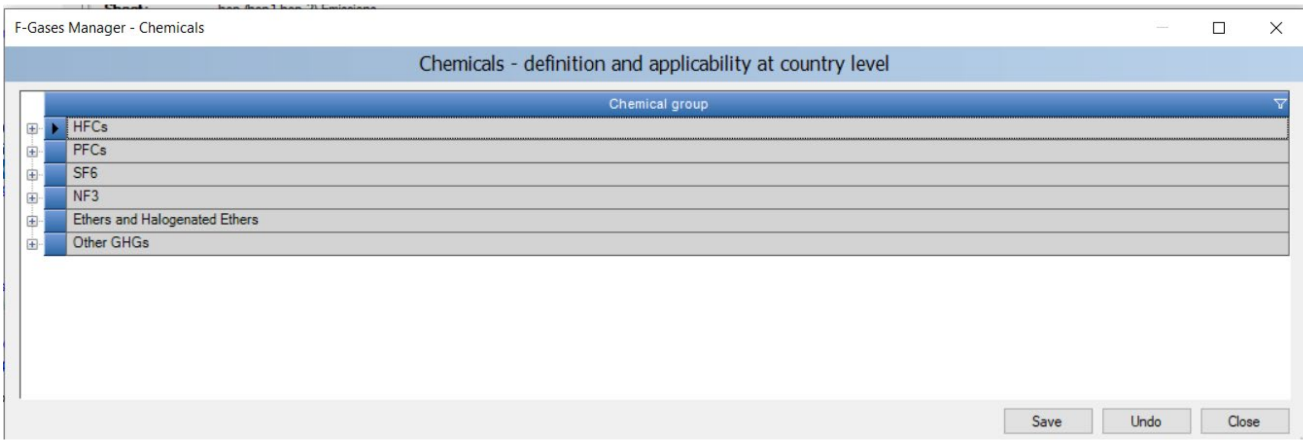
Users first need to populate the F-Gases Manager to identify the relevant F-gases/blends in the country before being able to input AD in the relevant category worksheets to estimate F-gas emissions.

To enter the relevant F-gases/blends at country level:

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

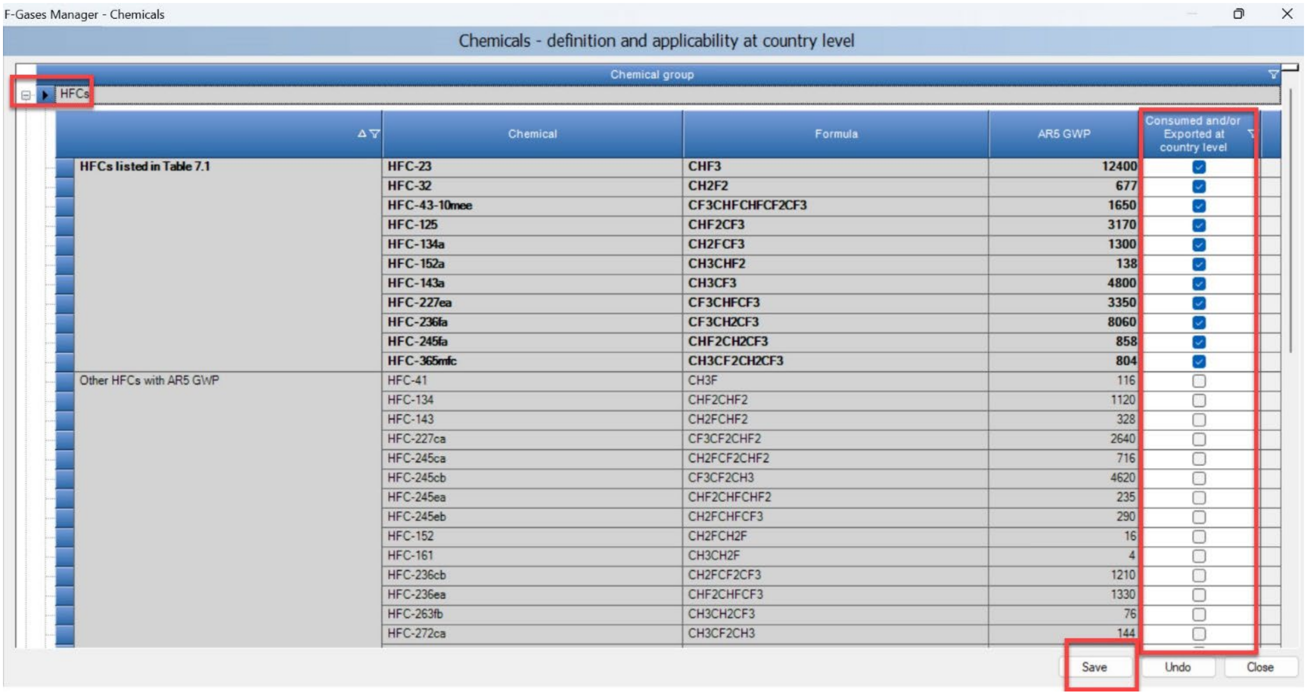


Then a new window will appear.



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.

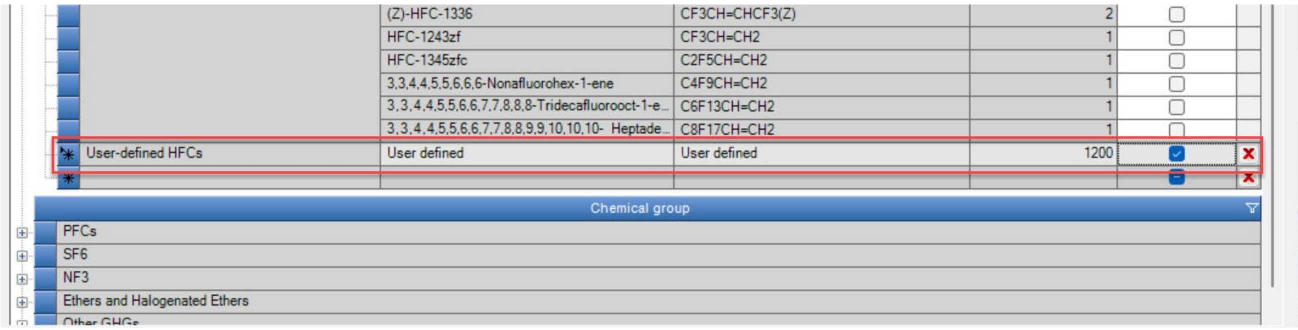
Click **Save** after selecting all F-gases.



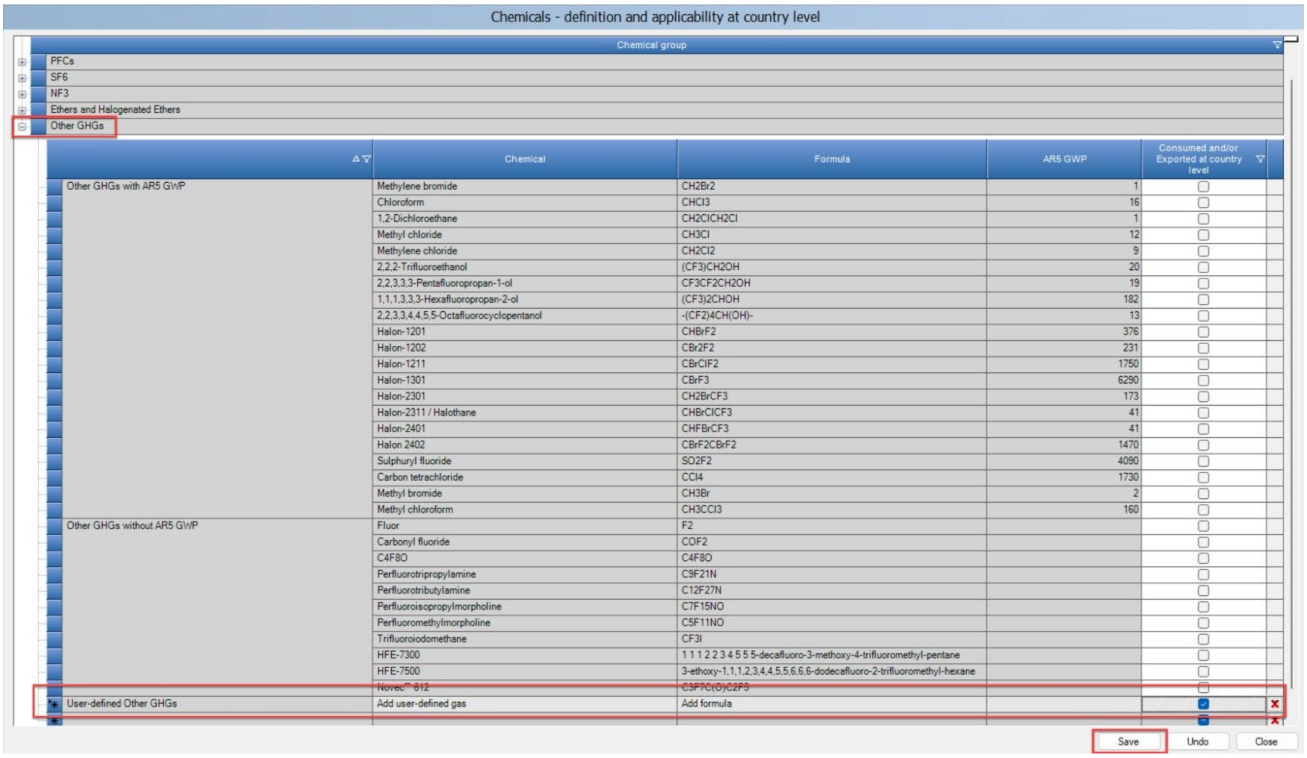
	Chemical	Formula	AR5 GWP	Consumed and/or Exported at country level
HFCs listed in Table 7.1	**HFC-23**	**CHF3**	**12400**	☑
	HFC-32	**CH2F2**	**677**	☑
	HFC-43-10mee	**CF3CHFCHFCF2CF3**	**1650**	☑
	HFC-125	**CHF2CF3**	**3170**	☑
	HFC-134a	**CH2FCF3**	**1300**	☑
	HFC-152a	**CH3CHF2**	**138**	☑
	HFC-143a	**CH3CF3**	**4800**	☑
	HFC-227ea	**CF3CHFCF3**	**3350**	☑
	HFC-236fa	**CF3CH2CF3**	**8060**	☑
	HFC-245fa	**CHF2CH2CF3**	**858**	☑
	HFC-365mfc	**CH3CF2CH2CF3**	**804**	☑
Other HFCs with AR5 GWP	HFC-41	CH3F	116	☐
	HFC-134	CHF2CHF2	1120	☐
	HFC-143	CH2FCHF2	328	☐
	HFC-227ca	CF3CF2CHF2	2640	☐
	HFC-245ca	CH2FCF2CHF2	716	☐
	HFC-245cb	CF3CF2CH3	4620	☐
	HFC-245ea	CHF2CHFCHF2	235	☐
	HFC-245eb	CH2FCHFCF3	290	☐
	HFC-152	CH2FCH2F	16	☐
	HFC-161	CH3CH2F	4	☐
	HFC-236cb	CH2FCF2CF3	1210	☐
	HFC-236ea	CHF2CHFCF3	1330	☐
	HFC-263fb	CH3CH2CF3	76	☐
	HFC-272ca	CH3CF2CH3	144	☐

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 chemicals (e.g. user-defined HFCs) or for other groups not specifically listed.

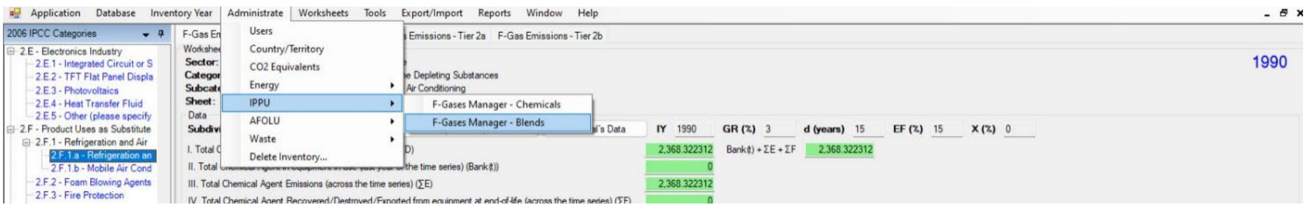
   To add a user-defined species, the user navigates to the bottom of the listed chemicals for that group (e.g. HFCs) and selects the asterisk. Information on the chemical name, formula and GWP value should be entered, and the box checked.



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.**



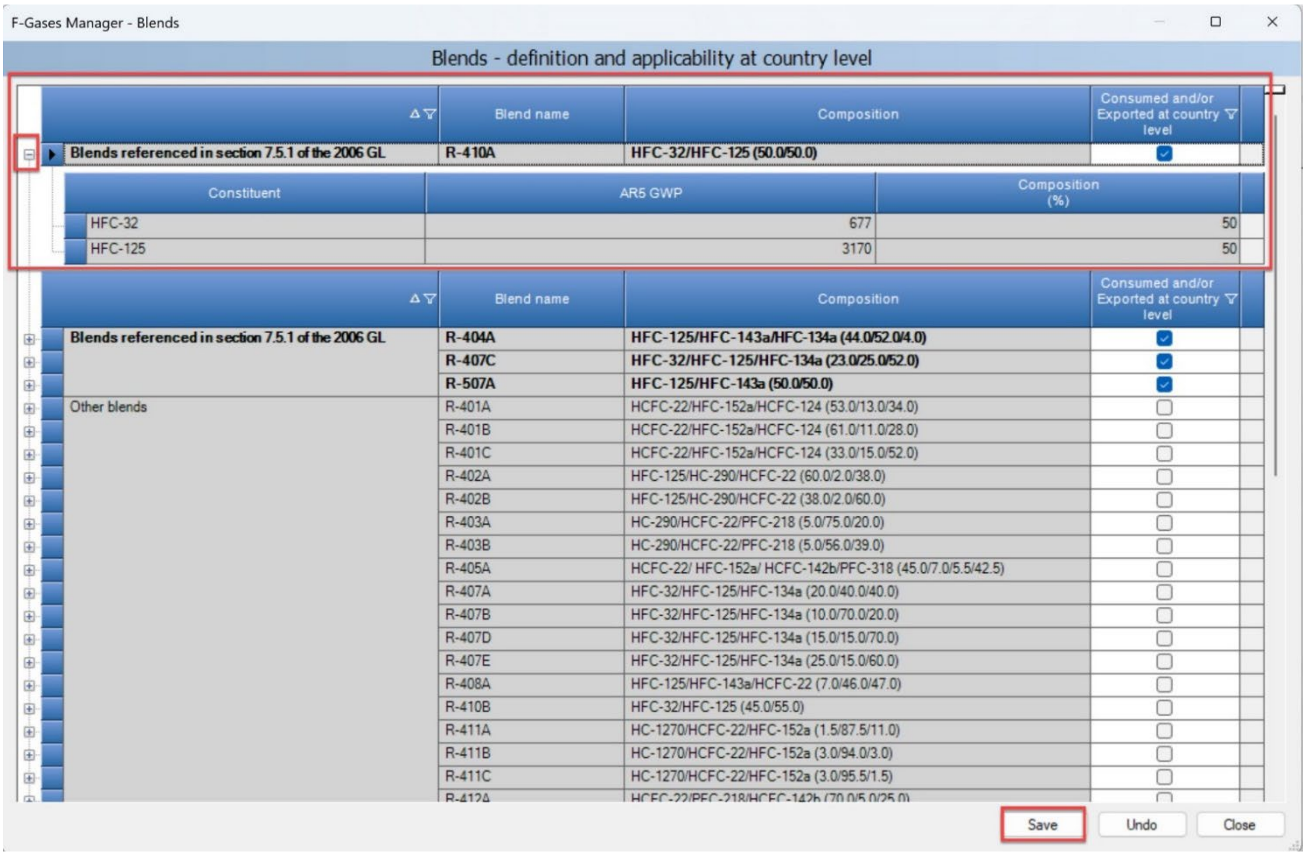
A new window will appear.

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.

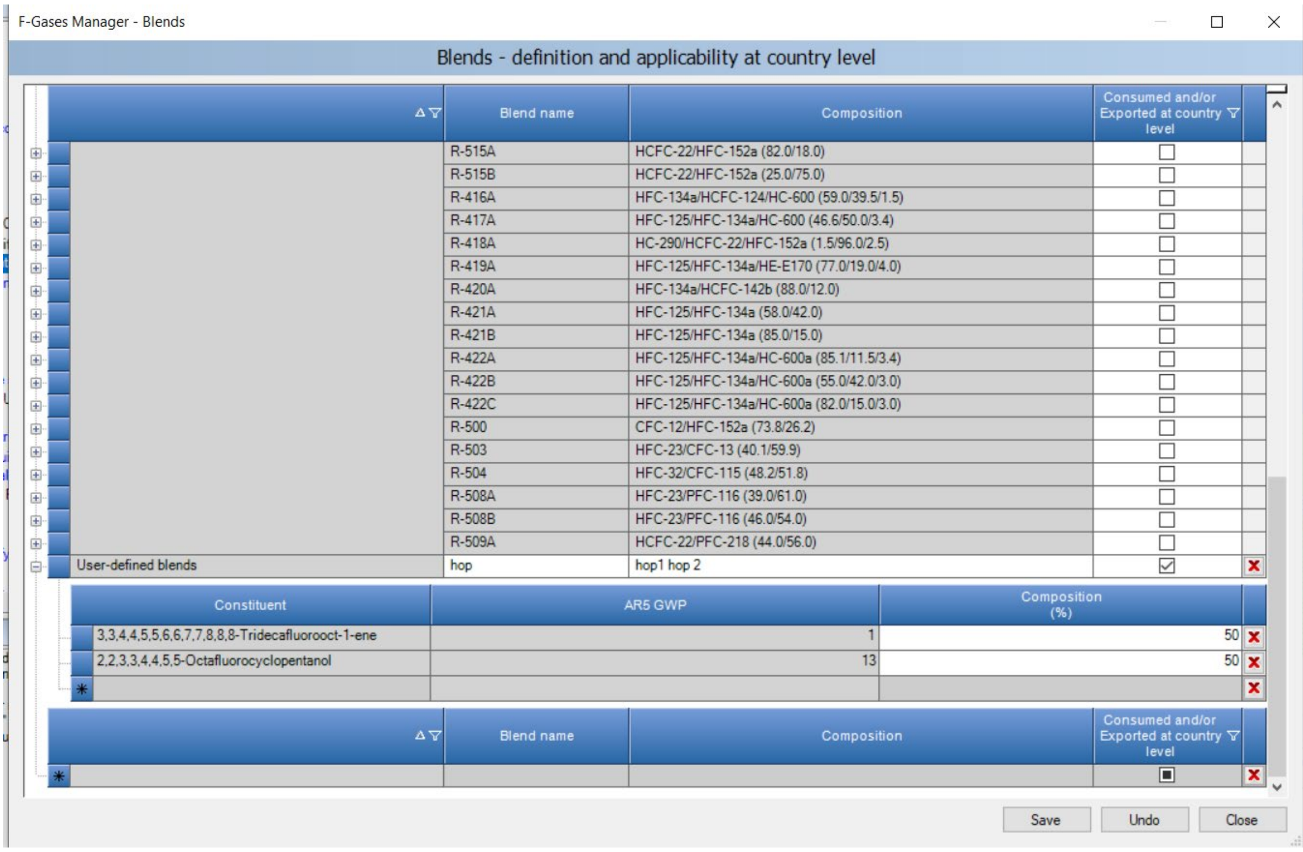
   Ideally, the AD used to estimate GHG emissions for categories that consume F-gases in calculation worksheets should be the individual chemical(s). In some cases, if information only on the blends consumed is known, they can be selected here and used for the purposes of calculating GHG emissions in the calculation worksheets. Important to note for blends, although calculation is done for the blend, reporting will be by individual constituent gases of the blend. (e.g. when emissions are reported for blend R-410A (figure below), 50% of emissions will be reported as HFC-32 and 50% as 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 percentage of the blend. The total composition need not equal 100% owing to the presence of other gases.

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

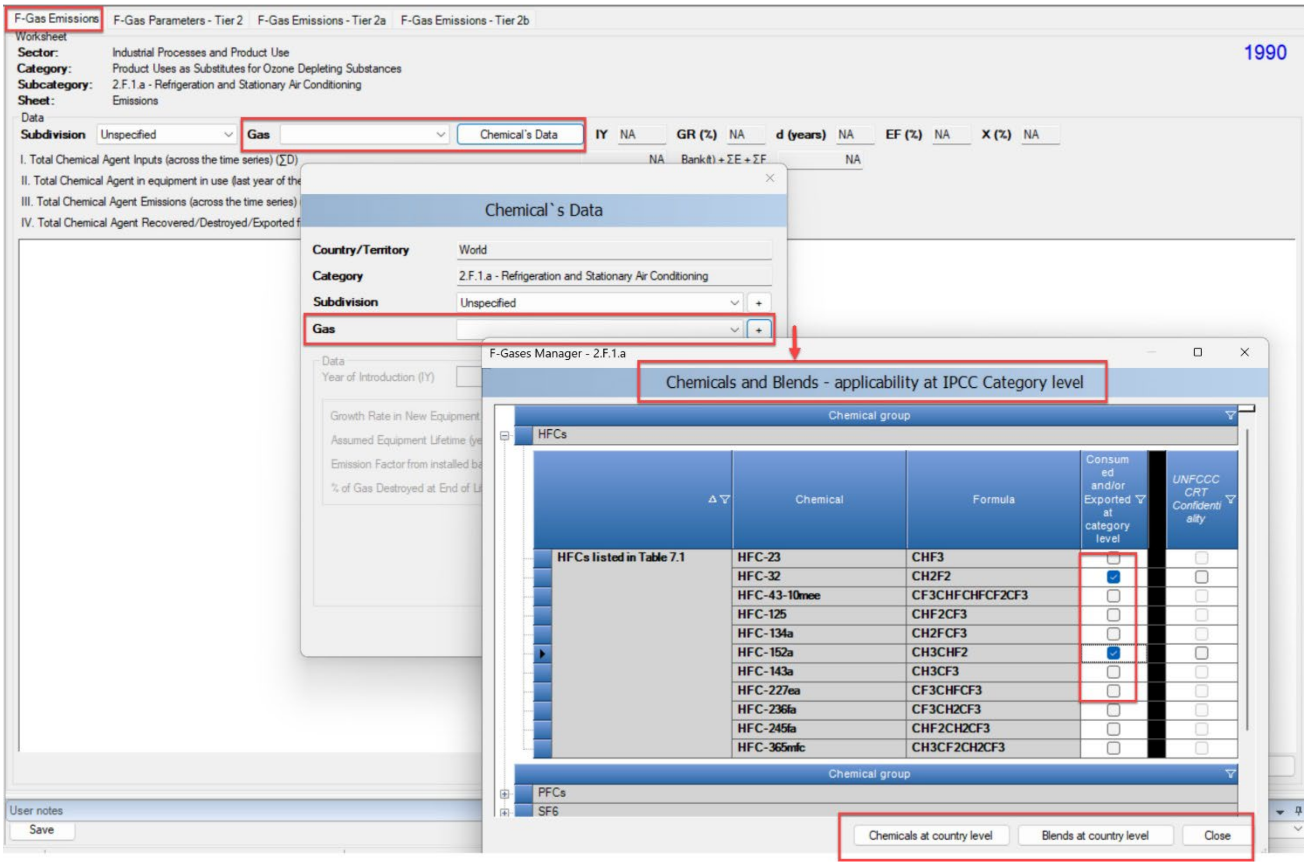


Entering information on F-gases and blends at the IPCC category level

Identifying the list of F-gases/blends relevant for the country is not sufficient to enter data on those chemicals and estimate GHG emissions for individual calculation worksheets, the user must then enter specific information in each category-level worksheet to identify the relevant F-gases for that category. In this category-level 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.

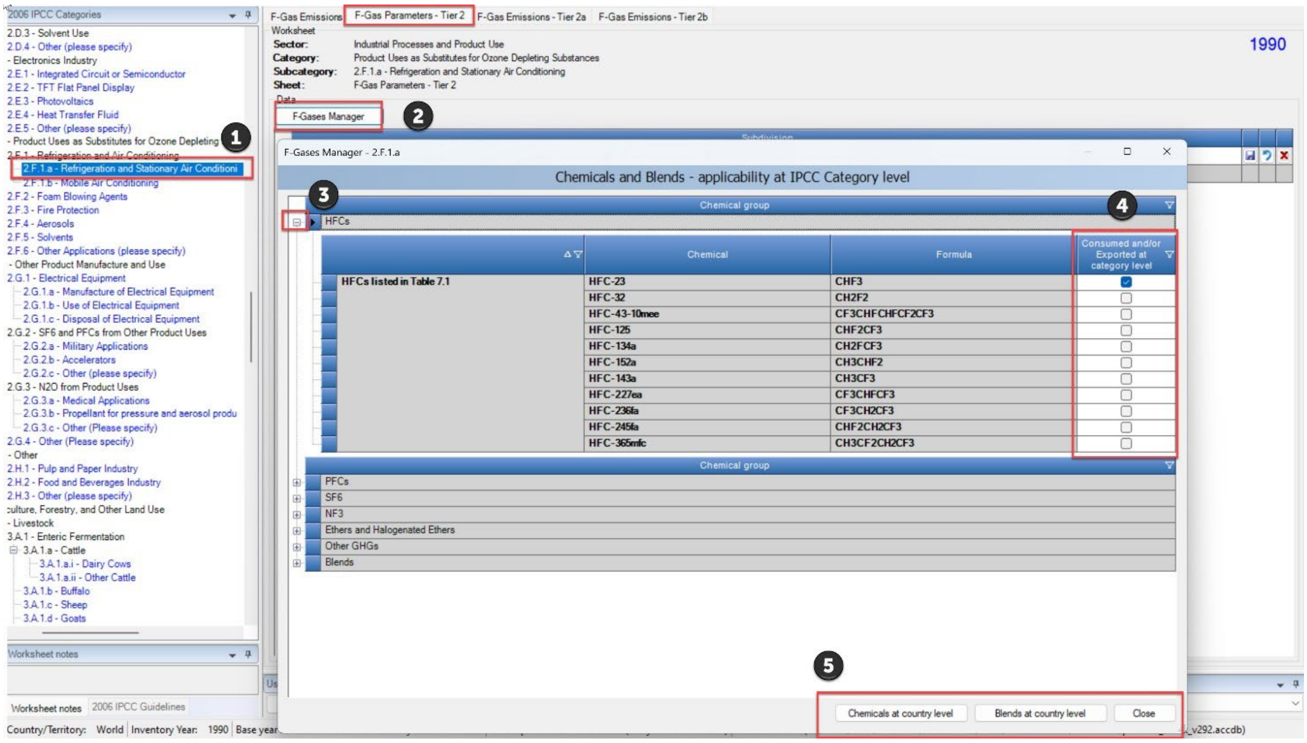
Example: **Identifying category level F gas and blend consumption: 2.F.1.and 2.F.2 (Tier 1 only) and 2.F.3**



<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 in</u> **<u>Chemical's Data</u>**

1. Navigate to the relevant worksheet
2. The user will not see any available options for F-gases initially 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 in the *Software* for reporting to the UNFCCC ETF Reporting Tool, they may indicate here if the consumption of gas in this category 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. If a gas/blend is not available for selection, it is because the gas/blend was not included as applicable at the national level. 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.
8. When all gases/blends have been selected, select **Close.**

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 through the</u> **<u>F-Gases Manager</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 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.

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[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.

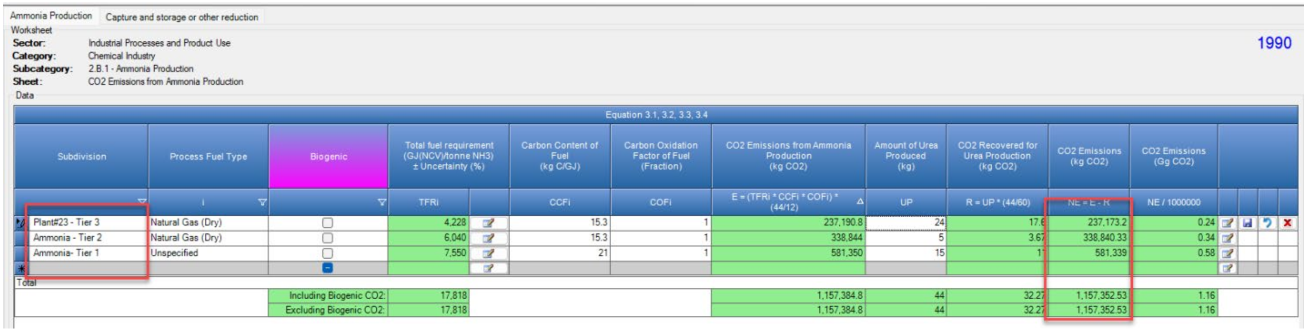
Where a user-specific Tier 3 method, which cannot be calculated by the *Software*, is used to prepare estimates of GHG emissions, the results of these calculations must be included in the *Software* for completeness. This can be accomplished as follows:

1. input in the *Software* the AD required by the IPCC default methodology.
2. back-calculate the GHG IEF(s), as the total emissions of the relevant GHG calculated through the user-specific Tier 3 method divided by the AD input in 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 IEF.

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 a combination of different tiers according to the significance of subcategories and data availability.

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


Ammonia Production | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.1 - Ammonia Production
Sheet: CO2 Emissions from Ammonia Production

1990

Data

Equation 3.1, 3.2, 3.3, 3.4

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
Plant#23 - Tier 3	Natural Gas (Dry)	☐	4,228	15.3	1	237,190.8	24	17.6	237,173.2	0.24
Ammonia - Tier 2	Natural Gas (Dry)	☐	6,040	15.3	1	338,844	5	3.67	338,840.33	0.34
Ammonia- Tier 1	Unspecified	☐	7,550	21	1	581,350	15	11	581,339	0.58
Total										
		Including Biogenic CO2:	17,818			1,157,384.8	44	32.27	1,157,352.53	1.16
		Excluding Biogenic CO2:	17,818			1,157,384.8	44	32.27	1,157,352.53	1.16

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

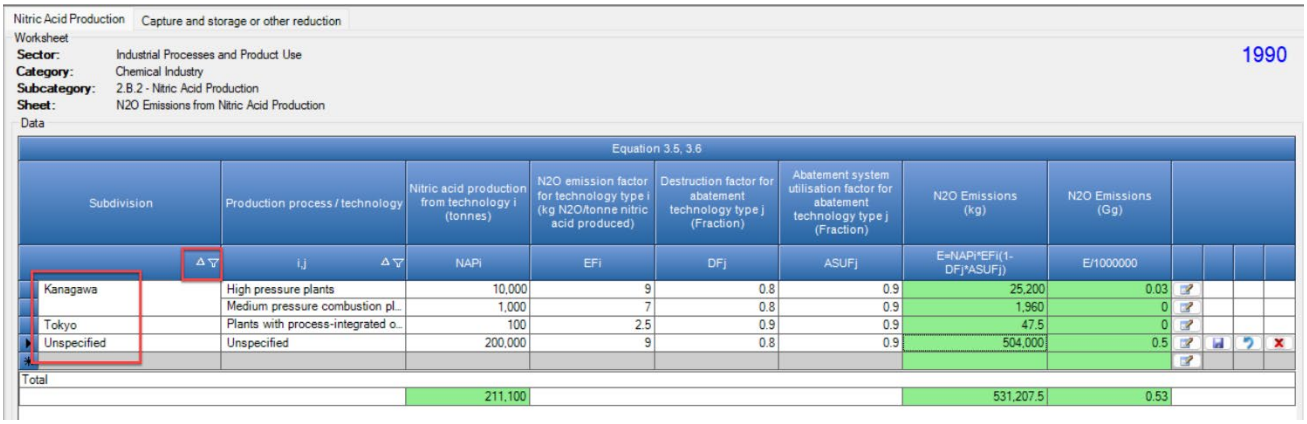
GHG inventories may be calculated at multiple levels of aggregation (e.g. facility, corporate, regional, national) to meet various domestic and international needs. Thus, *Subdivisions* can be entered for all source categories in the IPPU sector.

Where the user is interested in calculating GHG estimates at a single level of aggregation, e.g. national, in Column |Subdivision| either select *Unspecified* from the drop-down menu or input the single univocal name/code e.g. the *country name*. Where the user is interested in calculating GHG estimates for multiple subdivisions, the univocal name/code for each subdivision can be entered in Column |Subdivision|. Users have full flexibility to name subdivisions based on user-specific circumstances. Nevertheless, care shall be taken to ensure that subdivisions do not overlap, causing a double counting of some emissions.

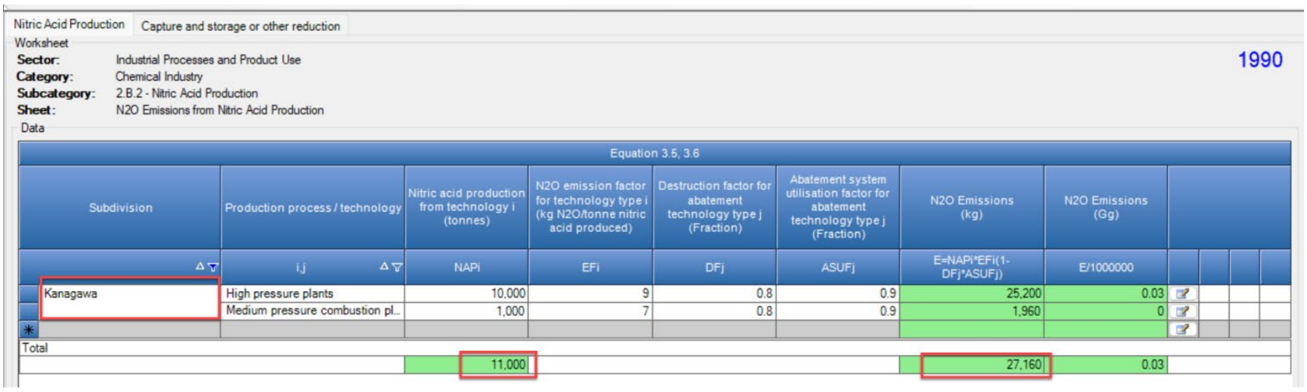
Every calculation worksheet[2] includes filters to enable the user to view data entry, by subdivision.

[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*

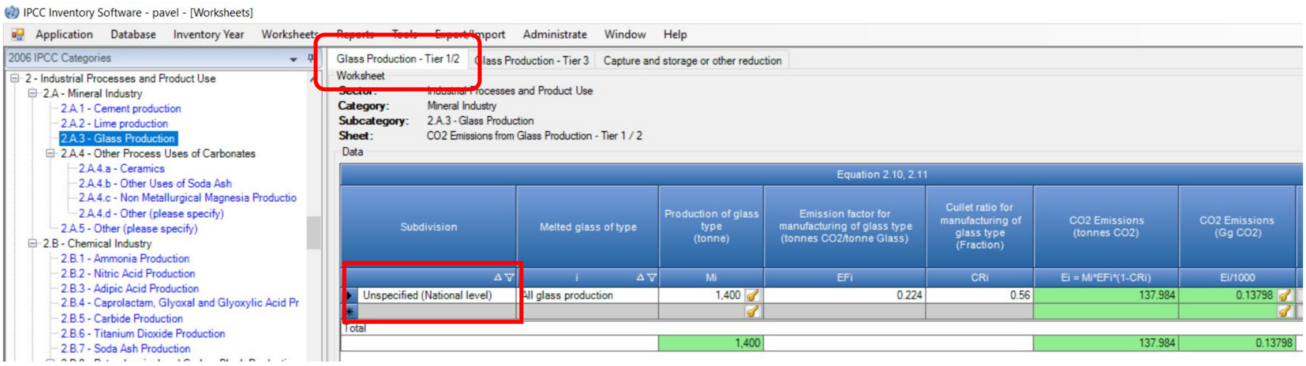
Example: **subdivisions and applying filter**



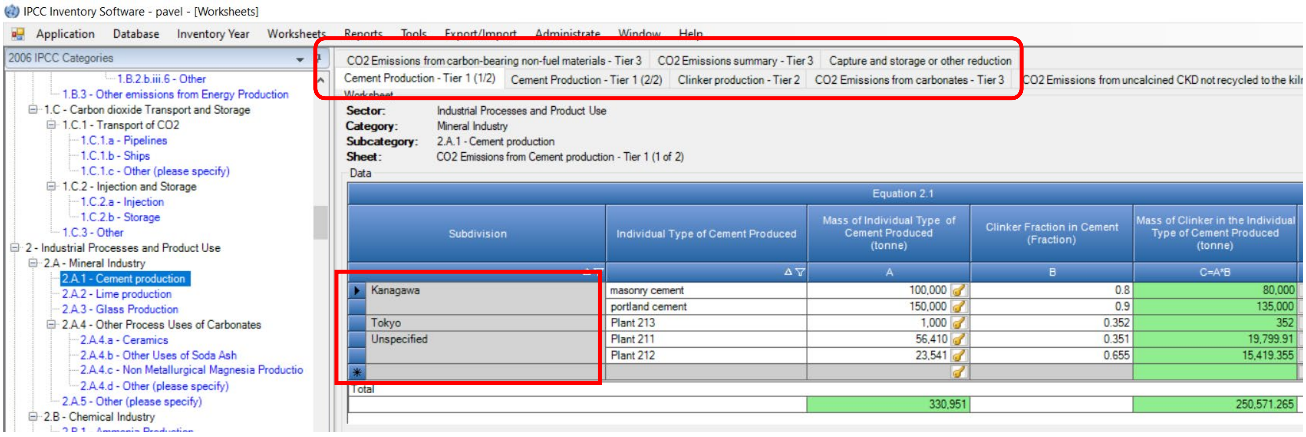
Example: **viewing filtered results**



Example: **tiers and subdivisions – combination** (several tiers in one worksheet table)



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

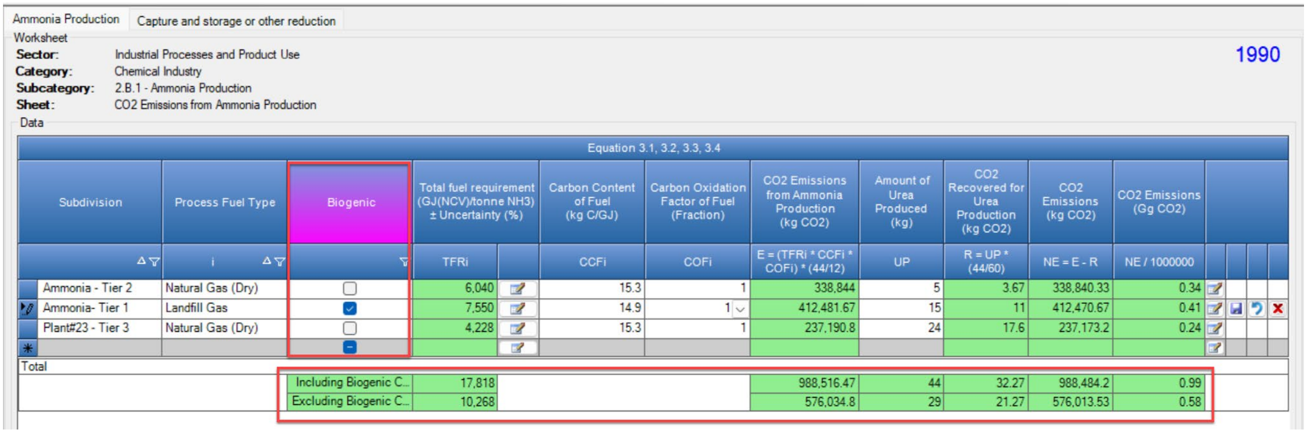


1.1.5 Biogenic fuels, feedstocks and reductants

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.

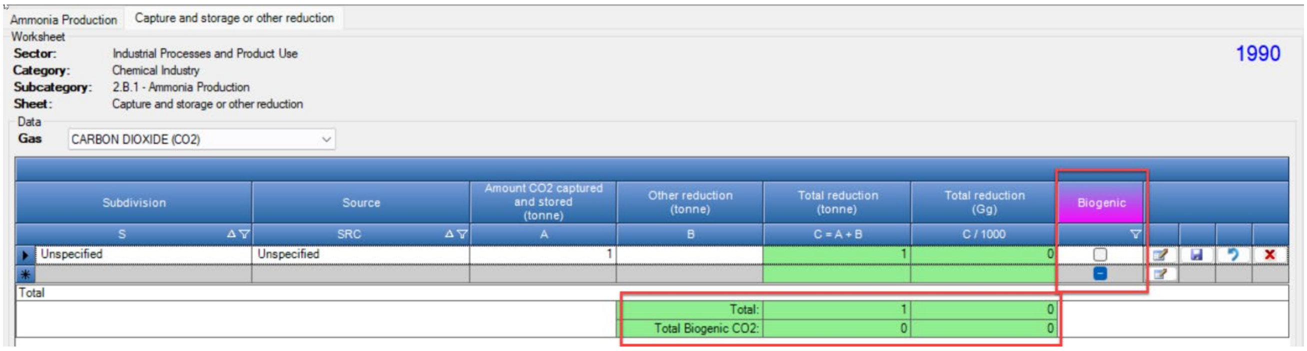
All source categories in the IPPU sector in which use of biogenic fuels is possible include a separate column(s), in magenta, to allow the user to indicate that the fuel input used in the process is of biogenic origin. In addition, for these categories, totals are provided including and excluding biogenic 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**

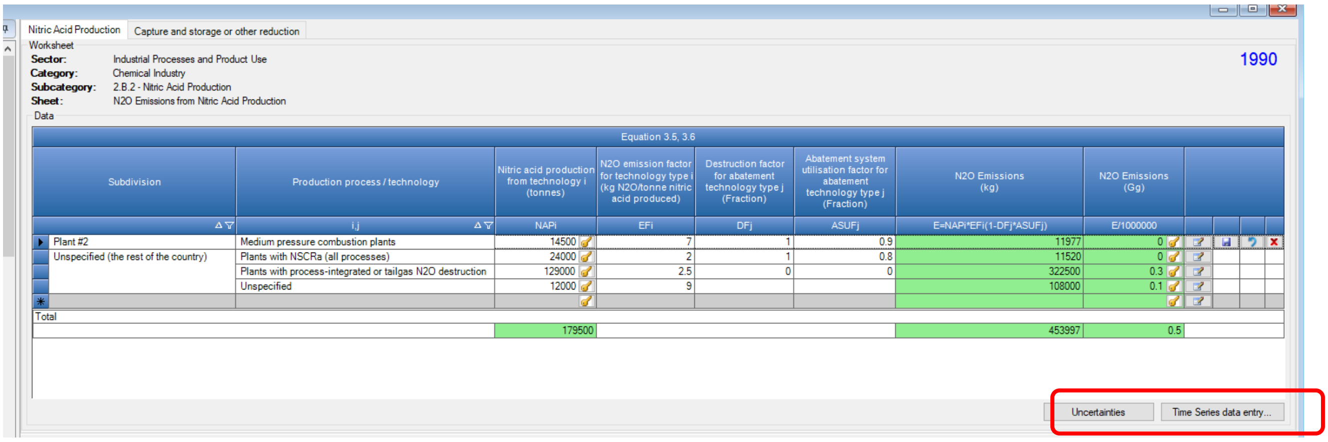


For more information on the reporting of emissions and removals of CO_2 of biogenic origin and reporting to the UNFCCC ETF Reporting Tool, see Annex I.

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).

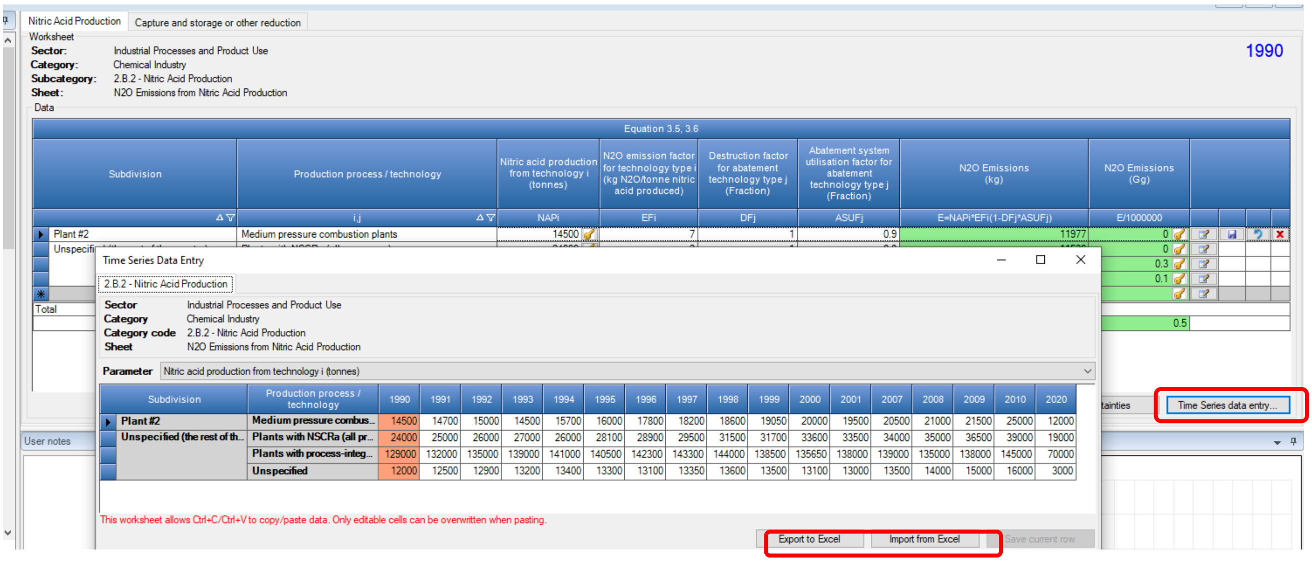
Example: **tabs for uncertainties and time series data entry**



Time Series Data Entry

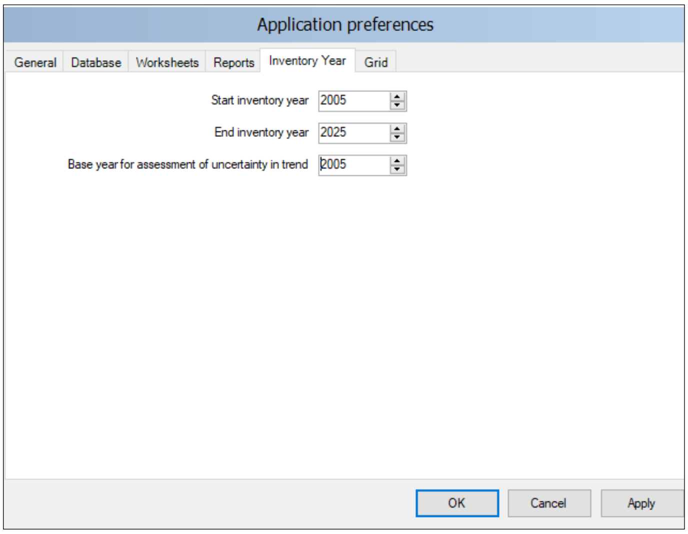
In each worksheet, there is a button *Time Series data entry* as shown in the screenshot below. After clicking on the tab *Time Series data entry* users select the parameters of interest from the Parameters bar to be exported/imported, depending on the information contained in each specific worksheet. 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**



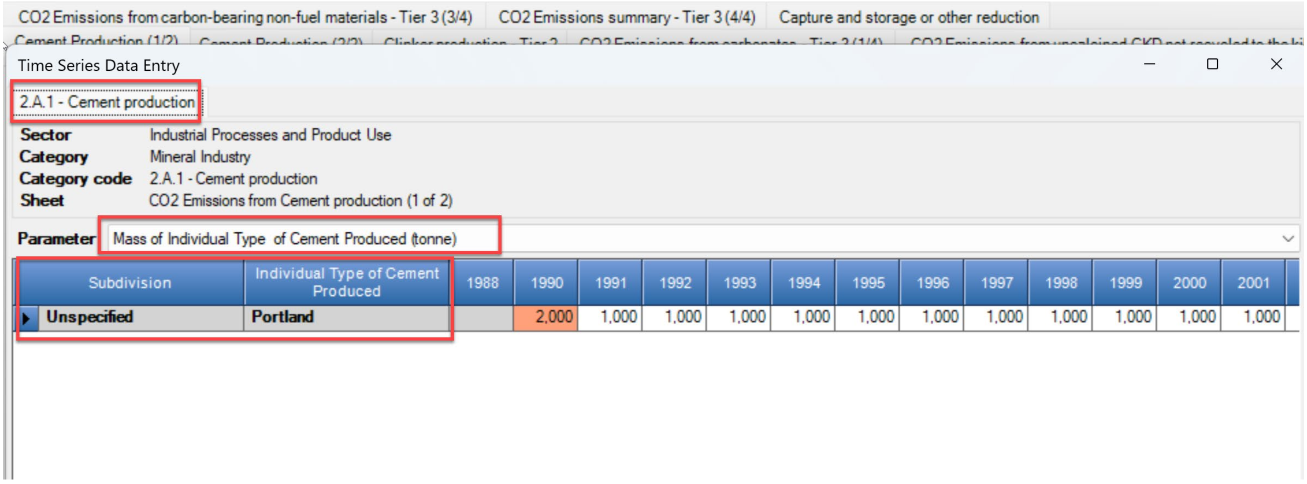
To use this functionality users:

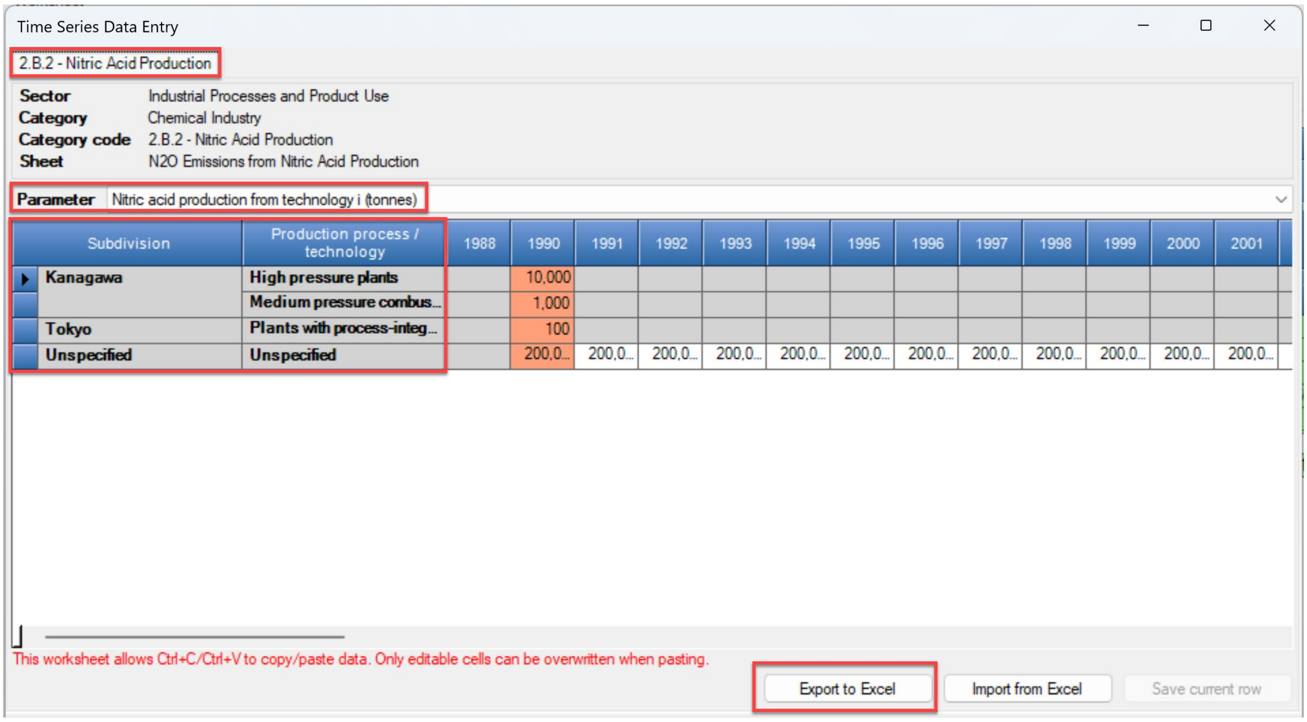
1. In the main menu, select in TAB **Application – Preferences**, sub-TAB **Inventory Year**, the time-period of the inventory and click on *Apply* to save it.



2. Ensure relevant identifying information for the category for which the user wants to update the time series is populated for each inventory year (e.g. subdivision name and process technology/fuel, etc). The minimum information can be identified by selecting *Export to Excel* and noting the column headers in gray. 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 to copy and paste underlying data into the exported data entry grids.

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





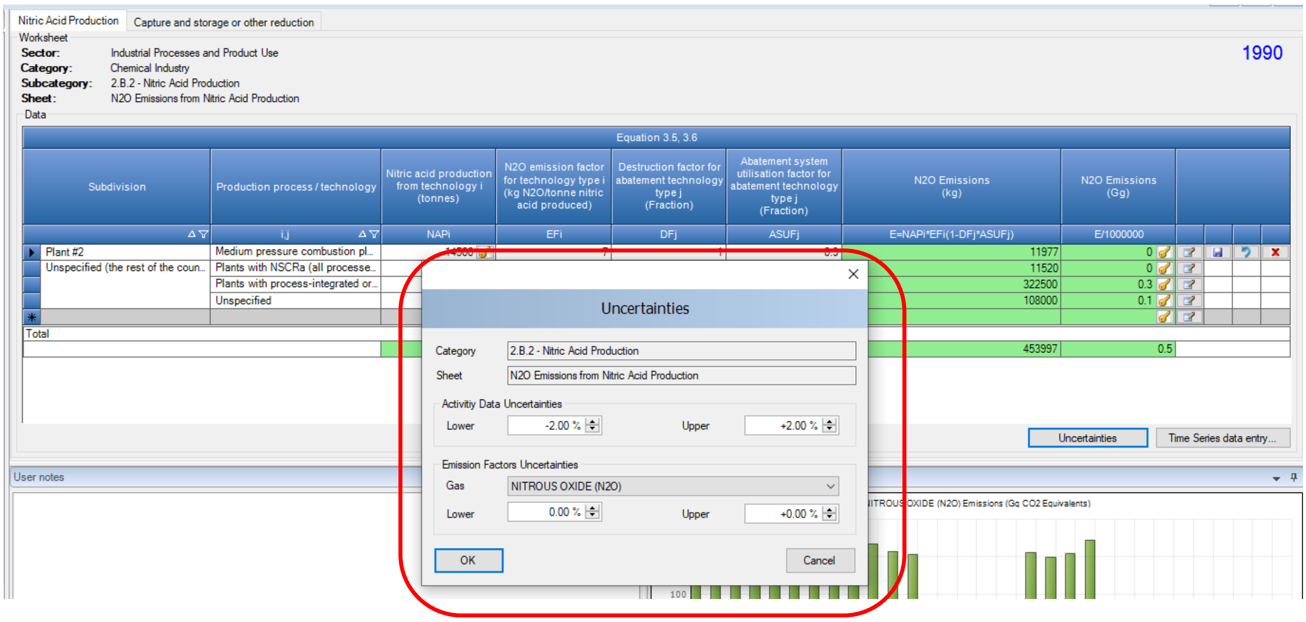
3. Select the *Export to Excel* button, name and save the file.
4. Users can open this exported file and make changes (in white cells only) directly there for various years.
5. Once changes are made, import the modified file into the *Software* (by clicking the *Import from Excel* button).

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**



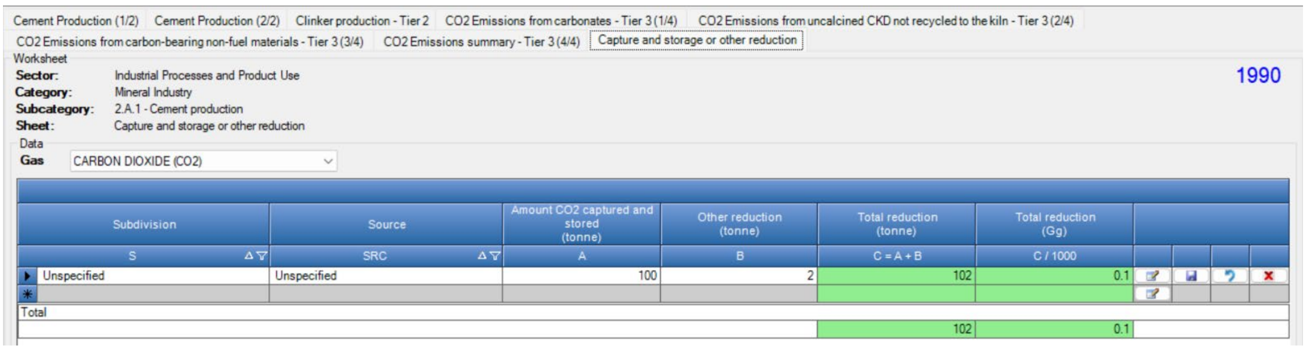
1.1.7 Capture and storage or other reduction

Most categories include the worksheet *Capture and storage or other reduction*. This worksheet 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 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 including 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. Users 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:

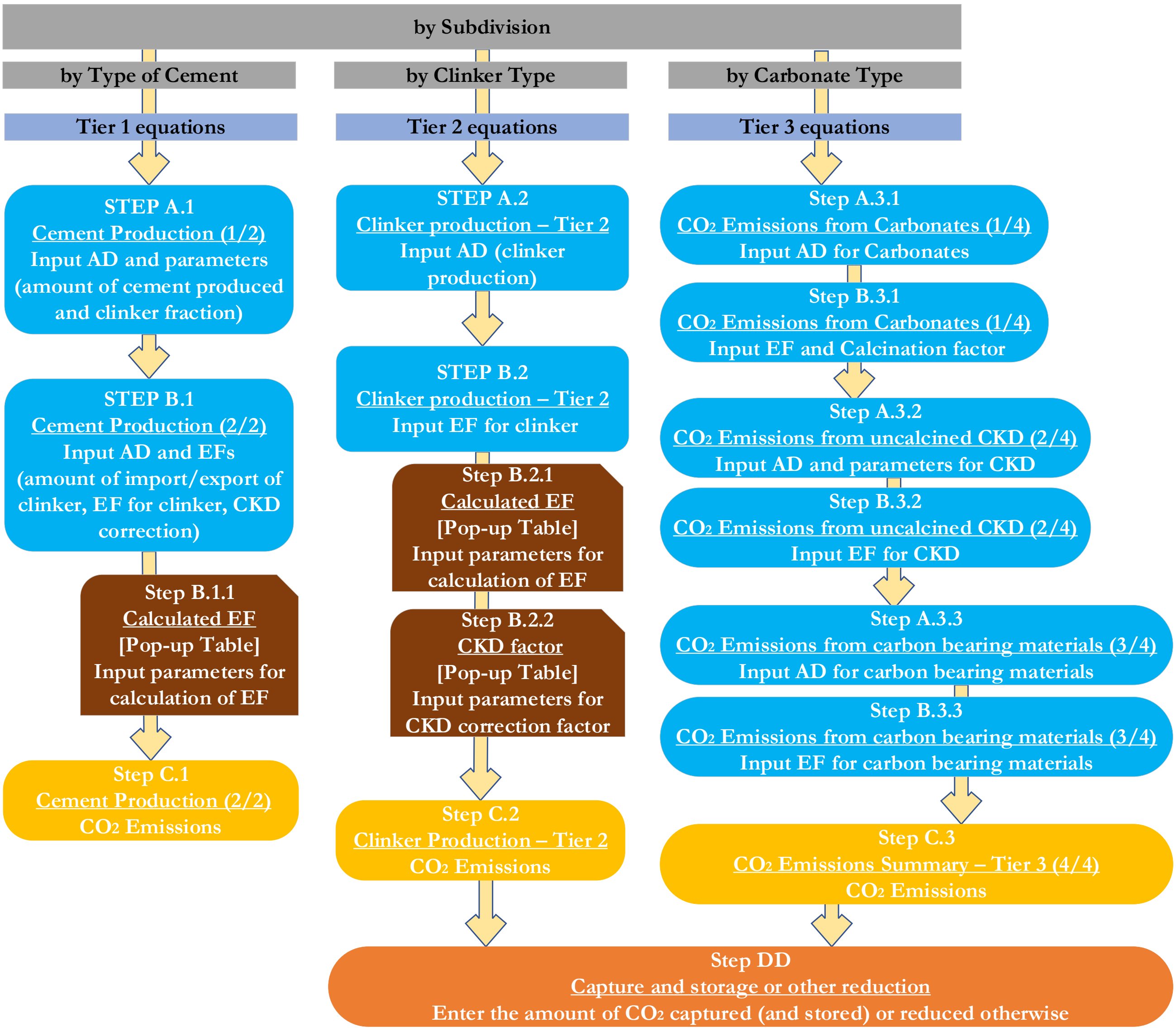
- ✓ **Cement Production (1/2):** contains for each subdivision and individual type of cement produced, information on the amount of cement produced and clinker fraction to estimate mass of clinker produced.
- ✓ **Cement Production (2/2):** contains for each subdivision information on import and export 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 worksheet **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),** 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).

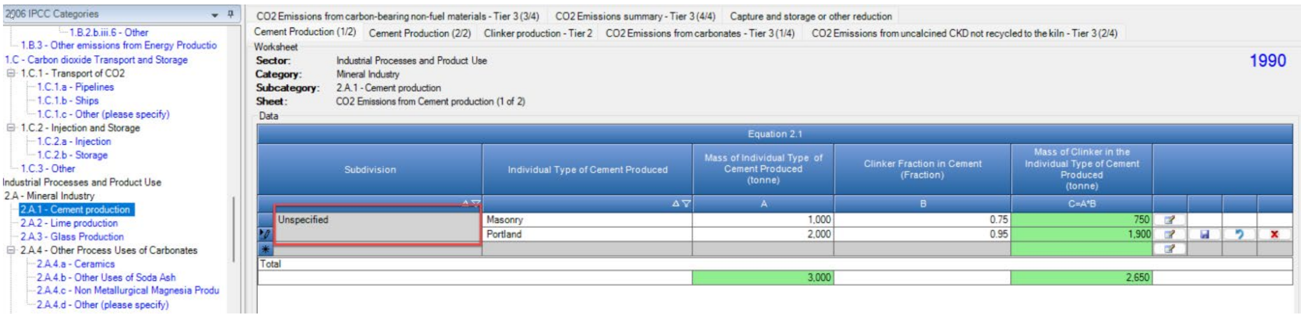
Activity data input

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

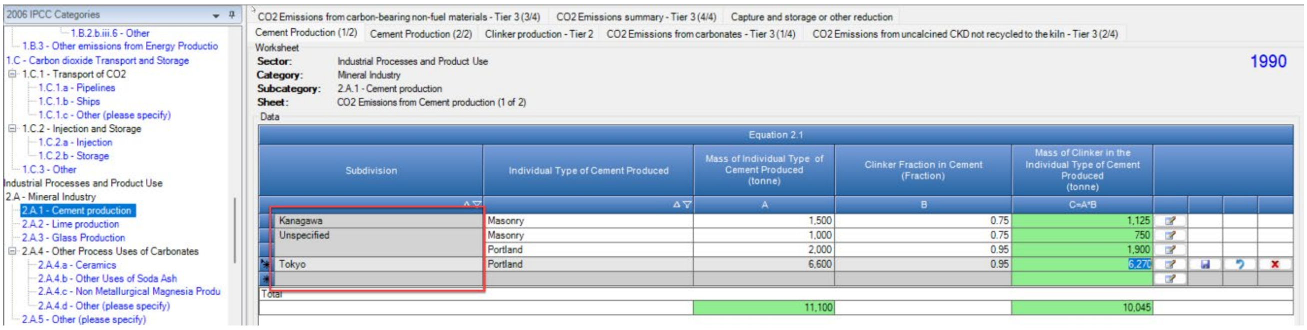
Input of AD for Cement Production requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified"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

.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



When Tier 1 Equations are applied:

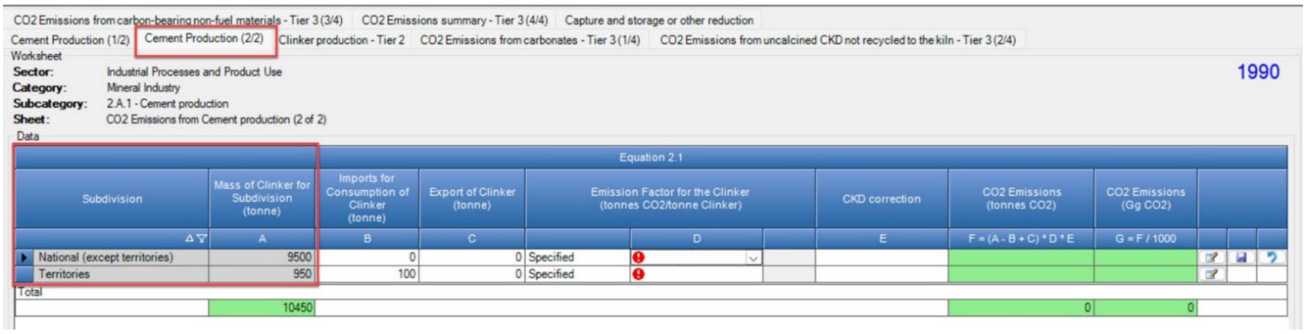
For each subdivision in Column |Subdivision|, data are entered in worksheet **Cement Production (1/2),** row by row, as follows:

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**

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 Clinker Production - Tier 2
Data

Equation 2.2

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.

In worksheet **CO_2 Emissions from Carbonates – Tier 3 (1/4)**, data are entered row by row, as follows:

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

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 carbonates - Tier 3 (1/4)
Data

Equation 2.3 (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
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

CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4), data are entered row by row, as follows:

Note that this worksheet will have the same subdivisions entered in the previous worksheet (1/4) available for selection from the drop-down menu.

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|: input 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

CO_2 Emissions from carbon-bearing materials – Tier 3 (3/4), data are entered row by row, as follows:

Note that this worksheet will have the same subdivisions entered in worksheet (1/4) available for selection from the drop-down menu.

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 category 2.A.1 Cement Production there are two main factors used across Tiers 1, 2 and 3 to define the CO_2 EF:

- ✓ 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
- ✓ 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 - $CaCO_3$):

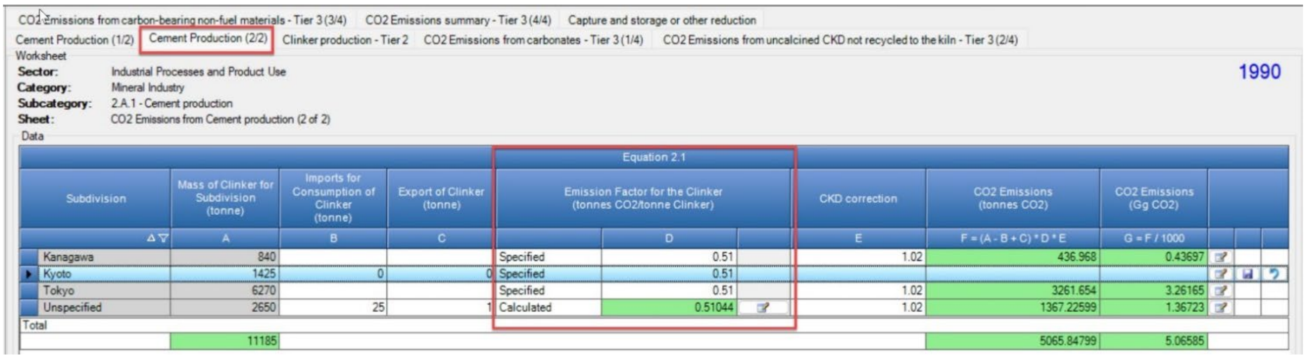
- ✓ **Clinker Production – Tier 2** (for CKD)
- ✓ **CO_2 Emissions from Carbonates – Tier 3 (1/4)**
- ✓ **CO_2 Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4)**
- ✓ **CO_2 Emissions from carbon-bearing materials – Tier 3 (3/4)**

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, for each subdivision, the user enters information, row by row, as follows:

1. Column |D|: Select either *Specified* or *Calculated* for the CO_2 EF.
   a. 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

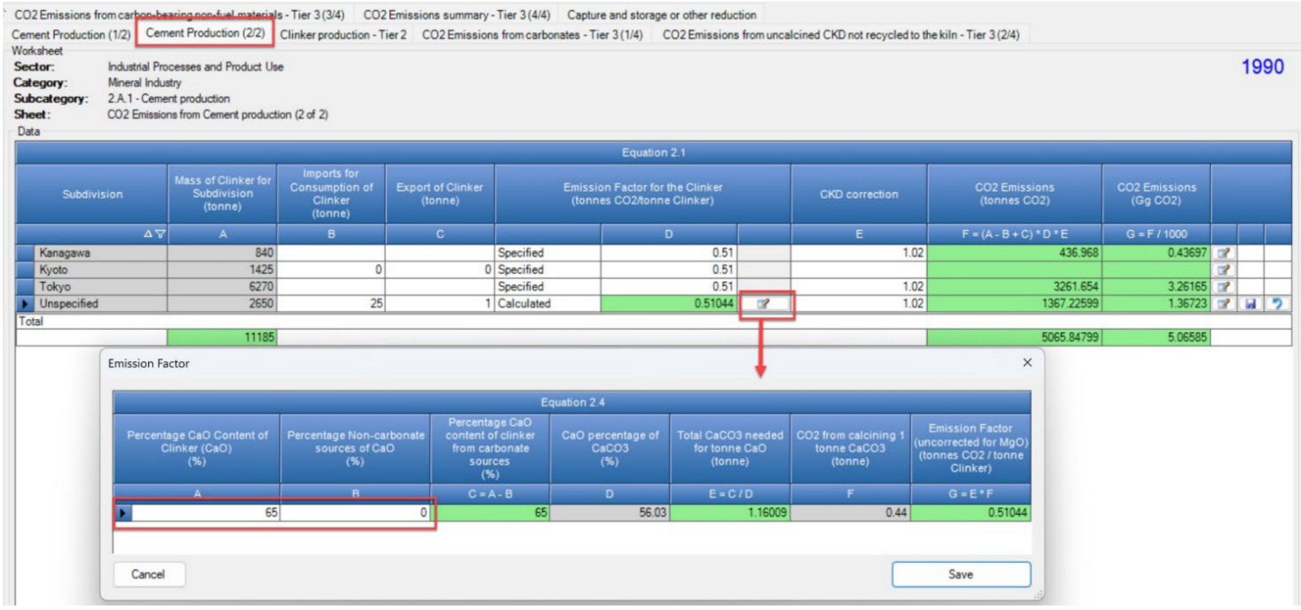
Data

Subdivision	Mass of Clinker for Subdivision (tonne)	Imports for Consumption of Clinker (tonne)	Export of Clinker (tonne)	Equation 2.1 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

   b. 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 input 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 input a user-specific value, dimensionless.

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

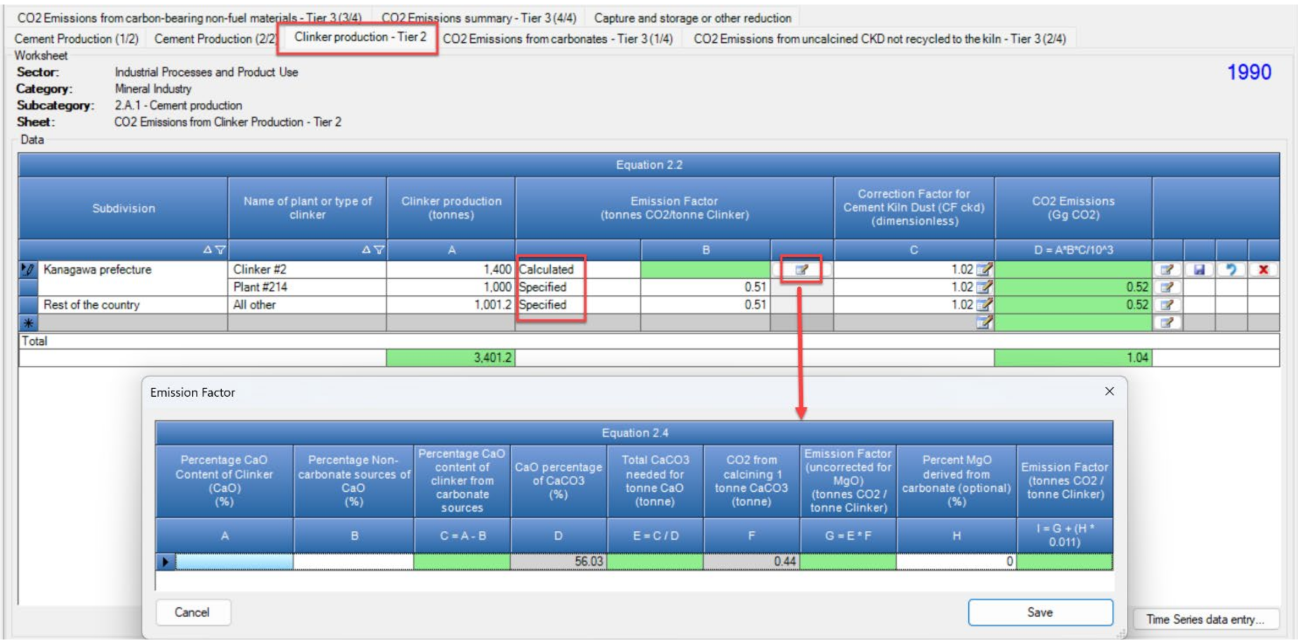


When Tier 2 Equations are applied:

For each subdivision/plant in worksheet **Clinker production – Tier 2**, input information, row by row, as follows:

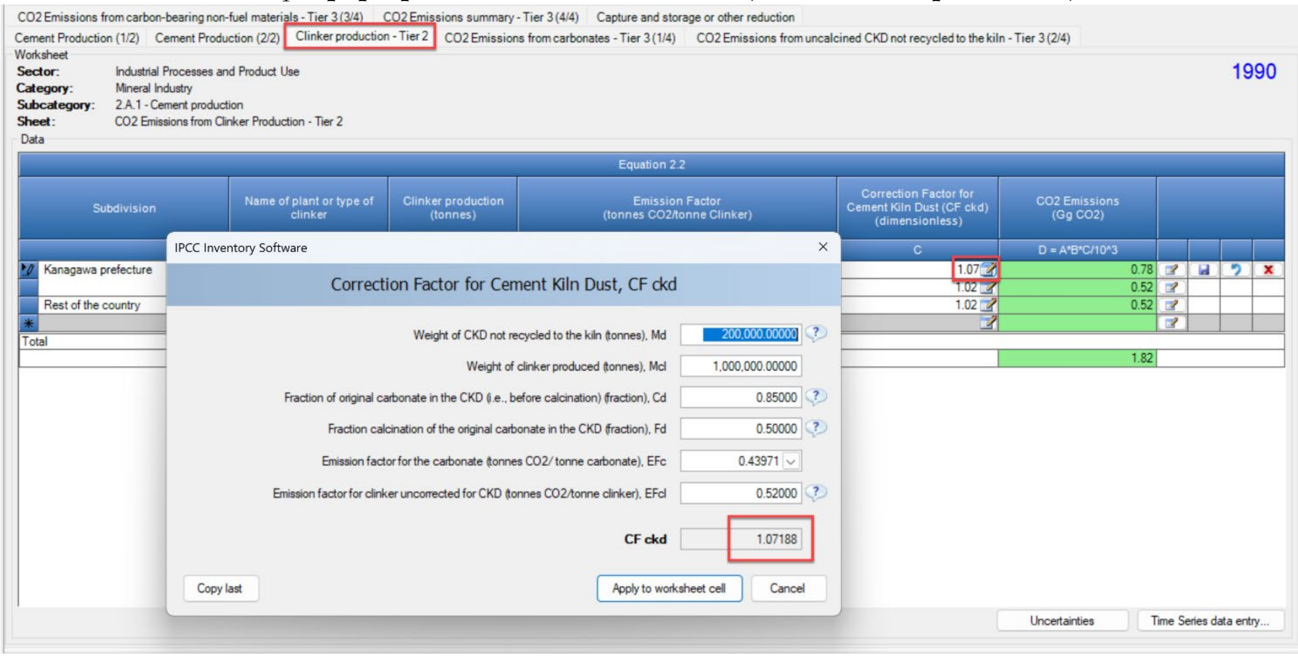
1. <u>Column |B|:</u> Select either *Specified* or *Calculated* for the CO_2 EF.
   a. If specified, directly enter the default CO_2 EF for clinker of **0.51 tonne CO_2 per tonne of clinker**, uncorrected for CKD, or input a user-specific CO_2 EF.
   b. If calculated, the CO_2 EF is calculated based 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**



2. Column |C|: Additional information is needed to estimate the correction factor for CKD not recycled into the kiln. The factor can be input 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:
    a. 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.
    b. Weight of clinker produced (Mcl), tonnes.
    c. 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.
    d. Fraction calcination of the original carbonate in the CKD, fraction (Fd)
    e. EF for the carbonate (Table 2.1) (EFc), tonnes CO_2/tonne carbonate may be selected from the drop-down menu or manually input.
    f. EF for clinker uncorrected for CKD (EFcl) is automatically populated from Column |B|.

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)** input information, row by row, as follows:

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

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

2. Column |EFd|: input the 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):**

3. Column |EFk|: input 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:

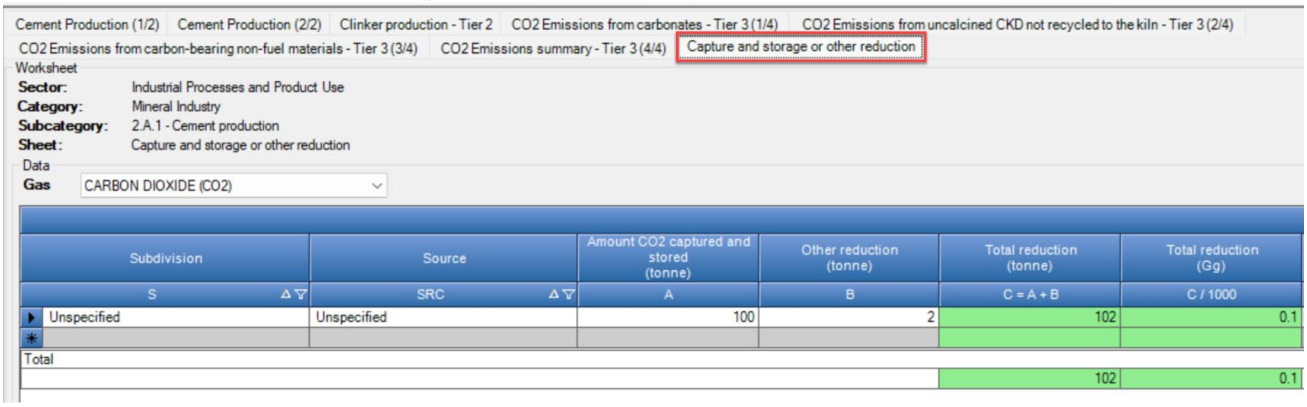
- ✓ **Cement Production – Tier 1 (2/2)**
- ✓ **Clinker Production – Tier 2**
- ✓ **CO_2 Emissions summary – Tier 3 (4/4)**

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|: 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| collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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	100	2	102	0.1
Total				102	0.1

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:** 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 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.

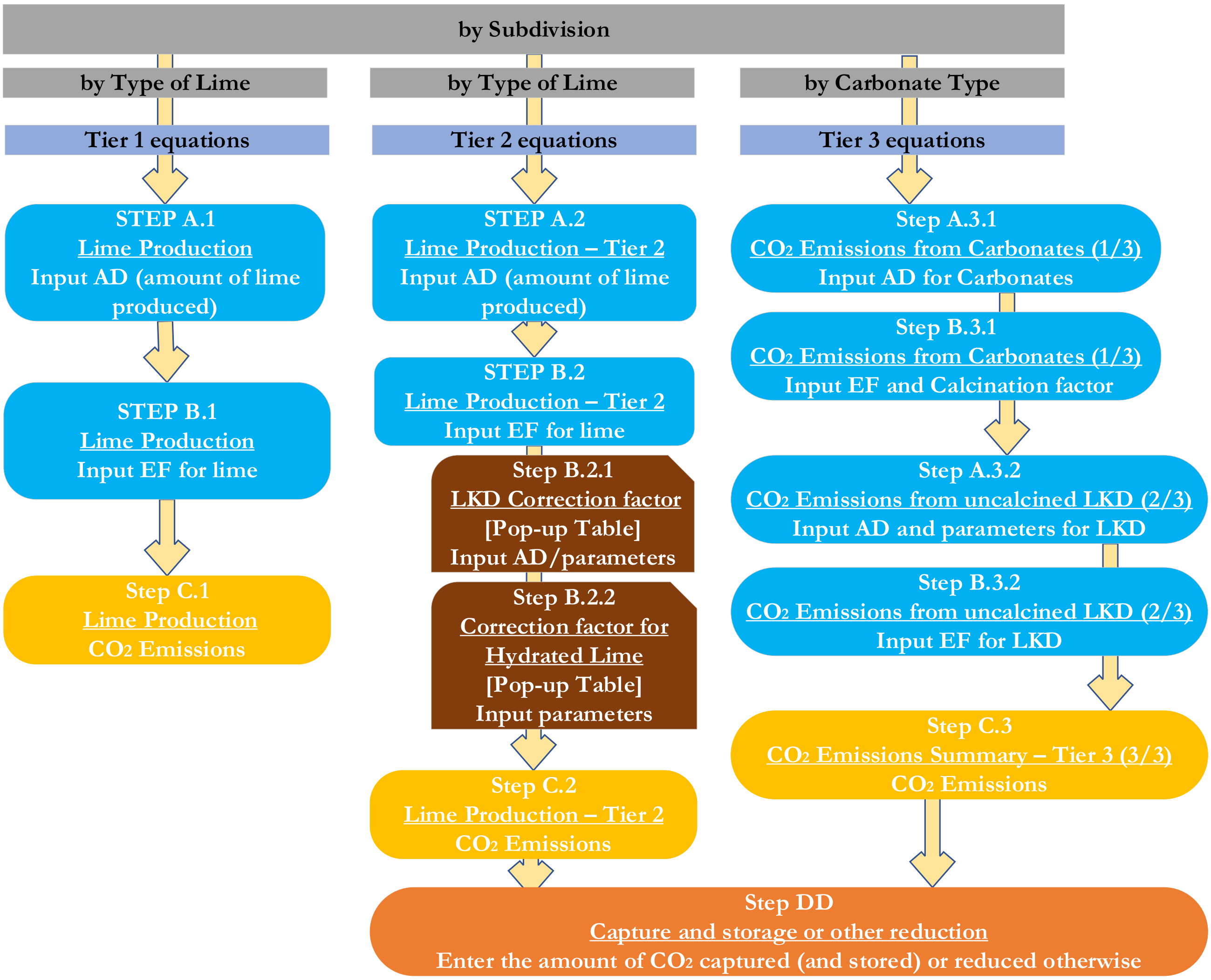
User's Work Flowchart

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

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

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

Then, for each tier, as appropriate:

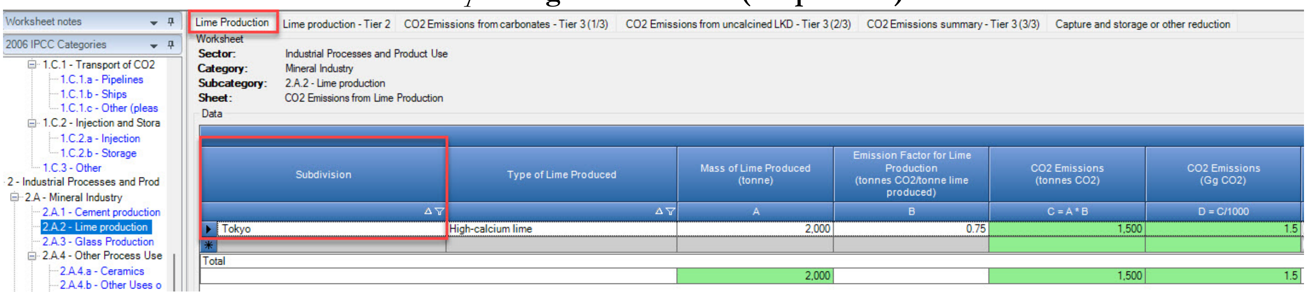
Step DD, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates), not otherwise captured in the worksheets above.

Activity Data Input

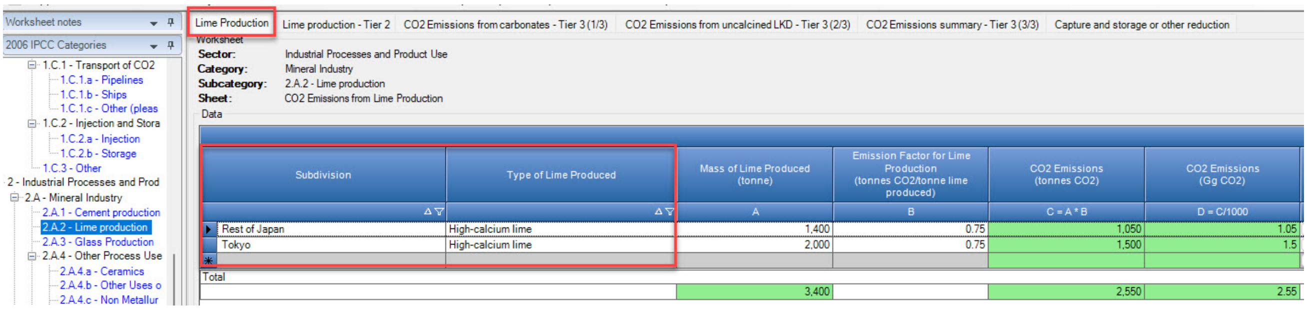
Section 2.3.1.3, in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for lime production.

Input of AD for Lime 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Worksheet

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

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	High-calcium lime	1,400	0.75	1,050	1.05
Tokyo	High-calcium lime	2,000	0.75	1,500	1.5
Total		3,400		2,550	2.55

When the Tier 1 Equation is applied:

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

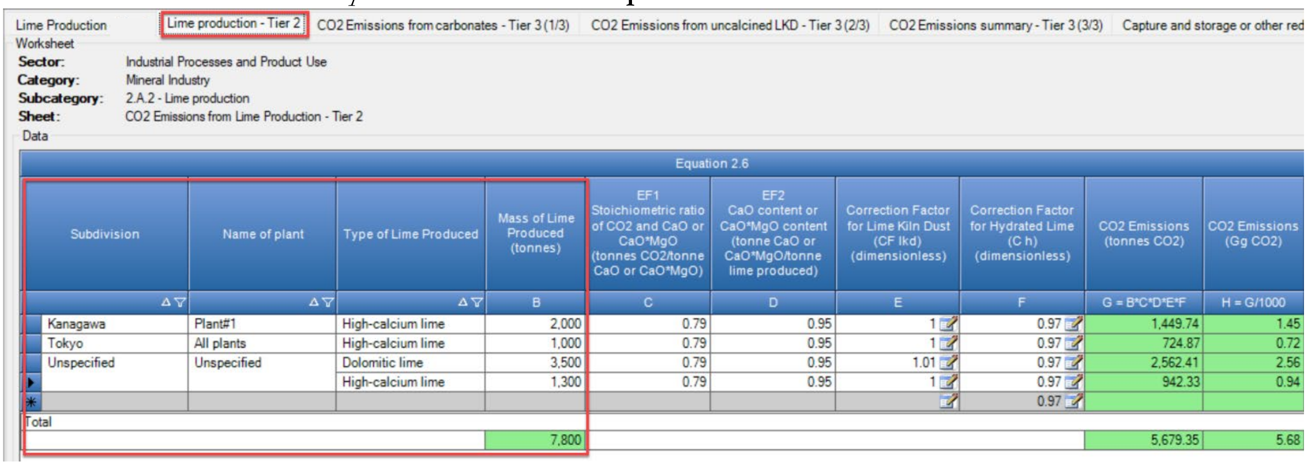
1. Column |Type of Lime Produced|: select from the drop-down menu the type of lime produced. If the type of lime is unknown, select *All lime production.*
   Note that, if type of lime is unknown, the 2006 IPCC Guidelines assume a breakdown of 85 percent high calcium lime / 15 percent dolomitic lime.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

When Tier 2 Equations are applied:

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

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

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



Worksheet

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

Equation 2.6

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, row by row, as follows:

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

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

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

Lime Production | 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

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.

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 | 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

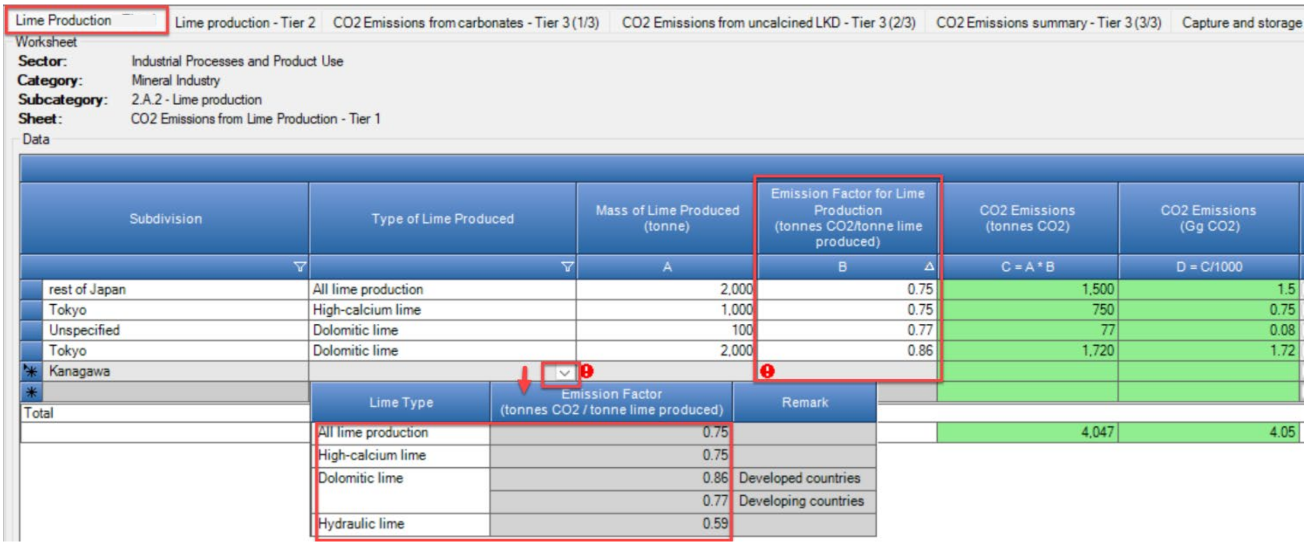
Section 2.3.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EF for Lime Production. IPCC default values for the Tier 1 and Tier 2 methods are contained in Equation 2.8 and Table 2.4, while the stoichiometric EF for use of each type of carbonates is found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

When the Tier 1 Equation is applied:

For each subdivision in worksheet **Lime Production**, input information, row by row, as follows**:**

1. Column |B|: the default CO_2 EF is automatically populated, in tonnes CO_2/tonne lime produced, depending on the type of lime produced in Column |Type of Lime Produced|. The user may overwrite this value with user-specific information.
   Note that 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**

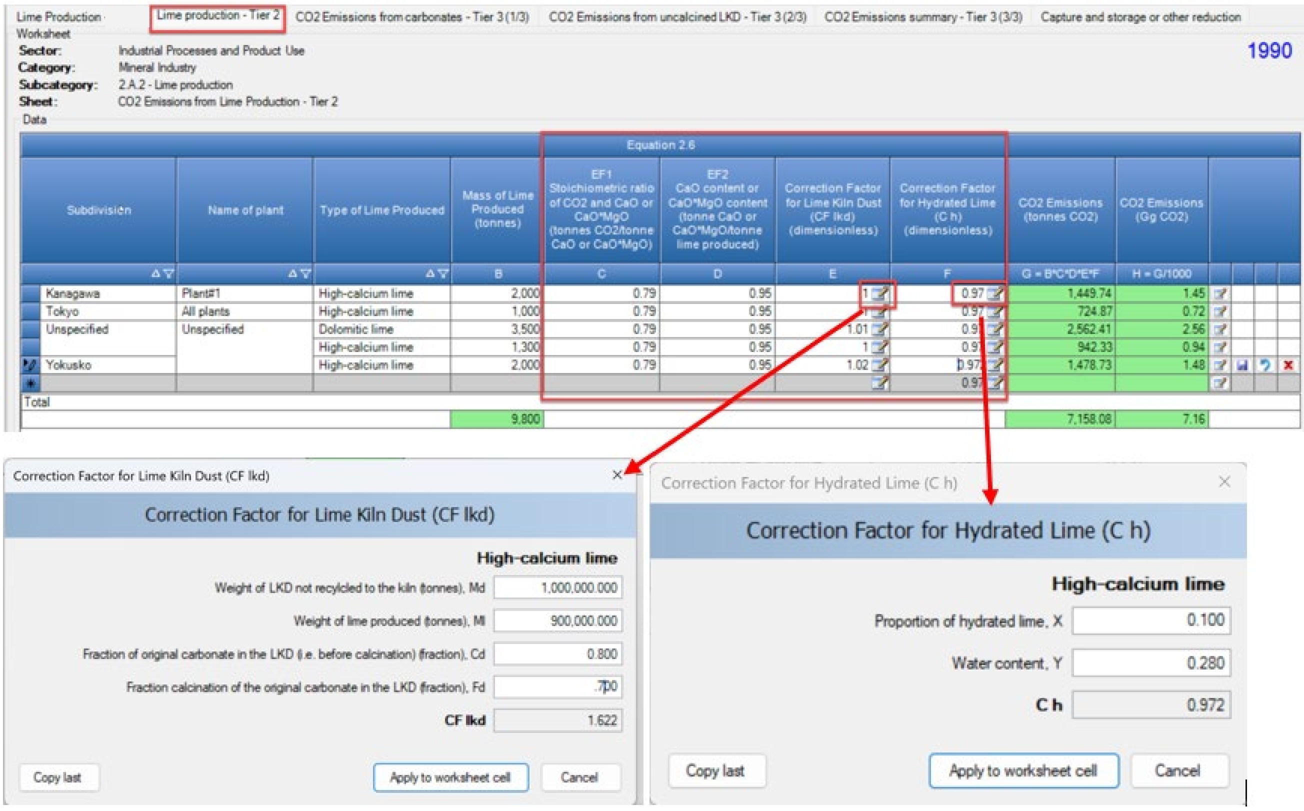


When Tier 2 Equations are applied:

For each subdivision/name of plant/type of lime produced in worksheet **Lime Production – Tier 2,** input information, row by row, as follows:

1. Column |C|: 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. Column |D|: 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. Column |E|: 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:
   a. Weight of LKD not recycled to the kiln (Md), tonnes.
   b. Weight of lime produced (Ml), tonnes.
   c. Fraction of original carbonate in the LKD (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 LKD is essentially the same as that in the raw mix kiln feed.
   d. Fraction calcination of the original carbonate in the LKD (Fd), fraction.
4. Column |F|: Additional information is needed to estimate the correction factor for hydrated lime (see discussion under Section 2.3.1.3. 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).
   a. Proportion of hydrated lime (X), fraction
   b. Water content (Y), fraction

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

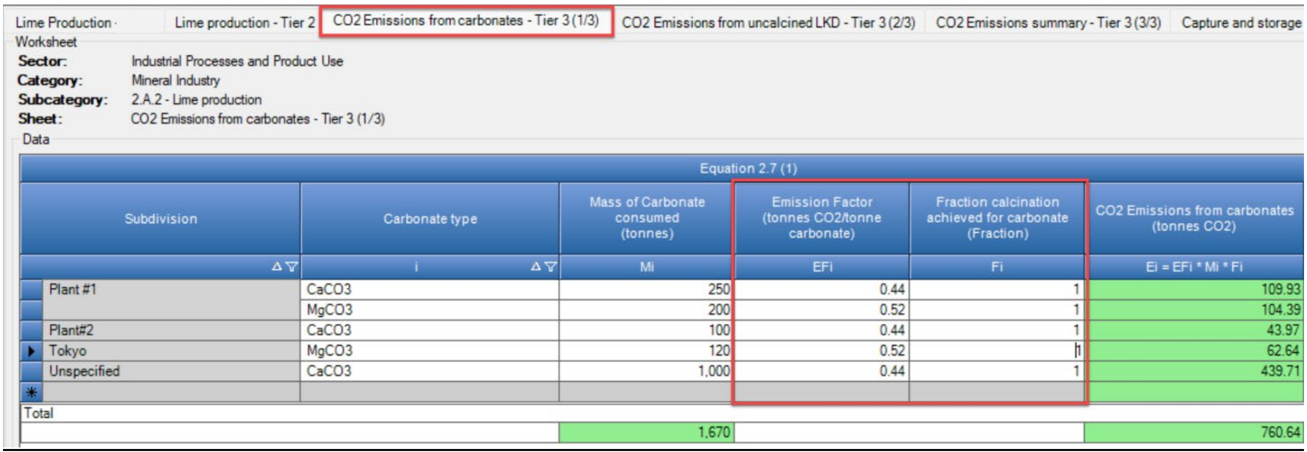


When the Tier 3 Equation is applied:

For each subdivision/carbonate type in worksheet **CO_2 Emissions from Carbonates – Tier 3 (1/3),** input information, row by row, as follows**:**

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

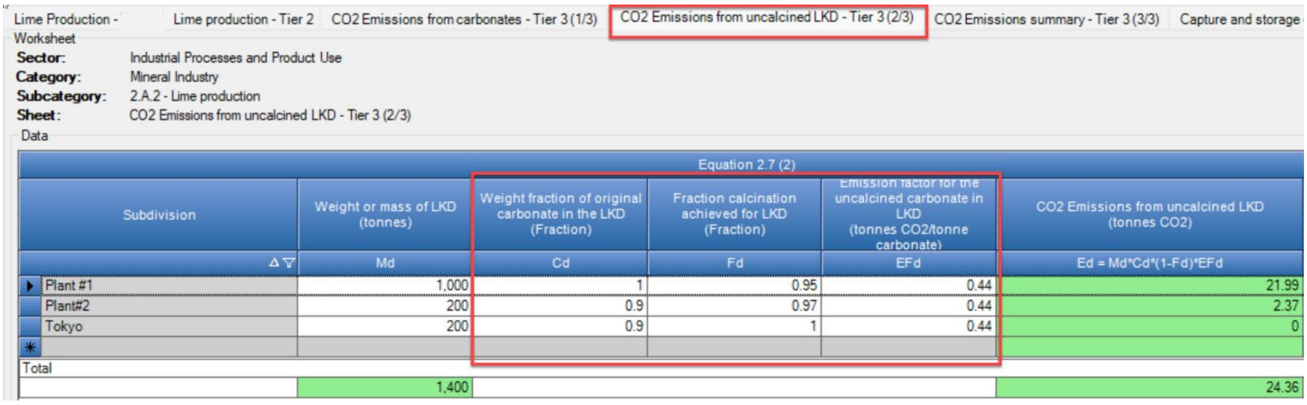
Example: **Tier 3 EF for lime production**



Then, in worksheet **CO_2 Emissions from uncalcined LKD not recycled to the kiln – Tier 3 (2/3),** input information, row by row, as follows:

1. <u>Column |Cd|</u>: input the weight fraction of original carbonate in the LKD.
2. <u>Column |Fd|</u>: input the 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>: input 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% 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 EF for calcium carbonate for EFd.

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



Lime Production - Worksheet | 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

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:

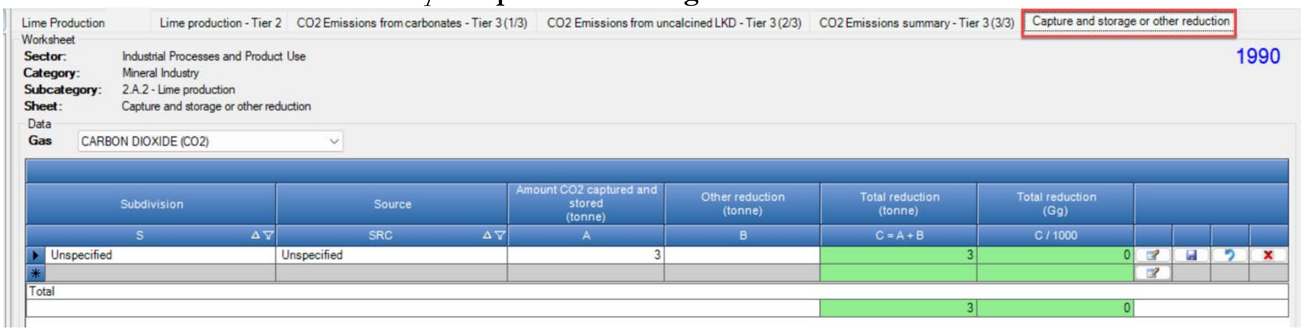
- ✓ **Lime Production**
- ✓ **Lime Production – Tier 2**
- ✓ **CO_2 Emissions summary – Tier 3 (3/3)**

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|: 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| collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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. The Tier 1 method can 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.

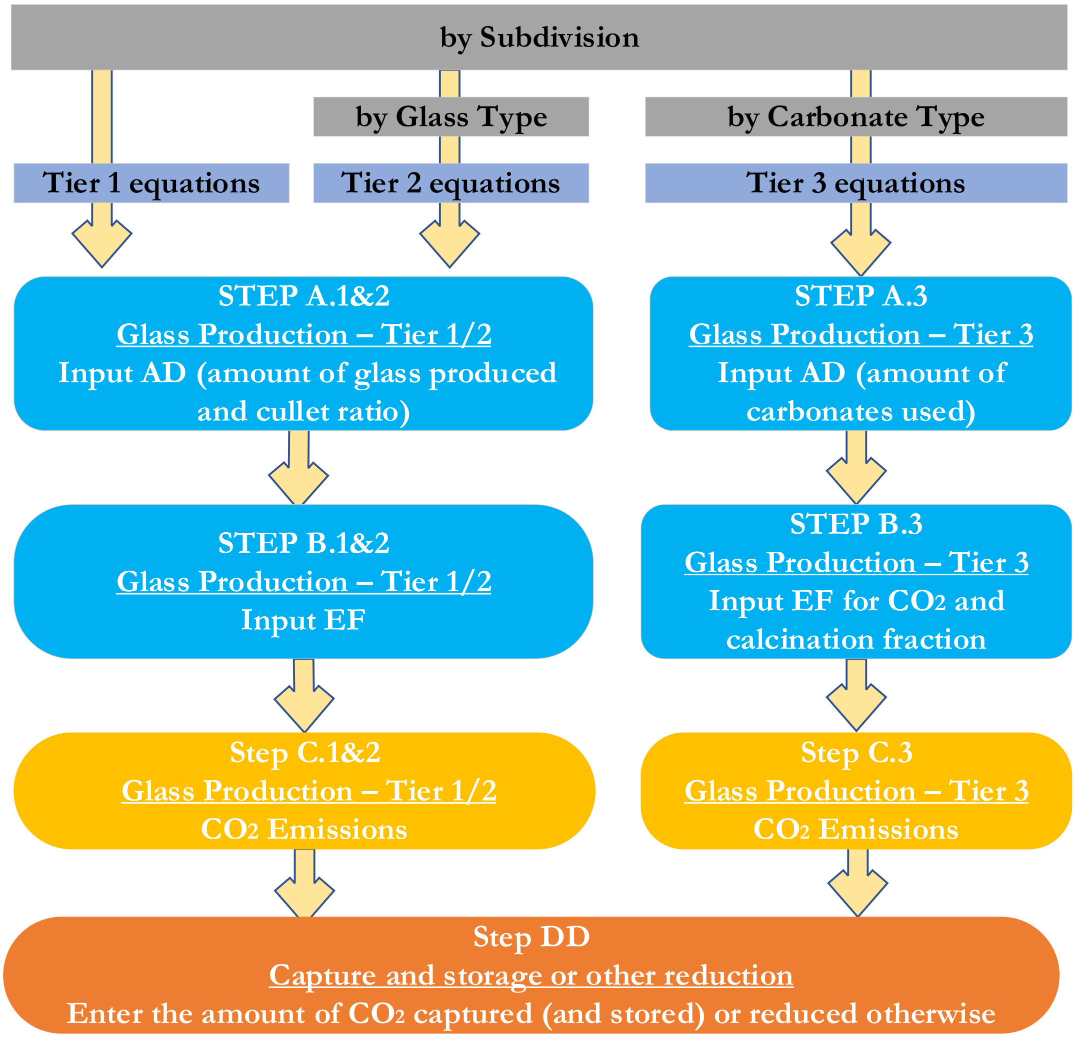
User's Work Flowchart

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 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 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:

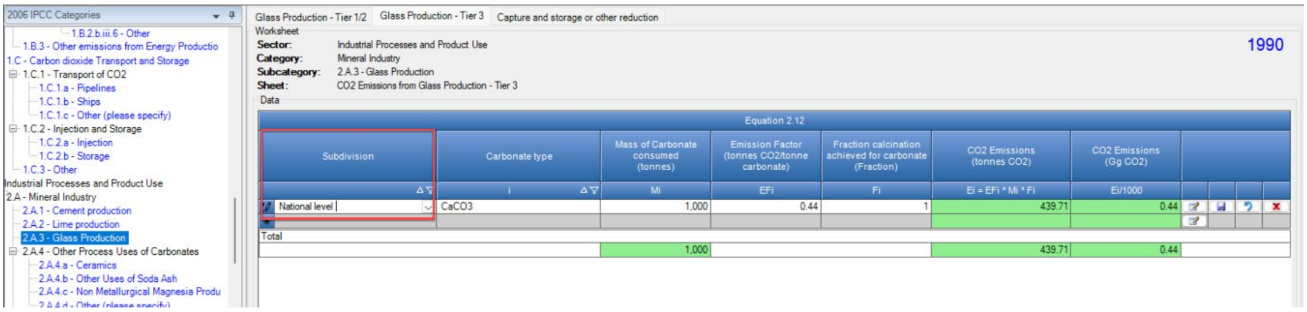
Step DD, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates), not otherwise captured in the worksheets above.

Activity Data Input

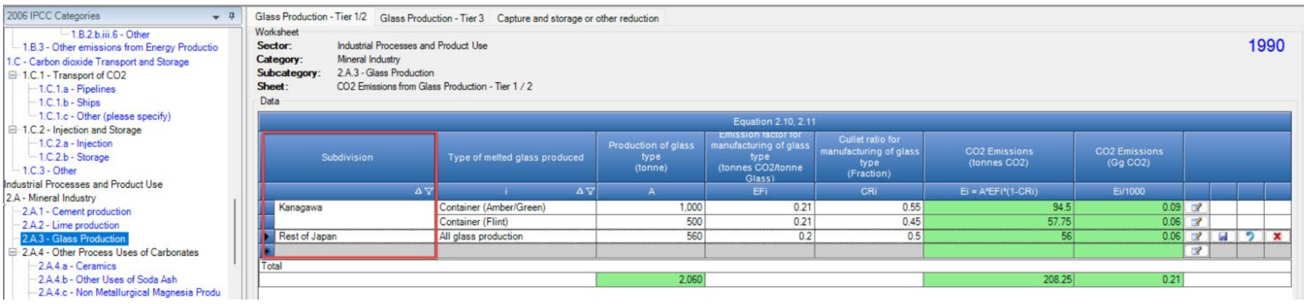
Section 2.4.1.3, in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for glass production.

Input of AD for Glass 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



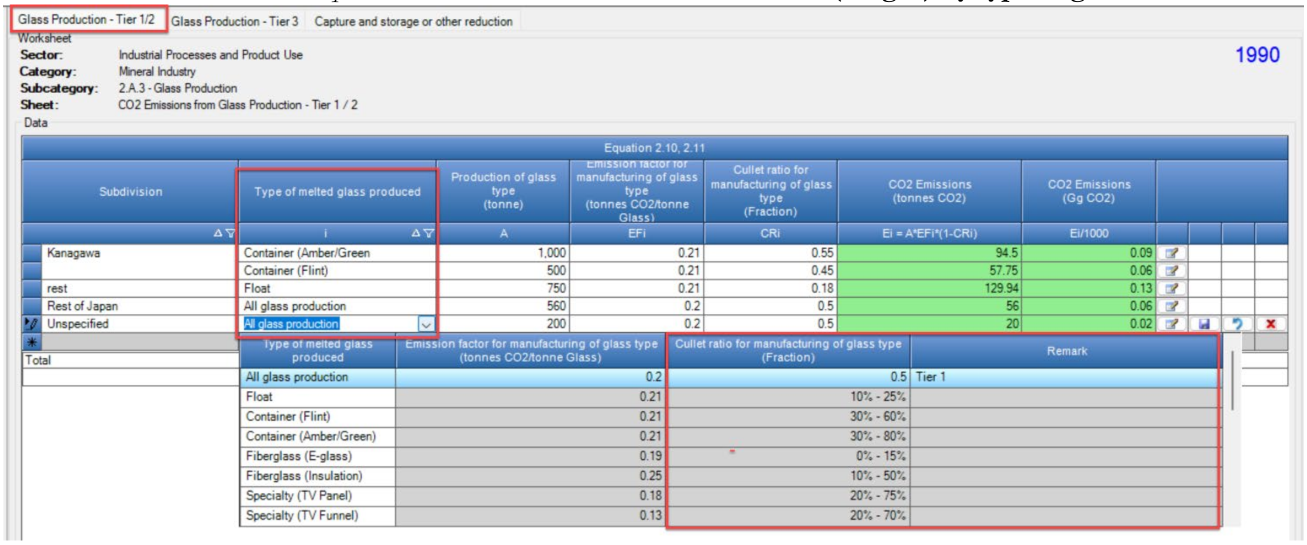
When Tier 1 and Tier 2 Equations are applied:

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 that 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 EF accordingly. Although the Tier 2 method provides typical default ranges for the cullet ratio (Table 2.6), 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						

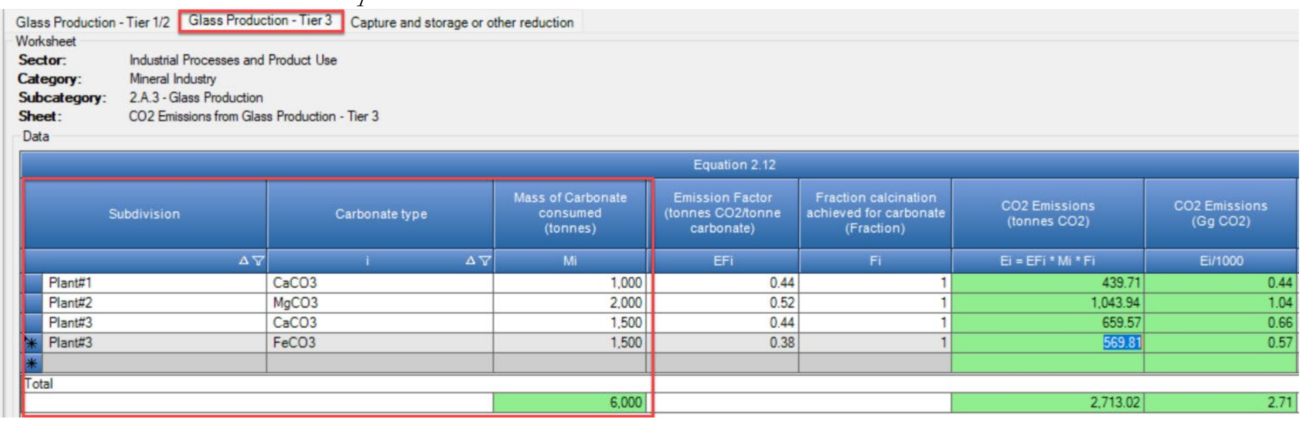
Type of melted glass produced	Emission factor for manufacturing of glass type (tonnes CO2/tonne Glass)	Cullet ratio for manufacturing of glass type (Fraction)	Remark
All glass production	0.2	0.5	Tier 1
Float	0.21	10% - 25%	
Container (Flint)	0.21	30% - 60%	
Container (Amber/Green)	0.21	30% - 80%	
Fiberglass (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)

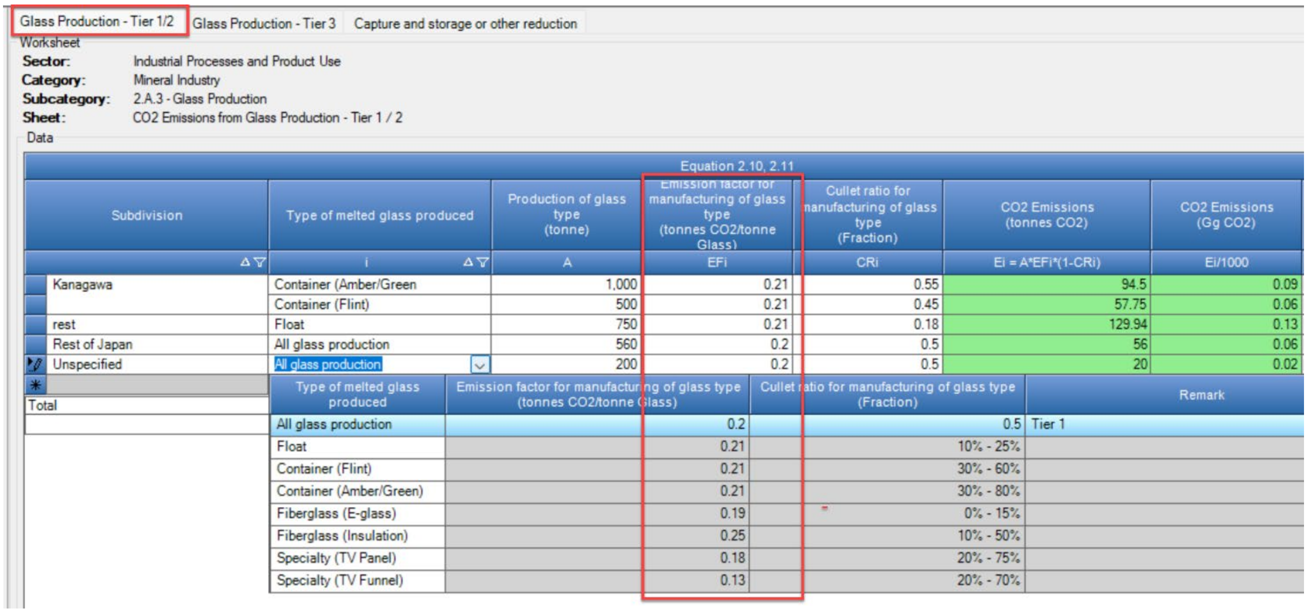
ii) CO_2 EF for carbonates consumed (based on stoichiometry of carbonates) in tonnes of CO_2 per tonne of carbonate used – Tier 3 (Table 2.1). Additionally, calcination fraction of carbonates is needed to make emission estimates.

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,** information is input, row by row, as follows:

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

Example: **Tier 1&2 EF for glass production**

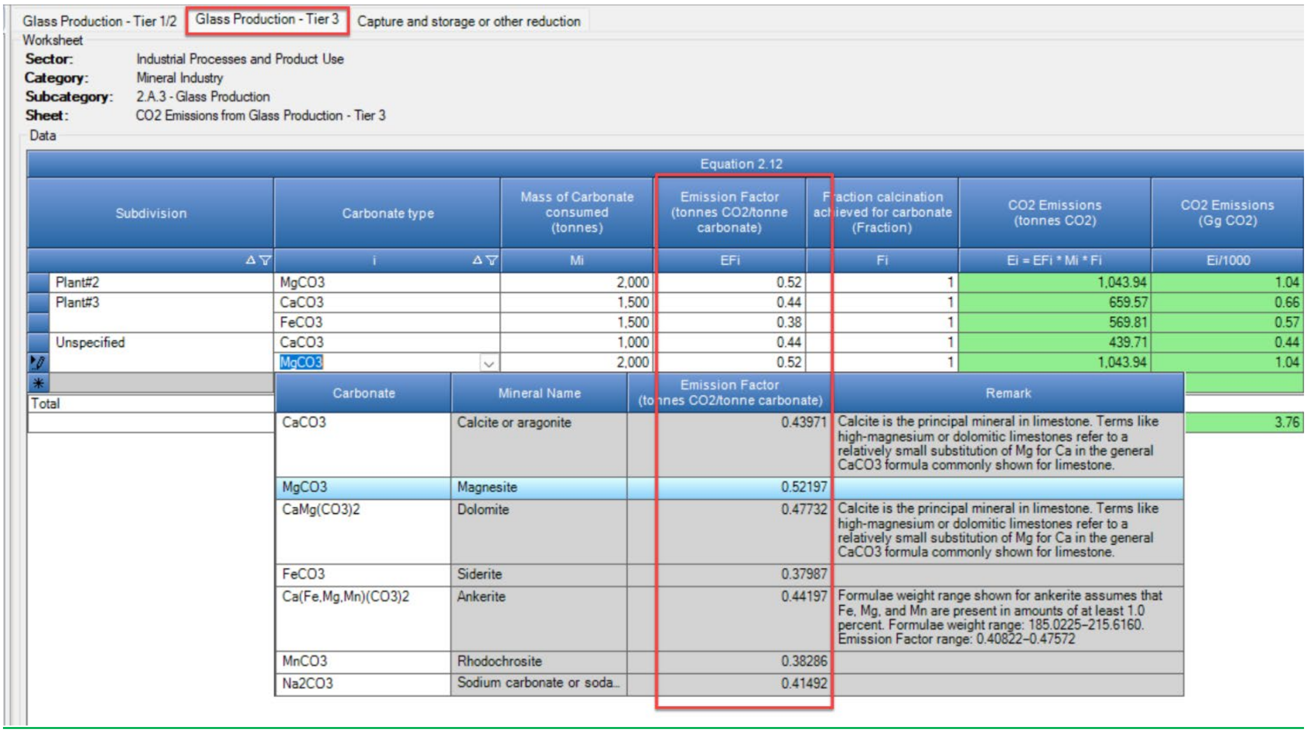


When the Tier 3 Equation is applied:

For each subdivision / carbonate type in worksheet **Glass Production – Tier 3,** information is entered, row by rows, as follows:

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

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

Equation 2.12

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:

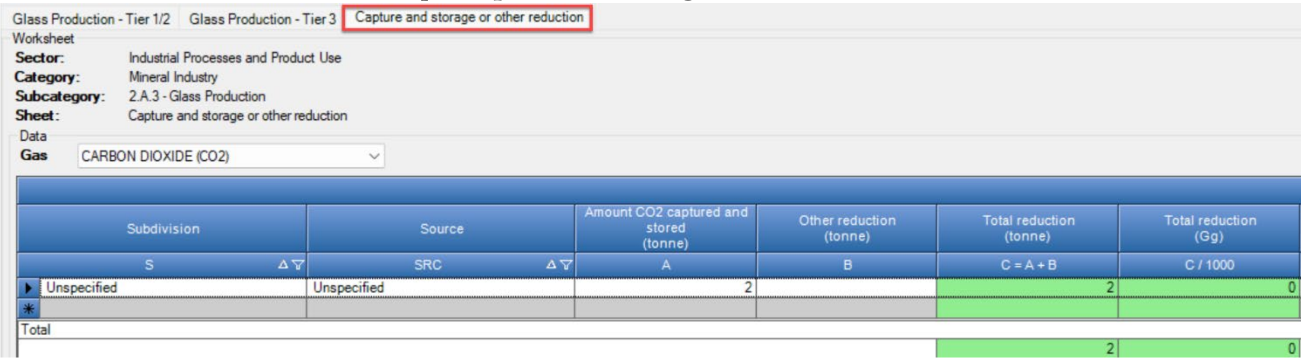
- ✓ **Glass Production – Tier 1/2**
- ✓ **Glass Production – Tier 3**

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|: 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| collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 Other Process Uses of Carbonates. Carbonates used in cement, lime and glass production have already been considered in previous sections of this Guidebook. As discussed in Section 2.3.1.1, all marketed and non-marketed production of lime should be reported under 2.A.2 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.

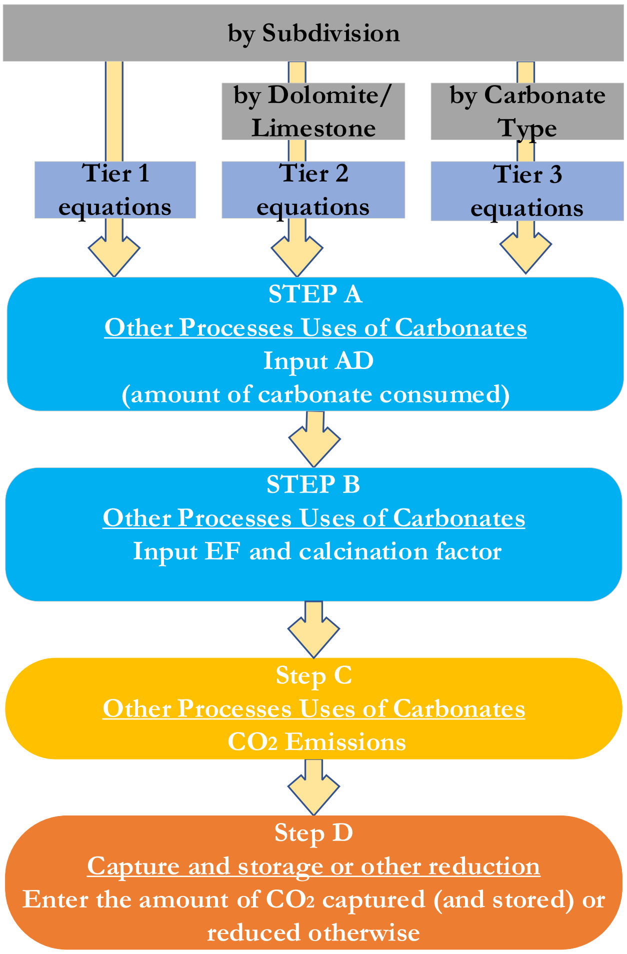
User's Work Flowchart

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.

[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

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.

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**, 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).

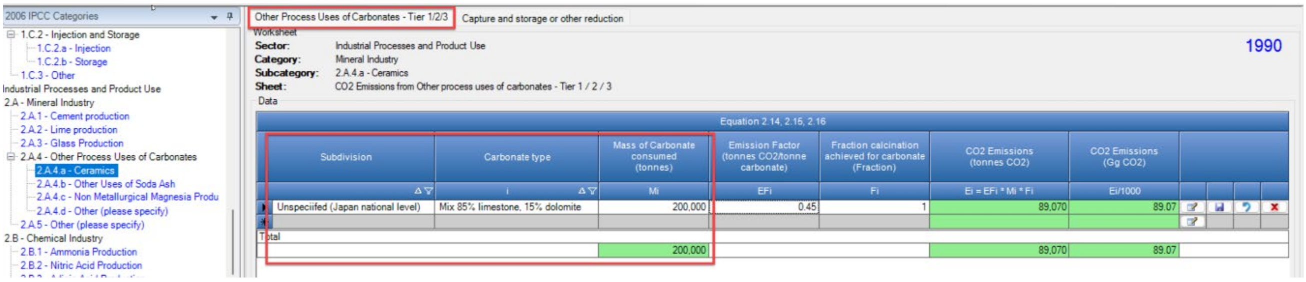
Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the country-specific EF.

Activity Data Input

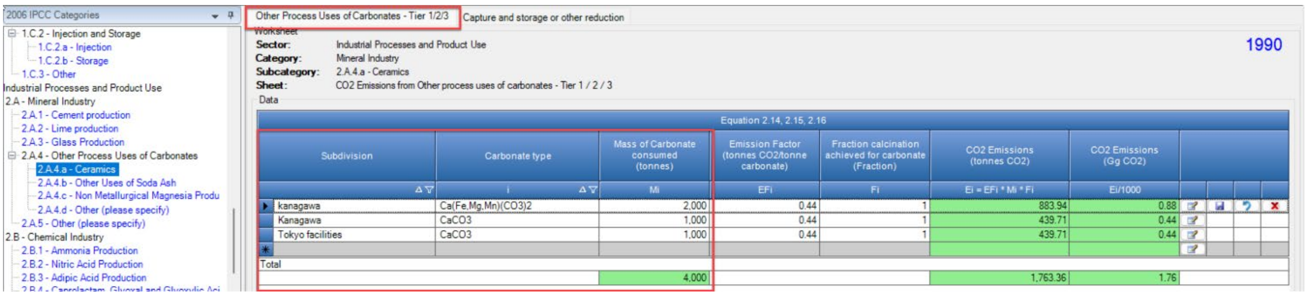
Section 2.5.1.3, in Chapter 2 Volume 3 of the *2006 IPCC* Guidelines contains information on the choice of AD for Other Process Uses of Carbonates.

Input of AD for Other Process Uses of Carbonates 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

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



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 input 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 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.

For each combination of subdivision/carbonate type in worksheet **Other Process Uses of Carbonates – Tier 1/2/3,** information is input, row by row, as follows:

1. Column |EFi|: the EF is automatically populated 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|, in tonne of CO_2 per tonne of carbonate.
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**

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: CO2 Emissions from Other process uses of carbonates - Tier 1 / 2 / 3

Data

Equation 2.14, 2.15, 2.16

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
kanagawa	Ca(Fe,Mg,Mn)(CO3)2	2,000	0.44	1	883.94	0.88
Kanagawa	CaCO3	1,000	0.44	1	439.71	0.44
Tokyo facilities	CaCO3	1,000	0.44	1	439.71	0.44
Total						1.76

Carbonate	Mineral Name	Emission Factor (tonnes CO2/tonne carbonate)	Remark
Mix 85% limestone, 15% dolomite		0.44535	
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 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|: 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| collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 (mineral industry) 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.

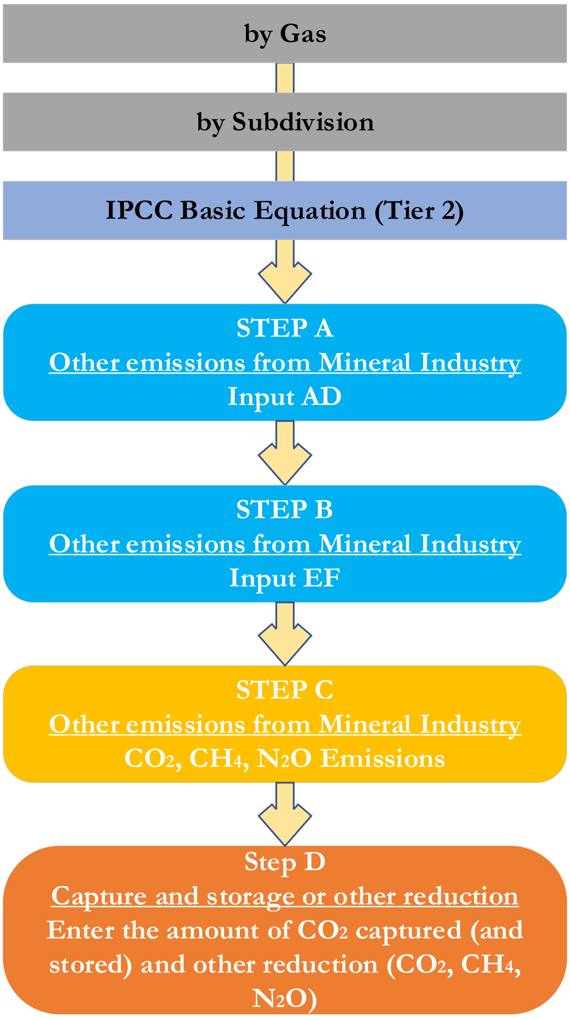
User's Work Flowchart

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 worksheet **Other**, users collect and input data in the *Software* on the source of emissions and AD.

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

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

Step D, in 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 (mineral industry) 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], or with subnational aggregations, and for each of those the univocal name/code entered in Column |Subdivision|.

For each subdivision in Column |Subdivision|, 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|: input the activity type corresponding to the source selected.
3. Column |AD|: input AD (quantity of the activity type input in Column |AT| and following the units in Column |U|).
4. Column |U|: input the unit of the AD.

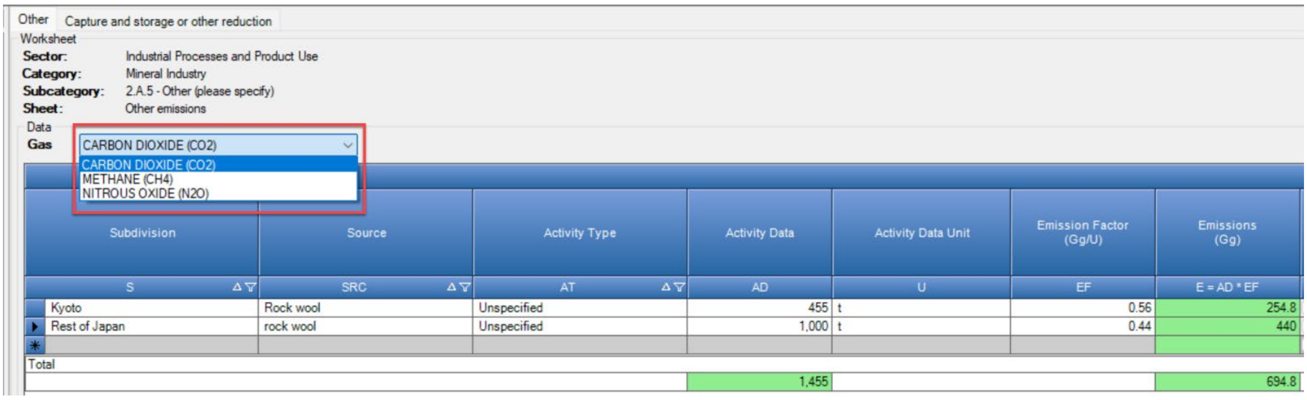
Emission Factor Input

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

1. Column |EF|: input 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**



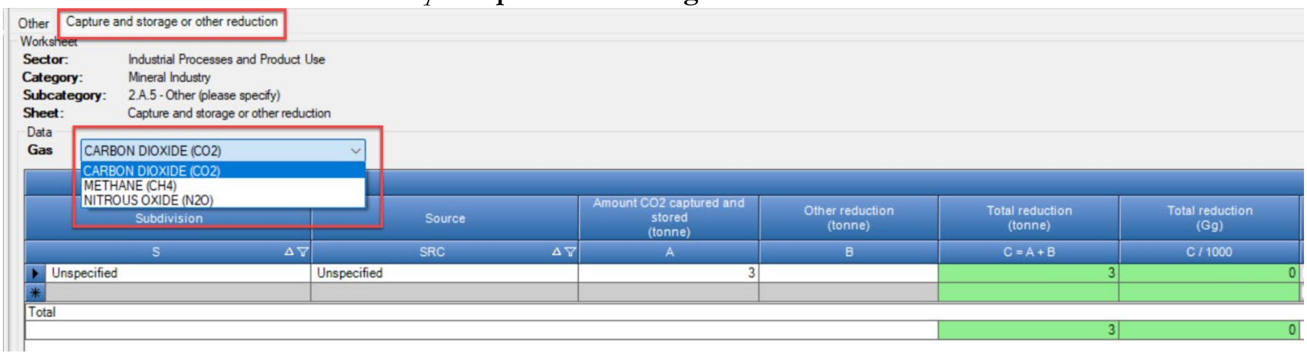
Results

Total CO_2, CH_4 and N_2O emissions from Other (mineral industry) is the sum of all subdivisions in worksheet **Other**, 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|: 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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

Section 3.2 of 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 GHGs 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.

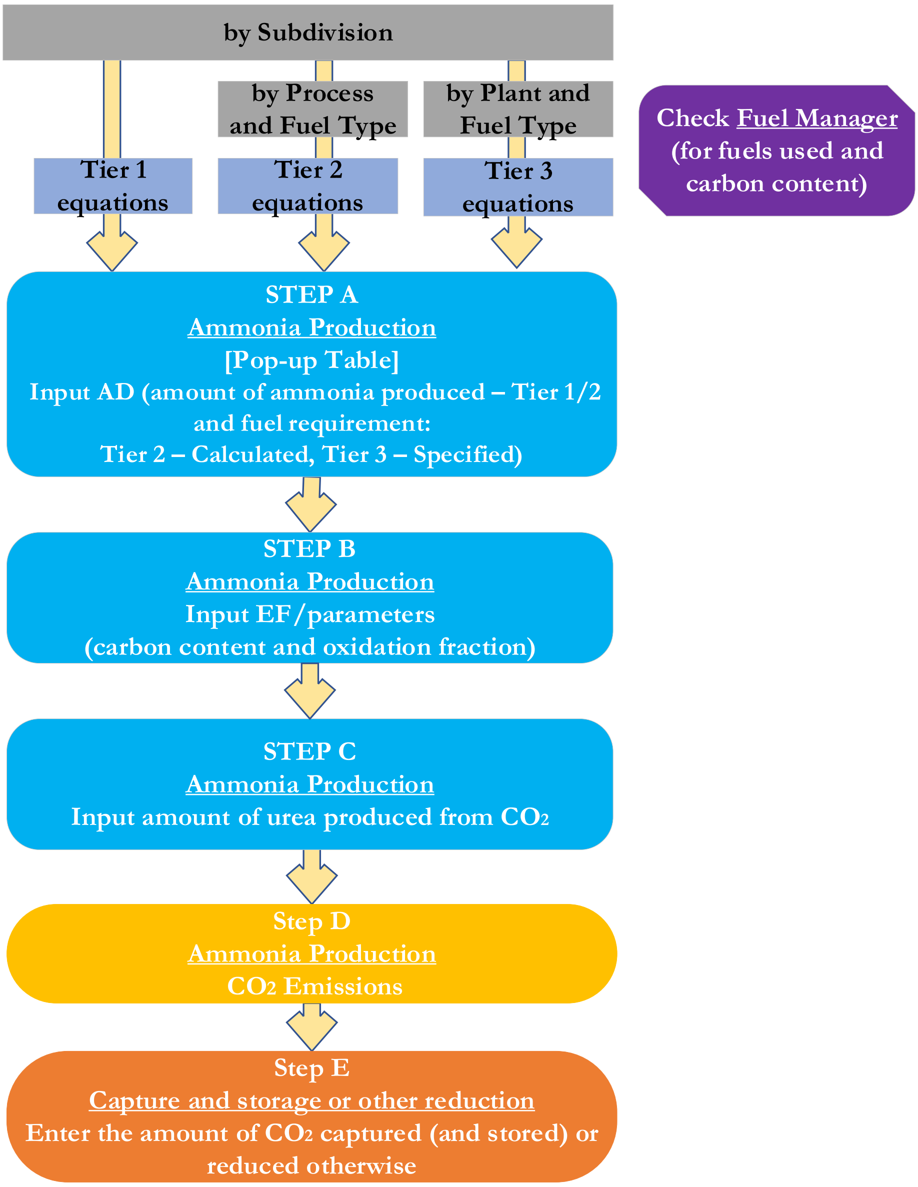
User's Work Flowchart

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.

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**, 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 accounted in Step **C**.

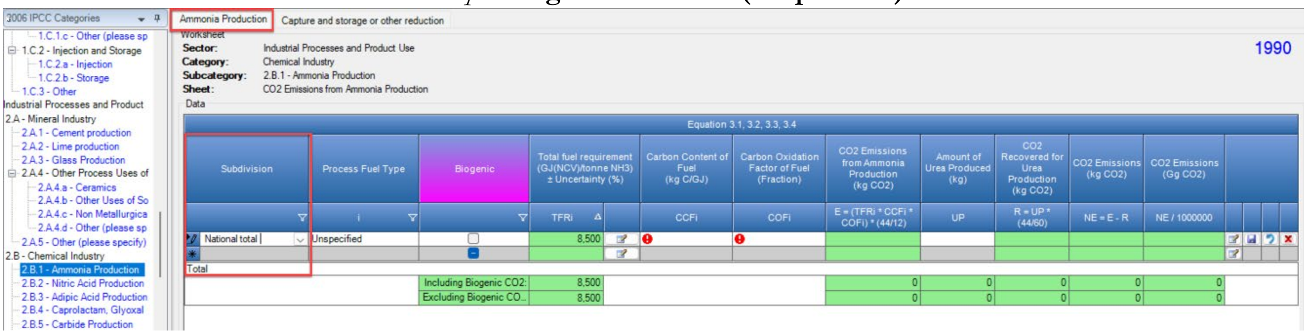
Activity Data Input

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.

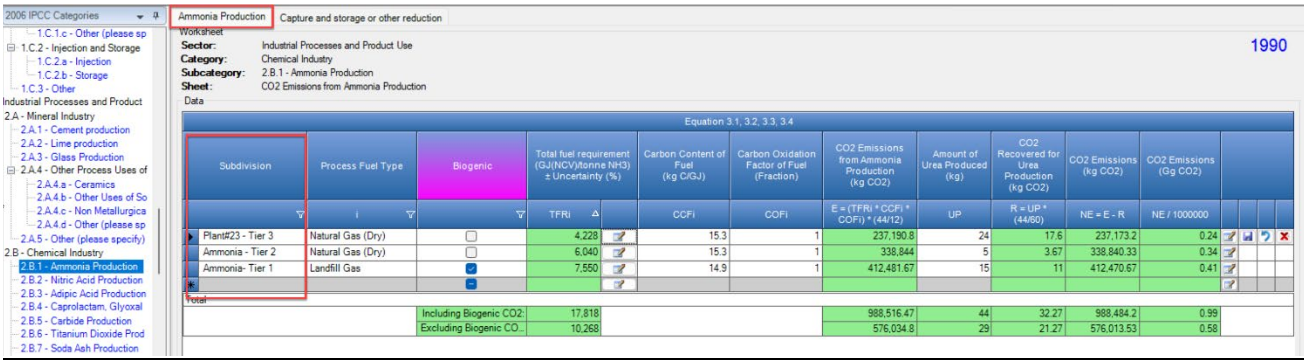
As a **starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for ammonia production; and for each fuel listed in the Fuel Manager, the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the drop-down menu.

Second, input of AD for Ammonia Production 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



The same general workflow is followed regardless of whether Tier 1, Tier 2 and/or Tier 3 Equations are applied. The guidance below distinguishes, at each step, the relevant input for the different tiers.

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 known. For Tier 1, the user may 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.

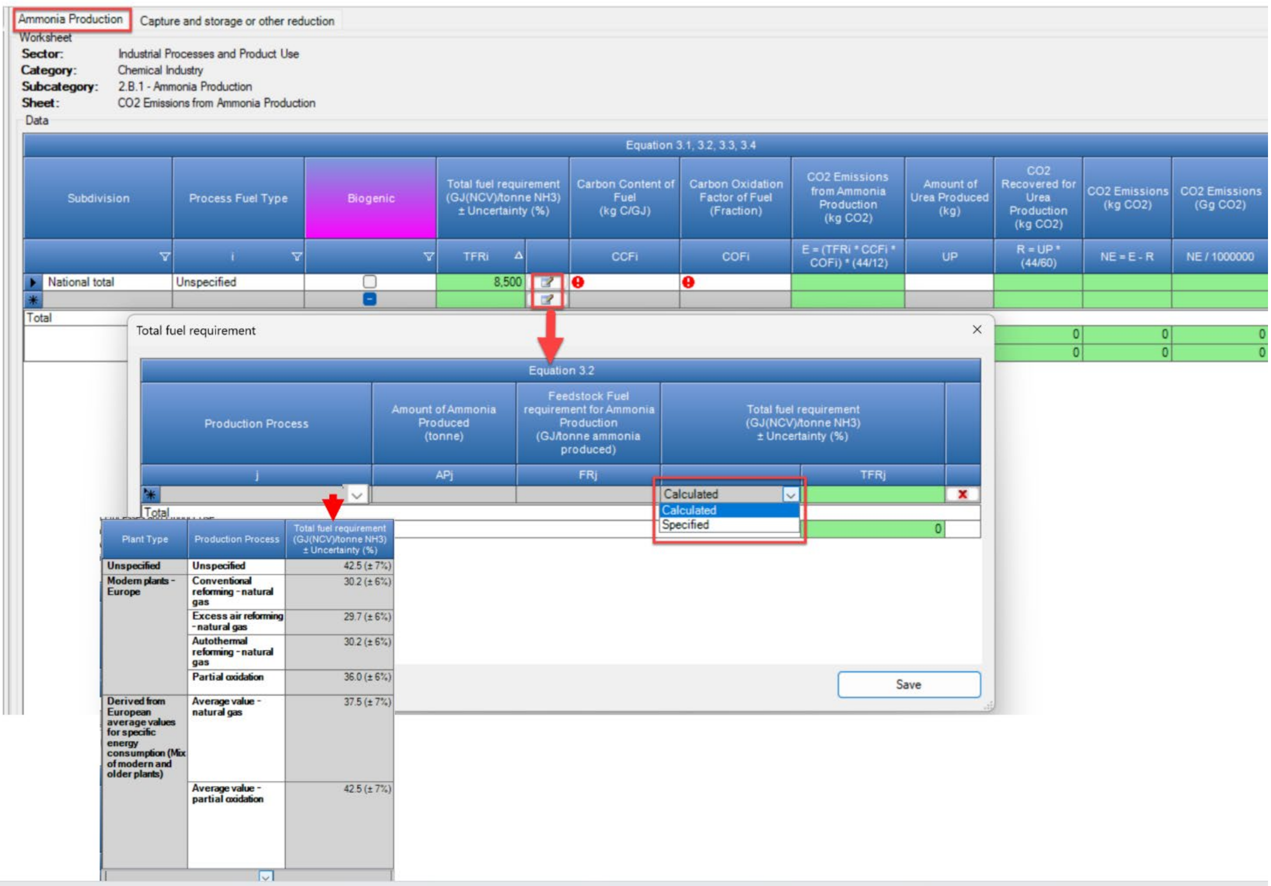
In the pop-up table indicate if TFRj will be *Calculated* or *Specified*:

If *Calculated* is selected in <u>Column |TFRi |</u> (Tier 1 and Tier 2)

a. <u>Column |j|</u>: 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).
b. <u>Column |APj|</u>: input the mass of ammonia produced, in tonnes, either national total (Tier 1) or by process type (Tier 2).
c. <u>Column |FRj|</u>: the feedstock fuel requirement for ammonia production will be automatically populated based on the production process selected in <u>Column |j|</u>, or the user may overwrite, in GJ/tonne NH_3 produced.
   <u>Note that</u> the Software automatically calculates the fuel requirement in the pop-up table and transfers the value into the main worksheet.

If *Specified* is selected (Tier 3) in <u>Column |TFRj|</u>: input the total fuel requirement for ammonia production for that subdivision/process fuel type/ production process.
<u>Note that</u> 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**



Then, if CO_2 is used to product urea, input information for each subdivision/process fuel type in

4. <u>Column |UP|</u>: input 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 for urea production is zero (i.e. <u>Column |UP|</u> =0).
   <u>Note that</u> the quantity of urea produced can be estimated by dividing the total CO_2 consumed for urea production by 0.733 tonnes of CO_2 required per tonne urea production.

Example: **input of urea production**

Ammonia Production | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.1 - Ammonia Production
Sheet: CO2 Emissions from Ammonia Production

Data

Equation 3.1, 3.2, 3.3, 3.4										
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

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.

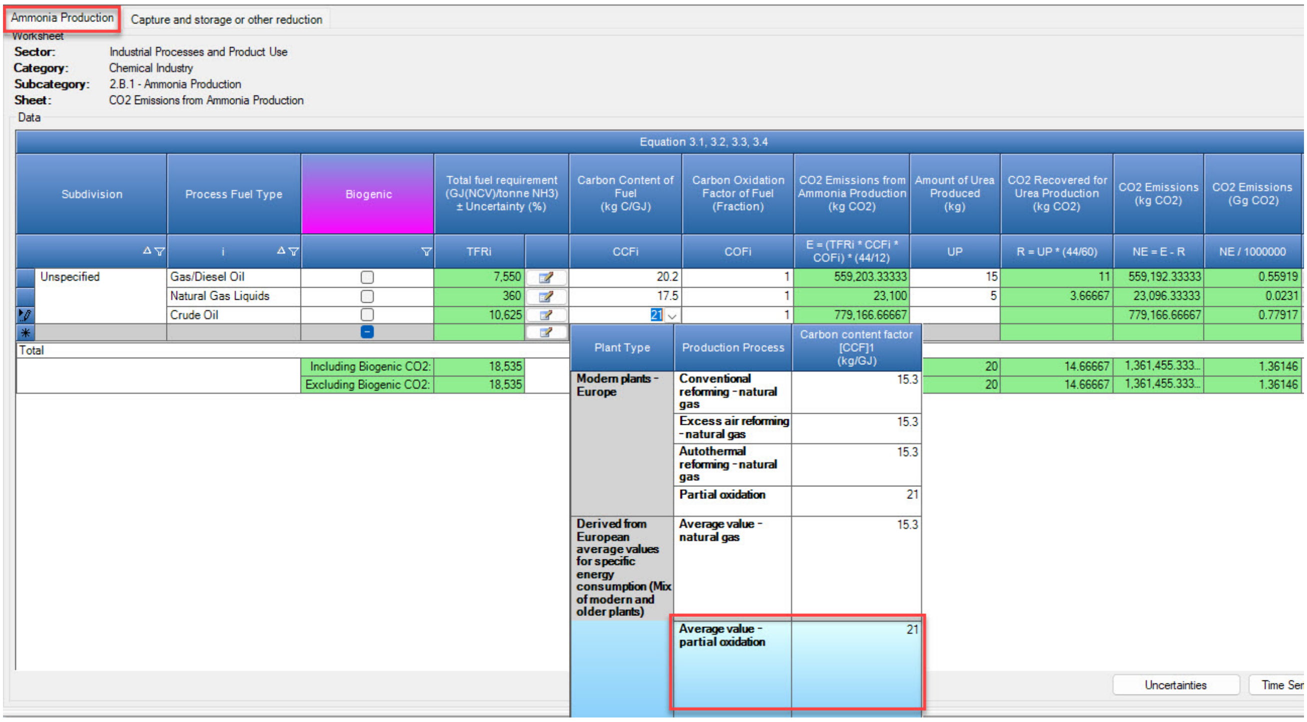
There are two types of EFs/parameters, with IPCC default values included in Table 3.1:

- ✓ Carbon content of fuel, in kgC/GJ of fuel
- ✓ Oxidation fraction of fuel, fraction

For each combination of subdivision/process fuel type/production process in worksheet **Ammonia Production,** enter information, row by row, as follows:

1. Column |CCFi|: the default carbon content of fuel from the **1.1.1 Fuel Manager** is automatically populated based on the process fuel selected in Column |i|. The user may overwrite this value with user-specific information, in kgC/GJ.
   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 – select highest value**



Ammonia Production | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.1 - Ammonia Production
Sheet: CO2 Emissions from Ammonia Production

Data

Equation 3.1, 3.2, 3.3, 3.4

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/Diesel Oil	☐	7,550	20.2	1	559,203.33333	15	11	559,192.33333	0.55919
	Natural Gas Liquids	☐	360	17.5	1	23,100	5	3.66667	23,096.33333	0.0231
	Crude Oil	☐	10,625	21	1	779,166.66667			779,166.66667	0.77917
Total										
		Including Biogenic CO2:	18,535				20	14.66667	1,361,455.333...	1.36146
		Excluding Biogenic CO2:	18,535				20	14.66667	1,361,455.333...	1.36146

Plant Type	Production Process	Carbon content factor [CCF]1 (kg/GJ)
Modern plants - Europe	**Conventional reforming - natural gas**	15.3
	Excess air reforming - natural gas	15.3
	Autothermal reforming - natural gas	15.3
	Partial oxidation	21
Derived from European average values for specific energy consumption (Mix of modern and older plants)	**Average value - natural gas**	15.3
	Average value - partial oxidation	21

Uncertainties | Time Ser

Results

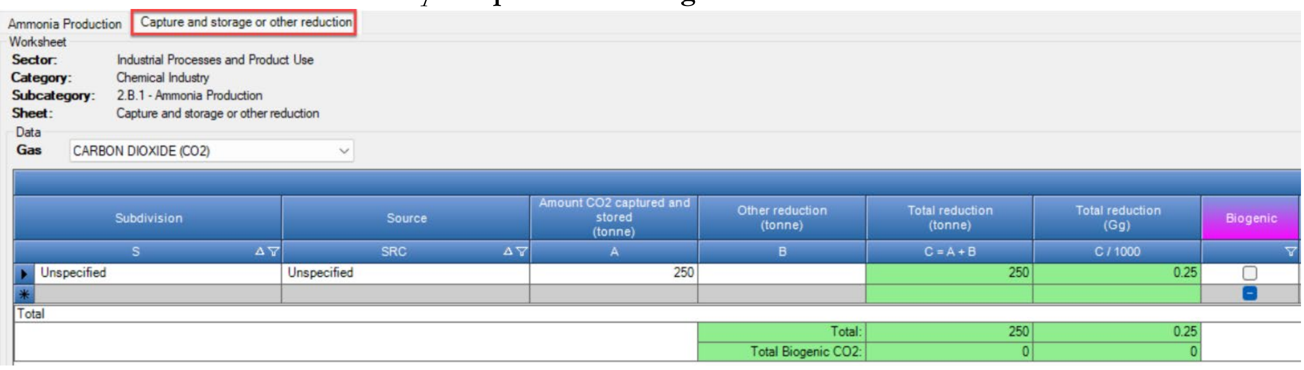
CO_2 emissions from Ammonia Production are estimated in mass units (kg and Gg) by the *Software* in the worksheet **Ammonia Production** for Tier 1, Tier 2 and Tier 3.

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|: 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 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**



Ammonia Production | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.1 - Ammonia 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)	Biogenic
S	SRC	A	B	C = A + B	C / 1000	
Unspecified	Unspecified	250		250	0.25	☐
Total						
			Total:	250	0.25	
			Total Biogenic CO2:	0	0	

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

Information

This section groups guidance for the following source categories owing 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**

Section 3.3, 3.4 and 3.5 of 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 IPCC default EFs. 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 *(Adipic Acid, Caprolactam, Glyoxal and Glyoxylic Acid Production)*		X				

The *2006 IPCC Guidelines* do not contain methods for estimating CO_2 emissions from adipic acid production or caprolactam, glyoxal and glyoxylic acid production, 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.

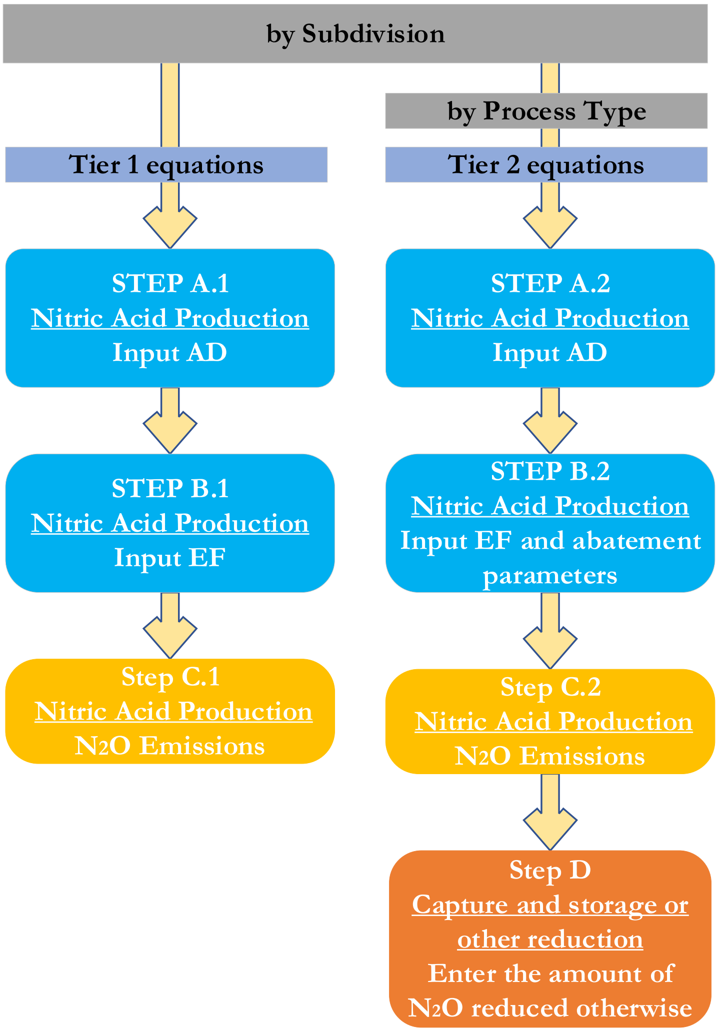
User's Work Flowchart

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:

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).

[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 the Tier 1 Equation is applied:

Step A.1, in worksheet [**Nitric Acid][Adipic Acid][Caprolactam, Glyoxal and Glyoxylic Acid] Production,** users collect and input in the *Software* information on the total amount of product 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][Adipic Acid][Caprolactam, Glyoxal and Glyoxylic Acid] Production,** users input the associated N_2O EF (N_2O emissions/ tonne of product produced).
*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][Adipic Acid][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 worksheet [**Nitric Acid][Adipic Acid][Caprolactam, Glyoxal and Glyoxylic Acid] Production,** users collect and input plant-level information 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][Adipic Acid][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][Adipic Acid][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**.

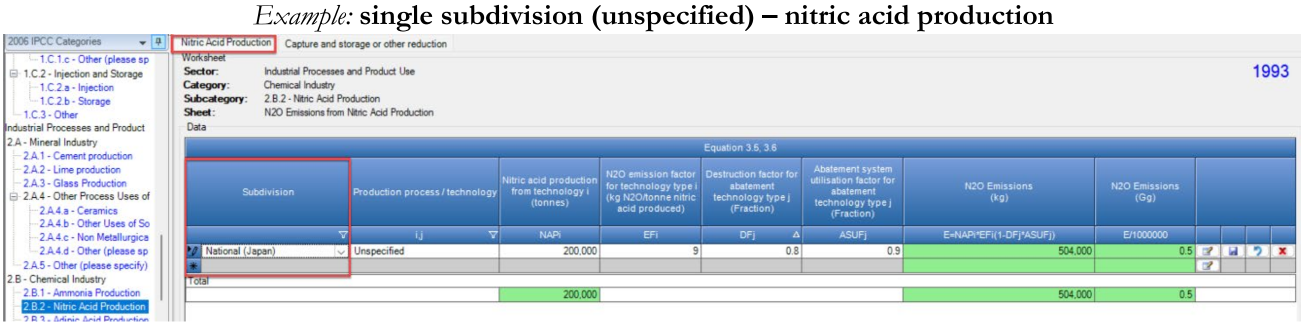
Activity Data Input

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

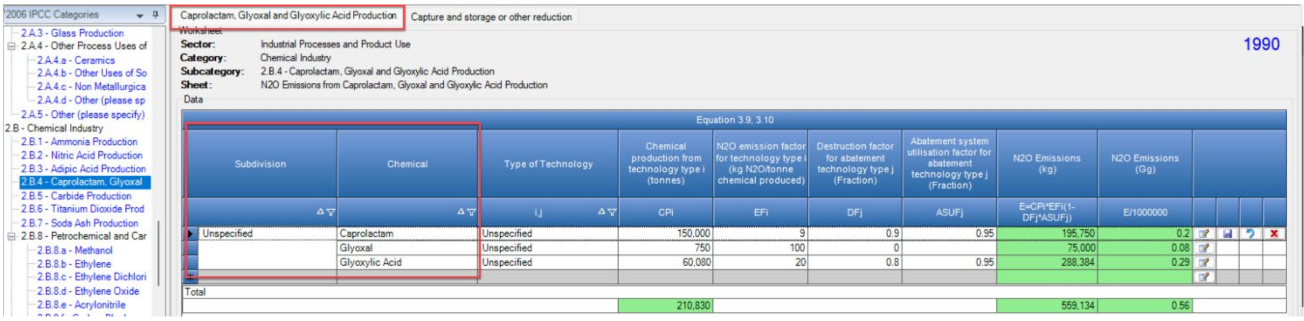
- ✓ Section 3.3.2.3 contains information on the choice of AD for Nitric Acid Production.
- ✓ Section 3.4.2.3 contains information on the choice of AD for Adipic Acid Production.
- ✓ Section 3.5.2.1 contains information on the choice of AD for Caprolactam Production. *Note that, although the 2006 IPCC 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

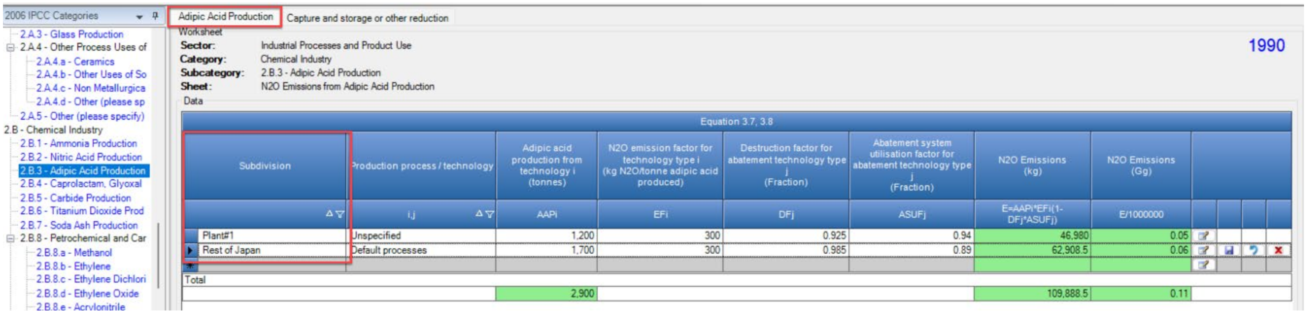
Example: **single subdivision (unspecified) – nitric acid production**



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



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



For each subdivision in Column |Subdivision|, data are entered in worksheet [**Nitric Acid][Adipic Acid][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|(nitric acid)/Column |AAPi|(adipic acid)/Column |CPi|(caprolactam, glyoxal and glyoxylic acid): input the mass of product produced, by subdivision/chemical (if applicable)/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

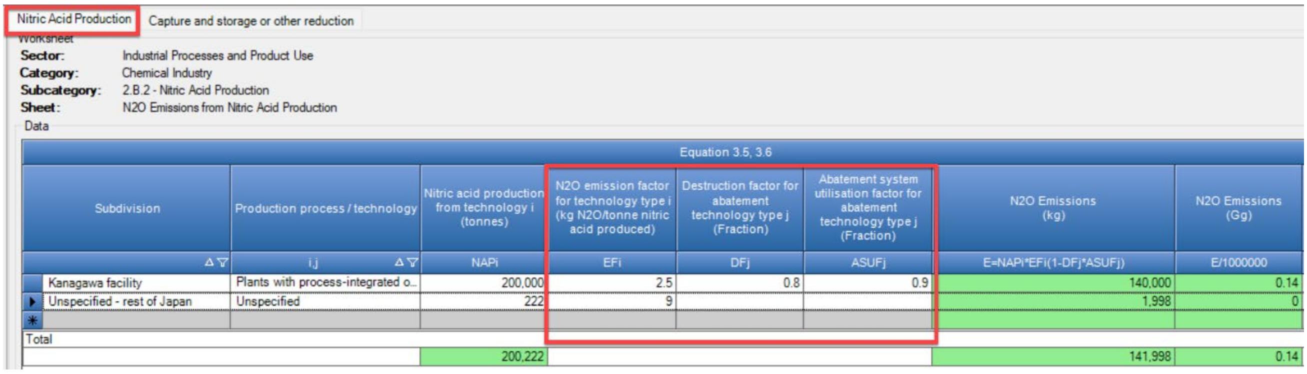
There are three types of EFs/parameters for all three source categories in the *2006 IPCC Guidelines*:

- ✓ N_2O emissions/ tonne of product produced.
- ✓ destruction factor for abatement technology, fraction.
- ✓ abatement system utilisation factor for abatement technology, fraction.

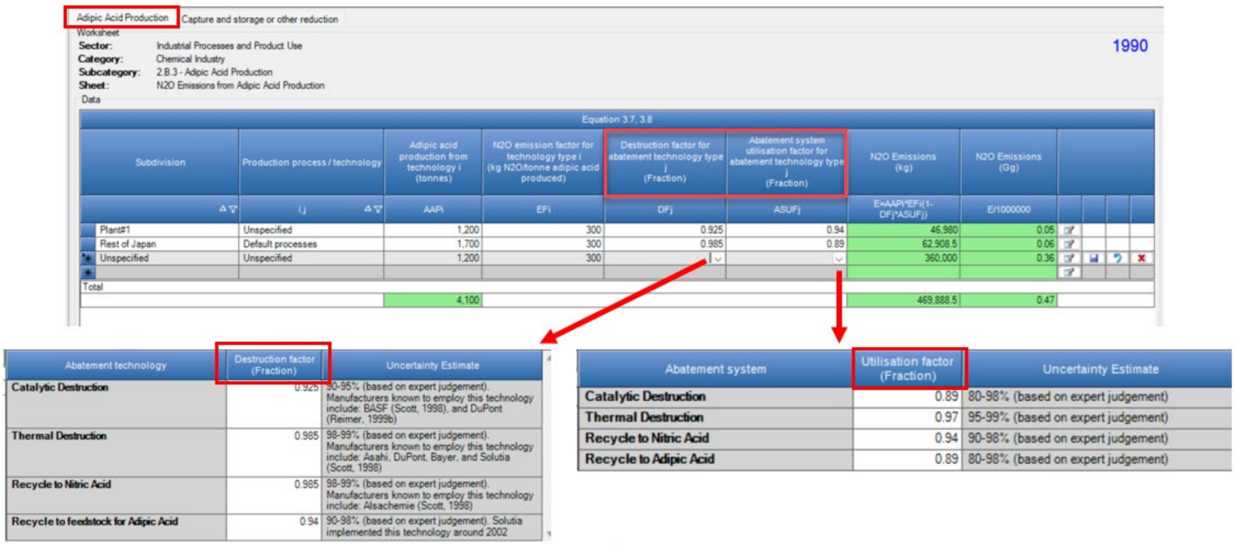
Then, for each combination of subdivision/ production process /technology/chemical (if applicable) in worksheet [**Nitric Acid**][**Adipic Acid**][**Caprolactam, Glyoxal and Glyoxylic Acid**] **Production**

1. Column |EFi|: select from the drop-down menu the default N_2O EF or overwrite this value with user-specific information, in kg N_2O/tonne product produced.
   *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, for users applying a Tier 1 method, DFi shall be 0.
   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.
   Note that, for users applying a Tier 1 method, ASUFi shall be 0.

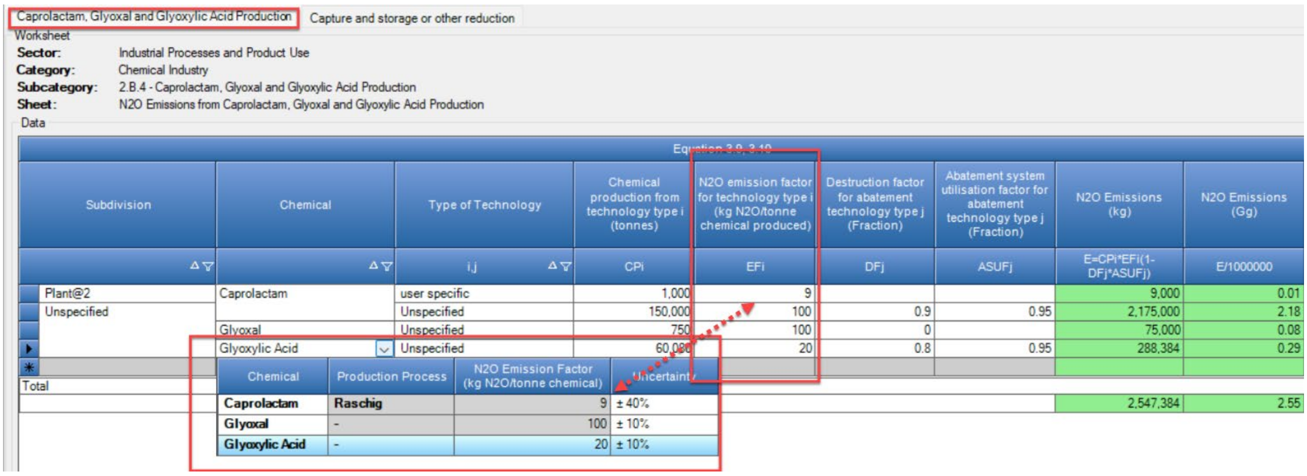
Example: **Tier 1 and 2 EFs for nitric acid production**



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



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][Adipic Acid][Caprolactam, Glyoxal and Glyoxylic Acid]:**

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|: select from the drop-down menu, 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 |A|: this column is not applicable for this category.
3. Column |B|: 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.

Section 3.6 in 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 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. 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.

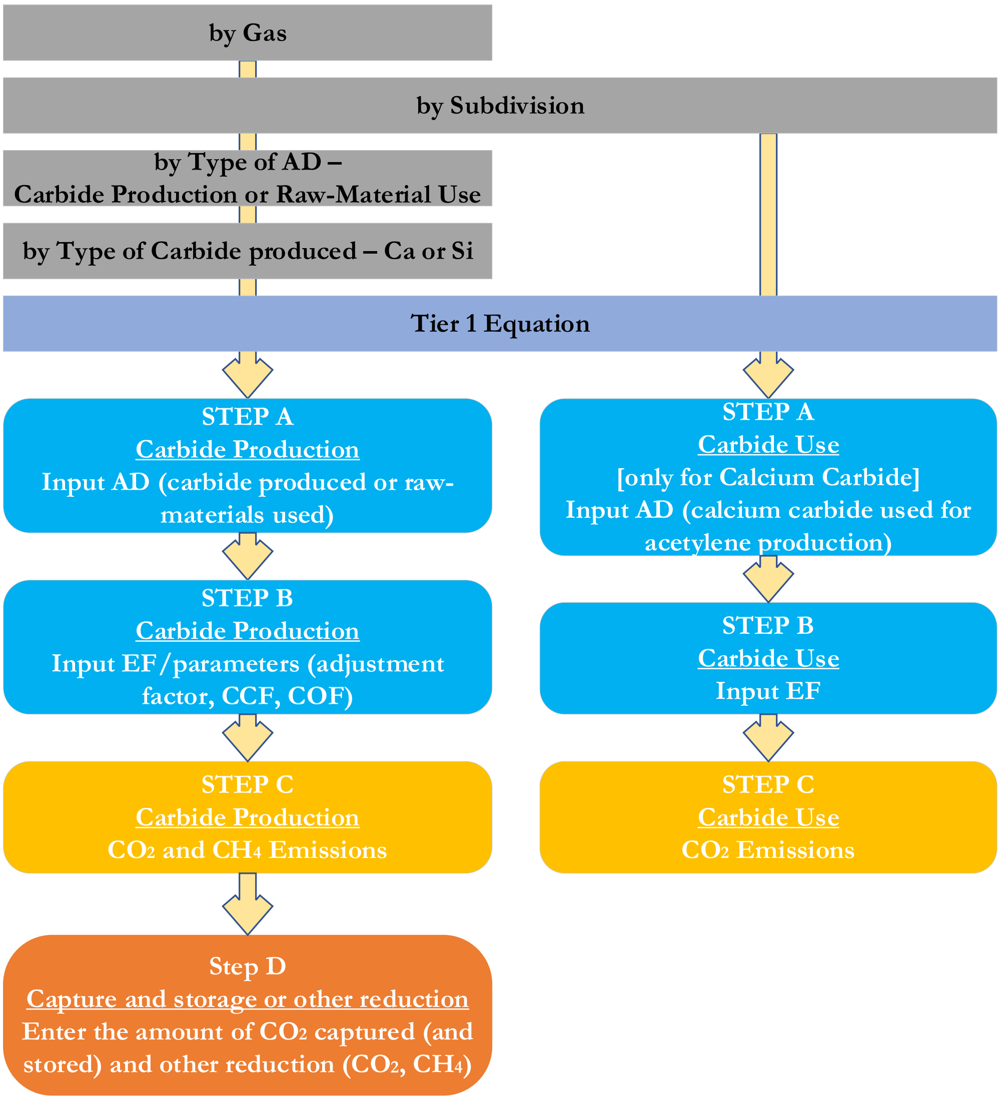
User's Work Flowchart

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

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

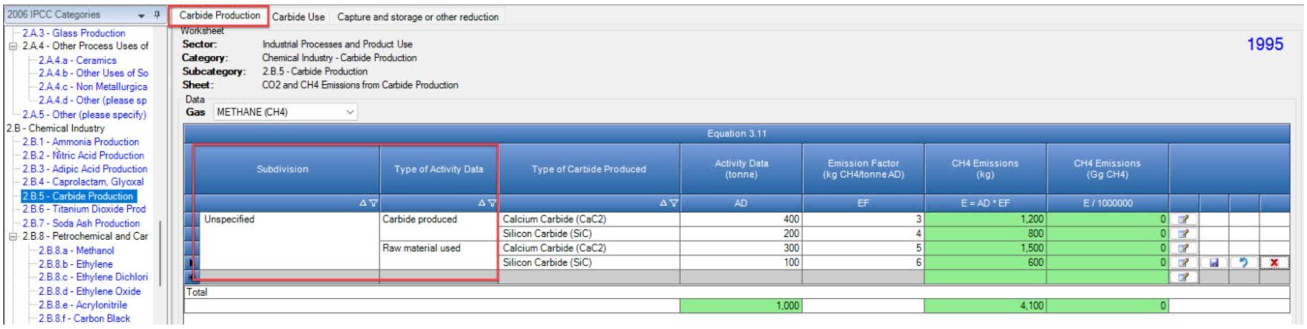
Step C, in worksheet **Carbide Use,** the *Software* calculates the associated emissions for each subdivision for CaC_2 in mass units (tonne and Gg).

Activity Data Input

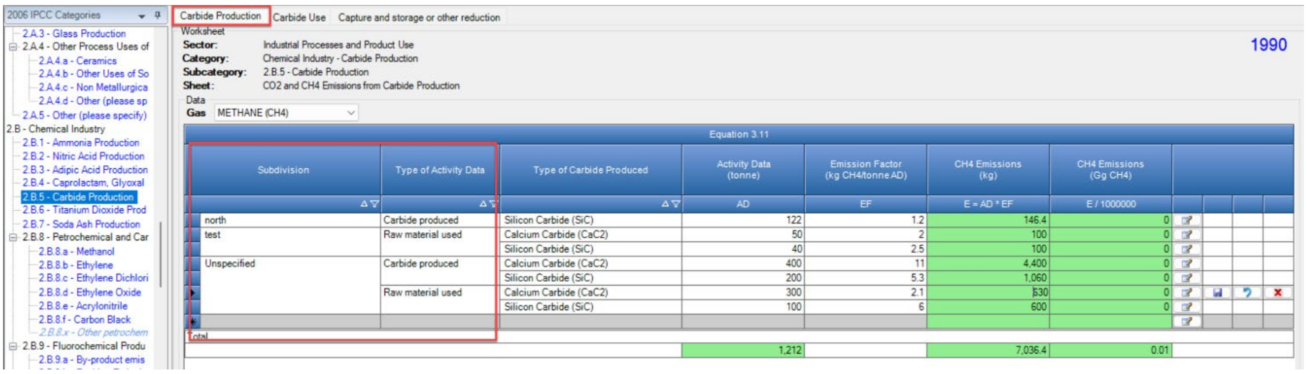
Section 3.6.2.3 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Carbide Production.

Input of AD for Carbide Production 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



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 |Biogenic|: indicate with a check, if known, if the process fuel is of biogenic origin.
3. 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.

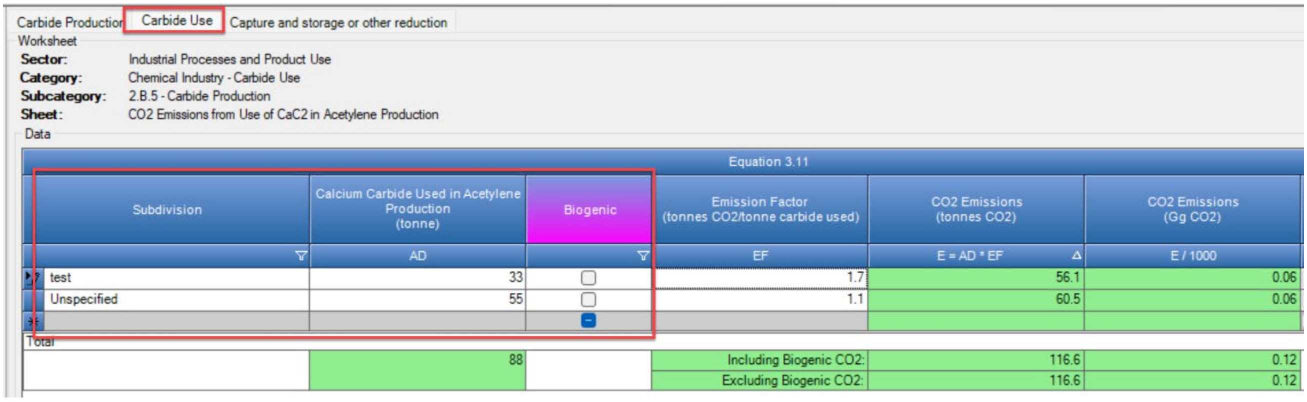
Note that users must enter a unique combination of subdivision/type of activity data/type of carbide produced. If the same combination is entered twice, an error will pop-up asking the user to re-enter a unique combination by changing either the subdivision or type of carbide produced.
Note that for users reporting to the UNFCCC ETF Reporting Tool that report carbide production other than SiC and CaC_2, AD emissions from this other carbide production will be reported under CRT category 2.B.10.b Other (chemical production).

4. 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.

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 used to produce the CaC_2 was 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:

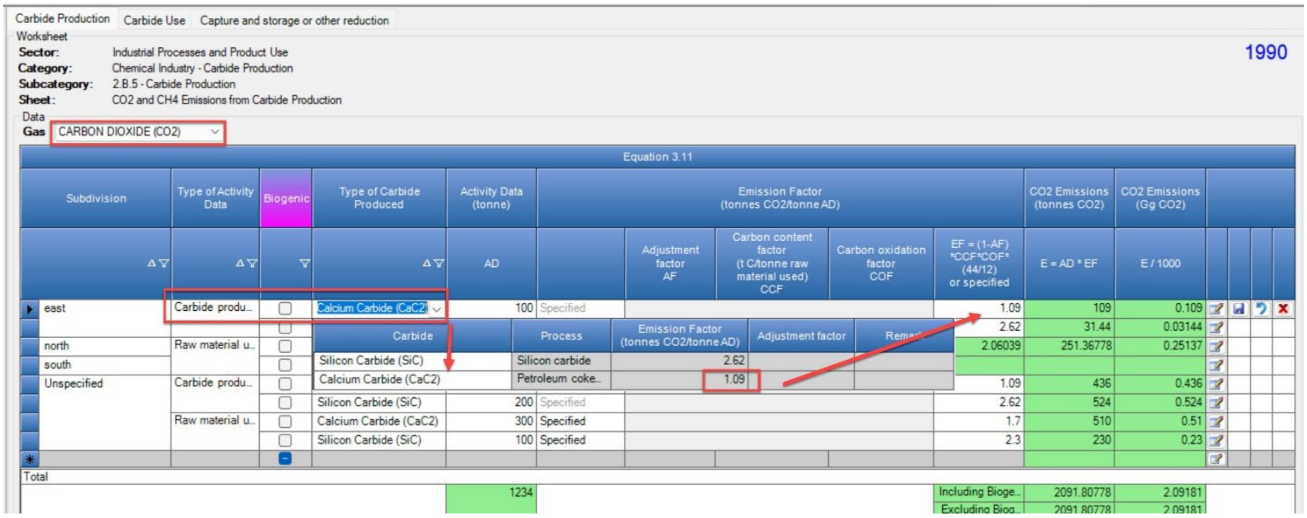
- ✓ CO_2 and CH_4 EFs based on carbide production AD - in tonnes of CO_2 and kg of CH_4 per tonne of carbide produced (Tables 3.7 and 3.8).
- ✓ CO_2 and CH_4 EFs based on raw materials consumption (petroleum coke) - in tonne of CO_2 and kg of CH_4 per tonne of petroleum coke (Tables 3.7 and 3.8)
- ✓ CO_2 EF for CaC_2 used in acetylene production in tonne of CO_2 per tonne of CaC_2 used (Table 3.8).

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 (e.g. 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.

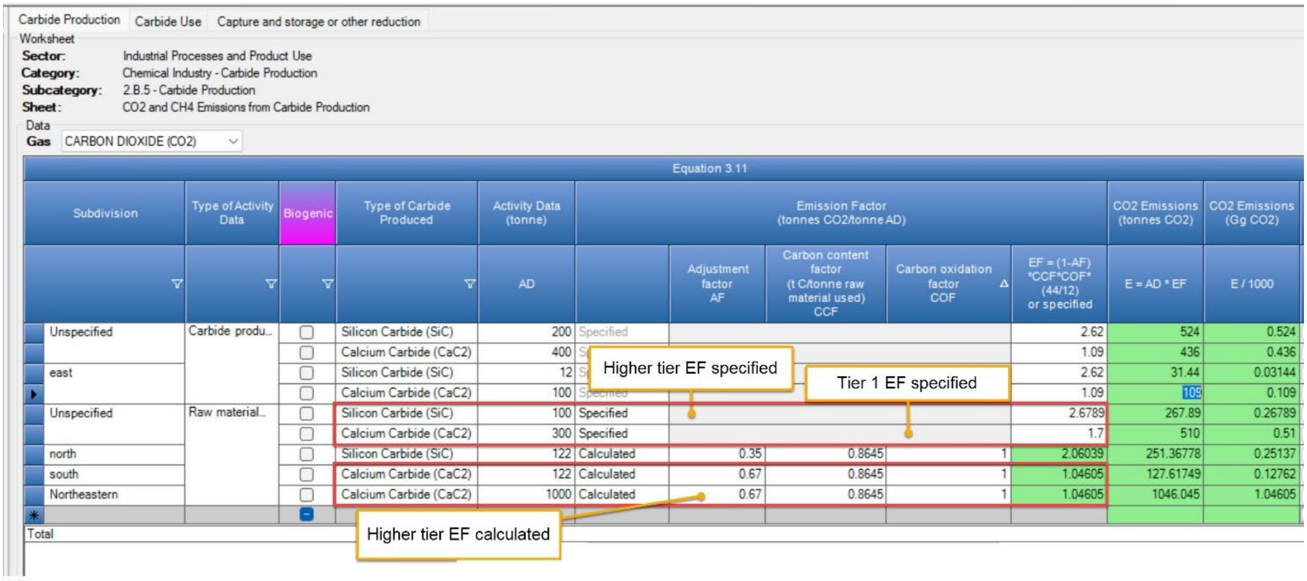
   i. If *Specified* (use for Tier 1 or for insertion of the results of a user-specific method (see section **1.1.3 Use of Multiple Tiers for Reporting**)

   3. <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, in t C/tonne raw material used.
   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

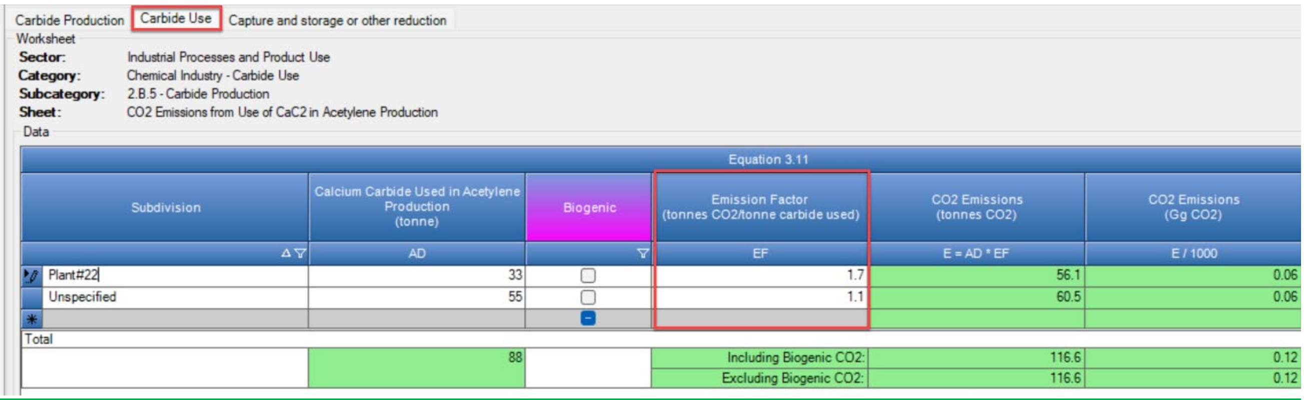
Subdivision	Type of Activity Data	Biogenic	Type of Carbide Produced	Activity Data (tonne)	Emission Factor (tonnes CO2/tonne AD)					CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
				AD		Adjustment factor AF	Carbon content factor (t C/tonne raw material used) CCF	Carbon oxidation factor COF	EF = (1-AF) *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	S				1.09	436	0.436
east		☐	Silicon Carbide (SiC)	12	S				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											

CO₂ EF for CaC₂ used in acetylene production

To calculate CO^2 emissions from the use of CaC_2 in acetylene production, for each subdivision, in worksheet **Carbide Use,** input information, row by row, as follows :

1. Column |EF|: 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 (Tier 1, Tier 2 and Tier 3) are estimated in mass units (tonnes and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets:

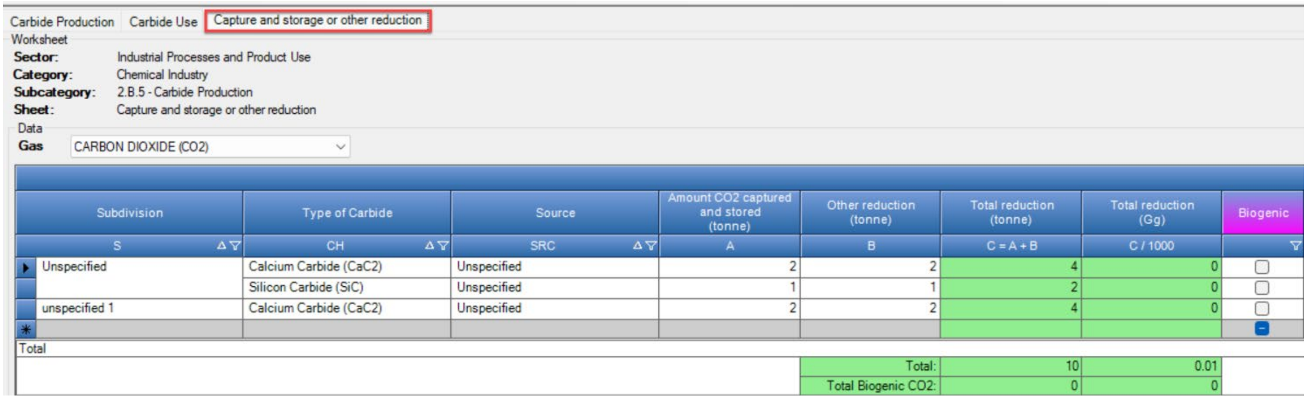
- ✓ **Carbide Production**
- ✓ **Carbide Use**

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|: select from the drop-down menu, 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 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.

Section 3.7 in 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.

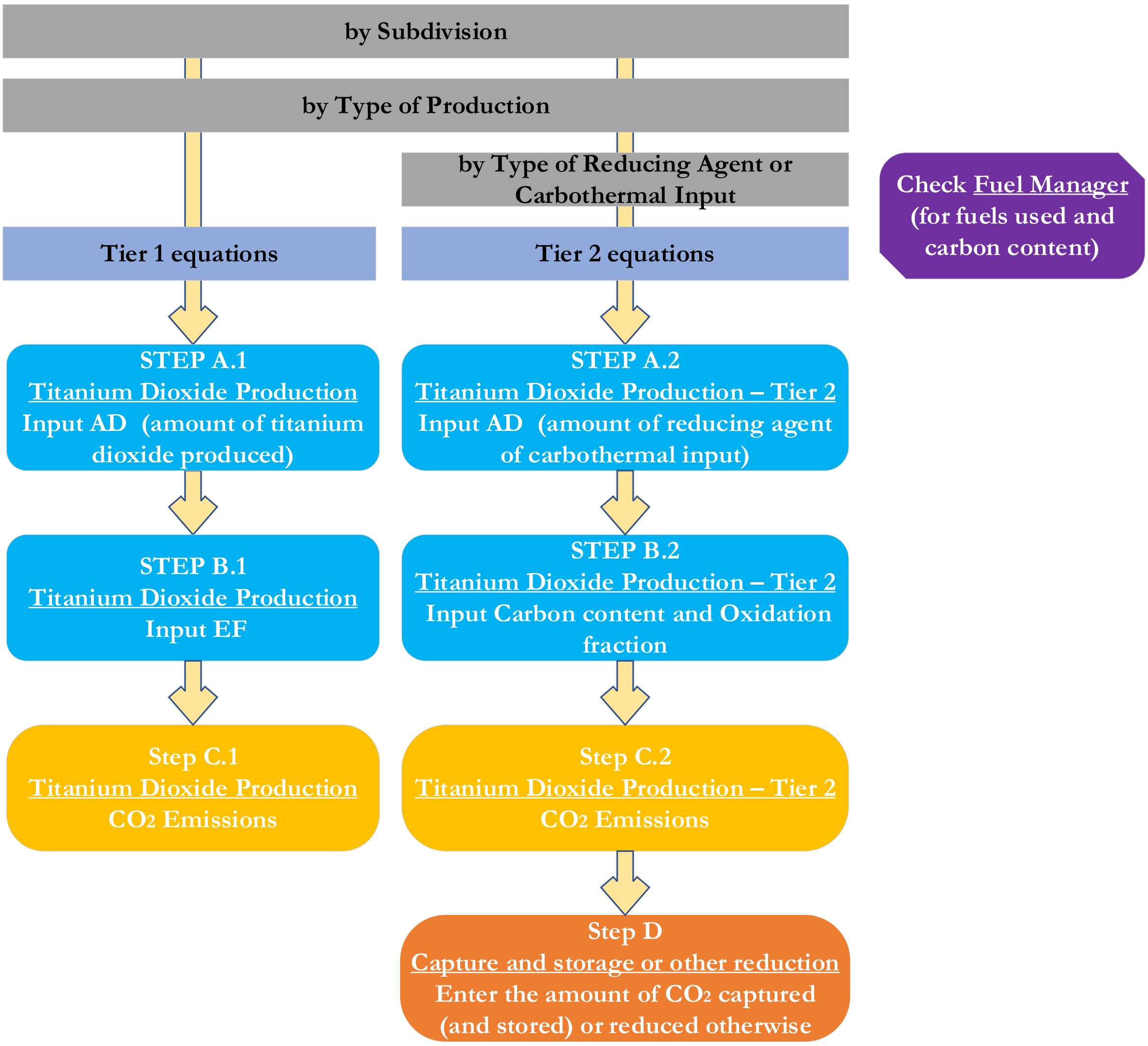
User's Work Flowchart

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.

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 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 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 worksheet **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.

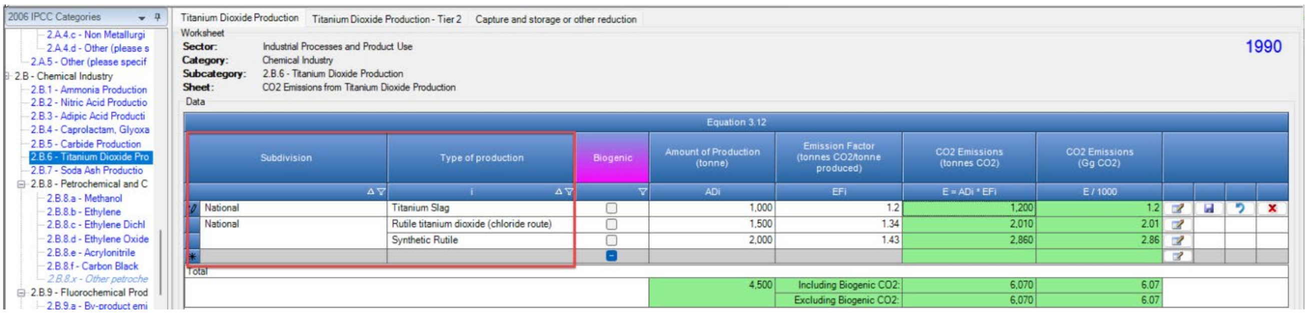
Activity Data Input

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.

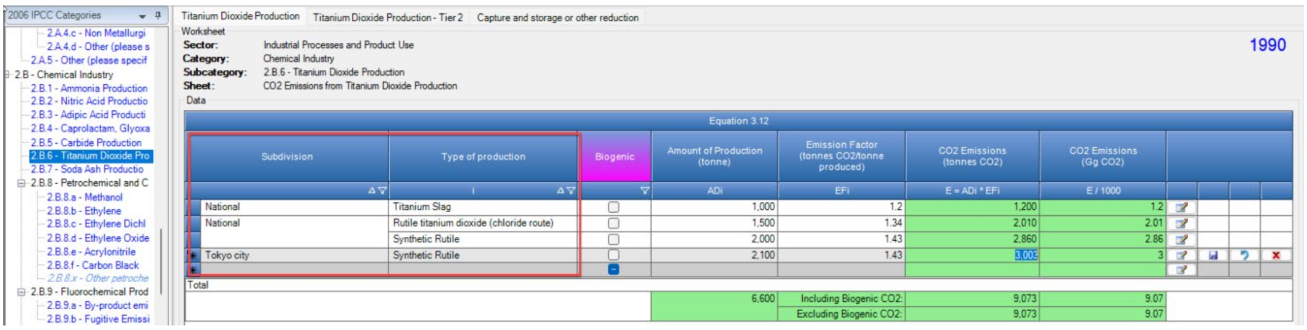
As a **starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for titanium dioxide production (Tier 2 only); and for each fuel listed in the Fuel Manager, the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the drop-down menu.

Second, input of AD for Titanium Dioxide Production 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

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



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 known, 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 produced 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 reducing agent/carbothermal input 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**

Titanium Dioxide Production | Titanium Dioxide Production - Tier 2 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.6 - Titanium Dioxide Production
Sheet: CO2 Emissions from Titanium Dioxide Production - Tier 2
Data

				Equation 3.13				
Name of plant	Plant-specific Type of Production	Fuel Type	Biogenic	Amount of reducing agent or carbothermal input i (GJ)	Carbon content factor of reducing agent or carbothermal input i	Carbon oxidation factor for reducing agent or carbothermal input i	CO2 Emissions (kg)	CO2 Emissions (Gg)
				ADi	CCFi	COFi	E=ADi*CCFi*COFi*(44/12)	E / 1000000
Plant TiO2 #1	Titanium Slag	Gas/Diesel Oil	☐	200	56	0.9	36,960	0.04
Plant TiO2 #2	Rutile TiO2	Petroleum Coke	☐	100	88	0.9	29,040	0.03
Total								
				300		Including Biogenic...	66,000	0.07
						Excluding Biogeni...	66,000	0.07

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:

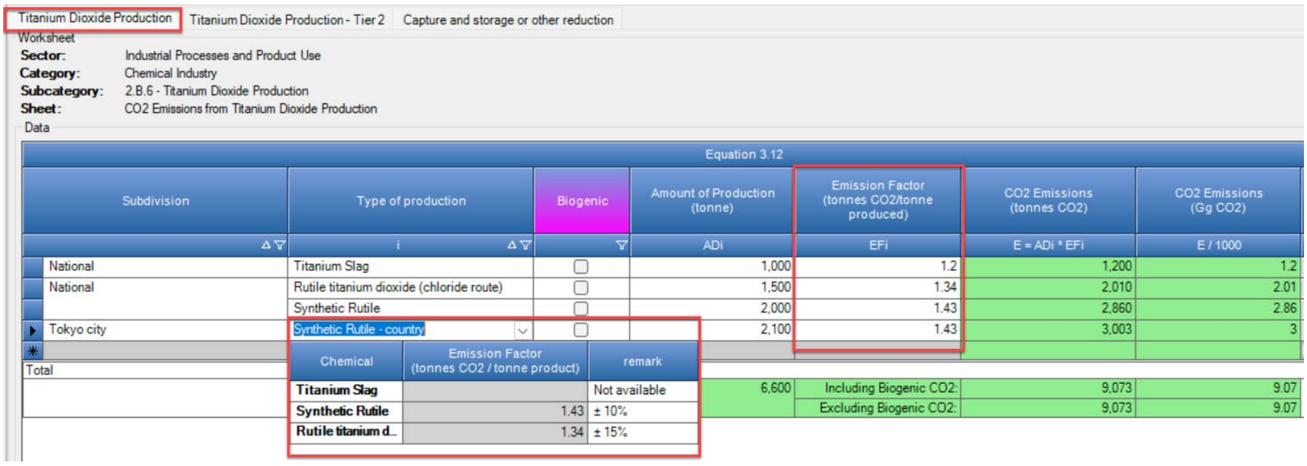
- ✓ Default CO_2 EF for Tier 1 - in tonne of CO_2 per tonne of product produced (Table 3.9).
- ✓ Plant-specific CO_2 EFs for Tier 2 collected by users – the carbon content and carbon oxidation factors for reducing agent or carbothermal input (kg C/GJ and fraction, respectively).

When the Tier 1 Equation is applied:

For each combination of subdivision/type of production in worksheet **Titanium Dioxide Production,** enter information, row by row, as follows:

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

Example: **EFs for titanium dioxide production – Tier 1**


Titanium Dioxide Production | Titanium Dioxide Production - Tier 2 | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.6 - Titanium Dioxide Production
Sheet: CO2 Emissions from Titanium Dioxide Production

Data

Equation 3.12

Subdivision	Type of production	Biogenic	Amount of Production (tonne)	Emission Factor (tonnes CO2/tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	i		ADi	EFi	E = ADi * EFi	E / 1000
National	Titanium Slag	☐	1,000	1.2	1,200	1.2
National	Rutile titanium dioxide (chloride route)	☐	1,500	1.34	2,010	2.01
	Synthetic Rutile	☐	2,000	1.43	2,860	2.86
Tokyo city	Synthetic Rutile - country	☐	2,100	1.43	3,003	3
Total			6,600	Including Biogenic CO2:	9,073	9.07
				Excluding Biogenic CO2:	9,073	9.07

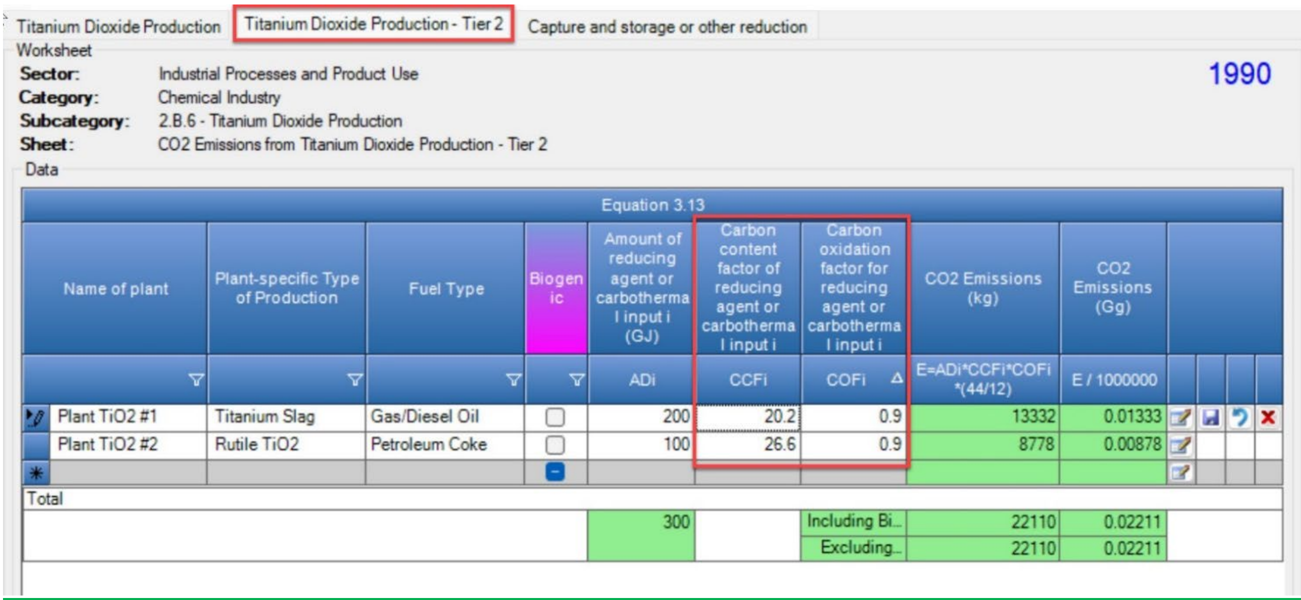
Chemical	Emission Factor (tonnes CO2 / tonne product)	remark
Titanium Slag		Not available
Synthetic Rutile	1.43	± 10%
Rutile titanium d...	1.34	± 15%

When the Tier 2 Equation is applied:

For each combination of subdivisions/individual plant/production process/reducing agent or carbothermal input (i.e. fuel) type, users input the following EFs/parameters, row by row, as follows:

1. <u>Column |CCFi|</u>: the carbon content factor for the corresponding fuel is automatically populated based on the fuel selected, or the user may overwrite with user-specific information, in kg C/GJ. Where a carbothermal input is used that is not in the Fuel Manager and thus Unspecified is selected in <u>Column |Reducing agent/Carbothermal input|</u>, the user must insert a user-specific value for the carbothermal input.
2. <u>Column |COFi|</u>: input the carbon oxidation factor for the reducing agent or carbothermal input, fraction

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


Titanium Dioxide Production | Titanium Dioxide Production - Tier 2 | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry
Subcategory: 2.B.6 - Titanium Dioxide Production
Sheet: CO2 Emissions from Titanium Dioxide Production - Tier 2

1990

Data

Equation 3.13

Name of plant	Plant-specific Type of Production	Fuel Type	Biogenic	Amount of reducing agent or carbothermal input i (GJ)	Carbon content factor of reducing agent or carbothermal input i	Carbon oxidation factor for reducing agent or carbothermal input i	CO2 Emissions (kg)	CO2 Emissions (Gg)
				ADi	CCFi	COFi	E=ADi*CCFi*COFi *(44/12)	E / 1000000
Plant TiO2 #1	Titanium Slag	Gas/Diesel Oil	☐	200	20.2	0.9	13332	0.01333
Plant TiO2 #2	Rutile TiO2	Petroleum Coke	☐	100	26.6	0.9	8778	0.00878
Total				300		Including Bi...	22110	0.02211
						Excluding...	22110	0.02211

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:

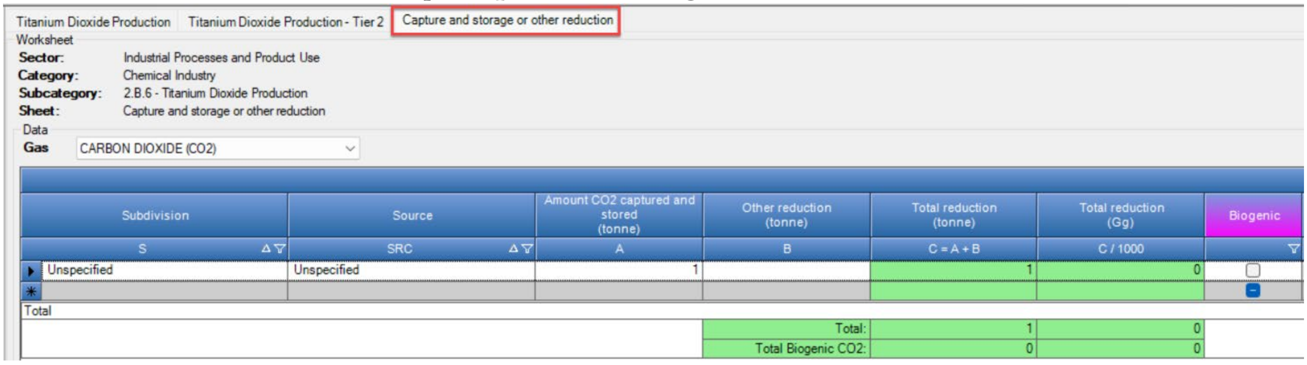
- ✓ **Titanium Dioxide Production**
- ✓ **Titanium Dioxide Production – Tier 2**

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|: select from the drop-down menu, 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 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.

Section 3.8 in 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.

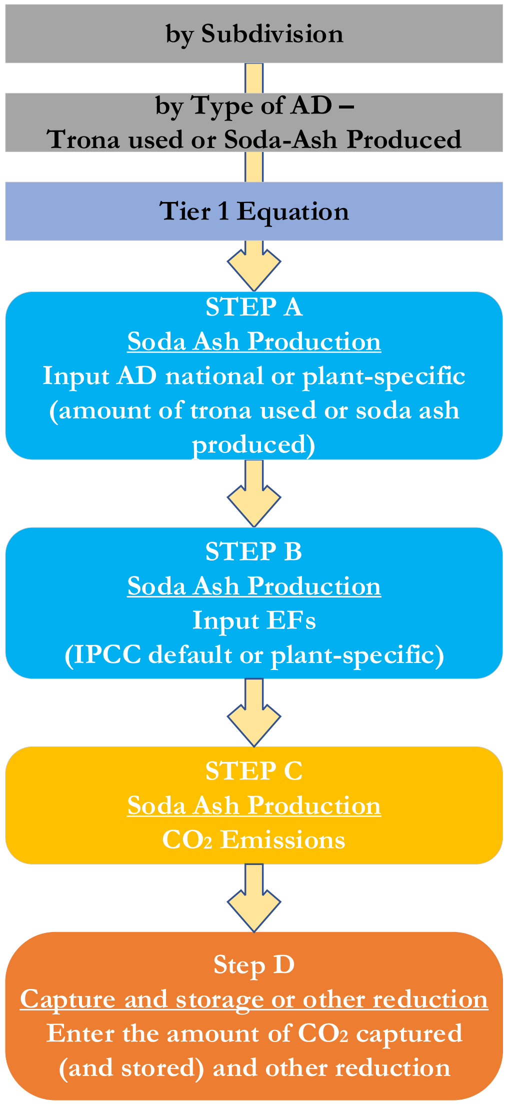
User's work Flowchart

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

Step C, in 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

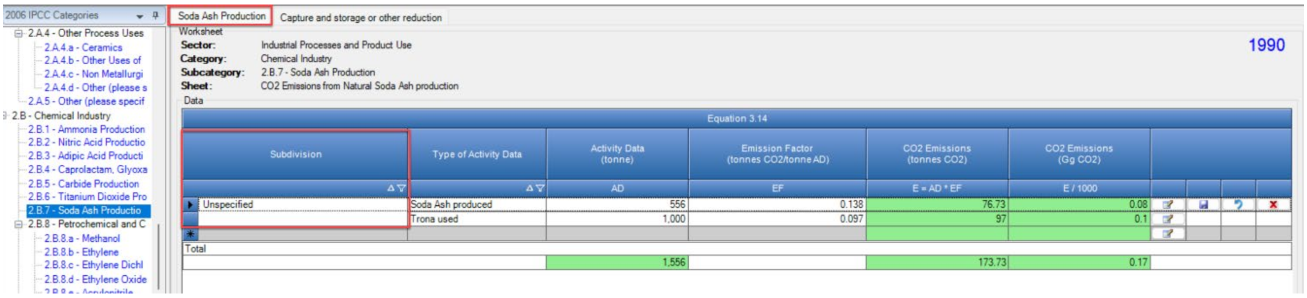
Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2.

Activity Data Input

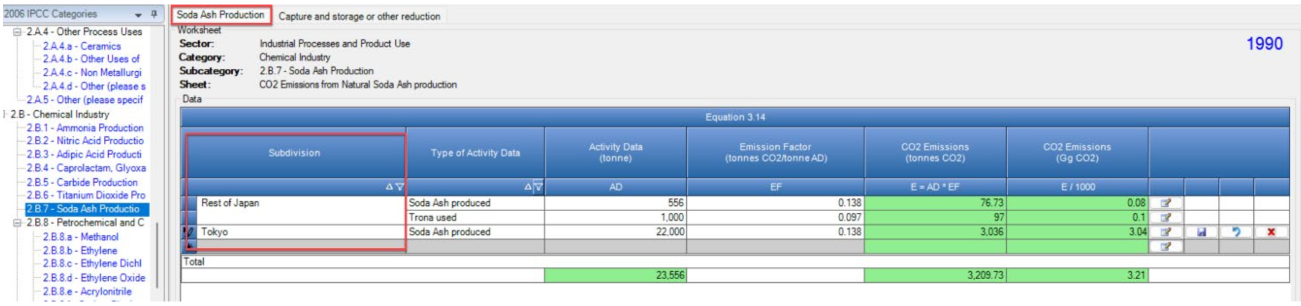
Section 3.8.2.1 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Soda Ash Production.

Input of AD for Soda Ash Production 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



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, based on either 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

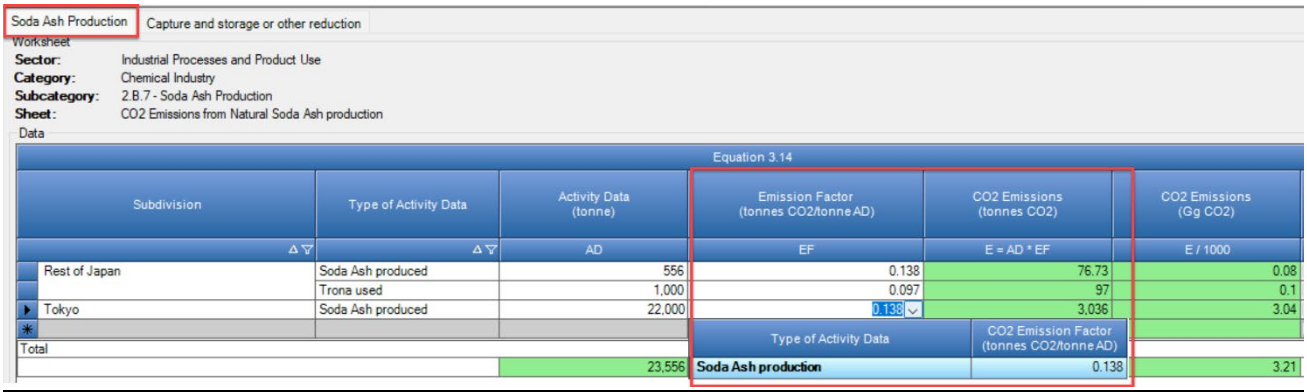
Section 3.8.2.1 in Chapter 3 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Soda Ash Production.

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|: select from the down-down menu 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

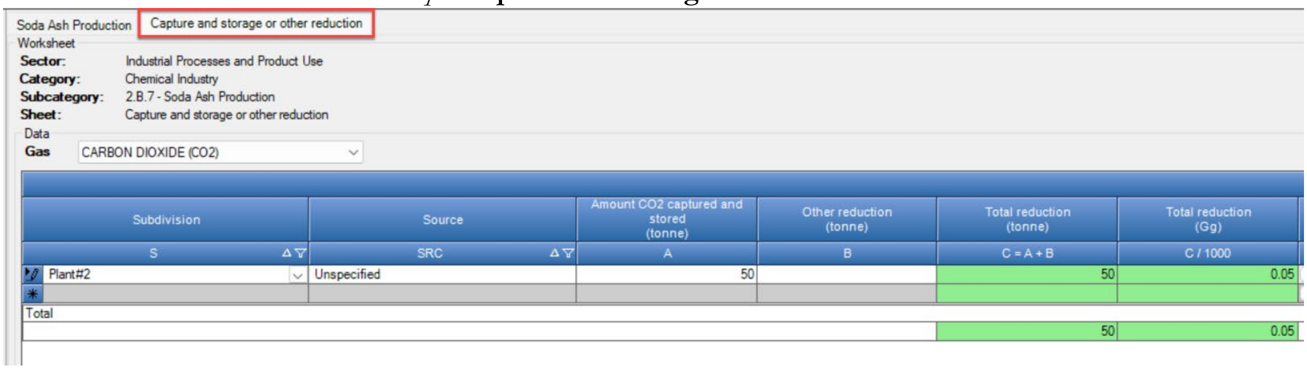
CO_2 emissions from Soda Ash Production are estimated in mass units (tonne and Gg) by the *Software* in the worksheet **Soda Ash Production.**

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|: select from the drop-down menu, 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| collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 other petrochemical processes that emit smaller 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.

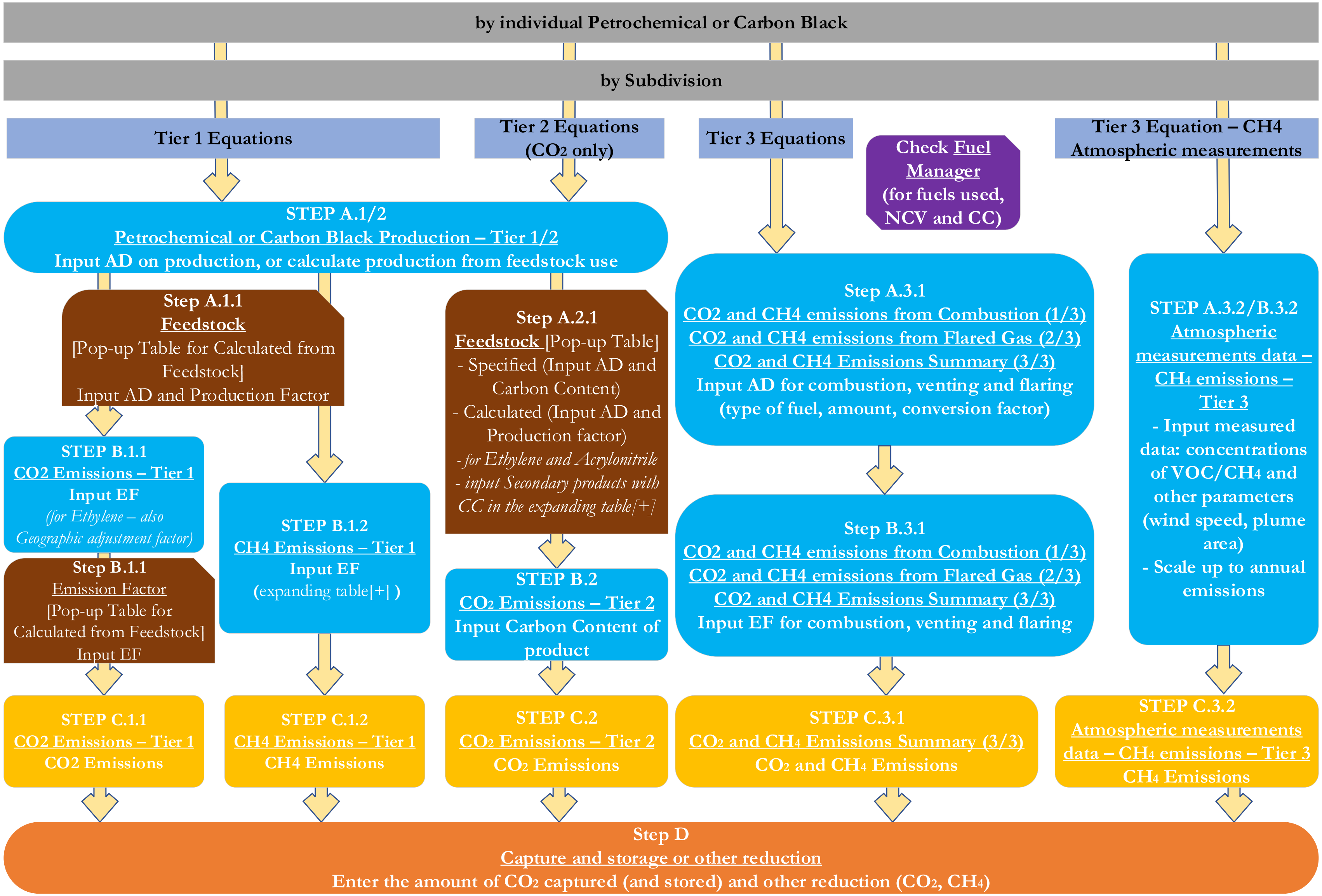
To ease the use of the *Software* as well as to avoid its misuse, for the Petrochemical and Carbon Black Production source category, users follow the following two flowcharts for CO_2 and CH_4 emissions. As the emissions from petrochemical and carbon black production vary both with the process used and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

Prior to following the flowchart below, 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** data for 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 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 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 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 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 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 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 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 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 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.

For the Atmospheric Measurement Approach

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.

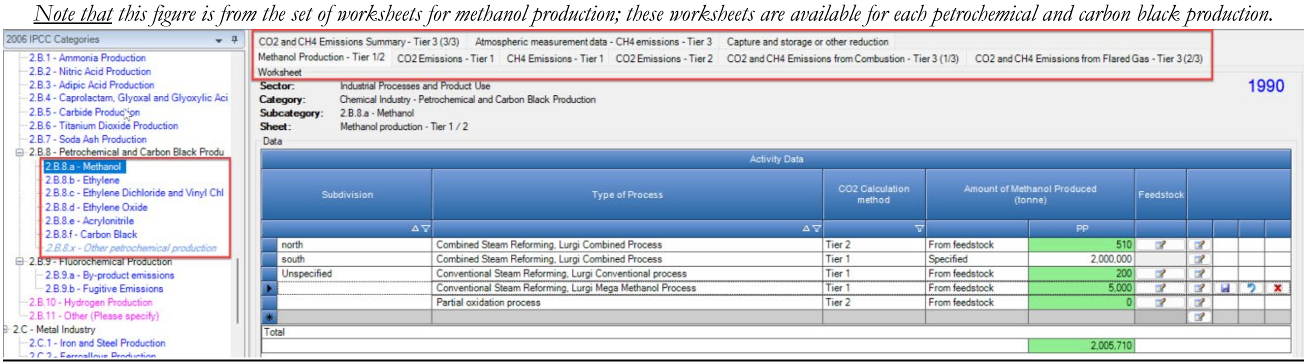
Activity Data Input

Section 3.9.2.3 in 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 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**

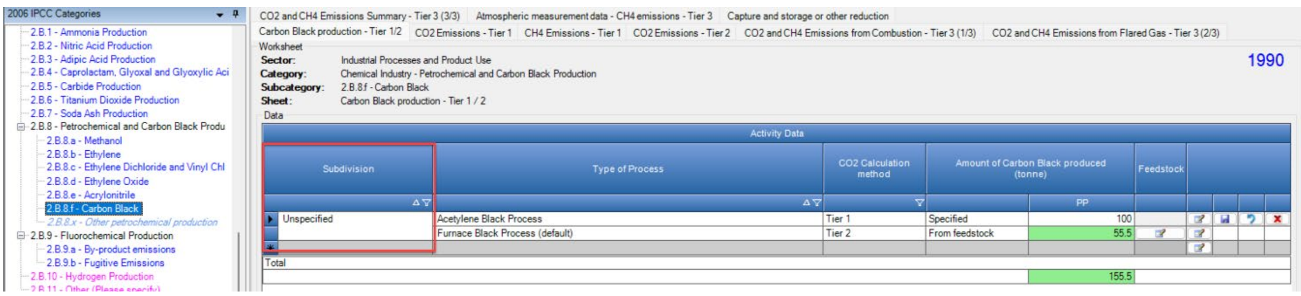
Note that this figure is from the set of worksheets for methanol production; these worksheets are available for each petrochemical and carbon black production.



Input of AD for the subcategories of Petrochemical and Carbon Black Production 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

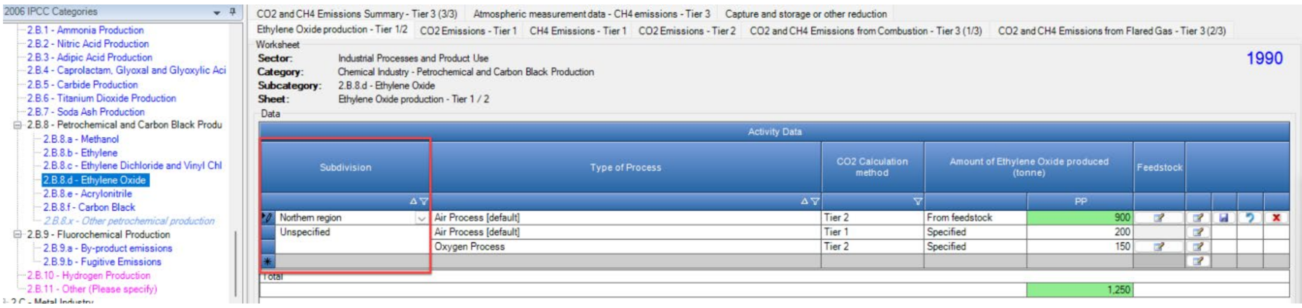
Example: **single subdivision (unspecified)**

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



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



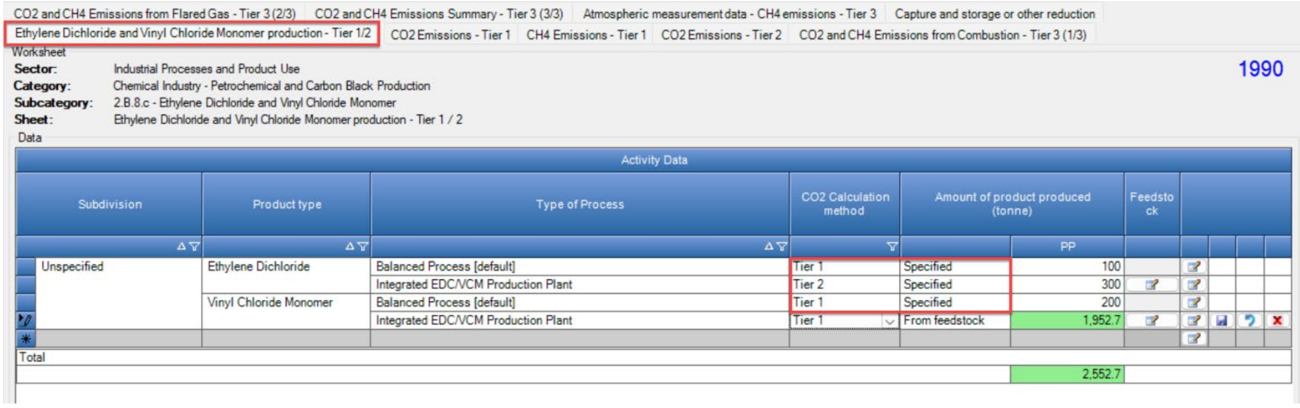
When the Tier 1 and Tier 2 Equations are applied:

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 production of ethylene dichloride (EDC) or vinyl chloride monomer (VCM).
   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. input directly) or *calculated* from the feedstock used (Tier 1 and Tier 2). For AD entry, the following column headers are applicable when either Tier 1or Tier 2 methods are implemented:
   a. If *specified*, the user inputs manually the amount of the chemical produced in Column |PP|.
   b. If *from feedstock* –the user inputs in a sub-table (accessed by clicking on the icon in Column |Feedstock|, row by row, the following:
      i. Column |Type of Feedstock| Select the type of feedstock from the drop-down menu or input 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.
      ii. Column |Biogenic| indicate with a check, if known, 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.*
      iii. Column |FA| enter the amount of feedstock consumed, in tonnes.
      iv. 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.
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 4 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.

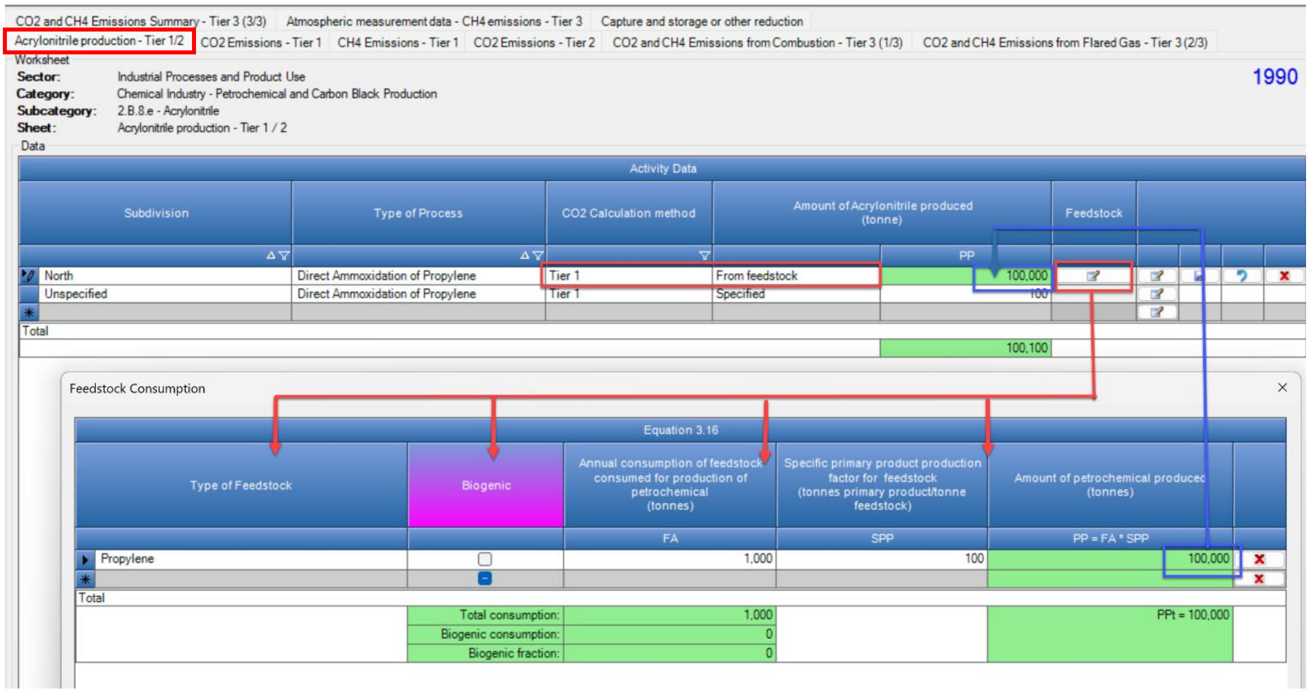
Example: **AD input Tier 1 and Tier 2–chemical produced is <u>specified</u> directly in <u>|Column PP|</u>**

<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.



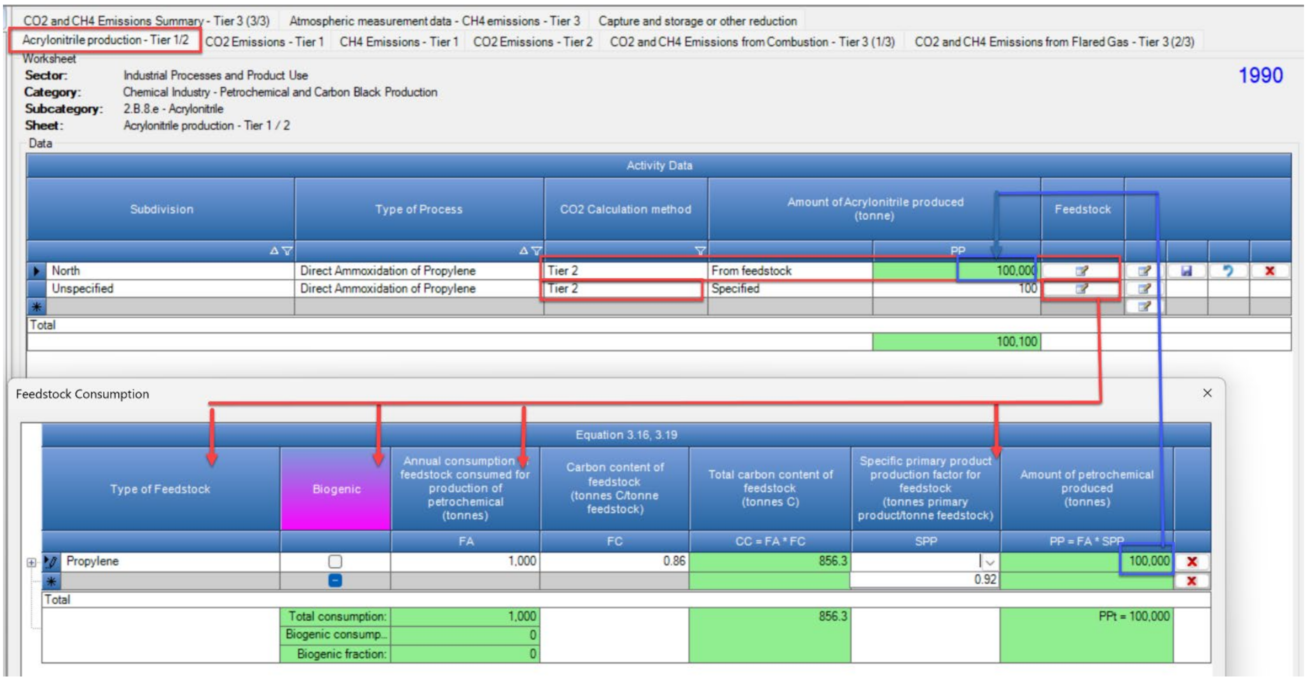
Example: **AD input Tier 1 –chemical produced calculated <u>from feedstock</u>**

<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.



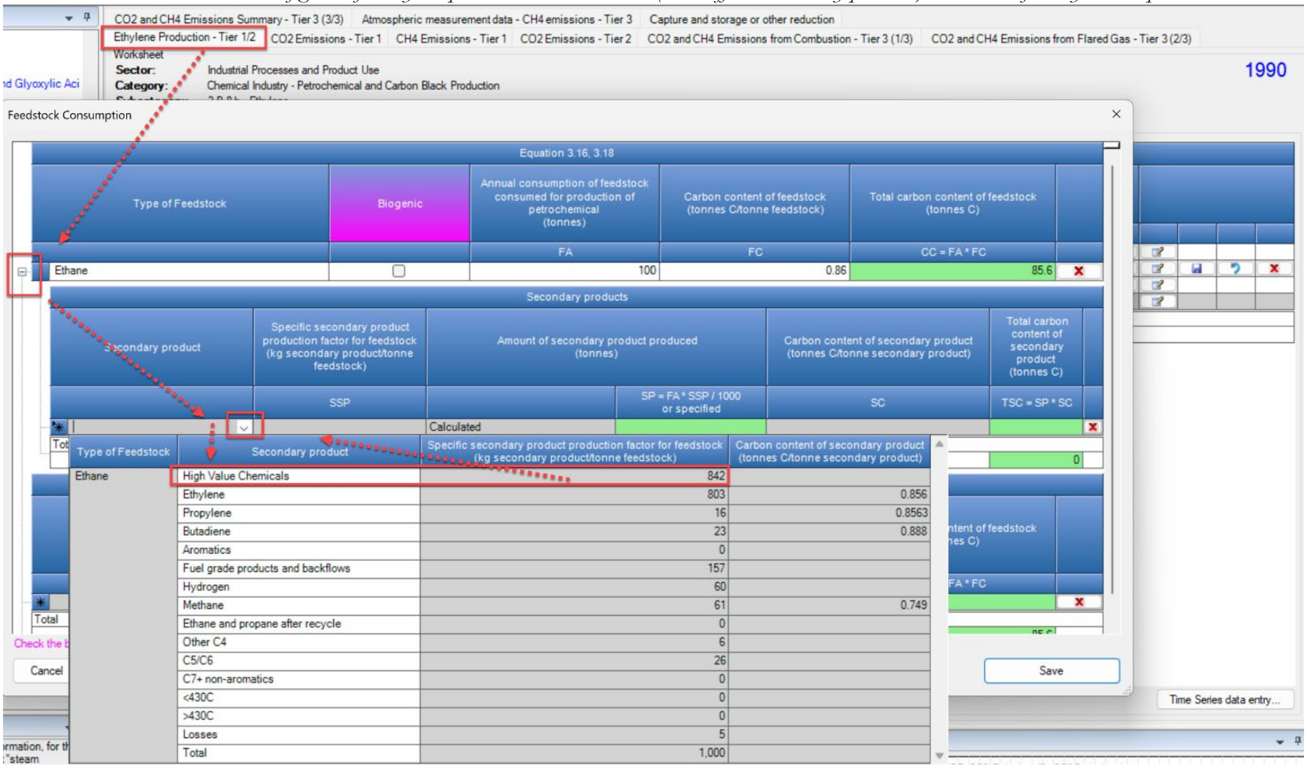
For the subcategories Ethylene Production (2.B.8.b) and Acrylonitrile Production (2.B.8.e) only:

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:

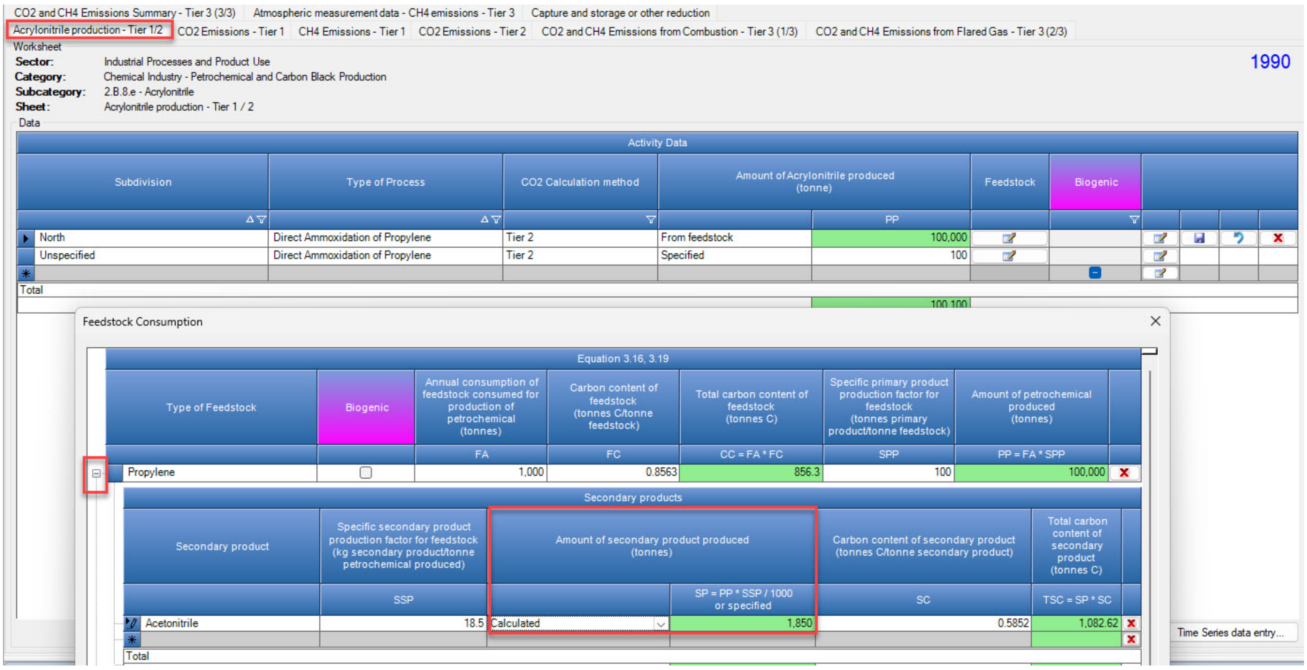
1. For each type of feedstock in the feedstock sub-table, click the symbol "⊞" on the left of the row to open a drop-down table where information on the secondary products are to be compiled. Then:
2. <u>Column |Secondary Product|</u>: select from the drop-down menu each secondary produced from the primary 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 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 grayed 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**

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



Example: **calculation of amount of secondary product produced – ethylene and acrylonitrile production only**



For the subcategory Other Petrochemical Production (2.B.8.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. <u>Column |Petrochemical type|</u>: 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 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.

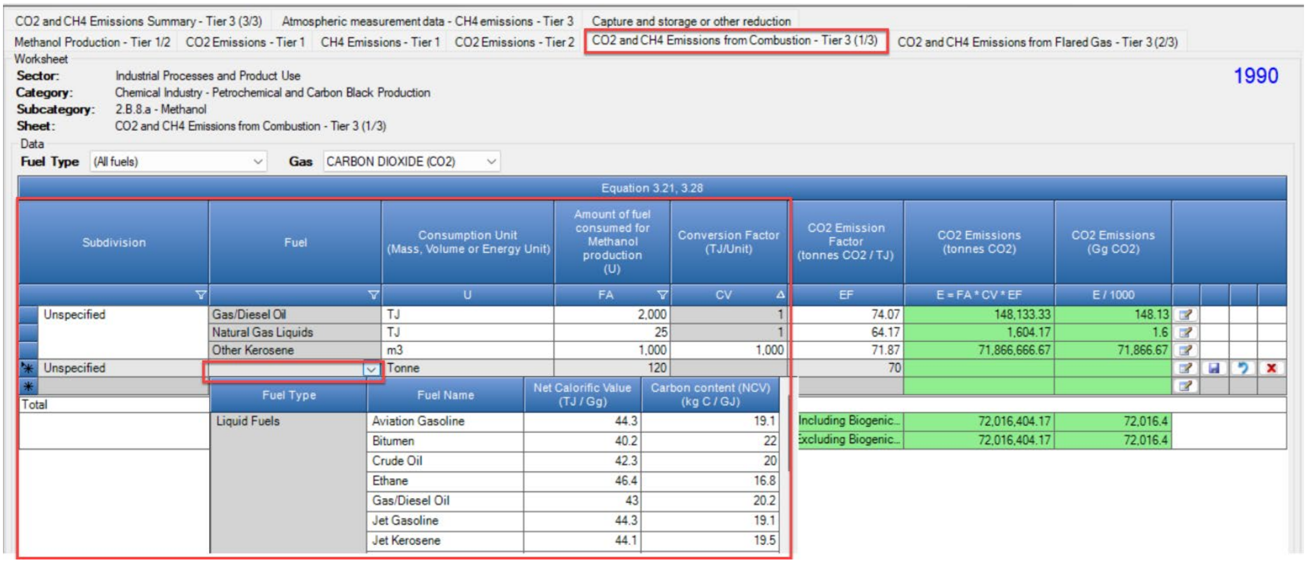
<u>Tier 3 using plant-specific data (CO_2 and CH_4 emissions)</u>

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

1. <u>Column |Fuel|</u>: select each fuel used from the drop-down menu (one row for each fuel). *<u>Note that</u> fuels shown in the drop-down menu are those listed in the Fuel Manager.*
   <u>Note that</u> user shall select "Fuel Type" in the "Fuel Type" bar at the top, to enter data for each fuel one by one.
2. <u>Column |U|</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. <u>Column |FA|</u>: input the amount of fuel consumed, in the units entered in <u>Column |U|</u>.
4. <u>Column |CV|:</u> input the conversion factor to convert the consumption unit to an energy unit (TJ). *<u>Note that</u> 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 must enter the relevant conversion factor here the user shall enter the relevant conversion factor here.*

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

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

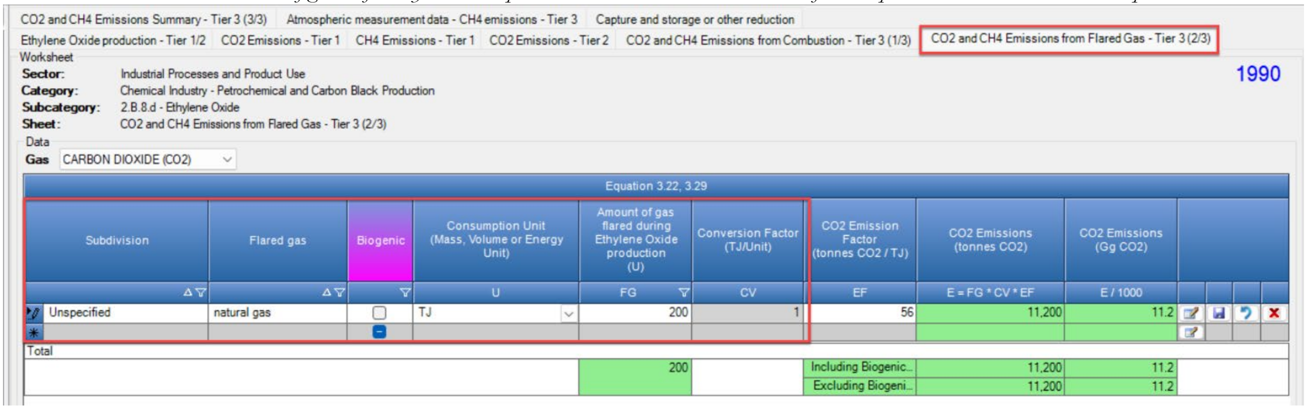


Then, for each chemical, and each subdivision for that chemical in worksheet **CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3)**, input information in a single row, or in a number of rows, plant-specific information as follows:

1. <u>Column |Flared Gas|</u>: input a name for, or description of, the flared gas (e.g. the type of gas).
2. <u>Column |Biogenic|</u> indicate with a check if the flared gas is of biogenic origin.
   <u>Note that</u> CO_2 emissions from flared gas of biogenic origin will not be included in national totals.
3. <u>Column |U|</u>: select the unit of the amount of flared gas (e.g. GJ, TJ, m^3) from the drop-down menu or overwrite with a user-specific unit.
5. <u>Column |FG|</u>: input the amount of gas flared during production of the chemical in the units entered in <u>Column |U|</u>.
6. <u>Column |CV|:</u> enter the conversion factor to convert the consumption unit to an energy unit (TJ). *<u>Note that</u> 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 input data in the *Software* for this method.

For the subcategory Other Petrochemical Production (2.B.8.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** below.

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.

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)**

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

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

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**.

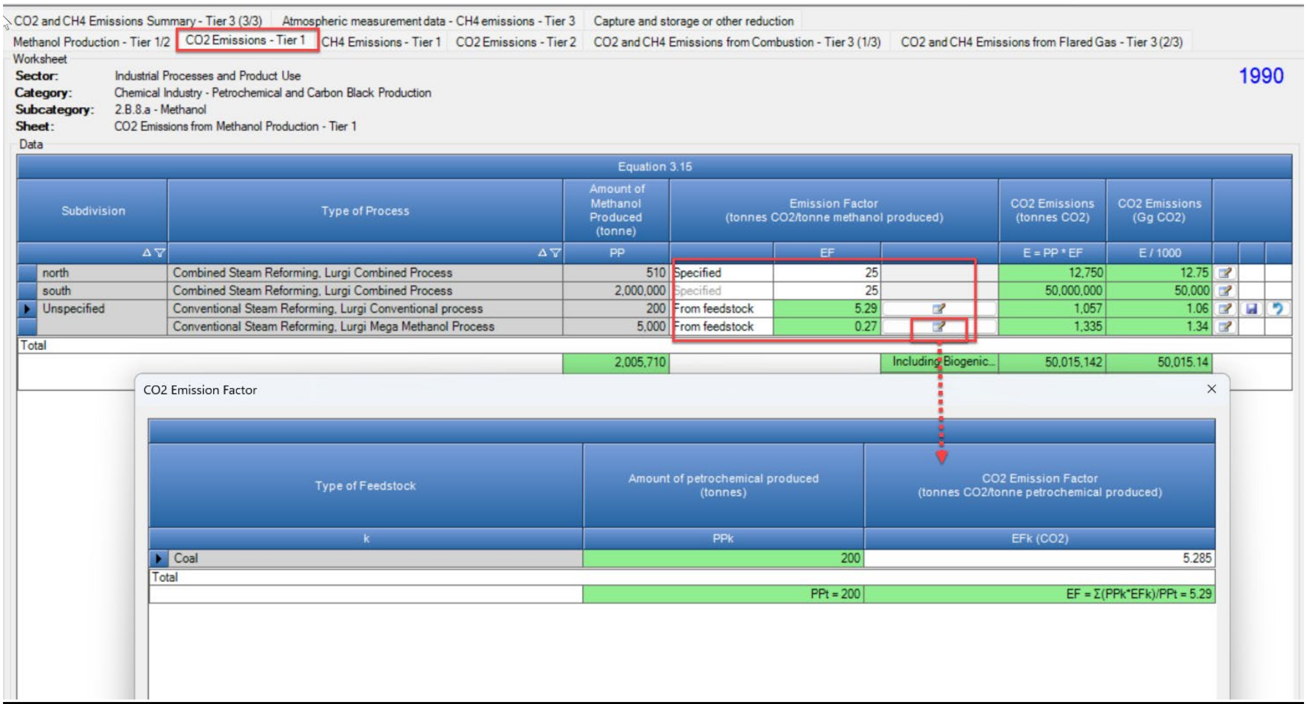
Note that: for the subcategory Ethylene Dichloride and Vinyl Chloride Monomer, the rows are further stratified by product type (either EDC or VCM). For the subcategory Other petrochemical production, rows are further stratified by petrochemical type entered by the user.

Then, for each subdivision, input EF information for 2.B.8.a **Methanol** and 2.B.8.b **Ethylene** in worksheet **CO_2 Emissions Tier 1**, row by row, as follows:

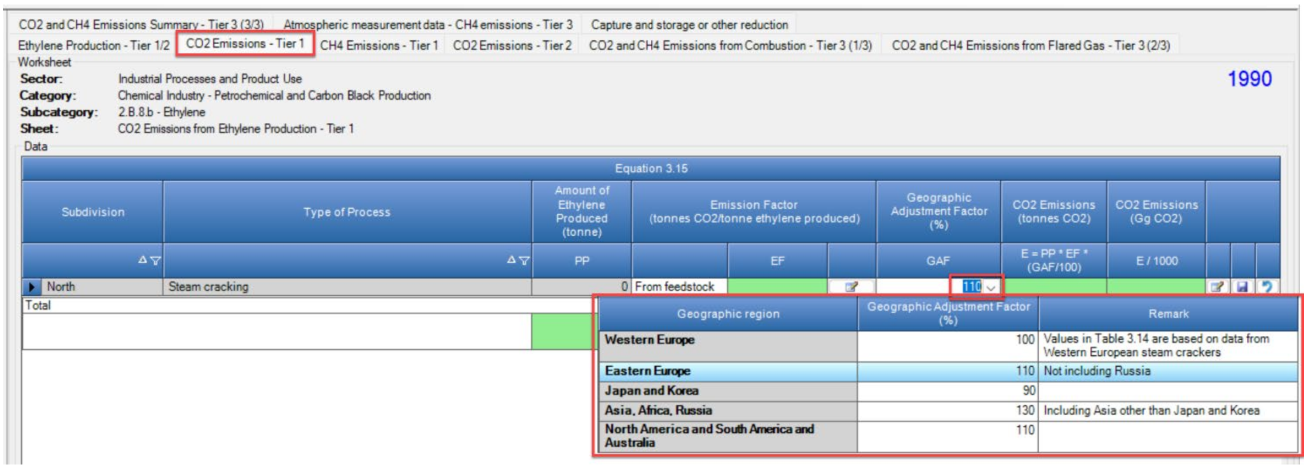
1. Column |EF|: select whether the CO_2 EF is specified or calculated from feedstock.
   a. *Specified:* when selected, the user inputs the CO_2 EF directly.
   b. *From feedstock:* to calculate the CO_2 EF from the feedstock, select the icon for the drop-down table. Any feedstock entered in the AD worksheet 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.
   Note that Tier 1 CO_2 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**

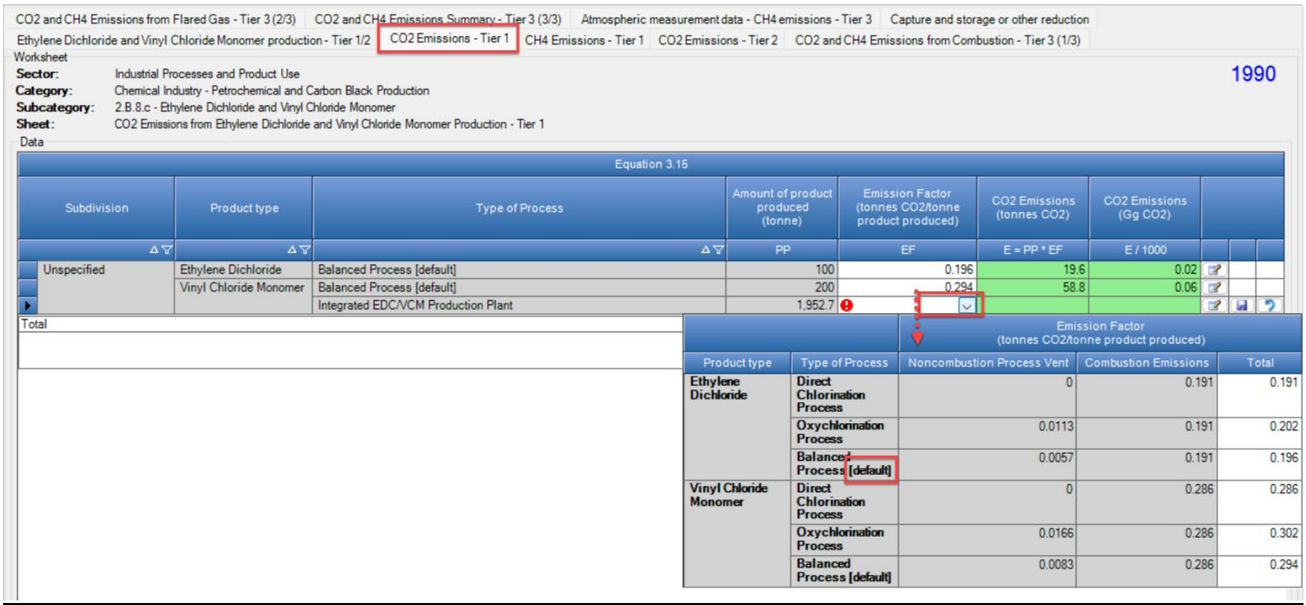


Then enter EF information for 2.B.8.c **Ethylene Dichloride and Vinyl Chloride Monomer,** 2.B.8.f **Carbon Black** and 2.B.8.x **Other petrochemical production** in worksheet **CO_2 Emissions Tier 1**, as follows:

1. Column |EF|: 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.
   Note that: 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**

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

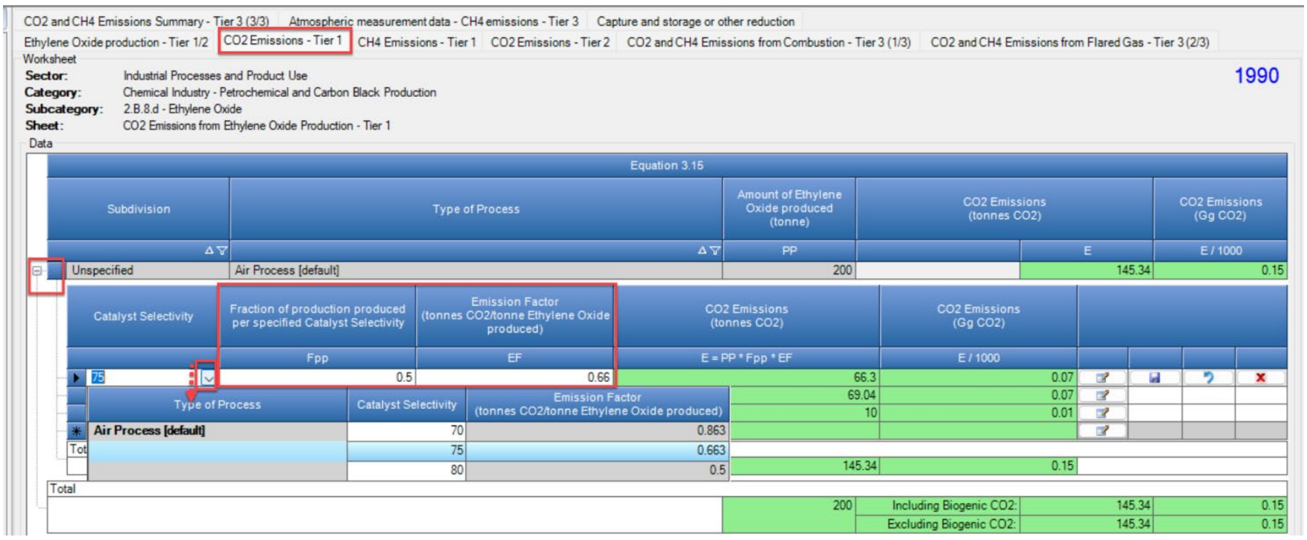


Then enter EF information for **2.B.8.d Ethylene Oxide** in worksheet **CO_2 Emissions Tier 1,** row by row, as follows:

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. Column |Catalyst selectivity|: in the sub-table, select from the drop-down the catalyst selectivity (see Table 3.20 of the *2006 IPCC Guidelines*, and accompanying guidance), otherwise input user-specific information.
3. Column |Fpp|: input the fraction (0-1) of the production produced using the catalyst selectivity identified in Column |Catalyst selectivity|

   Note that: The total in Column |Fpp| for each subdivision should equal 1.
4. Column |EF|: the *Software* automatically populates the IPCC default CO_2 EF based on the selection in Column |Catalyst selectivity|. The user may overwrite this value, in tonnes CO_2/tonne ethylene oxide produced.

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

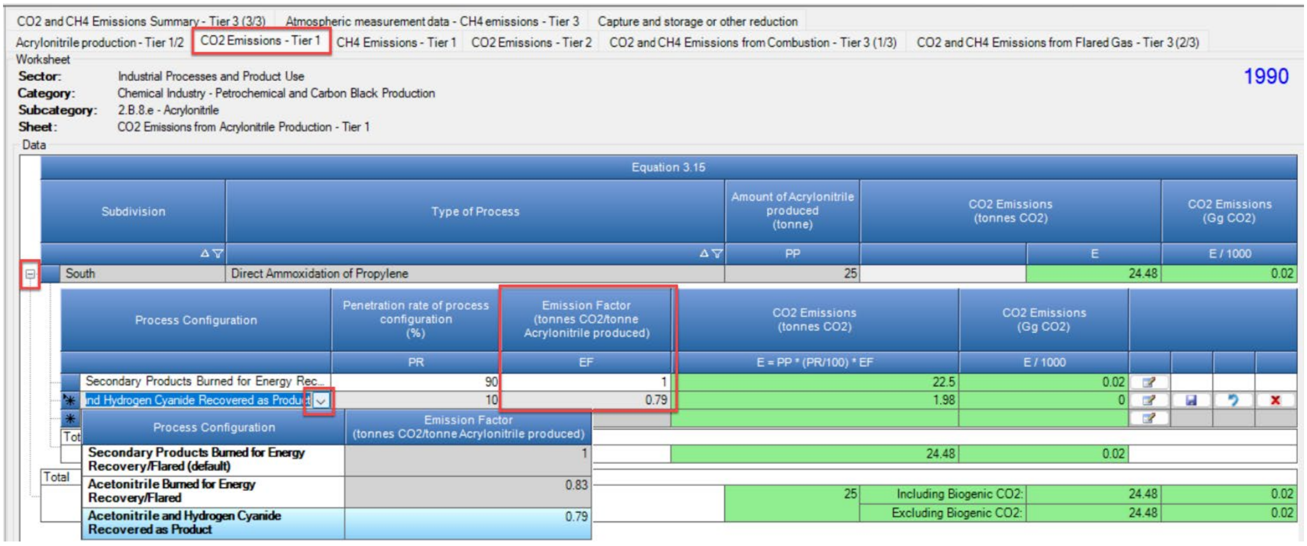


Then enter EF information for 2.B.8.e **Acrylonitrile** as follows:

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 input user-specific information.
3. Column |PR|: input 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 based on the selection in Column |Process Configuration|. The user may overwrite this value, in tonnes CO_2/tonne acrylonitrile produced.

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



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.

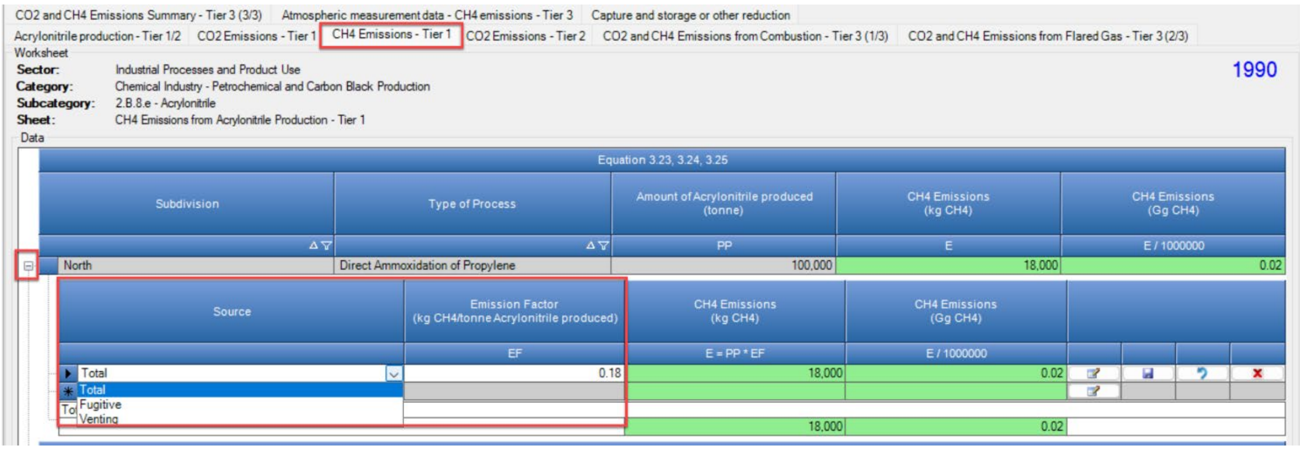
Then, enter EF information for 2.B.8.a **Methanol,** 2.B.8.d **Ethylene Oxide**, 2.B.8.e **Acrylonitrile and** 2.B.8.x **Other petrochemical production,** row by row, as follows:

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**

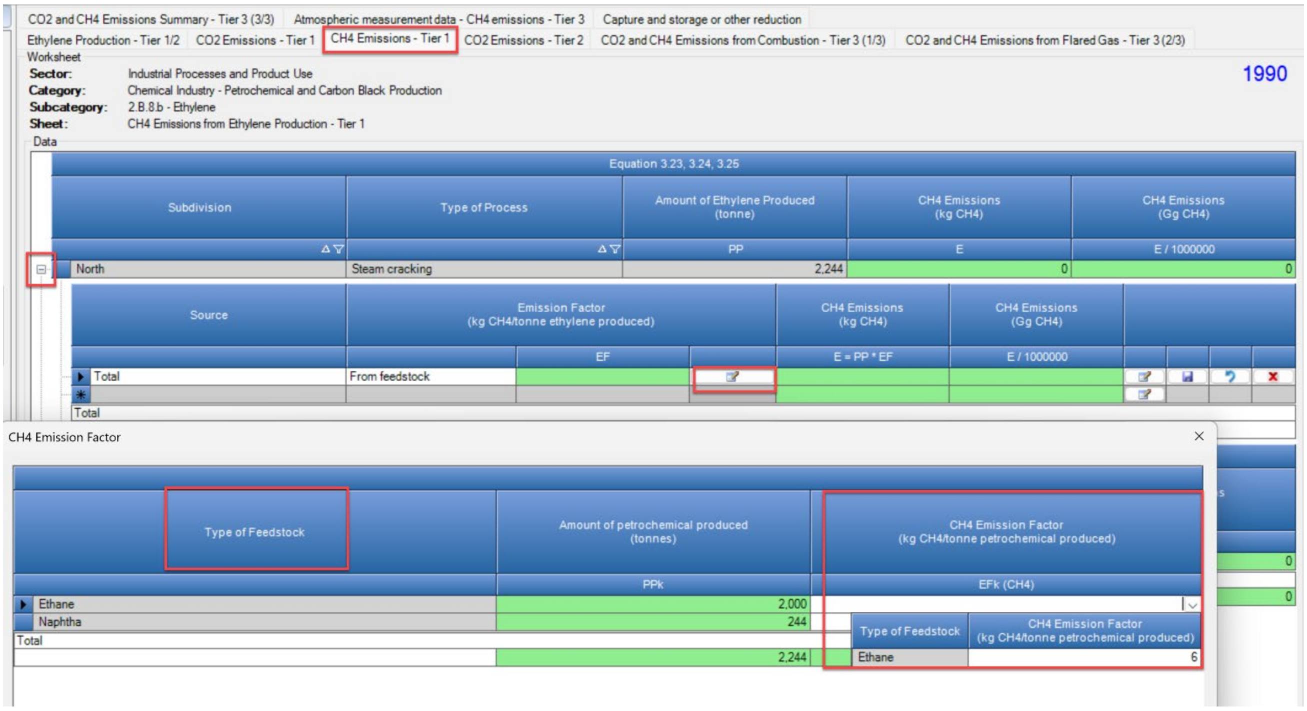
<u>Note that</u> this figure is for acrylonitrile production; a similar worksheet is available for the other listed chemicals



Then enter EF information for **2.B.8.b Ethylene Production in** worksheet **CH_4 Emissions – Tier 1**, row by row, 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. <u>Column |Source|:</u> select from the drop-down menu whether the CH_4 EFs to be entered are based on fugitive, vented or total emissions.
3. <u>Column |EF|:</u> select whether the CH_4 EF is *specified* or *based on feedstock*.
    a. If specified, directly input the CH_4 EF directly.
    *<u>Note that:</u> users that select indicate in worksheet **Ethylene Production- Tier 1/2** that the amount of ethylene is "specified" must also specify the CH_4 EF. There will be no option in the drop-down menu to calculate based on feedstock. Users that selected "from feedstock" in **Ethylene Production- Tier 1/2** may choose in worksheet CH_4- Tier 1 to specify or calculate the EF based on feedstock.*
    b. If from feedstock, the user selects the icon to input the EF, and a pop-up box opens. To input the CH_4 EFs for ethylene production (EFs are available for ethane, naphtha and all other feedstocks), the user enters the following information in the pop-up box: Information on the feedstocks are entered by selecting the icon for the drop-down table in Column |EF|:
    *<u>Note that:</u> 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 <u>Column |PP|</u>.*
        i. <u>Column |Type of Feedstock|:</u> The feedstocks are automatically populated based on information entered in **Ethylene Production – Tier 1/2.**
        ii. <u>Column |EFk(CH_4)|:</u> select the IPCC default CH_4 EF, otherwise input a user-specific EF.

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

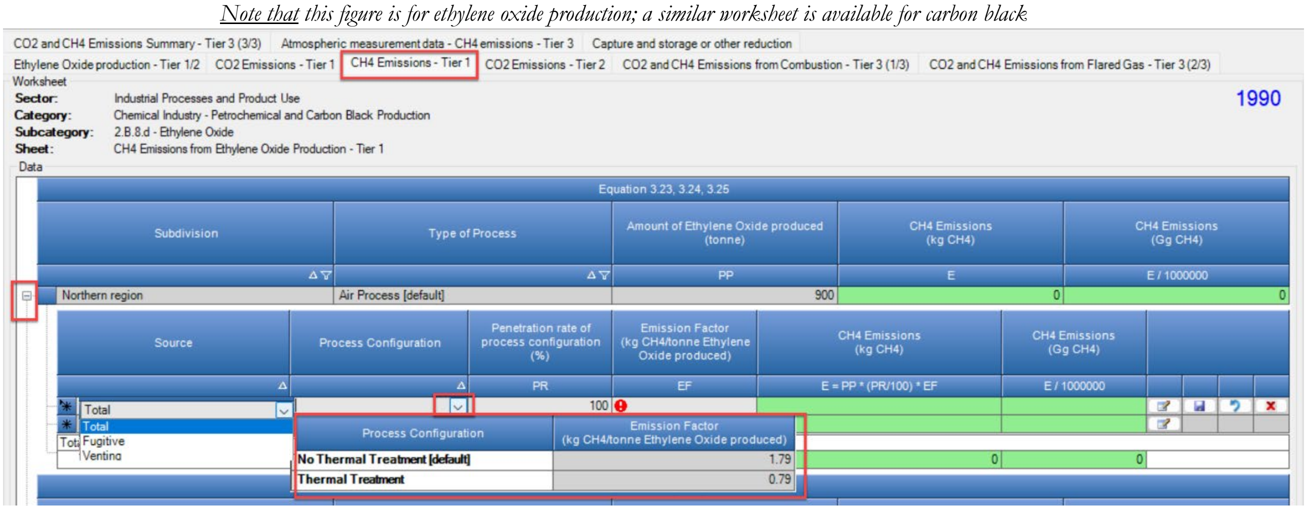


Then enter EF information for **2.B.8.d Ethylene Oxide** and **2.B.8.f Carbon Black** in worksheet **CH_4 Emissions – Tier 1**, row by row, as follows:

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 based on the selection in Column |Process Configuration|, otherwise enter in the user-specific value, in kg CH_4/tonne chemical produced.

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.**

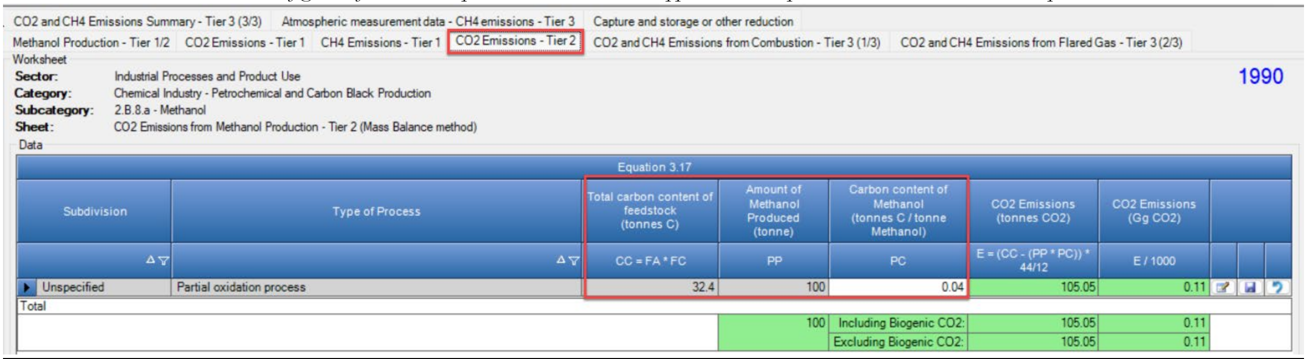
<u>Note that</u>: for the subcategory Ethylene Dichloride and Vinyl Chloride Monomer, the rows are further stratified by product type (either EDC or VCM). For the subcategory Other petrochemical production, rows are further stratified by petrochemical type entered by the user.

Then,

1. <u>Column |CC|:</u> the total carbon content of the feedstock is automatically populated, in tonnes C, based on information entered in the AD worksheet.
2. <u>Column |PP|:</u> the total amount of chemical produced is automatically populated, in tonnes, based on information entered in the AD worksheet.
3. <u>Column |PC|:</u> 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**

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

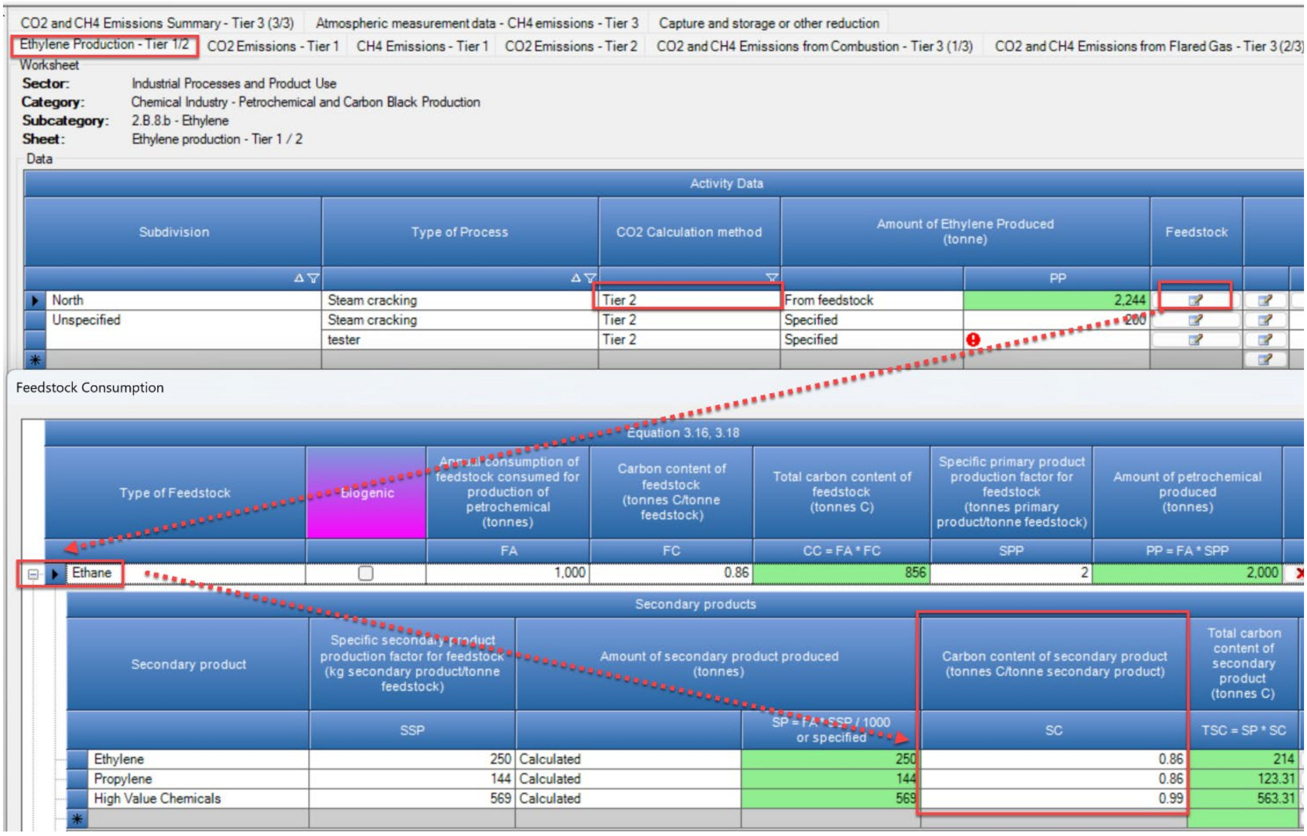


For 2.B.8.b **Ethylene Production** and **2.B.8.e Acrylonitrile Production**, the carbon content of secondary products shall also be considered in the mass balance equation. The carbon content of these secondary products appear in <u>Column |SPC|</u> of **worksheet CO_2 Emissions – Tier 2**, and are automatically transferred here based on information entered by the user in worksheet **[Ethylene Production – Tier 1/2]** and [**Acrylonitrile Production- Tier 1/2]**, as follows:

1. 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.
2. For each row, users click the symbol "⊞" on the left of the row to open a drop-down table where secondary products are to be entered.
3. <u>Column |SC|:</u> 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, in tonnes C / tonne secondary products.

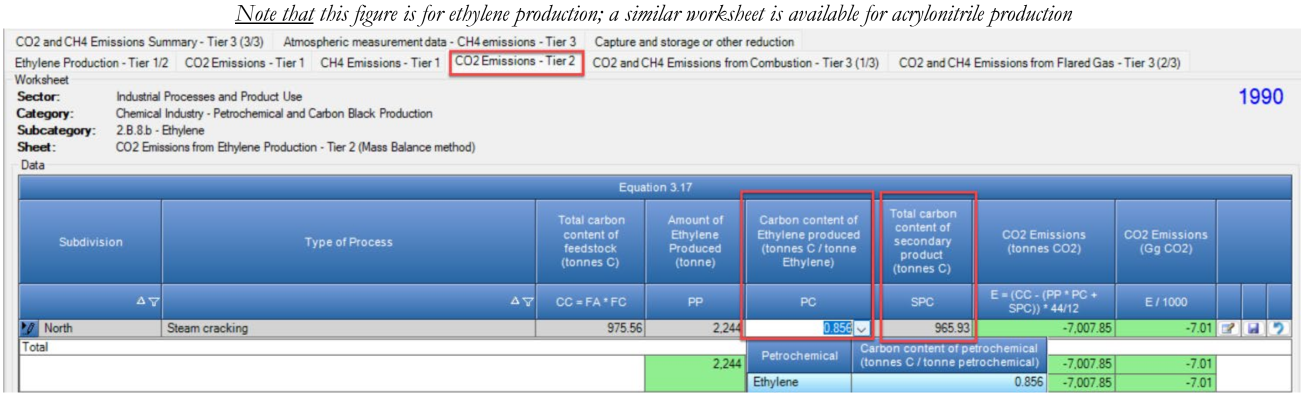
Example: **Tier 2 CO_2 carbon content of secondary products (2.B.8.b ethylene and 2.B.8.e acrylonitrile production)**

<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:

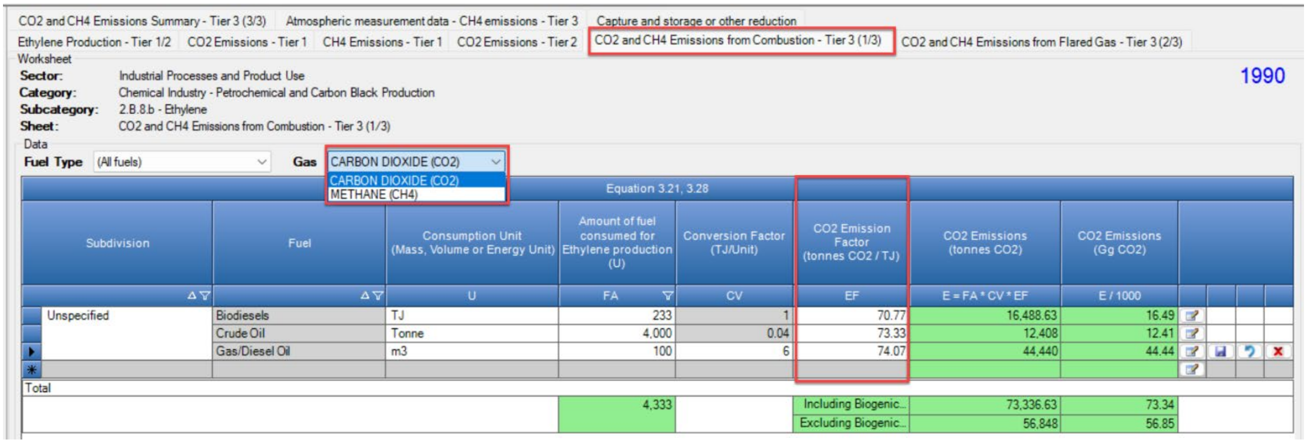
<u>Tier 3 CO_2 and CH_4 EFs using plant-specific data</u>

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

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

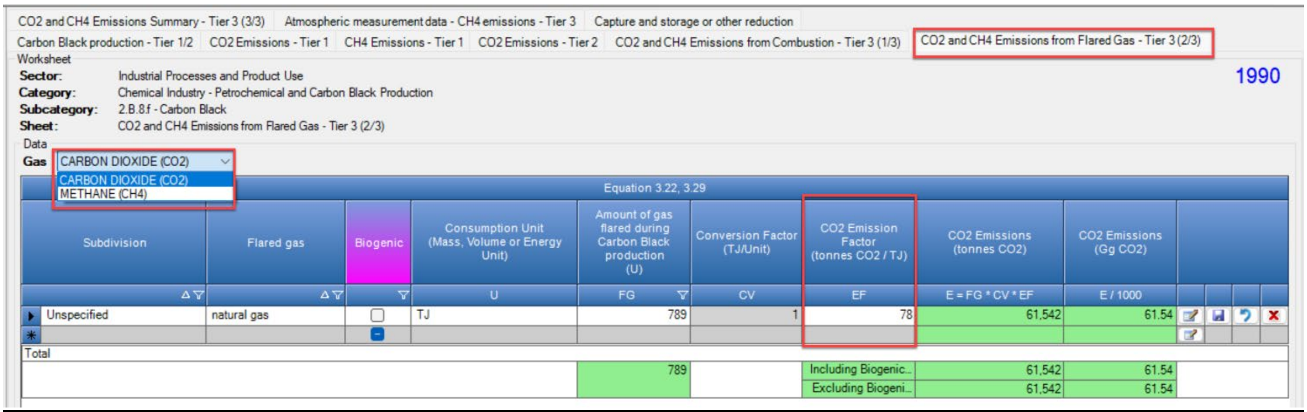


Then, for each chemical, and each subdivision for that chemical in worksheet **CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3)**, the user will input information in a single row, or in a number of rows, plant-specific information as follows:

1. 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/TJ or kg CH_4/TJ.
   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 3 CO_2 and CH_4 EF for flared gas**

Note that 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 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:

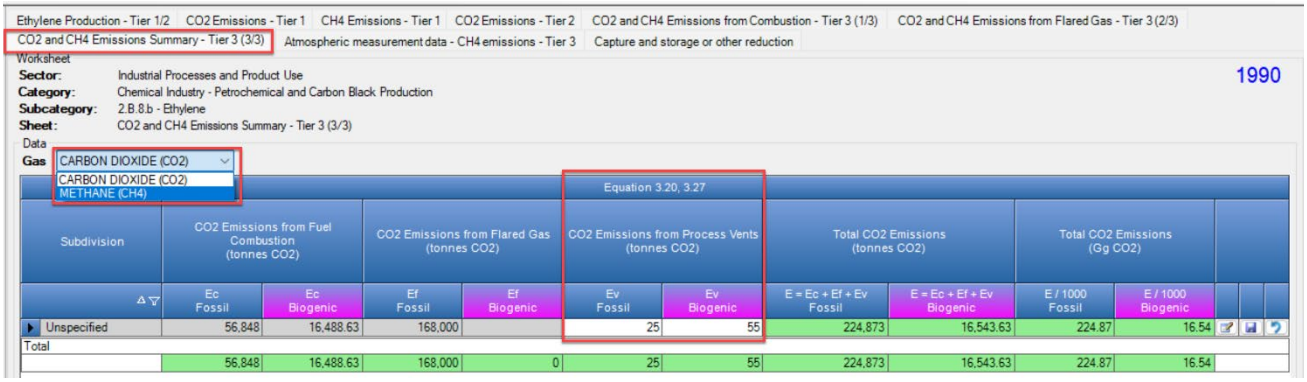
1. Column |Ev Fossil|: input user-specific value for CO_2 emissions from process vents that are of fossil origin, in tonnes CO_2.
2. Column |Ev Biogenicl|: input user-specific value for CO_2 emissions from process vents that are of biogenic origin, in tonnes CO_2.

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

1. Column |Ev|: input 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 ethylene 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**, input plant-specific information in a single row, or in a number of rows, as follows:

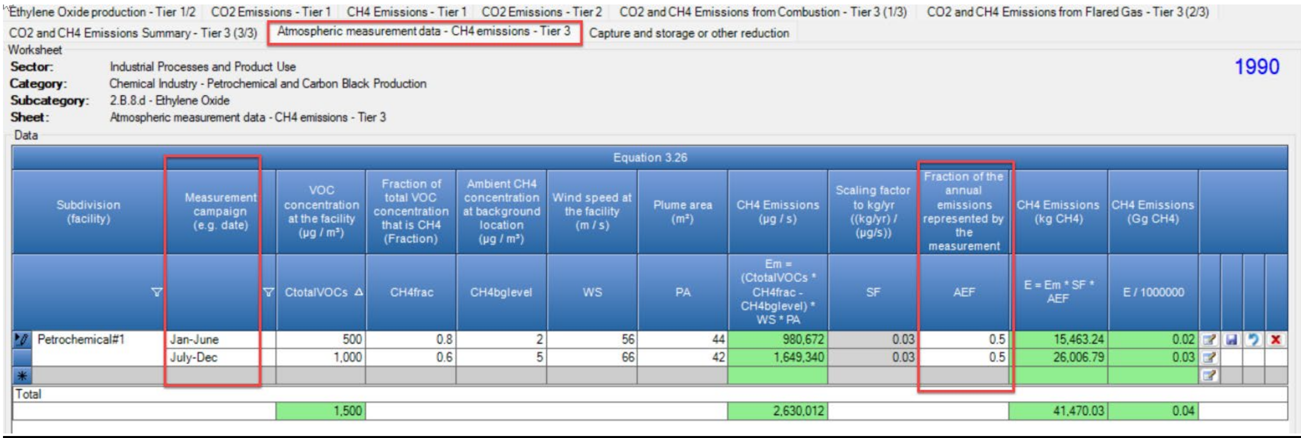
1. Column |Measurement Campaign|: enter name or dates of measurements campaigns.
   Note that: the dates of the measurement campaigns, when summed, must cover the entire reporting year.
2. Column |CtotalVOCs|: for each measurement campaign input concentration of total measured VOCs, in µg/m³.
3. Column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



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.

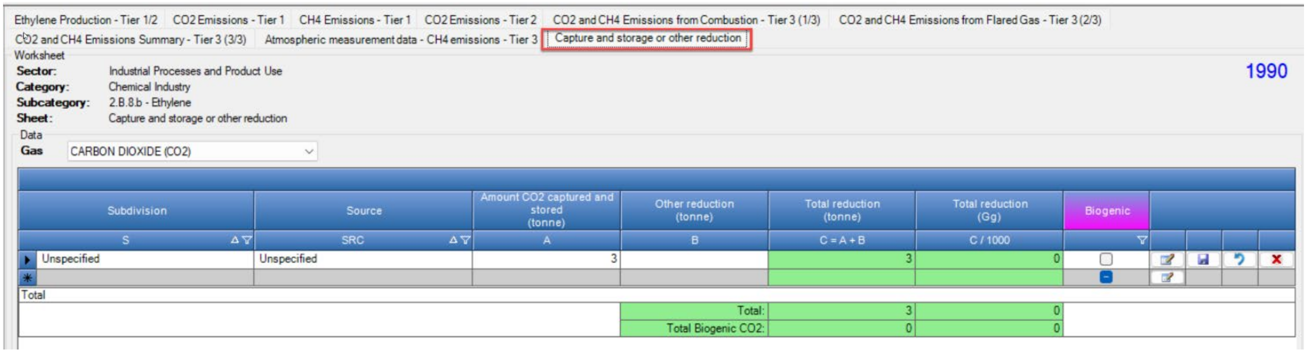
Total CO_2 and CH_4 emissions from the production of each chemical, is the sum of all emissions in the above worksheets for that chemical, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate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

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

1. Column |SRC|: select from the drop-down menu, 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 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 (e.g. HFC-23 from HCFC-22 production). 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 can be calculated and reported 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 as 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 calculate emissions from fluorochemical production in one of the set of IPCC category worksheets below, deciding in particular whether release of a gas is significant (calculate under 2.B.9.a) or not significant (calculate under 2.B.9.b):

- ✓ 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 calculated, 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.

Section 3.10.1 of the *2006 IPCC Guidelines* provides 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			

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:

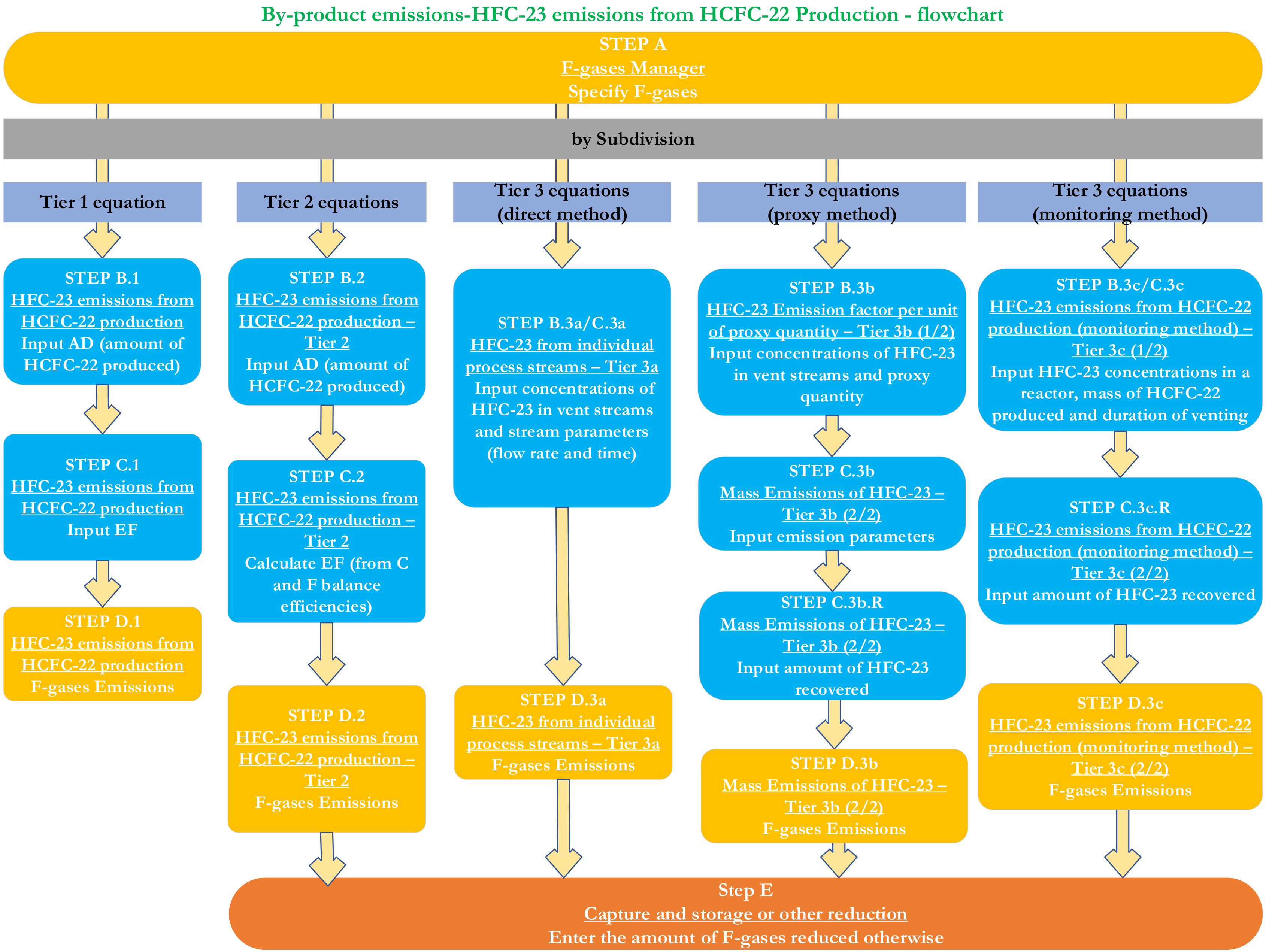
- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **HFC-23 emissions from HCFC-22 production:** this worksheet contains for each subdivision the amount of HCFC-22 produced and HFC-23 default EFs. The users may input country-specific 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 an 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
STEP A
F-gases Manager
Specify F-gases
by Subdivision
Tier 1 equation
Tier 2 equations
Tier 3 equations (direct method)
Tier 3 equations (proxy method)
Tier 3 equations (monitoring method)
STEP B.1
HFC-23 emissions from HCFC-22 production
Input AD (amount of HCFC-22 produced)
STEP C.1
HFC-23 emissions from HCFC-22 production
Input EF
STEP D.1
HFC-23 emissions from HCFC-22 production
F-gases Emissions
STEP B.2
HFC-23 emissions from HCFC-22 production – Tier 2
Input AD (amount of HCFC-22 produced)
STEP C.2
HFC-23 emissions from HCFC-22 production – Tier 2
Calculate EF (from C and F balance efficiencies)
STEP D.2
HFC-23 emissions from HCFC-22 production – Tier 2
F-gases Emissions
STEP B.3a/C.3a
HFC-23 from individual process streams – Tier 3a
Input concentrations of HFC-23 in vent streams and stream parameters (flow rate and time)
STEP D.3a
HFC-23 from individual process streams – Tier 3a
F-gases Emissions
STEP B.3b
HFC-23 Emission factor per unit of proxy quantity – Tier 3b (1/2)
Input concentrations of HFC-23 in vent streams and proxy quantity
STEP C.3b
Mass Emissions of HFC-23 – Tier 3b (2/2)
Input emission parameters
STEP C.3b.R
Mass Emissions of HFC-23 – Tier 3b (2/2)
Input amount of HFC-23 recovered
STEP D.3b
Mass Emissions of HFC-23 – Tier 3b (2/2)
F-gases Emissions
STEP B.3c/C.3c
HFC-23 emissions from HCFC-22 production (monitoring method) – Tier 3c (1/2)
Input HFC-23 concentrations in a reactor, mass of HCFC-22 produced and duration of venting
STEP C.3c.R
HFC-23 emissions from HCFC-22 production (monitoring method) – Tier 3c (2/2)
Input amount of HFC-23 recovered
STEP D.3c
HFC-23 emissions from HCFC-22 production (monitoring method) – Tier 3c (2/2)
F-gases Emissions
Step E
Capture and storage or other reduction
Enter the amount of F-gases reduced otherwise

Thus, for the source-category:

Step A, **F-gases Manager**: the selection of HFC-23 is automatically done for this category; no further user action is needed.

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 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 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 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 Tier 2 Equations are applied:

Step B.2, in 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 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 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 Tier 3 Equations are applied:

Tier 3.a Direct method

Step B.3a/C.3.a, in 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 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 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 worksheet **Mass emission 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 worksheet **Mass emission 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 worksheet **Mass emission 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 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 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 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 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.

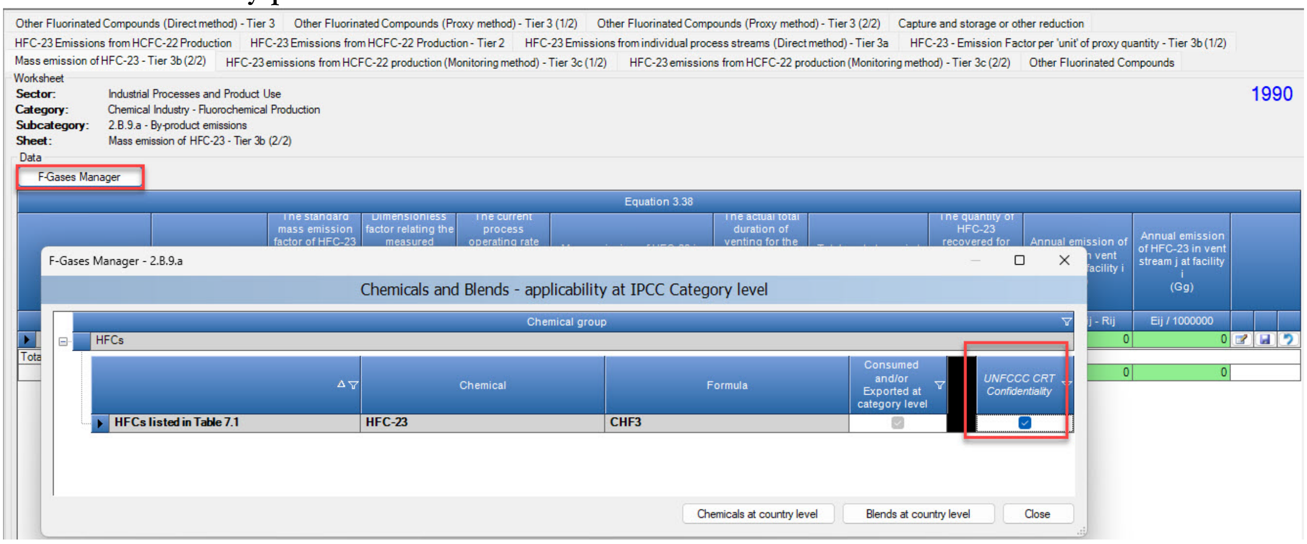
Activity Data Input

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 typically must ensure that the **F-Gases Manager** has been populated for all F-gases (or, if applicable, blends) to be reported for an IPCC source category. However, the user is not required to select F-gases for By-product emissions of HFC-23 from HCFC-22 production (HFC-23 is automatically checked).

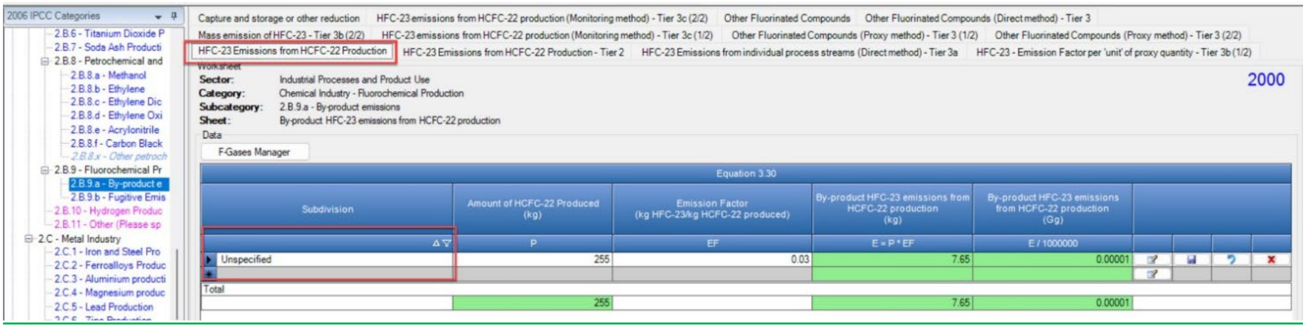
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality in the ***F-Gases Manager****. If checked, "C" will be reported for AD and "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: **Designating confidentiality for category:**
By-product emissions-HFC-23 emissions from HCFC-22 Production

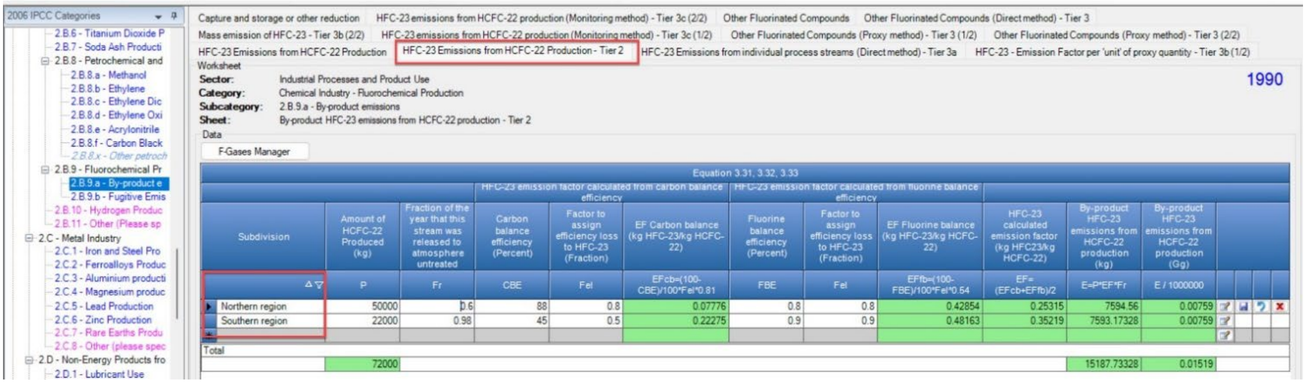


Second, input of AD for By-product emissions of HFC-23 from HCFC-22 production requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



When the Tier 1 Equation is applied:

Then, for each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **HFC-23 emissions from HCFC-22 production**, row by row, as follows:

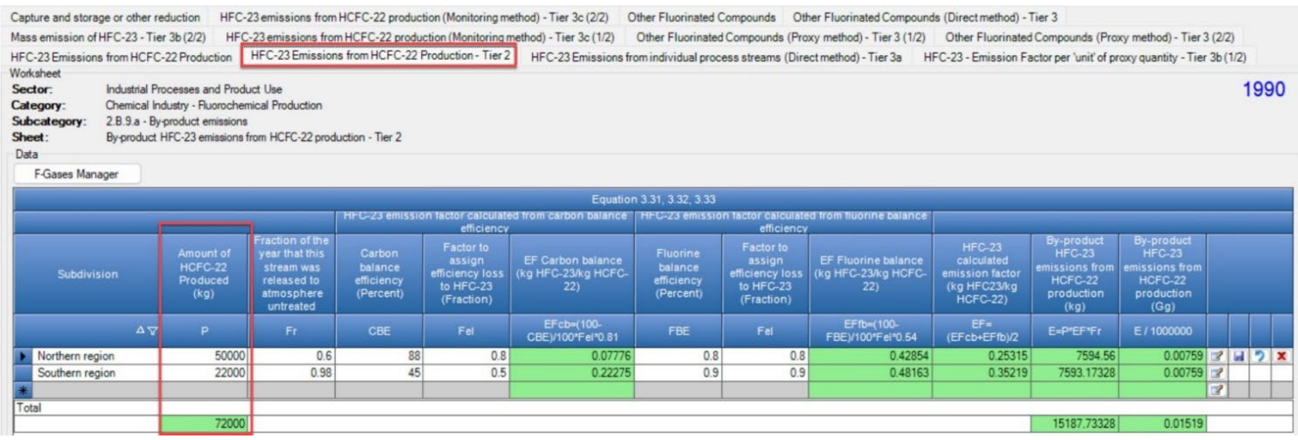
1. <u>Column |P|</u>: input the amount of HCFC-22 produced, in kg.

When Tier 2 Equations are applied:

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **HFC-23 emissions from HCFC-22 production – Tier 2**, row by row, as follows:

1. <u>Column | P|</u>: input the amount of HCFC-22 produced, in kg.

Example: **AD input – Tier 2**



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

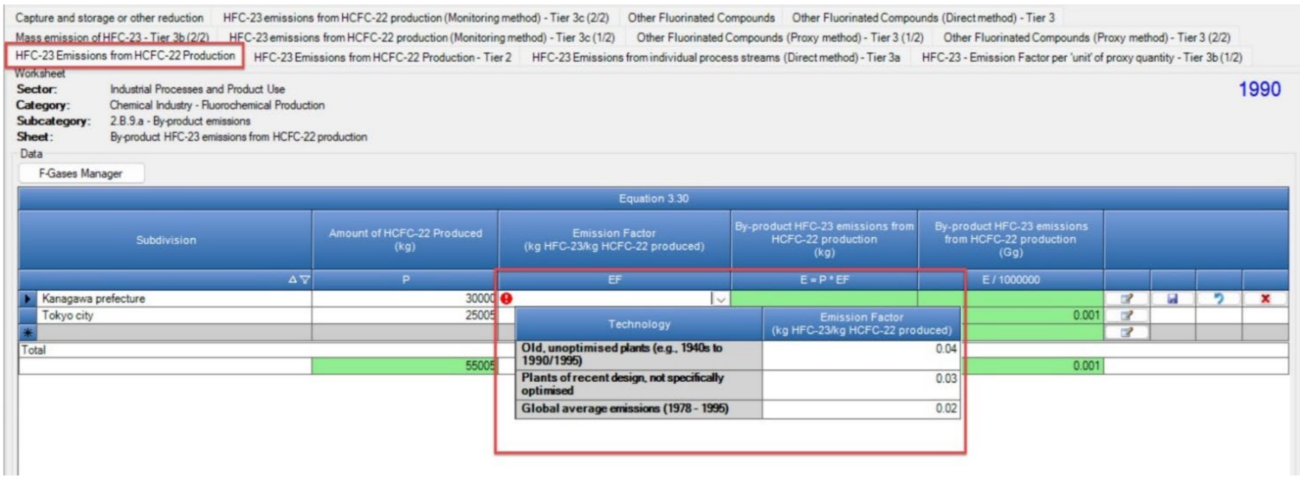
Section 3.10.1.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for By-product emissions of HFC-23 from HCFC-22. Tier 1 default EFs are provided in Table 3.28. Higher-tier methods rely on plant-specific measurements or sampling.

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are input in worksheet **HFC-23 emissions from HCFC-22 production** row by row, as follows:

1. Column |EF|: 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 production**



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.

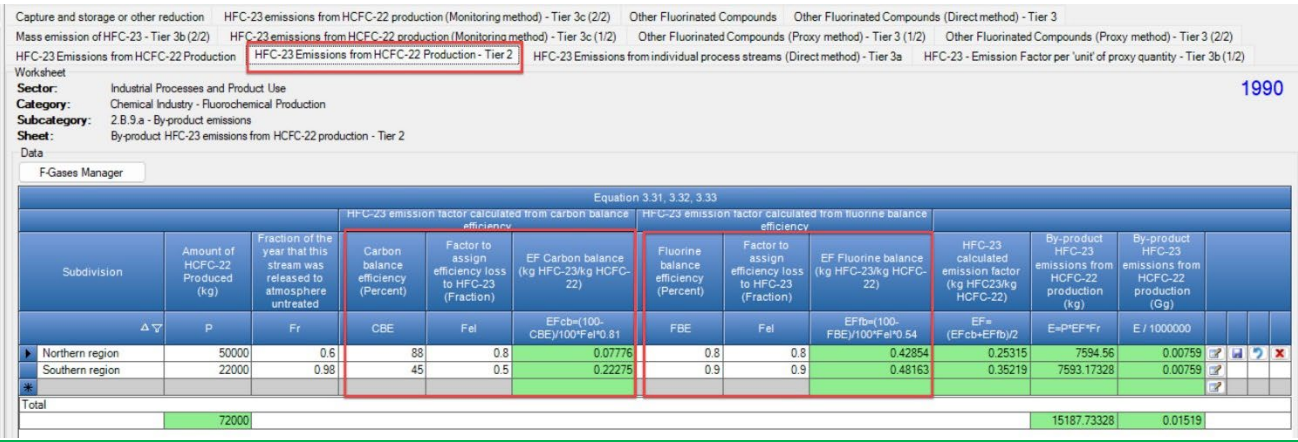
Annual average carbon and fluorine balance efficiencies are features of a well-managed HCFC-22 plant and are normally available to the plant operator or may be obtained by examination of process accounting records. Similarly, if there is a vent treatment system, the length of time that this stream was 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 input in worksheet **By-product emissions of HFC-23 from HCFC-22 Production - Tier 2**, row by row, as follows:

1. Column |Fr|: input the fraction of the year when the vent stream was released to the atmosphere without treatment.
2. Column |CBE|: input the carbon balance efficiency taken from the plant operator, in percent.
3. Column |Fel|: input 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; i.e. all loss in efficiency is due to co-production of HFC-23. In practice, this is commonly the most significant efficiency loss, and much larger than losses of raw materials or products.
4. Column |FBE|: input the fluorine balance efficiency taken from the plant operator, in percent.
5. Column |Fel|: input 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; i.e. all loss in efficiency is due to co-production of HFC-23. In practice, this is commonly the most significant efficiency loss, and 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

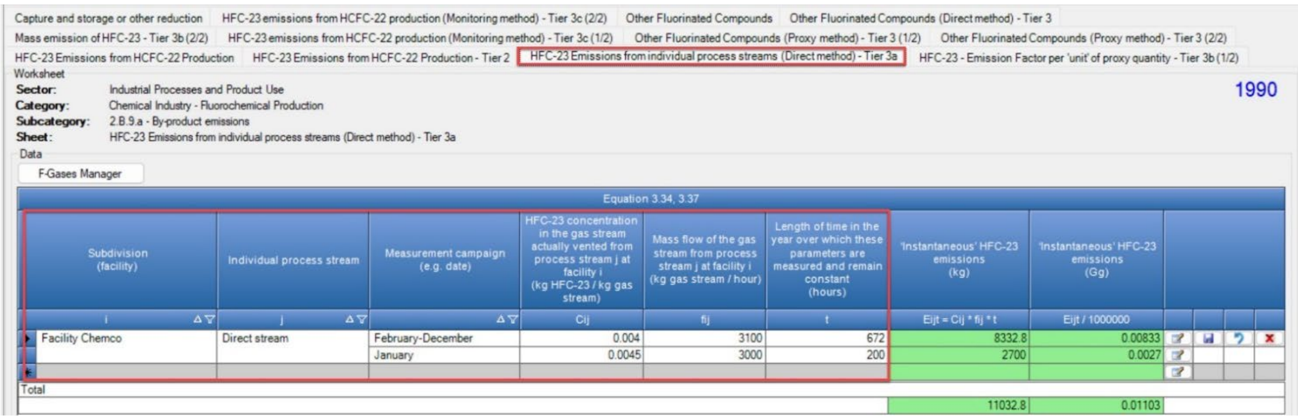
Direct measurement

Tier 3.a Direct method

For each subdivision in Column |i|, data are input 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 the individual process stream.
2. Column |Measurement campaign|: for each subdivision/process stream input the name or dates of the measurement campaign.
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 input 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**



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 input 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 |days, ij|: for each subdivision/vent stream input the number of days of the trial campaign. This value is used in cases where more than one trial campaign is undertaken for a given subdivision/vent stream, to ensure the resulting standard EF in Column |Sij| is weighted based on the length of each trial campaign.
4. 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.
5. 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.
6. 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 a **weighted average** HFC-23 EF per unit of proxy over the time T in which the test was conducted. Then, the subdivisions/vent streams and the EF calculated 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/standard mass EF in worksheet **Mass emissions of HFC-23 – Tier 3b (2/2),** data are entered, row by row, as follows:

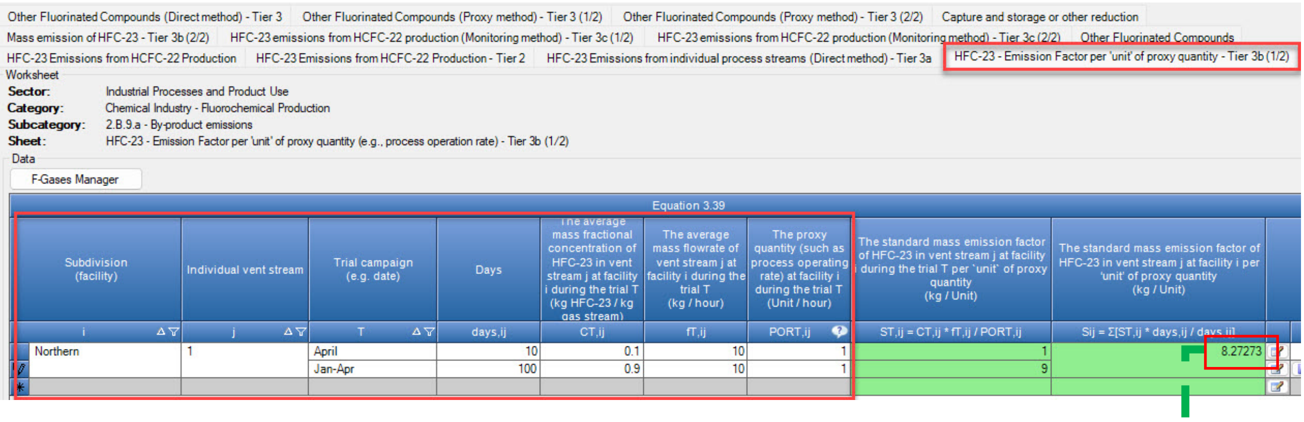
7. Column | F_{ij}|. input a dimensionless factor relating the measured standard mass emission rate to the emission rate at the actual plant operating rate.
   Note that in many cases, the fraction produced is not sensitive to operating rate and Fij is unity (i.e., the emission rate is proportional to operating rate). In other cases, the emission rate is a more complex function of the operating rate. In all cases Fij 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.***

8. Column |POR_{ij}|: input the current process operating rate applicable to that vent stream, j, averaged over time, 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.
9. Column |t|.: input 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. For a given vent stream, the total in Column |t| should not exceed 8,760 (the number of hours in a year)

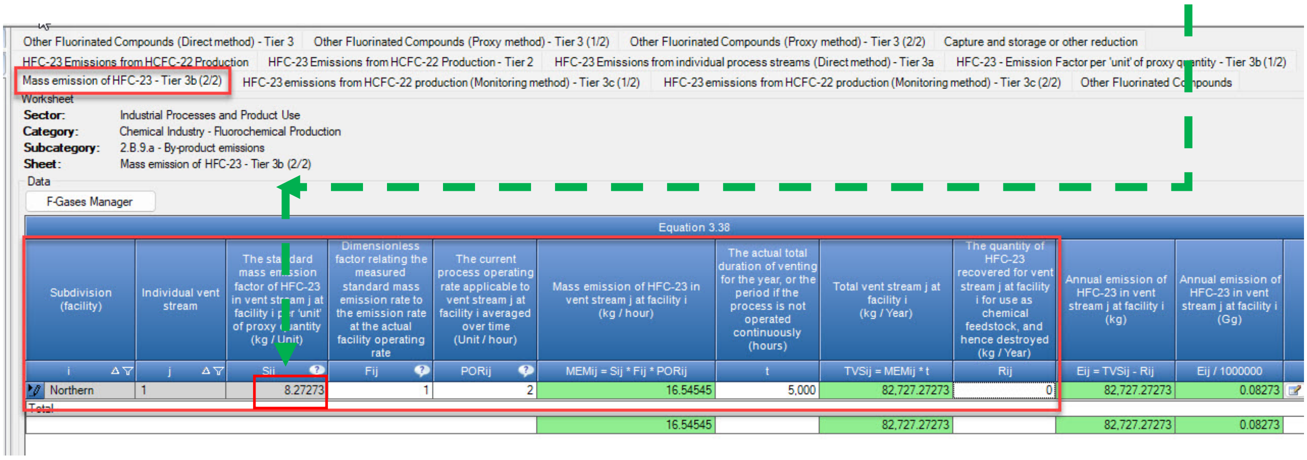
10. Column |Rij|: input the quantity of HFC-23 recovered from each vent stream for use as chemical feedstock, and hence destroyed, in kg/year.

Example: **AD for Tier 3b – proxy method (1/2)**



Subdivision (facility)	Individual vent stream	Trial campaign (e.g. date)	Days	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	days,ij	CT,ij	fT,ij	PORT,ij	ST,ij = CT,ij * fT,ij / PORT,ij	Sij = Σ[ST,ij * days,ij / days,ij]
Northern	1	April	10	0.1	10	1	1	8.27273
		Jan-Apr	100	0.9	10	1	9	

Example: **AD for Tier 3b – proxy method (2/2)**



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 rate	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 (hours)	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 (kg / Year)	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
Northern	1	8.27273	1	2	16.54545	5,000	82,727.27273	0	82,727.27273	0.08273
Total					16.54545		82,727.27273		82,727.27273	0.08273

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:

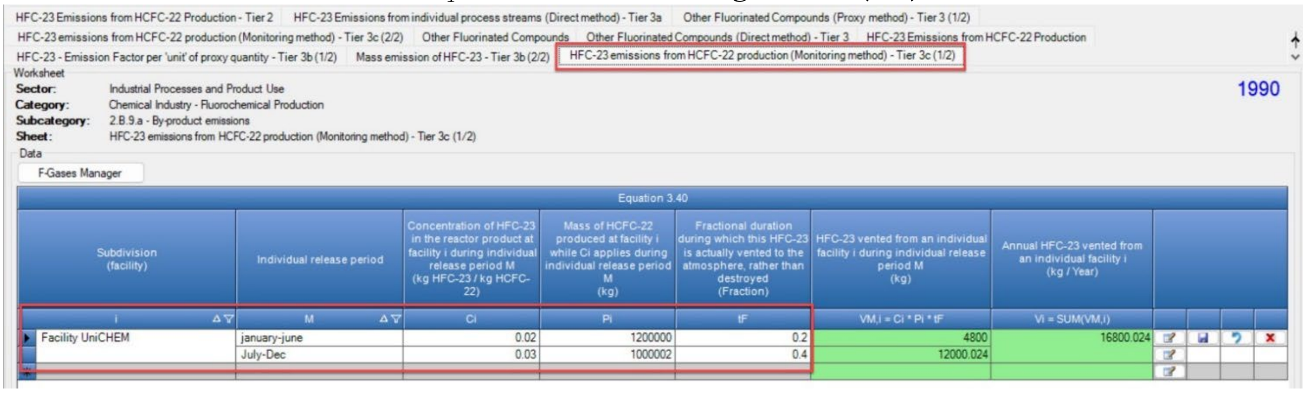
1. Column |M| users input the name or time for individual release period(s).
2. Column |C_i|:For each subdivision/individual release period input the concentration of HFC-23 in the reactor product, in kg HFC-23 per kg HCFC-22 produced.
3. Column |P_i|: input the mass of HCFC-22 produced during individual release period M, in kg.
4. Column |tF|: input 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.

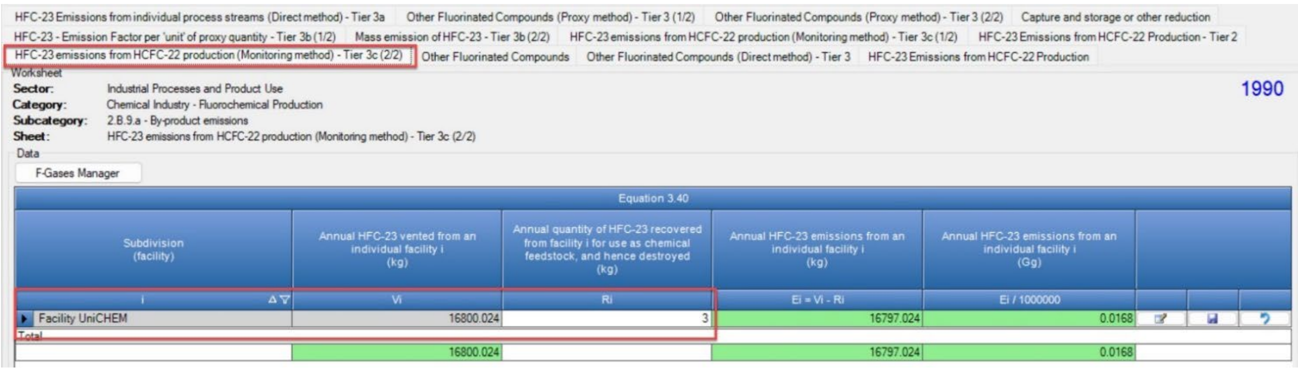
Then, in worksheet **HFC-23 emissions from HCFC-22 (Monitoring Method) – Tier 3c (2/2),** data are input for each subdivision and quantity of HFC-23 vented, row by row, as follows**:**

5. <u>Column |R_i|: </u>enter the amount of HFC-23 recovered from the facility for use as chemical feedstock and hence destroyed.
   <u>Note that:</u> 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 3c – monitoring method (1/2)**



Example: **Tier 3c – monitoring method (2/2)**



<u>Results</u>

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)**

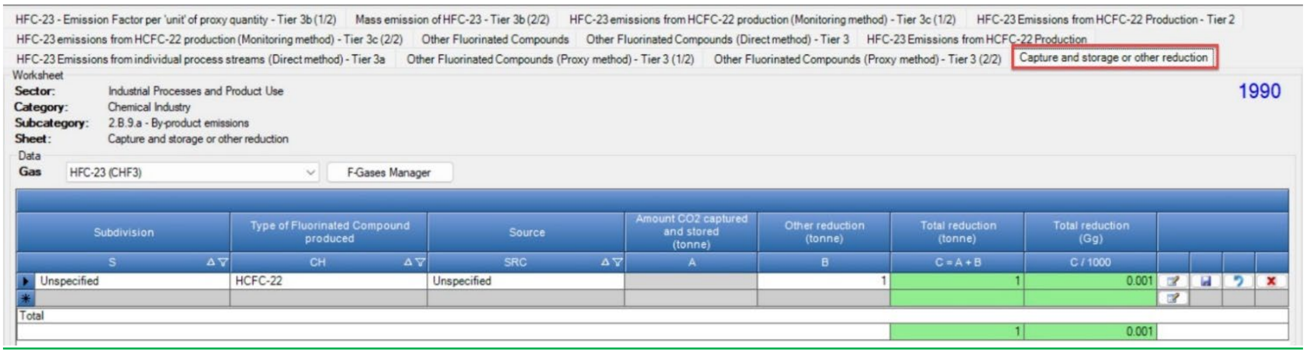
Total HFC-23 emissions from HCFC-22 production is the sum of all emissions in the above worksheets, taking into account any capture or destruction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate further reductions, if any. As described above, recovery 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 (if HFC-23 is not available from the drop-down menu, select F-Gases Manager, and add as described <u>above</u>):

1. <u>Column |CH|</u>: select from the drop-down menu HCFC-22

2. Column |SRC|: enter any identifying information for the source, if applicable.
3. Column |A|: this column is not applicable for this source category.
4. 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

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 can be calculated and reported 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 as 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.

Section 3.10.2.of 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 flow rate 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, 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:

- ✓ **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 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.

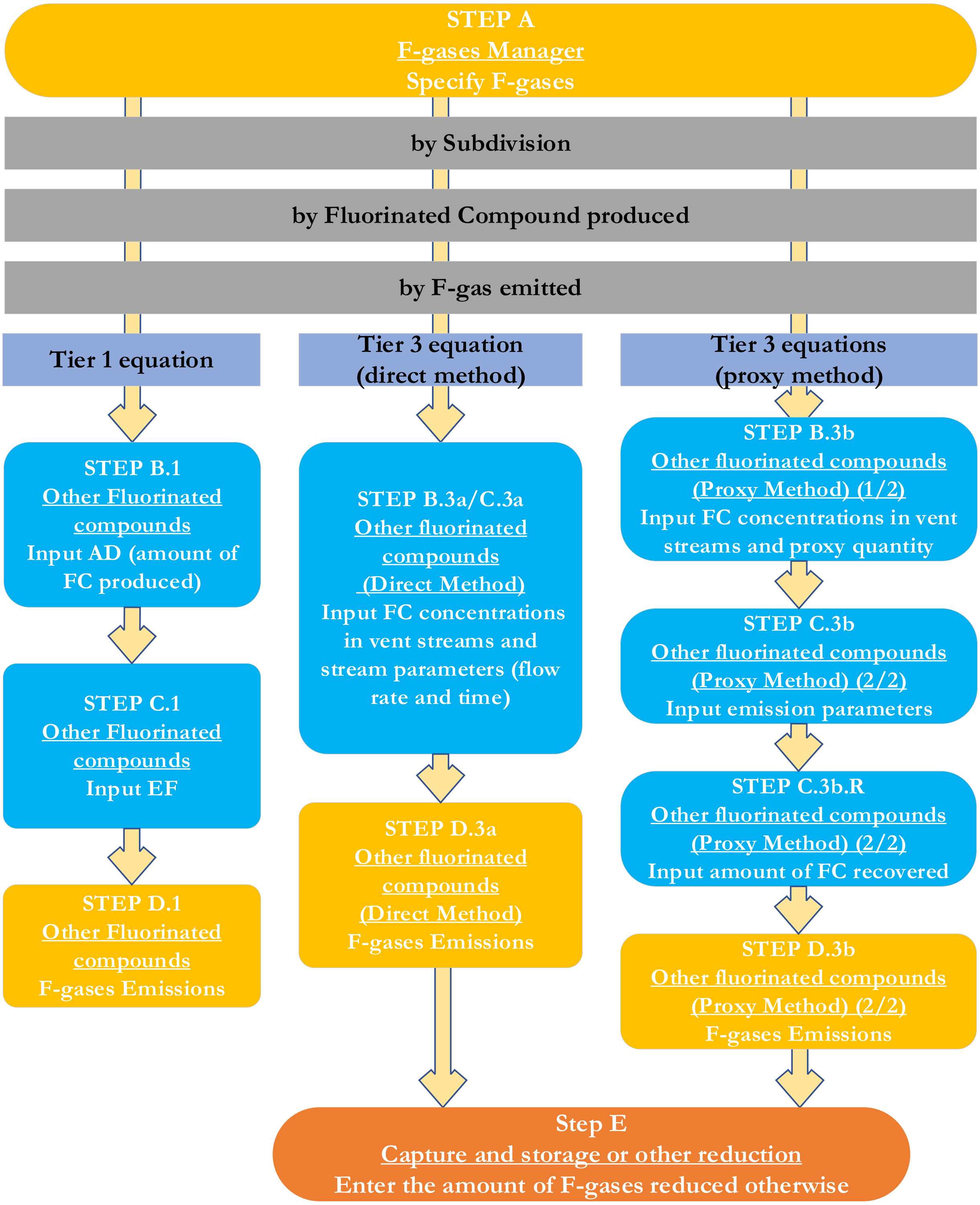
User's Work Flowchart

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, **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 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 worksheet **Other Fluorinated Compounds,** users input an EF for the by-product fluorinated compounds emitted.
Step D.1, in worksheet **Other Fluorinated Compounds,** the *Software* calculates the associated fluorochemical compounds emissions in mass units (kg and Gg).

When Tier 3 Equations are applied:

Tier 3a Direct method

Step B.3a/C.3.a in 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 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).

Tier 3.b Proxy method

Step B.3b, in 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 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 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 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:

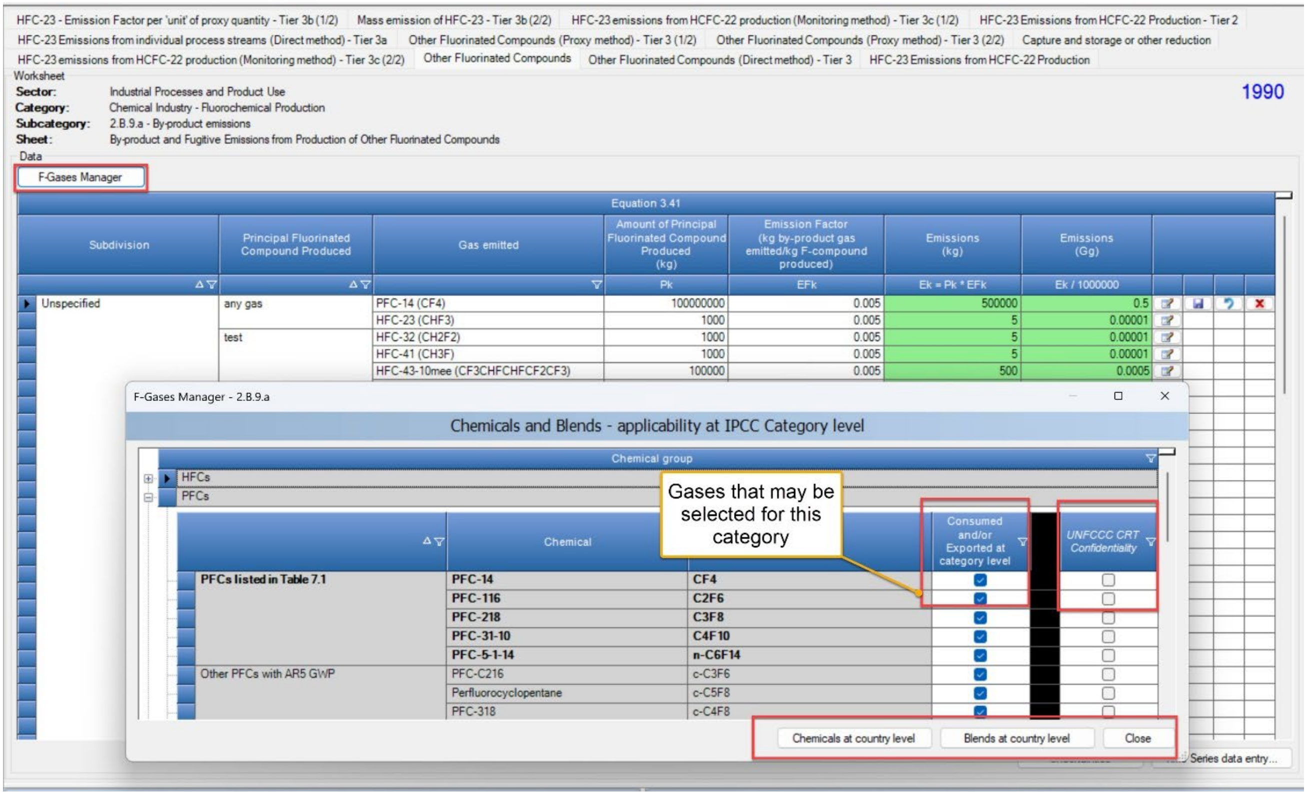
Step E, in the worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of recovered/reduced fluorinated compounds, which are not accounted for elsewhere in calculation worksheets.

Activity Data Input
Section 3.10.2.2 in 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 **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 more information, refer to populating the F-Gases Manager, in the section above.*

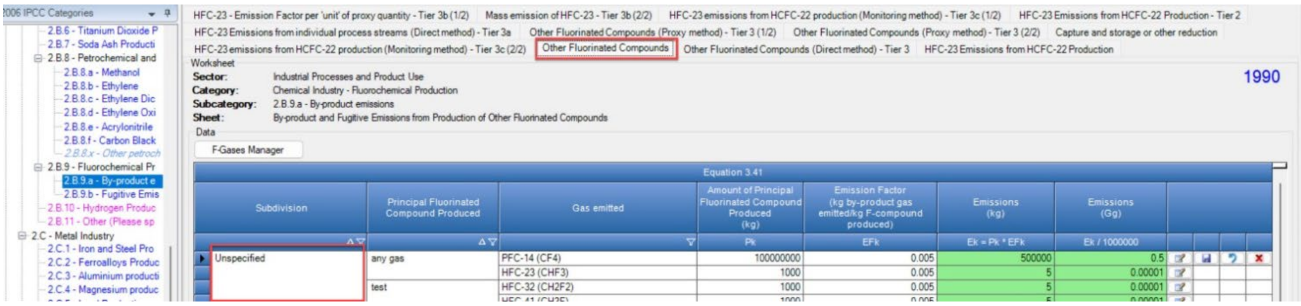
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. If checked, "C" will be reported for AD 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**

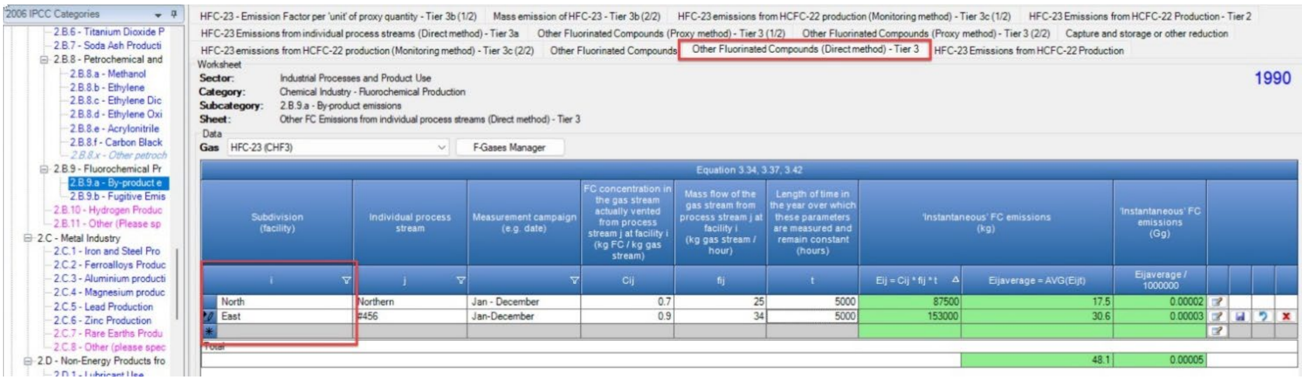


Second, input of AD for By-product emissions from production of other fluorinated compounds requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in <u>Column |Subdivision|</u> [e.g. "country name" or "Unspecified" as selected from the drop-down menu] or where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**

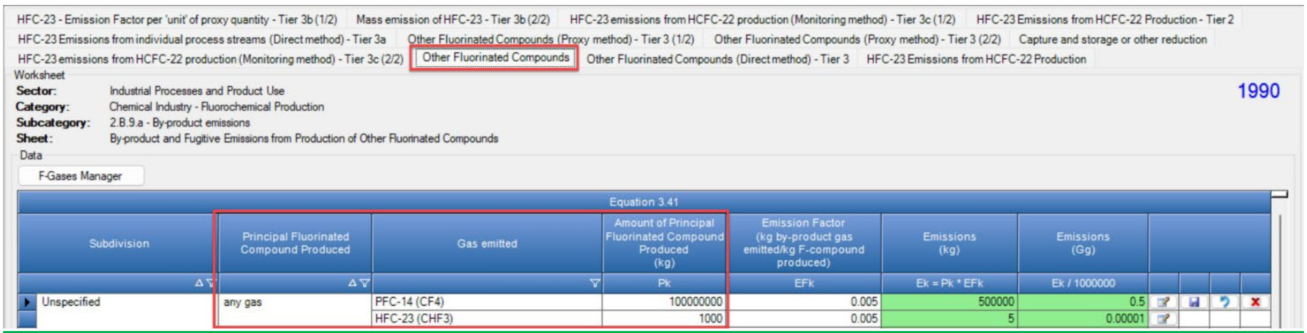


When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are entered in **Other fluorinated Compounds** worksheet, row by row, as follows:

1. Column |Principal compound produced|: input the principal compound produced.
2. Column |Gas emitted|: select from the drop-down menu, the gas emitted.
   Note that the selection of gases in the drop-down menu will be consistent with those selected in the IPCC Category level F-Gases Manager.
3. Column |Pk|: input the amount of principal fluorinated compound produced, in kg.

Example: **AD for other fluorinated compounds – Tier 1**



When Tier 3 Equations are applied:

Tier 3a Direct method

The Tier 3a 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 3b Proxy method

The Tier 3b 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

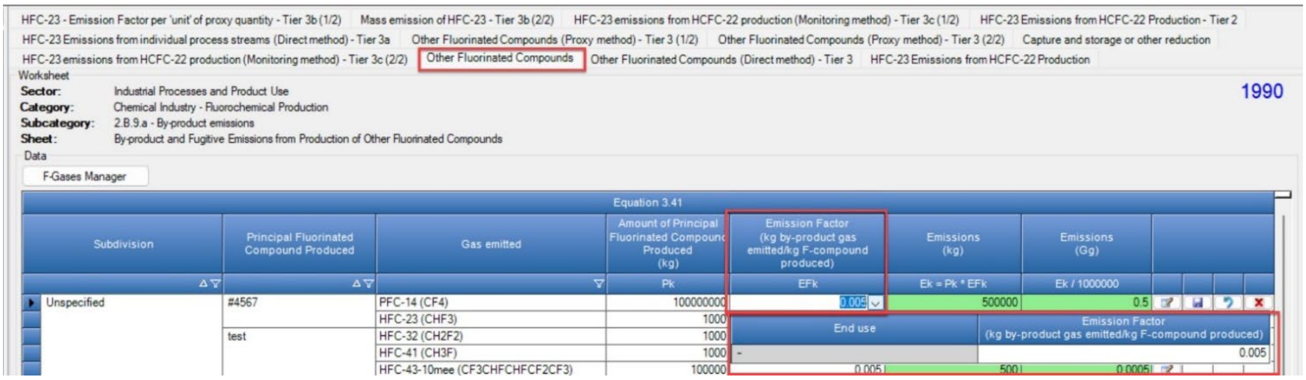
Section 3.10.2.2 in Chapter 2 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for By-product emissions from production of other fluorinated compounds.

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, in data 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**



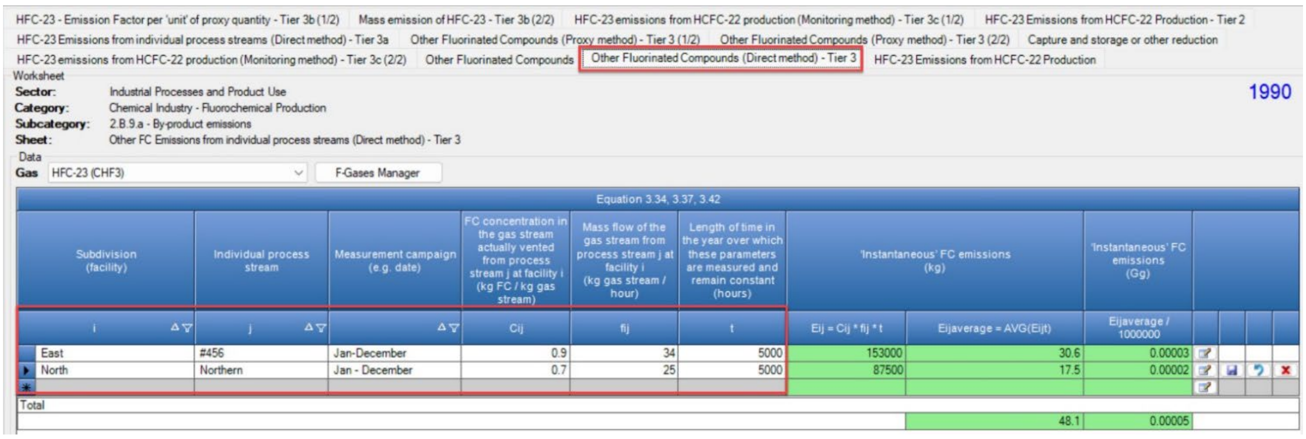
Direct Measurement

Tier 3a Direct method

For each subdivision in Column |i|, data are input in worksheet **Other Fluorinated Compounds (Direct Method) – Tier 3,** row by row, as follows:

1. Column |j|: input a name for individual process stream.
2. Column |Measurement campaign|: for each subdivision/process stream input the name or dates of the measurement campaign(s).
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 3b 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 campaign(s).
3. Column |days, ij|: for each subdivision/vent stream input the number of days of the trial campaign. This value is used in cases where more than one trial campaign is undertaken for a given subdivision/vent stream, to ensure the resulting standard EF in Column |Sij| is weighted based on the length of each trial campaign.
4. 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.
5. 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.
6. 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/standard mass EF in worksheet **Other Fluorinated Compounds (Proxy method) – Tier 3 (2/2),** data are entered, row by row, as follows:

7. Column $|F_{ij}|$. input 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****.*
8. Column $|POR_{ij}|$: input 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
9. Column |t|.: input 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.
10. Column |Rij|: input the quantity of fluorinated compound recovered from each vent stream for use as chemical feedstock, and hence destroyed.

For an illustration of data entry for other fluorinated compounds refer to the similar category for using the proxy method for HFC-23 emissions from HCFC-22 production.

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.

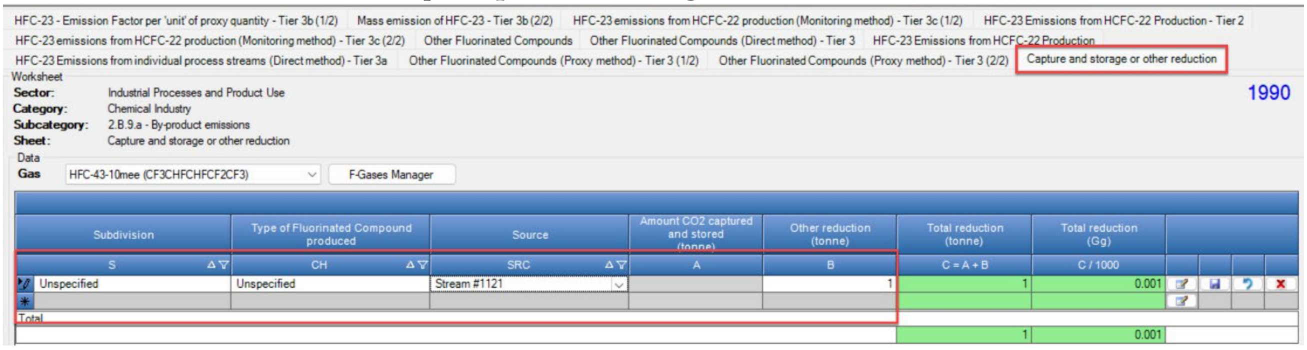
- ✓ **Other Fluorinated Compounds:**
- ✓ **Other Fluorinated Compounds (Direct Method) – Tier 3**
- ✓ **Other Fluorinated Compounds (Proxy Method) – Tier 3 (2/2)**

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|: select from the drop-down menu, or manually input, the type of fluorinated compound produced and for which the destruction / reduction activity is taking place.
2. Column |A|: this column is not applicable for this source category.
3. Column |SRC|: input any identifying information for the source, if applicable.
4. 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 can be calculated and reported 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 as 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 worksheets:

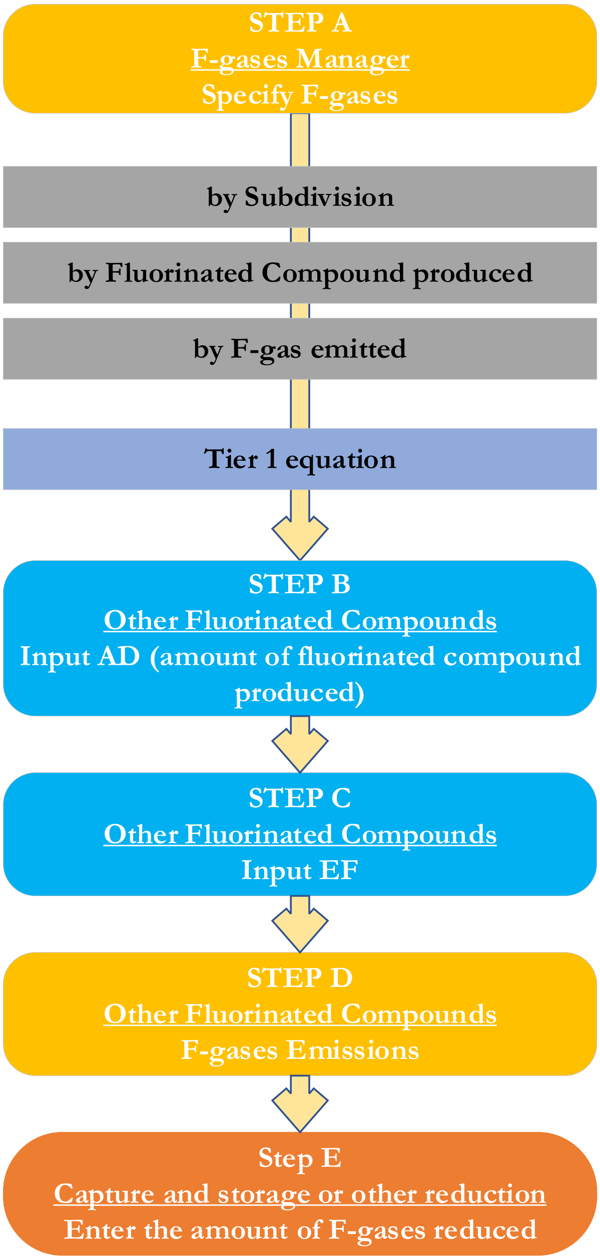
- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Other Fluorinated Compounds:** contains for each subdivision information on the amount of fluorinated gas produced and the fugitive EF. The worksheet calculates the associated F-gases 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, **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 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 worksheet **Other Fluorinated Compounds,** the *Software* calculates the associated fluorochemical compounds emissions in mass units (kg and Gg).

Step E, in 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.

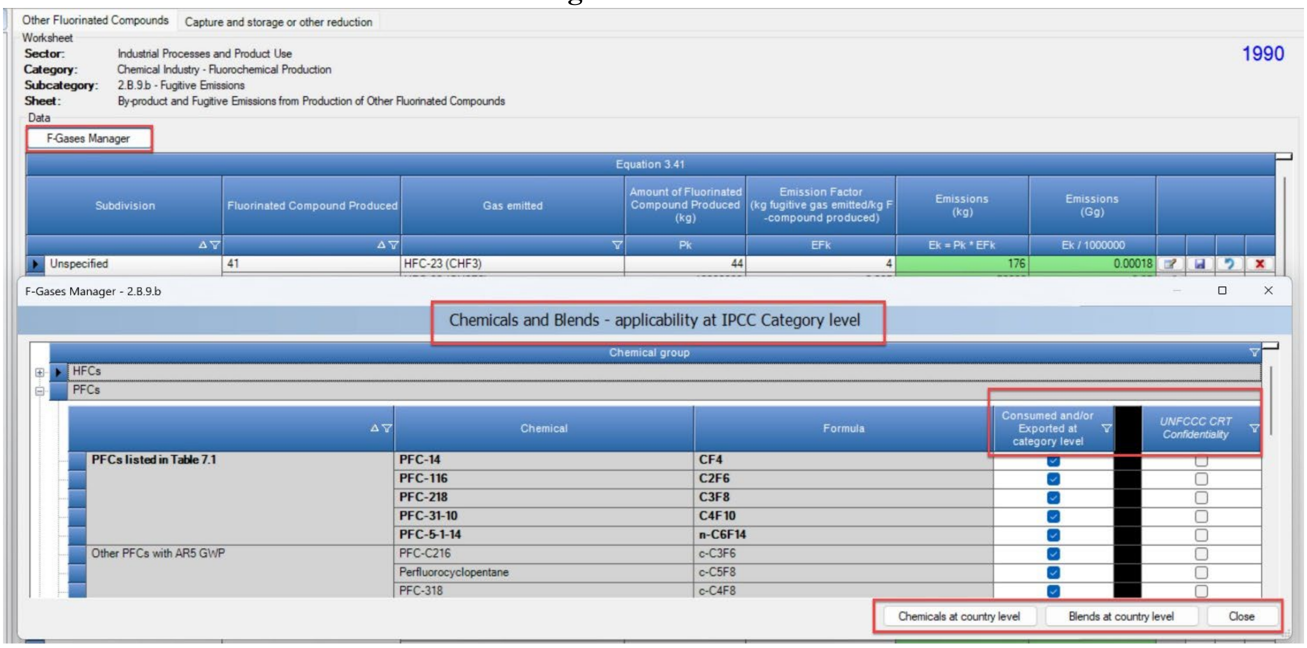
Activity Data Input

Section 3.10.2.2 in 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 **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 more information, refer to populating the F-Gases Manager, in the section above.*

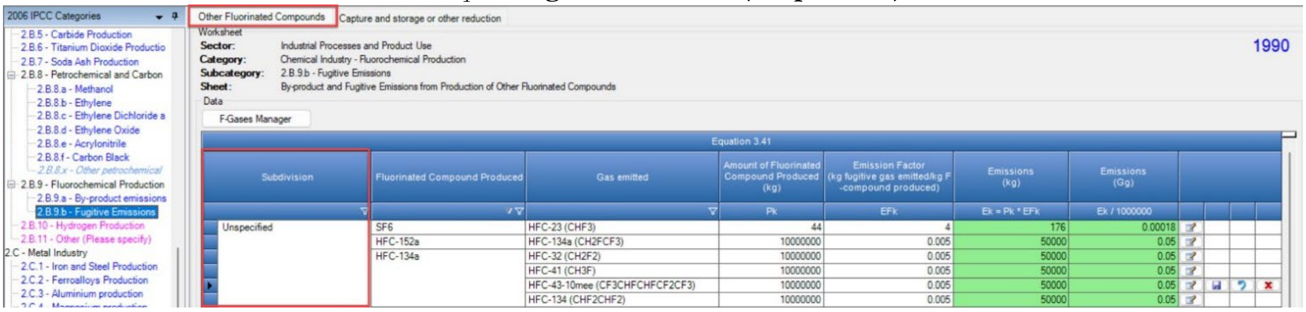
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. If checked, "C" will be reported for AD 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**

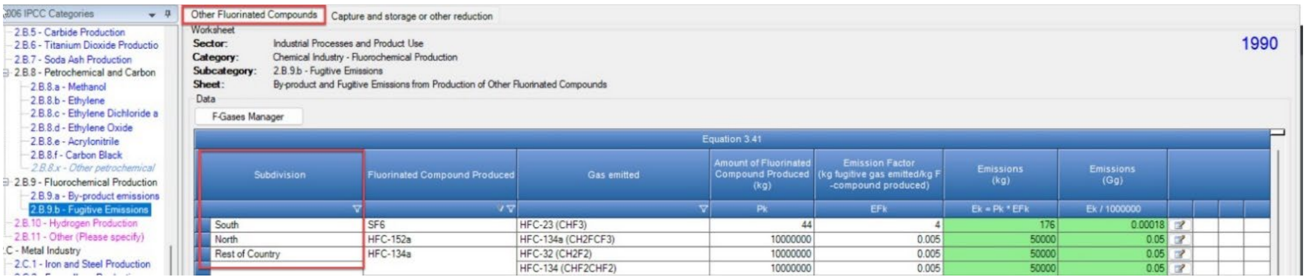


Second, input of AD for Fugitive Emissions requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name"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

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **Other Fluorinated Compounds**, row by row, as follows:

1. Column |Fluorinated compound produced|: Select from the dropdown menu one of the primary identified fluorinated compounds (HFC-134a, SF_6 or NF_3) or directly input the fluorinated compound produced.
2. Column |Gas emitted|: select from the drop-down menu, the gas emitted.
   Note that the selection of gases in the drop-down menu will be consistent with those selected in the IPCC Category level F-Gases Manager.
3. Column |Pk|: input the amount of fluorinated compound produced, in kg.

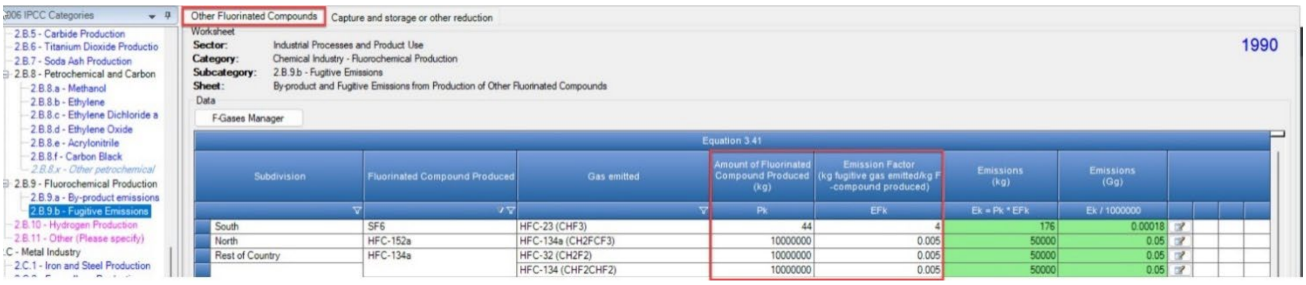
Emission Factors Input

Section 3.10.2.2 in 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 Column |Subdivision|, input data 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 fugitive gas emitted/kg of principal gas produced.

Example: **AD and EFs for fugitive emissions – Tier 1**



Results

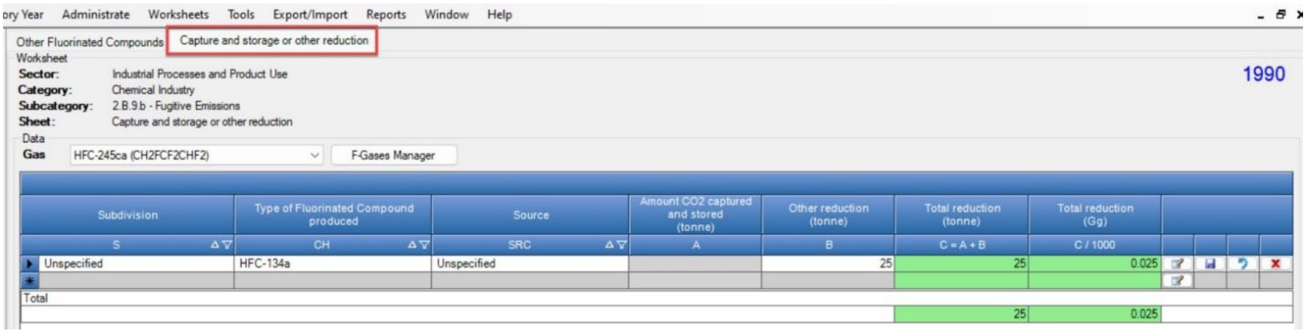
Fugitive emissions from production of other fluorinated compounds are estimated in mass units (kg and Gg) by the *Software* in the worksheet **Other Fluorinated Compounds.**

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 |CH|: select from the drop-down menu, or manually input, the type of fluorinated compound produced and for which the destruction / reduction activity is taking place.
2. Column |SRC|: input any identifying information for the source, if applicable.
3. Column |A|: this column is not applicable for this source category.
4. 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 in 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, AD for the process combustion source are likely to be difficult to obtain, and the literature evidence is insufficient to establish an estimation method. Hence, no methods for CH_4 and N_2O emissions is included in 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 GHGs for the Hydrogen Production source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X				

IPCC Equations

CO₂

- ✓ 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 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 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:** 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.

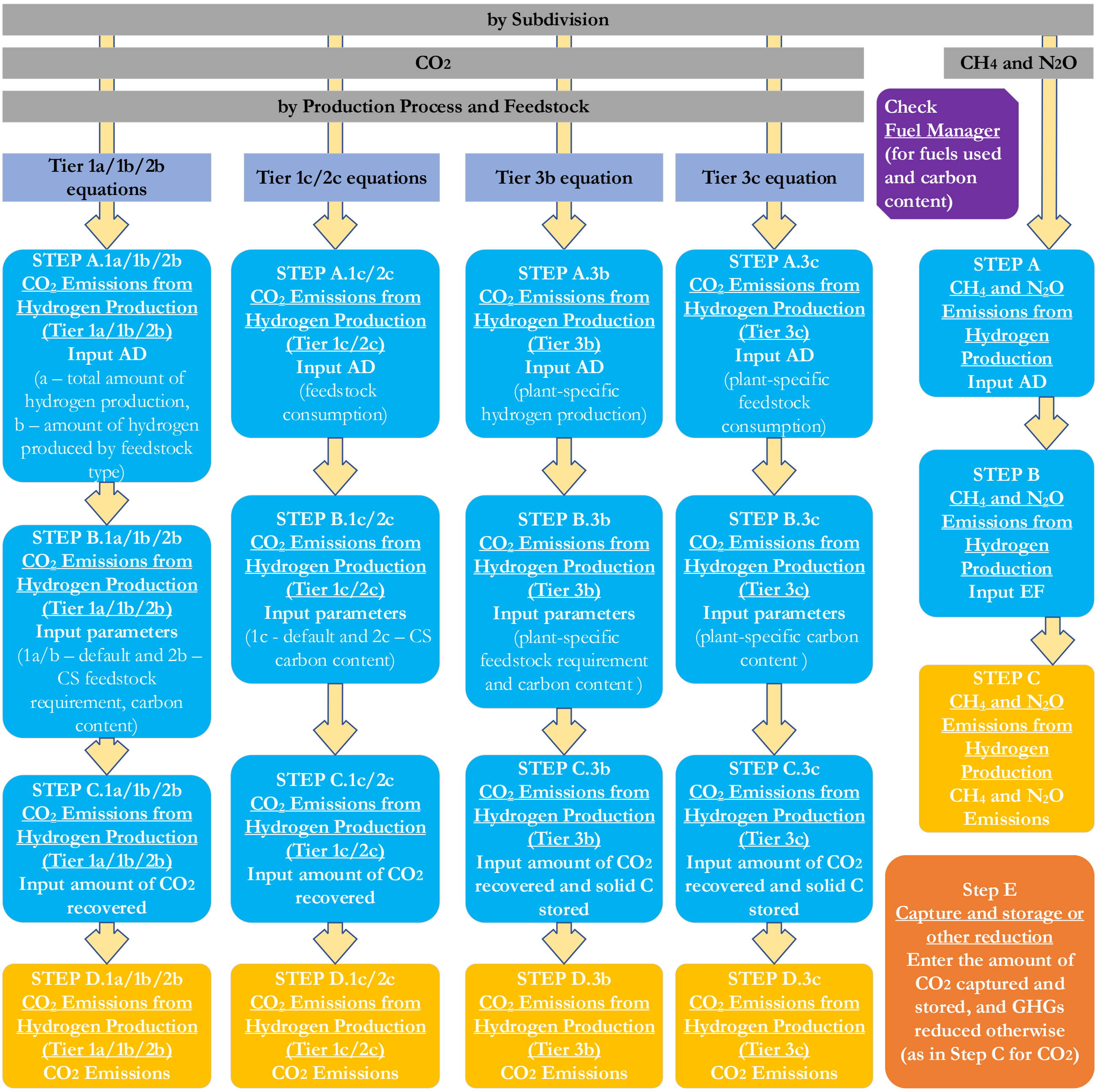
User's Work Flowchart

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 worksheet **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 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 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 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/or Gg). In addition, total CO_2 emissions are calculated.

When Tier 2 Equations are applied:

Step A.2b and A.2c, in worksheet **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 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 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 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/or Gg). In addition, total CO_2 emissions are calculated.

When the Tier 3 Equation is applied:

Step A.3b and A.3c, in worksheet **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 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 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 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/or 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 worksheet **CH_4 and N_2O 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 worksheet **CH_4 and N_2O 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 worksheet **CH_4 and N_2O Emissions from Hydrogen Production,** for each subdivision, CH_4 and N_2O emissions are calculated in Gg.

ii) if there is capture <u>additional to</u> 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.

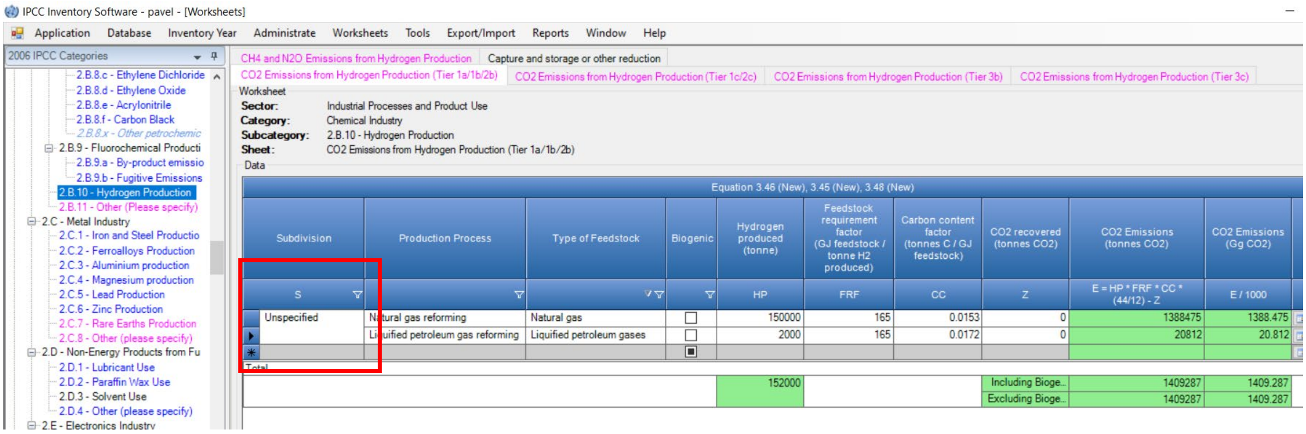
Activity Data Input

Section 3.11.2.3 in Chapter 3 Volume 3 of the *2019 Refinement* contains information on the choice of AD for hydrogen production.

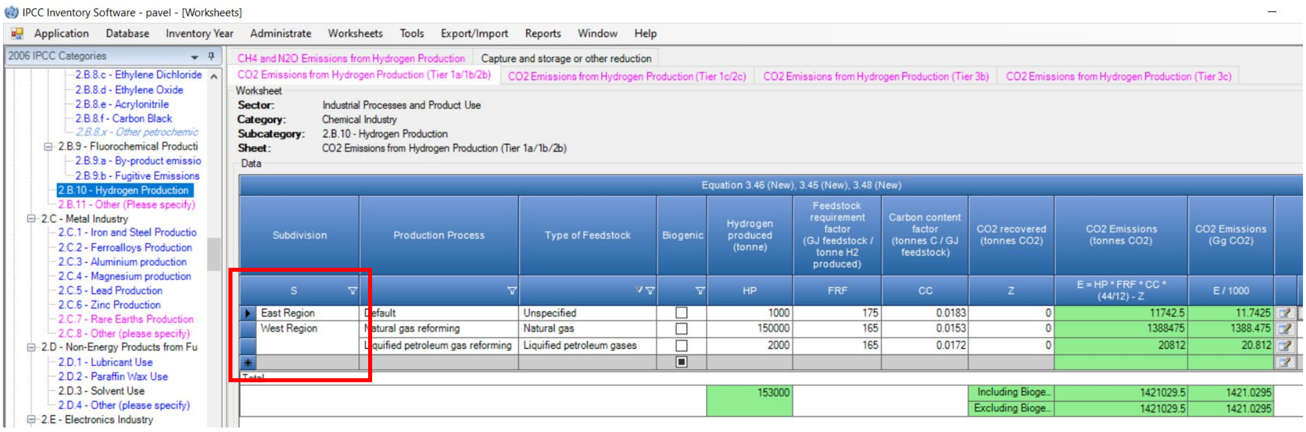
As a **starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for hydrogen production (if the Tier 1c, Tier 2.c, or Tier 3 methods are applied); and for each fuel listed in the Fuel Manager, the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the drop-down menu.

Second, input of AD for the Hydrogen Production requires the user to input 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] or where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**



Then,

When Tier 1 and Tier 2 Equations are applied:

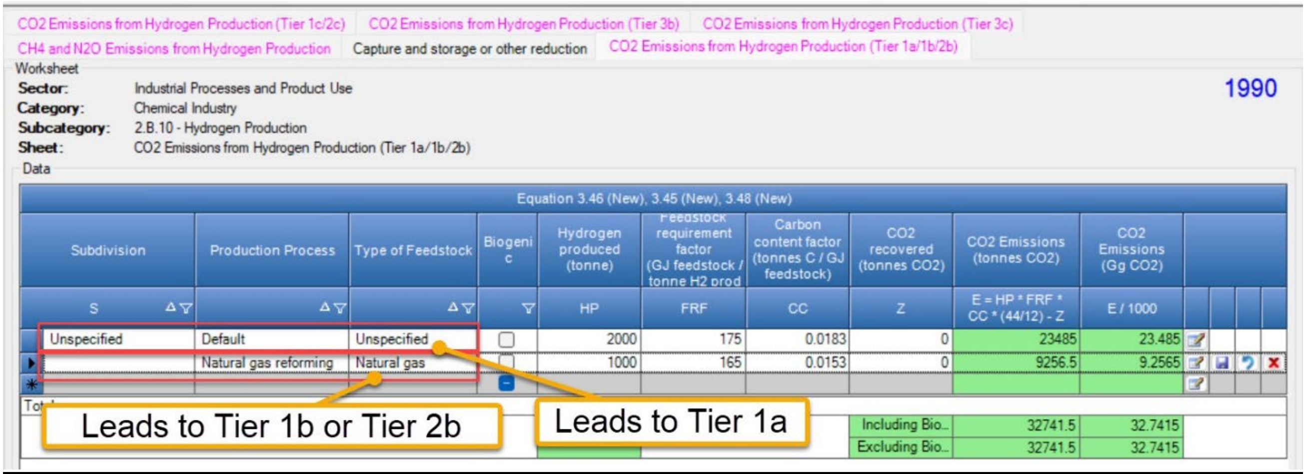
Following a Tier1 or Tier 2 approach, the following AD are entered, depending on the method chosen:

- ✓ 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 |Subdivision|, 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.

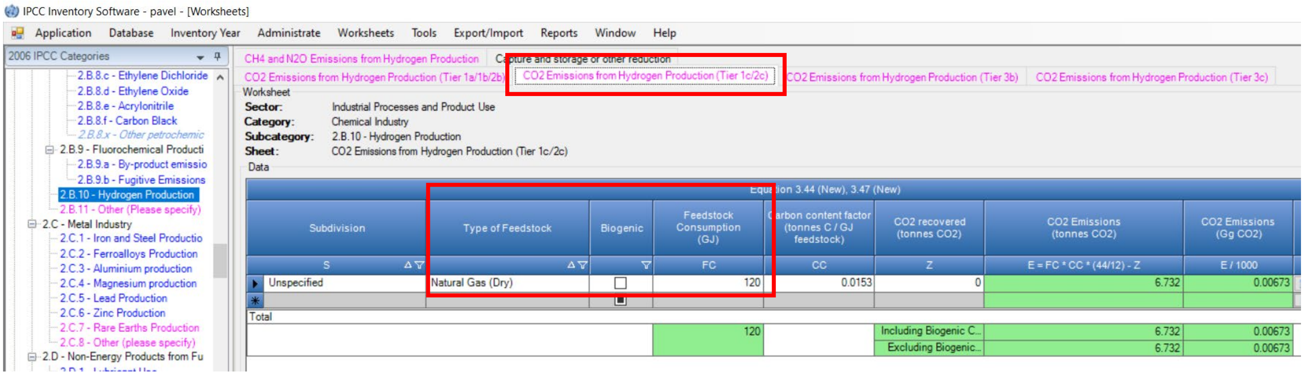
Example: **AD input for Tier 1a/1b /2b Hydrogen Production**



For the Tier 1c and Tier 2c methods: for each subdivision in Column |Subdivision|, 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 from the drop-down menu the relevant fuel used as feedstock (one row for each feedstock).
   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 input in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3b)**, while for Tier 3c data are input in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3c)**.

Emission Factor Input

Section 3.11.2.2 in 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).

The Tier 1 assumes default parameters and no capture of CO_2. For Tier 2, users must collect country-specific parameters and for Tier 3 – plant-specific feedstock requirement and carbon content by process and feedstock types.

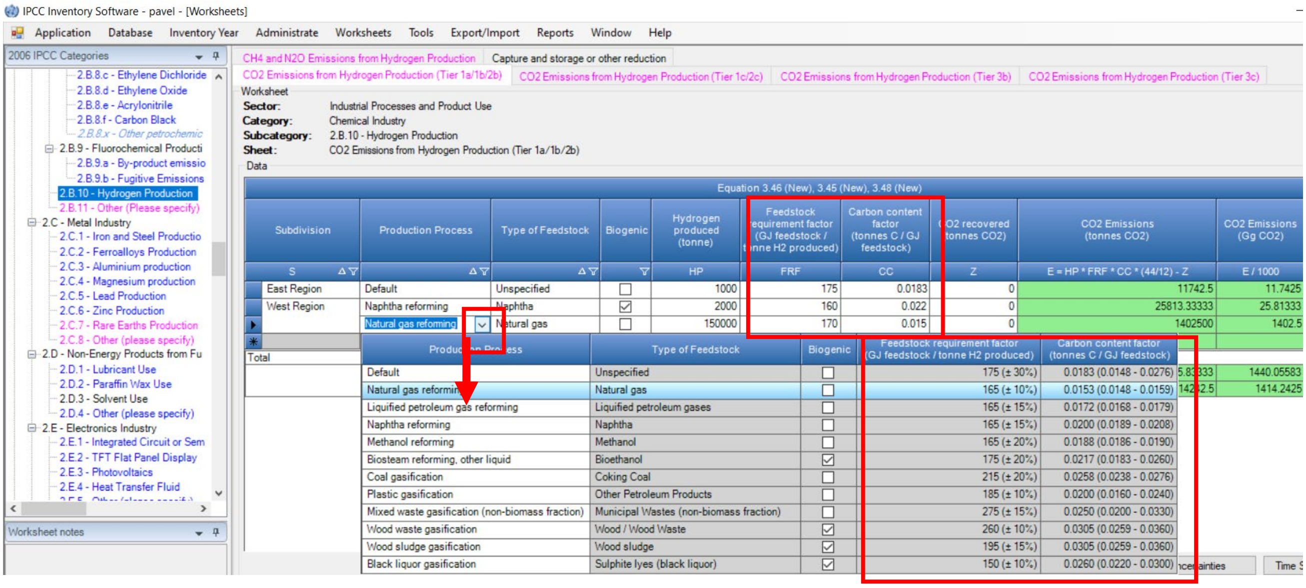
When Tier 1 and Tier 2 Equations are applied:

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 feedstock 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 data for the columns above are automatically populated based on the selection made in Column |Production Process| (default values are visible when the drop-down menu in that column is selected). The user may overwrite these values. 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 input 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:

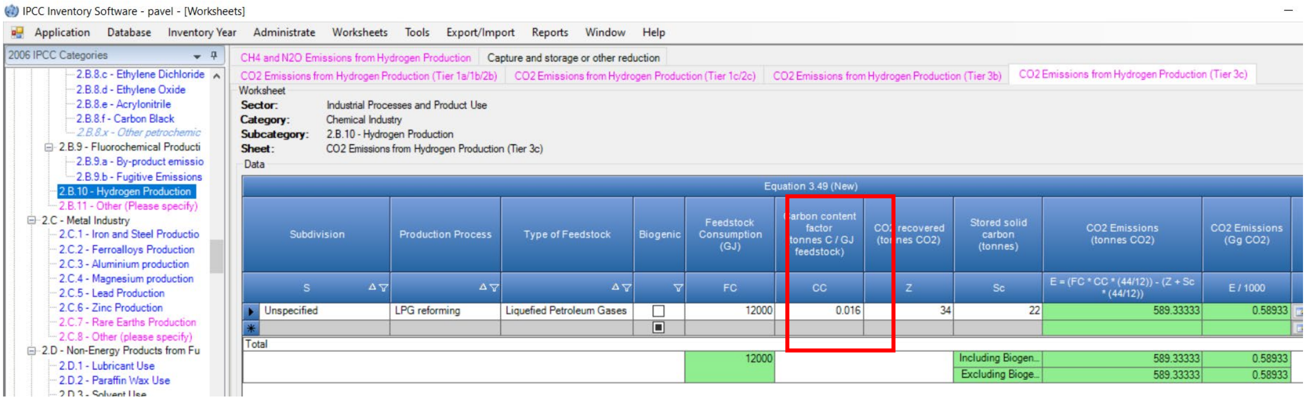
For the Tier 3b method: for each combination of subdivision/production process/type of feedstock, data are input in worksheet **CO_2 Emissions from Hydrogen Production (Tier 3b)**, row by row, as follows.

1. Column |FRF|: input plant-specific feedstock requirement in GJ feedstock 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 input 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 |Subdivision| [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 |Subdivision|.

For each subdivision in Column |Subdivision|, data are input in worksheet **CH_4 and N_2O Emissions from Hydrogen Production**, row by row, as follows:

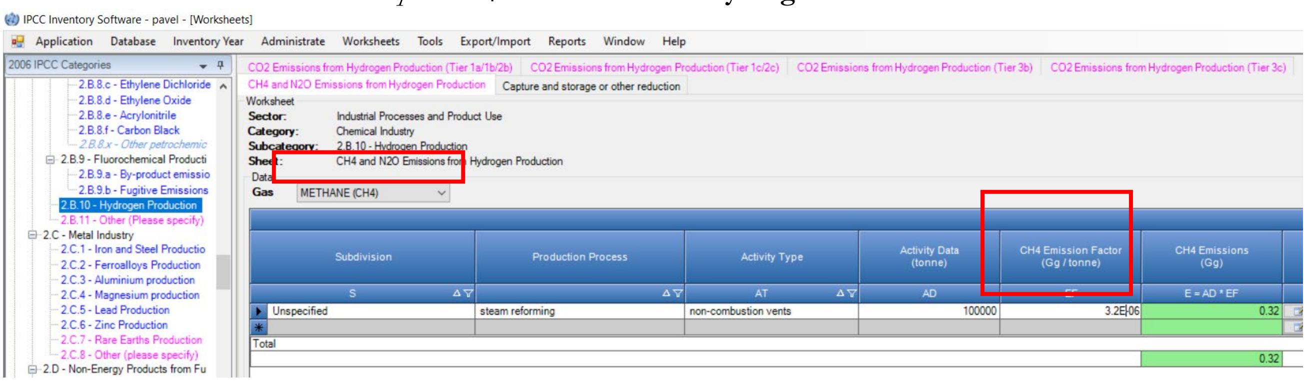
1. Column |Production Process|: describe the type of production process emitting GHG emissions from this category (e.g. consider those identified for estimating CO_2 emissions).
2. Column |AT|: input the activity type corresponding to the production process identified.
3. Column |AD|: input AD (quantity), in tonnes.

Emission Factor Input

For each row of data entered in worksheet **CH_4 and N_2O Emissions from Hydrogen Production**, data are input as follows:

1. Column |EF|: input 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)).

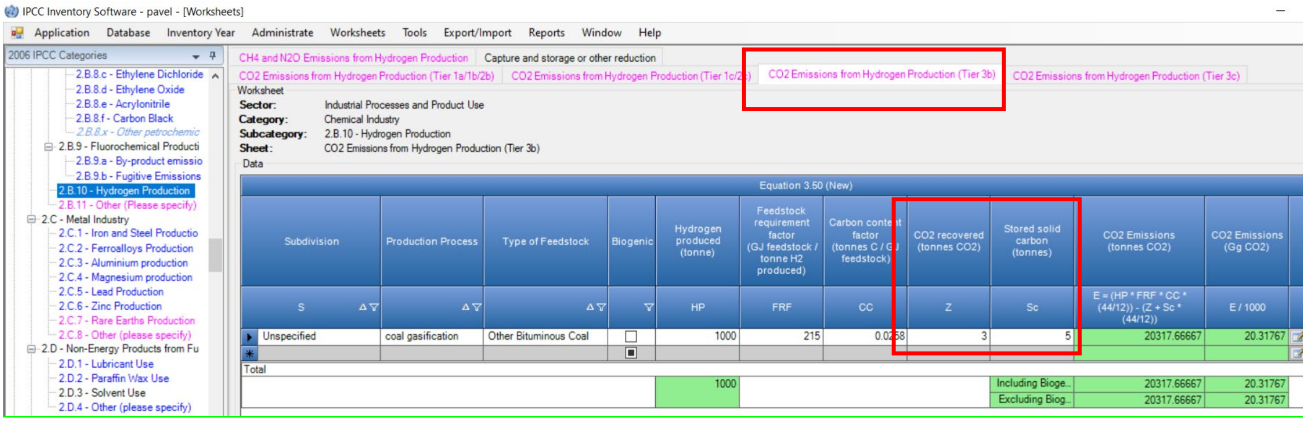
To estimate the total CO_2 emitted into the atmosphere, the amount of CO_2 released from that subdivision that has been instead recovered is to be entered in Gg CO_2 in Column |Z| of the following worksheets:

- ✓ **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:

- ✓ **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 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)**

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**.

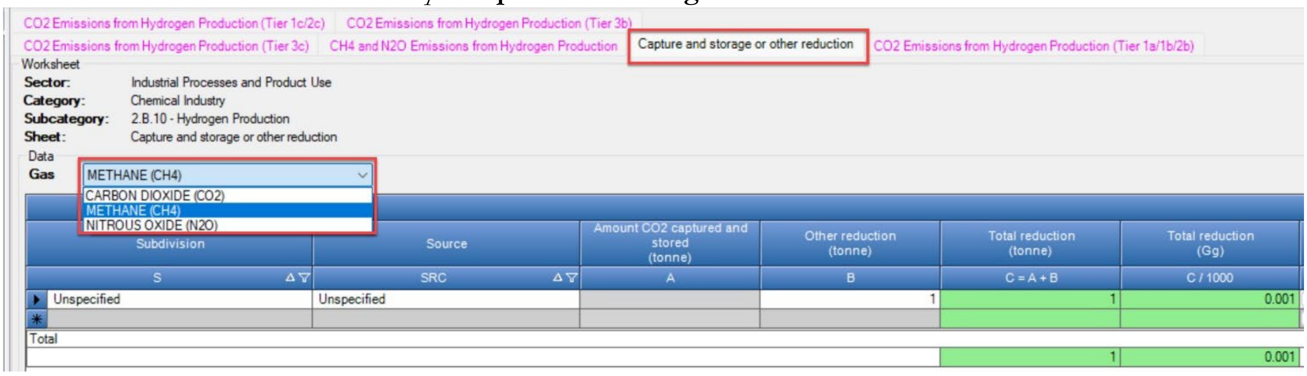
Total emissions from hydrogen production is the sum of all emissions in the above worksheets, taking into account any CO_2 capture with subsequent storage and any other reduction of CO_2, CH_4 and N_2O.

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. <u>Column |SRC|</u>: 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> collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO_2 (e.g., re-conversion to carbonates), in tonnes. <u>Column |B|</u> 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. <u>Column |Biogenic|</u>: indicate with a check if the reductant is of biogenic origin. *<u>Note that</u> consistent with 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 CRT 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.

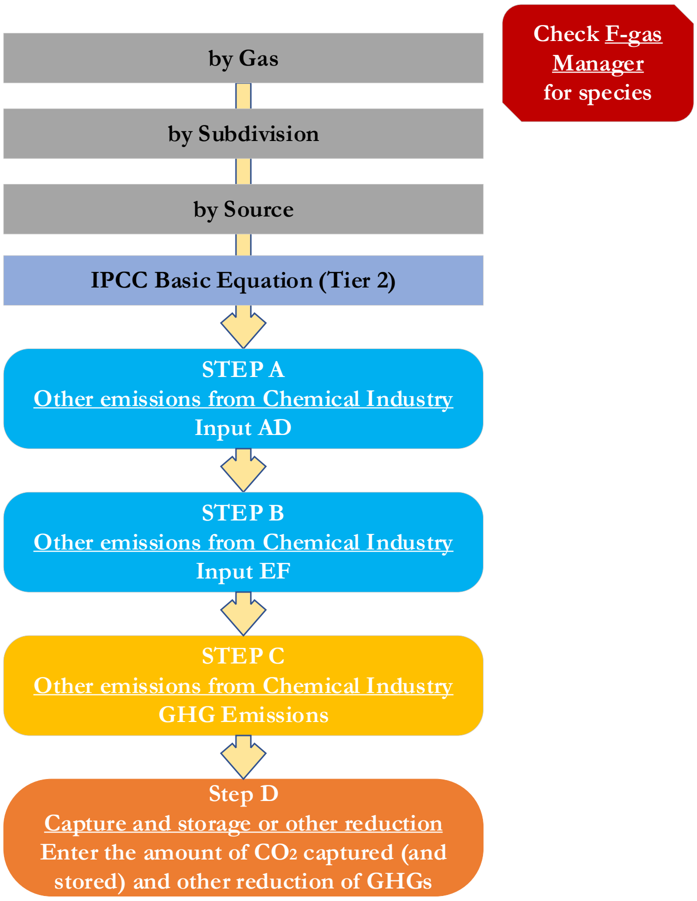
User's Work Flowchart

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. For more information on populating the F-Gases Manager, refer to section above.

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 worksheet **Other**, users collect and input data on the source of emissions and AD.

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

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

Step D, in 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.

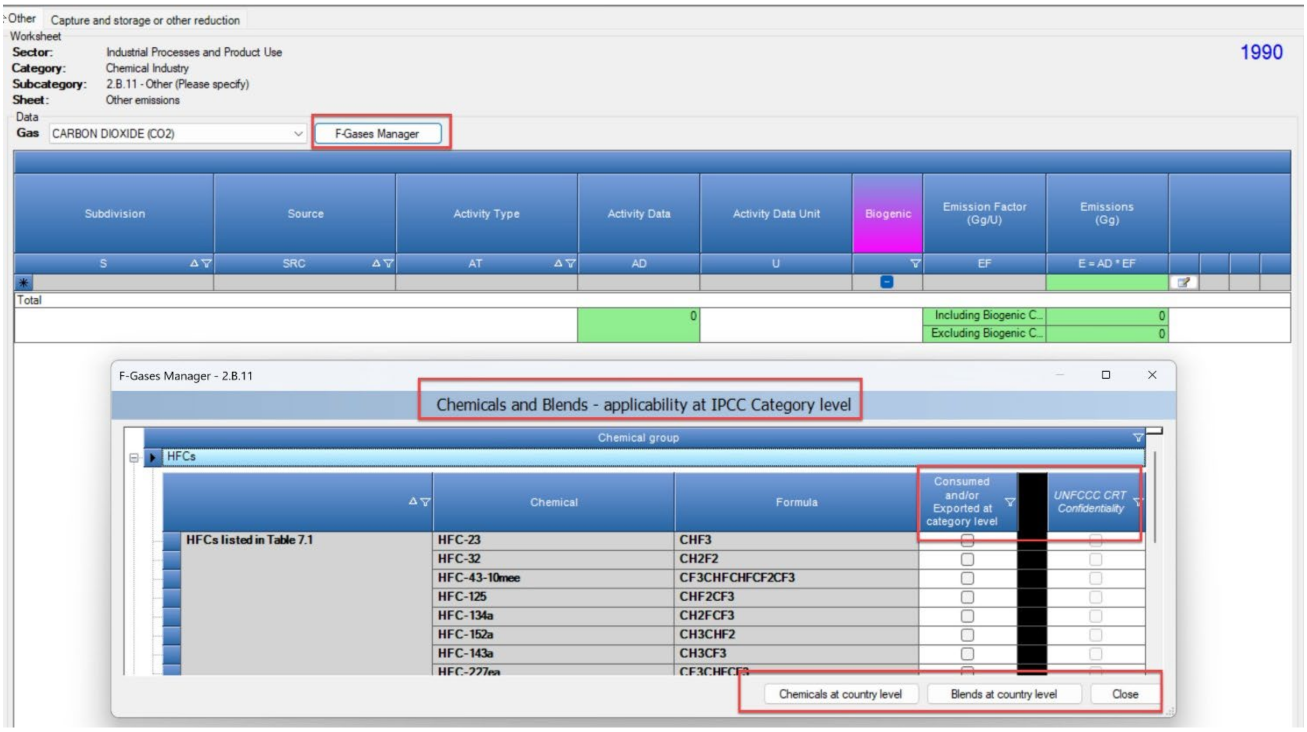
Activity Data Input

As a **starting step**, if the source to be entered results in emission of F-gases, users must ensure that the **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 more information on populating the F-Gases Manager, refer to section above.*

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 Other (Chemical industry) 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], or with subnational aggregations, and for each of those the univocal name/code entered in Column |Subdivision|.

For each subdivision in Column |Subdivision|, 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. 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.
2. Column |AT|: input the activity type corresponding to the source selected.
3. Column |AD|: input AD (quantity), in units corresponding to the unit type in in Column |U|.
4. Column |U|: input the user-defined unit of the AD.

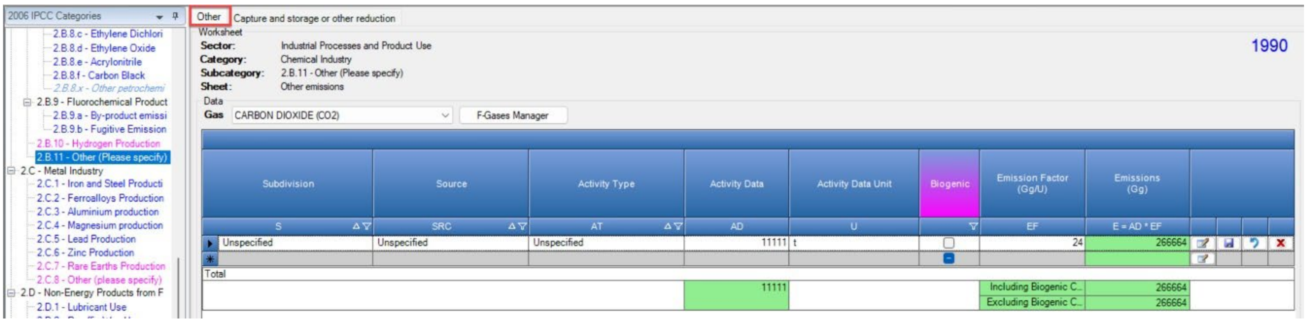
5. Column |Biogenic| (CO_2 only): indicate with a check, and if applicable, if the process feedstock is of biogenic origin.

Emission Factor Input

For each subdivision/source, input information in worksheet **Other**, row by row, as follows:

1. Column |EF|: input 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**



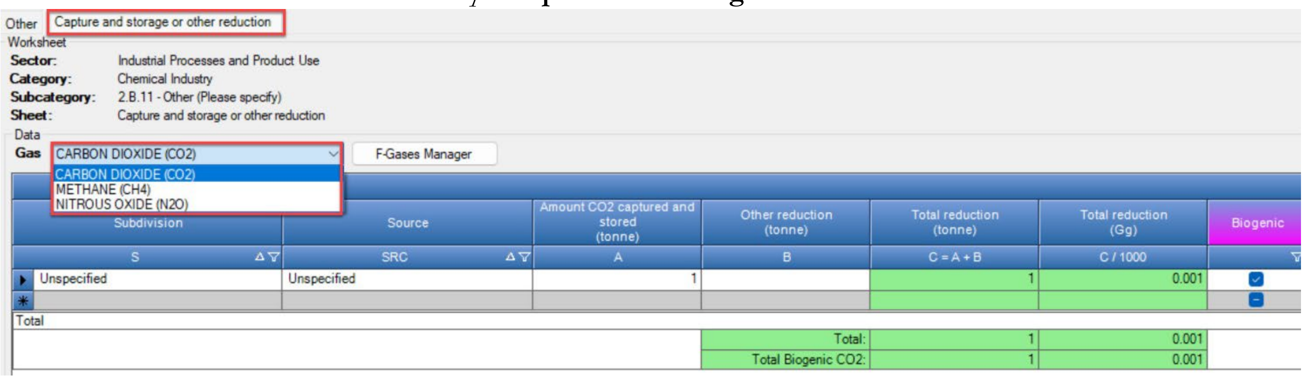
Results

Total GHG emissions from Other (Chemical Industry) 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|: 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 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

Information

Section 4.2 in the *2006 IPCC Guidelines* provides 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 estimation of CO_2 emissions 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.

For CH_4, a tier 1 method based on national production data and default EFs is available, as well as a Tier 3 method using plant-specific data.

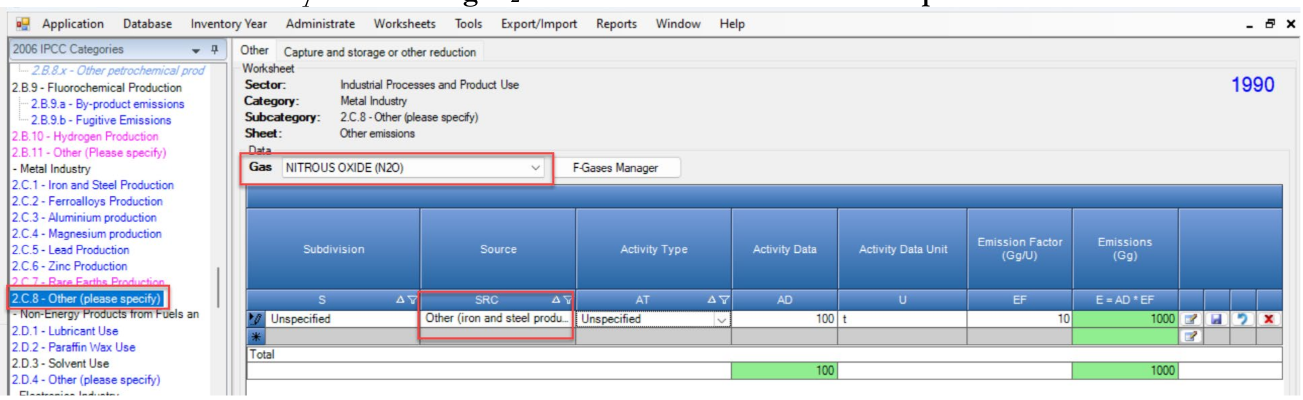
GHGs

The *Software* includes the following GHGs for the Iron and Steel Production source category (including coke production):

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**



IPCC Equations

Coke Production Emissions are estimated in the iron and steel production source category and reported in the Energy sector. References are from the *2006 IPCC Guidelines* and the *2019 Refinement*:

- ✓ Tier 1 (CO_2, CH_4): Equation 4.1 or, for CO_2 only, 4.1B (New)
- ✓ Tier 2 (CO_2): Equation 4.2 (Updated)
- ✓ Tier 3 (CO_2, CH_4): Either measure emissions or, for CO_2 only, apply the Tier 2 equations, using plant-specific carbon contents of all materials used and produced

Iron and Steel Production (*2006 IPCC Guidelines*):

- ✓ Tier 1 (CO_2): Equations 4.4, 4.5, 4.6, 4.7 and 4.8
- ✓ Tier 1 (CH_4): Equations 4.12, 4.13 and 4.14
- ✓ 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.

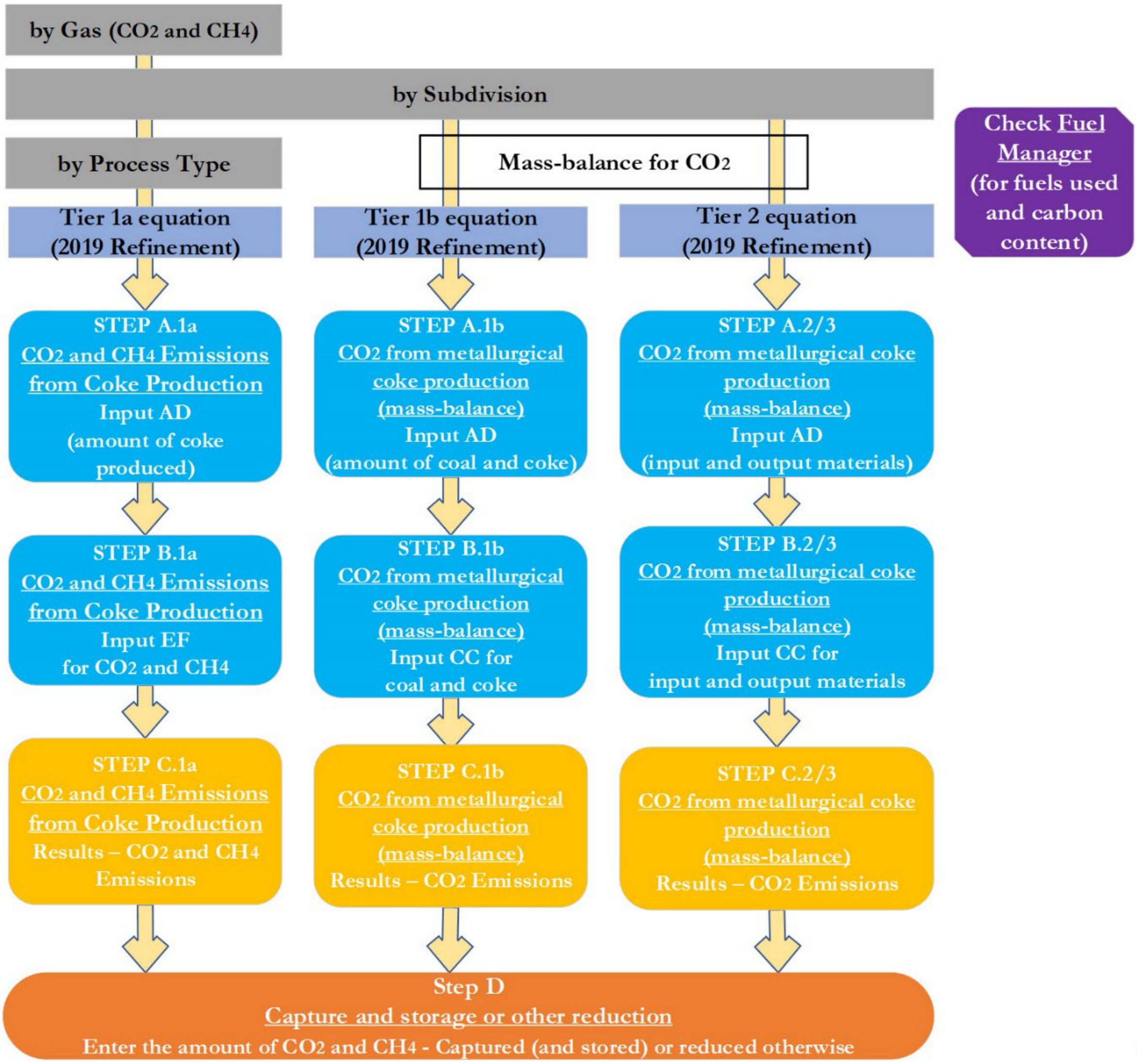
Similarly, consistent with the key category analysis and the decision trees in Figure 4.7 for CO_2 and Figure 4.8 for CH_4 of the *2006 IPCC Guidelines,* GHG estimates are calculated for Iron and Steel Production.

[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, users follow the following two flowcharts to estimate GHG emissions for Coke Production and Iron and Steel Production.

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 worksheet **CO_2 and CH_4 Emissions from Coke Production**, users collect and input in the *Software* information on the amount of coke produced.

Step B.1a, in worksheet **CO_2 and CH_4 Emissions from Coke Production** users input CO_2 and CH_4 EFs.

Step C.1a in 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 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 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 and coke.

Step C.1b in 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 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.

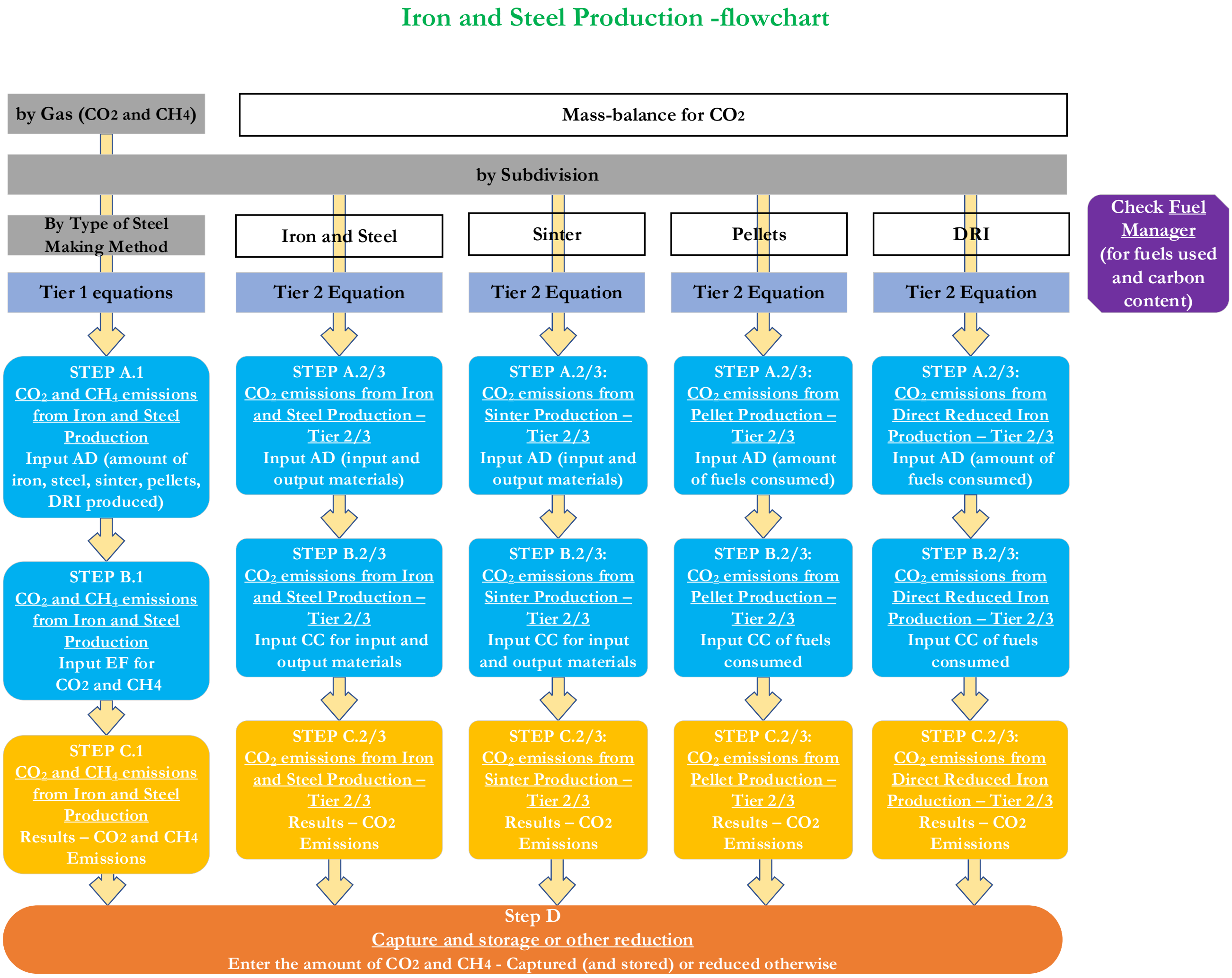
Step B.2/3, in worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, users input carbon content of each input and output material. National statistics are appropriate for the Tier 2 method; for Tier 3 plant-level carbon content information is required.

Step C.2/3, in 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



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 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 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 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 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 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 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 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 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 (tonnes 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.

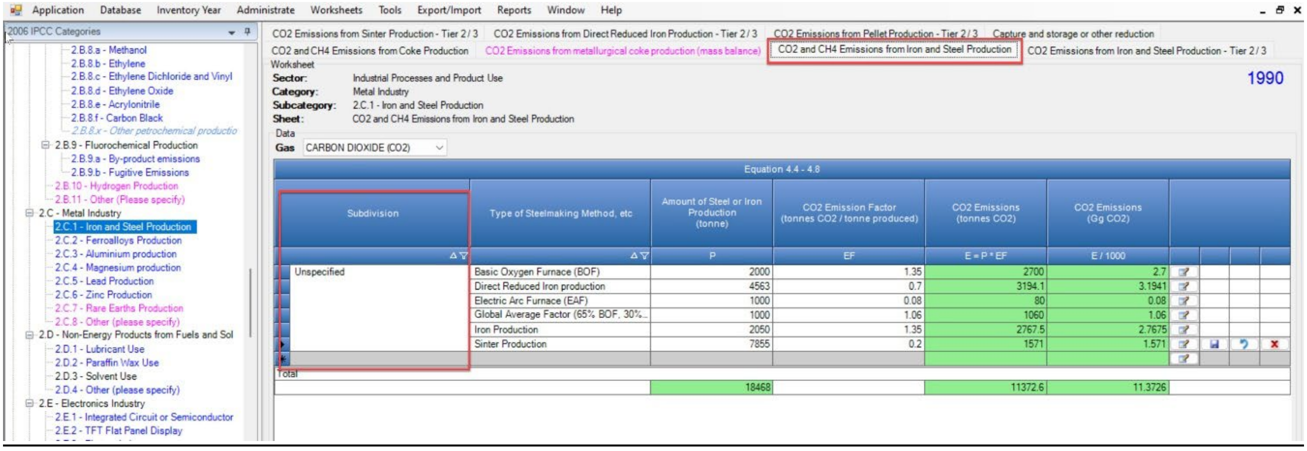
Activity Data Input

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, in Volume 3 of the *2006 IPCC Guidelines*, as well as Box 1.1 in Chapter 1 of Volume 3.

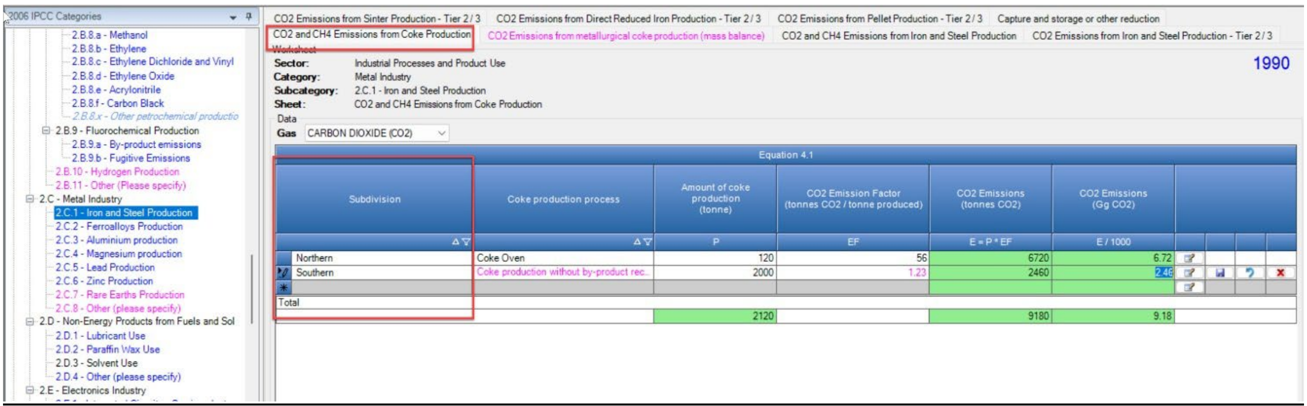
As a **starting step**, users ensure that the **Fuel Manager** contains all fuels to be reported for coke production and iron and steel production (Tier 1b (coke production only), Tier 2 and Tier 3); and for each fuel listed in the Fuel Manager, the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from the drop-down menu.
Second, input of AD for Iron and Steel Production 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

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 source 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**



Example: **multiple subdivisions – coke production**



<u>Then, for Coke Production</u>

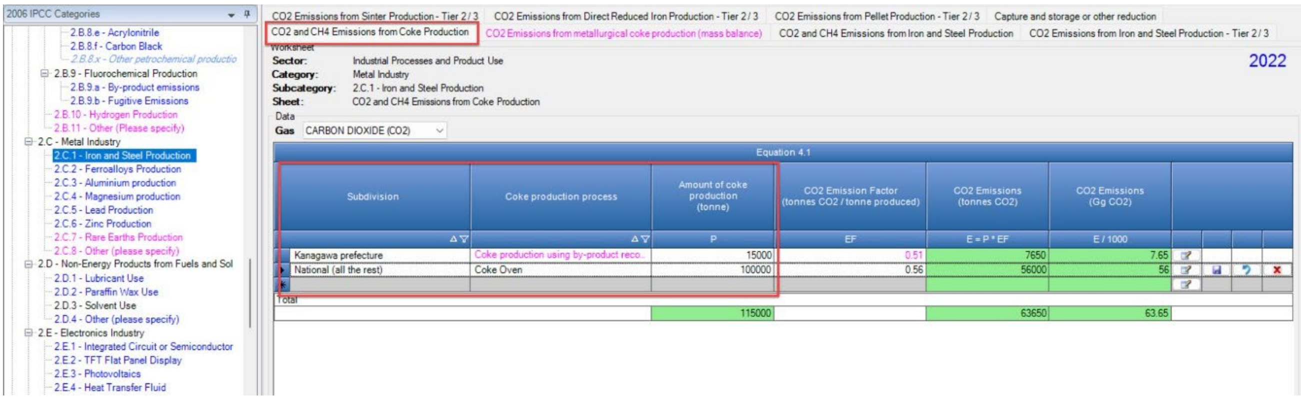
When Tier 1 Equations are applied:

For each subdivision in <u>Column |Subdivision|</u>, data are input 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, as described below.

When the Tier 2 Equation is applied:

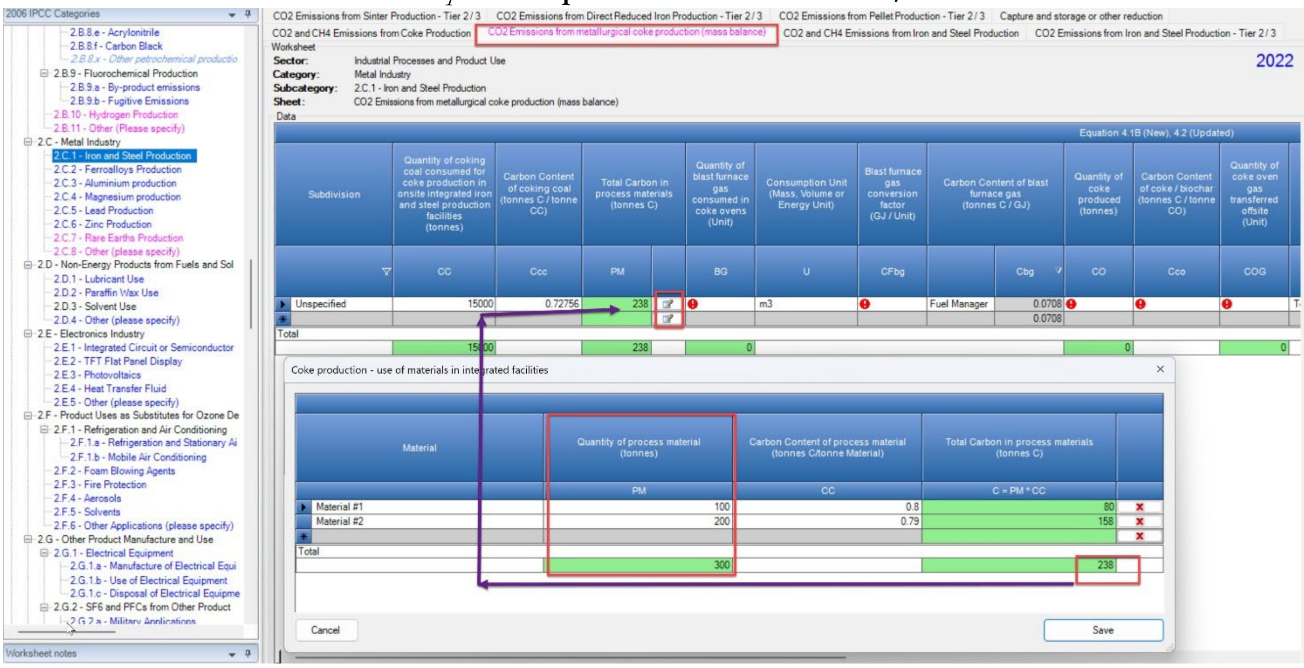
For each subdivision in Column |Subdivision|, data are entered in worksheet **CO₂ Emissions from metallurgical coke production (mass balance),** row by row, as follows, recalling that national statistics are appropriate for a Tier 2 method, while plant-specific data are required for Tier 3.

The mass balance method requires information on input and output materials as follows:

Input materials

1. Column |CC|: input the amount/mass of coking coal consumed for coke production, in tonnes.
2. Column |PM|: this information is input through selection of the sub-table associated with Column |PM|. Select the edit box and input information for:
   a. Column |Material|: select from the drop-down menu the fuel material used (taken from the Fuel Manager)
   b. Column |PM|: input the amount of process materials used for coke production, in tonnes.
3. Column |BG|: input the amount/mass blast furnace gas consumed in coke ovens, using the unit input by the user in Column |U|.
4. Column |U|: input the unit of the blast furnace gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
5. Column |CFbg|: input 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, using the unit input by the user in Column |U|.
8. Column |U|: input the unit of the coke oven gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
9. Column |CFcog|: input a 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.
10. Column |BPC|: this information is input through selection of the sub-table associated with Column |BPC|. Select the edit box and input information for:
    a. Column |By-product|: directly input the by-product produced.
    b. Column |COB|: input the amount coke oven by-product transferred offsite, in tonnes.

Then, for Iron and Steel Production

When Tier 1 Equations are applied:

For each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 and CH_4 emissions from Iron and Steel Production,** row by row:

1. Column |Type of Steel Making Method, etc|: select 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 input 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 input row by row, as follows:

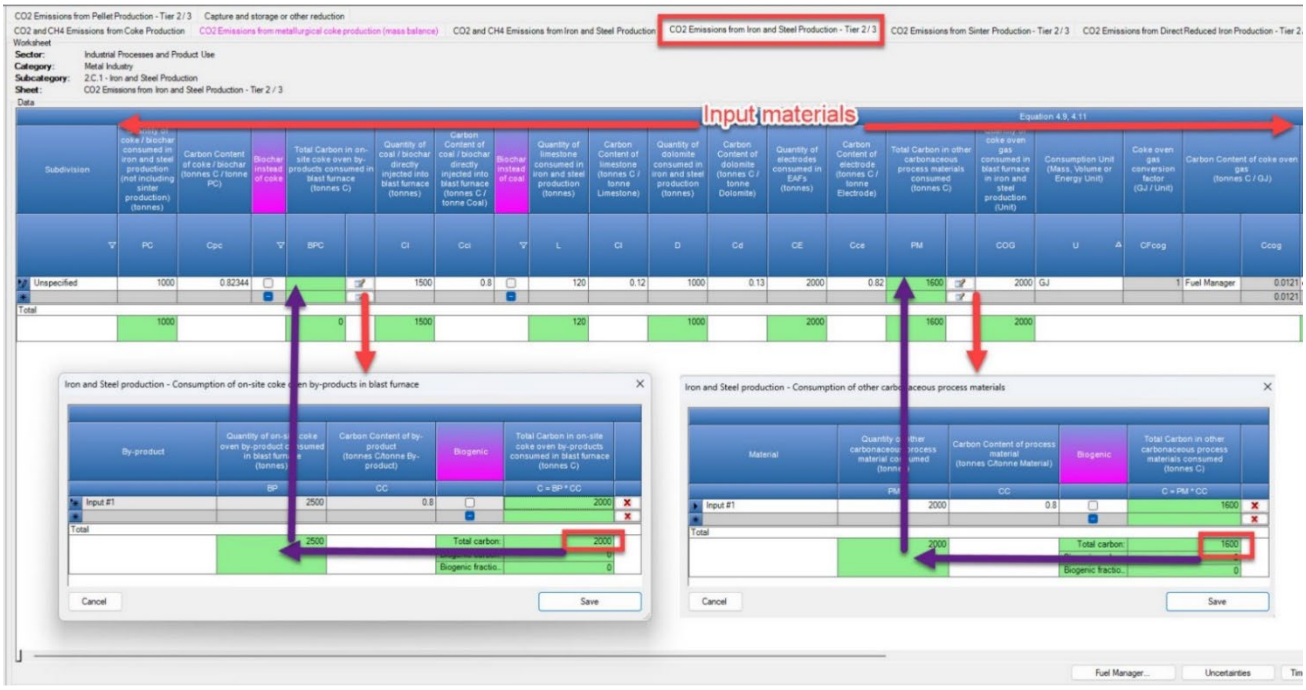
Input materials

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|: this information is input through selection of the sub-table associated with Column |BPC|. Select the edit box and input information for:
    a. Column |By-product|: directly input the by-product produced.
    b. Column |COB|: input the amount of on-site coke oven by-product consumed in the blast furnace, in tonnes.
4. Column |CI|: input the quantity of coal directly injected into the blast furnace, in tonnes.
5. Column |Biochar instead of coal|: check if biochar is used instead of coal.
6. Column |L|: input the quantity of limestone consumed in iron and steel production, in tonnes.
7. Column |D|: input the quantity of dolomite consumed in iron and steel production, in tonnes.
8. Column |CE|: input the quantity of carbon electrodes consumed in EAFs, in tonnes.
9. Column |PM|: this information is input through selection of the sub-table associated with Column |PM|. Select the edit box and input information for:
    a. Column |Material|: select from the drop-down menu the fuel material used (taken from the Fuel Manager).
    b. Column |PM|: input the quantity of other carbonaceous process materials consumed, in tonnes.
10. Column |COG|: input the quantity of coke oven gas consumed in the blast furnace, using the unit input by the user in Column |U|.
11. Column |U|: input the unit of the coke oven gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
12. 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.

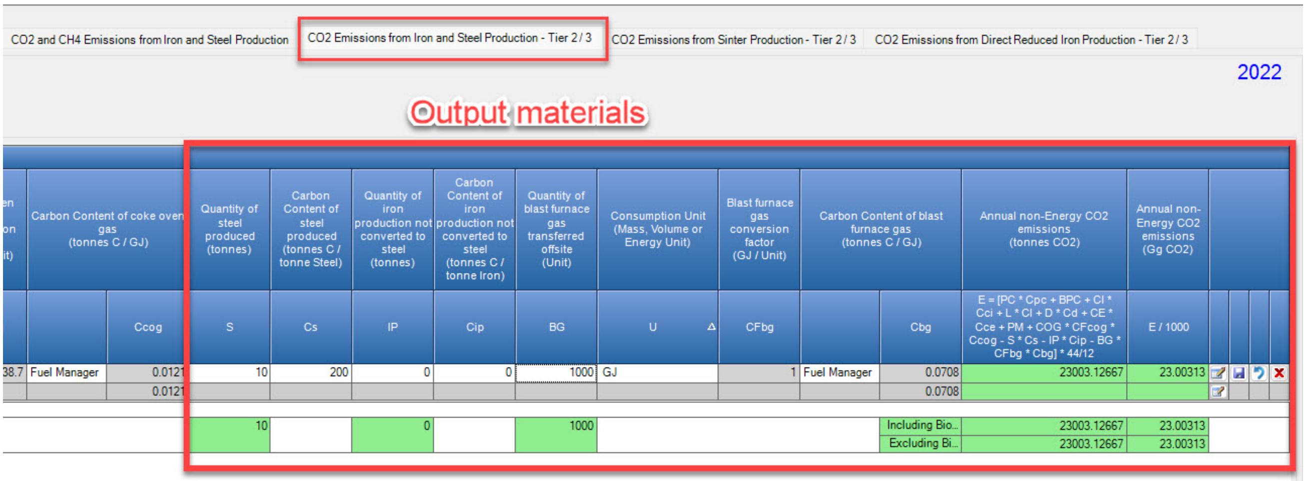
Output Materials

13. Column |S|: input the quantity of steel produced, in tonnes.
14. Column |IP|: input the quantity of iron production not converted to steel, in tonnes.
15. Column |BG|: input the quantity of blast furnace gas transferred offsite, using the unit input by the user in Column |U|.
16. Column |U|: input the unit of the blast furnace gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
17. Column |CFbg|: input 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 input row by row, as follows, and as applicable:

Input Materials

1. Column |CBR|: input the quantity of coke breeze/biochar purchased and produced onsite for sinter production, in tonnes.
2. Column |Biochar instead of coke breeze|: check if biochar is used instead of coke breeze for sinter production. By default, this column is unchecked.
3. Column |COG|: input the quantity of coke oven gas consumed in the blast furnace for sinter production, using the unit input by the user in Column |U|.

4. Column |U|: input the unit of the coke oven gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
5. Column |CFcog|: input 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|: input the quantity of blast furnace gas consumed in sinter production, using the unit input by the user in Column |U|.
7. Column |U|: input the unit of the blast furnace gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
8. Column |CFbg|: input 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|: this information is input through selection of the sub-table associated with Column |OPM|. Select the edit box and input information for:
   a. Column |Material|: select from the drop-down menu the fuel material used (taken from the Fuel Manager).
   b. Column |OPM|: input the quantity of other process materials consumed, in tonnes.

Output Materials

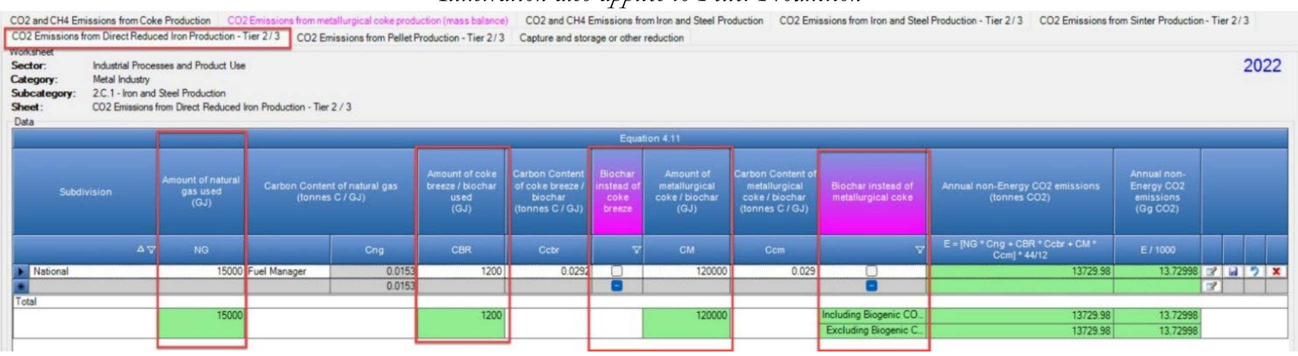
10. Column |SOG|: input the quantity of sinter off gas transferred offsite either to iron and steel production facilities or other facilities, using the unit input by the user in Column |U|.
11. Column |U|: input the unit of the sinter off gas entered (e.g. Gg, TJ, m^3, tonne), or manually input a user-specific unit (e.g. BTUs).
12. Column |CFsog|: input 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 input 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:

- ✓ Tier 1 EFs for CO_2 (Table 4.1), and, additionally for coke production, Table 4.1 (Updated)
- ✓ Tier 1 EFs for CH_4 (Table 4.2)
- ✓ Tier 2/3 EFs for CO_2 – carbon content of materials/fuels (Table 4.3)

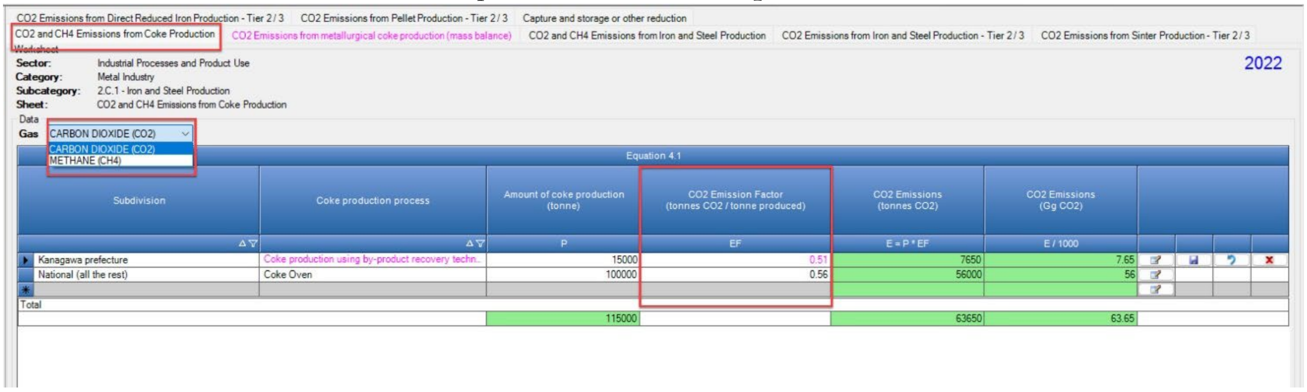
Then, for Coke Production

When Tier 1 Equations are applied:

For each combination of subdivision/coke production process data are input in worksheet **CO_2 and CH_4 Emissions from Coke Production**, row by row, as follows:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or input 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**



Alternatively, where data are input following the simplified Tier 1b method, for each subdivision in worksheet **CO_2 Emissions from metallurgical coke production (mass balance)**, data are input row by row, as follows:

1. Column |Ccc|: select from the drop-down menu the carbon content for coking coal taken from the **Fuel Manager** or input a user-specific value, in tonnes C/tonne coking coal.
2. Column |Cco|: select from the drop-down menu the carbon content for coke or input 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 input 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 **Fuel Manager** or input a user-specific value, in tonnes C/tonne coking coal.
2. Column |PM|: select the edit box to open the sub-table associated with Column |PM|. In Column |CC| input the carbon content of each process material selected, in tonnes C/tonne material.

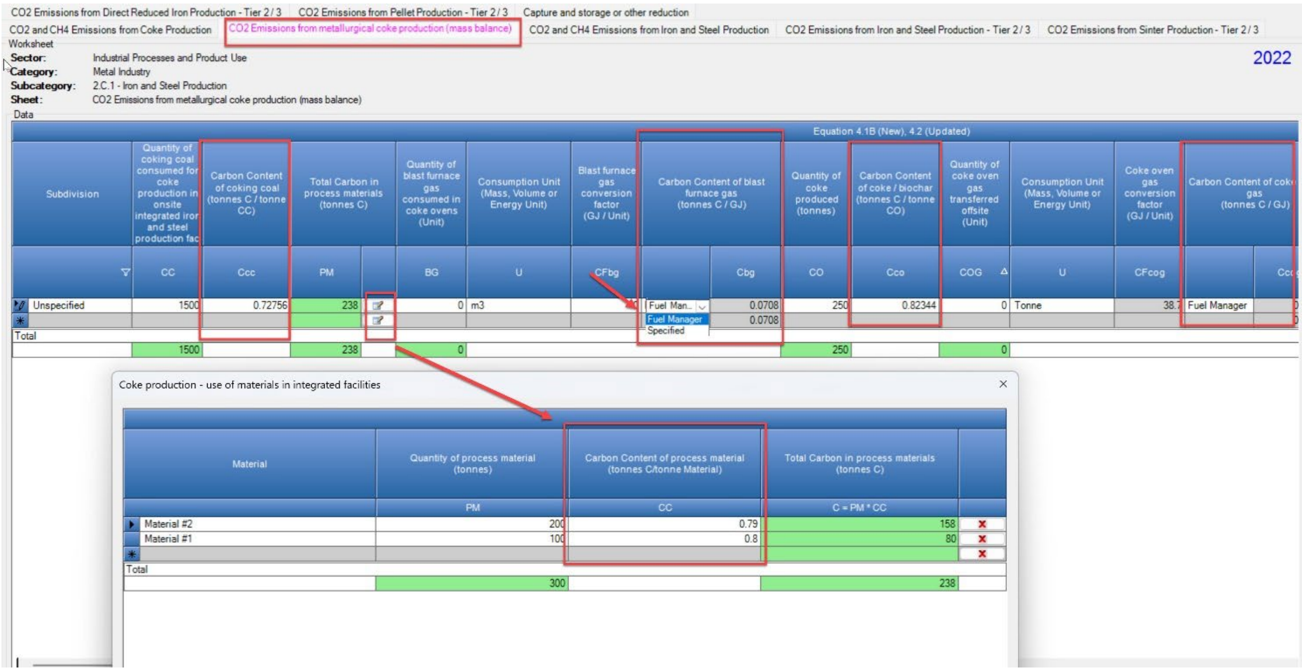
3. Column |Cbg|: indicate whether the carbon content for blast furnace gas shall be taken from the Fuel Manager or specified. Where the carbon content is taken from the *Fuel Manager*, the value will automatically appear in the gray-colored cell. Where *Specified*, the cell becomes white and the user must 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 **Fuel Manager** or input 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 must 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

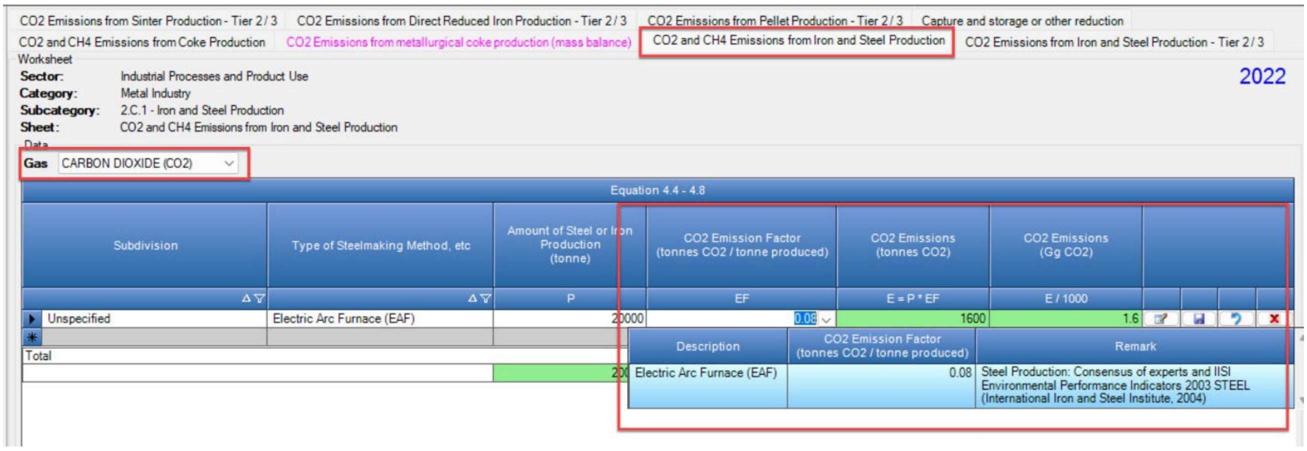
When Tier 1 Equations are applied:

For each combination of subdivision/ type of steelmaking method, etc in worksheet **CO_2 and CH_4 Emissions from Iron and Steel Production** data are input, row by row, as follows:

1. Column |EF|: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in 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 data are input, row by row, as follows:

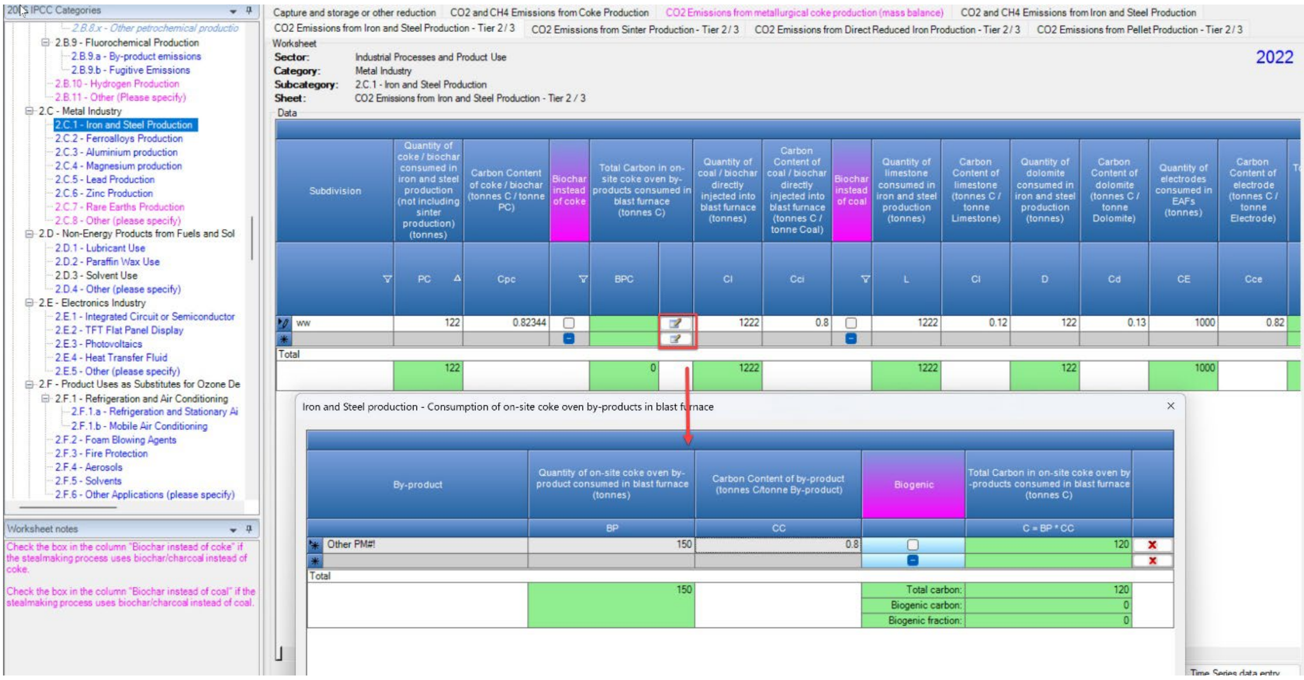
Note that default carbon contents should be used only if an inventory compiler does not have information on conditions in iron and steel-making facilities but has detailed AD for the process materials and offsite transfers.

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|: select the edit box to open the sub-table associated with Column |BPC|. In Column |CC| input the carbon content of each by-product selected, in tonnes C/tonne by-product.
3. Column |CCi|: input the carbon content of coal/biochar directly injected into the blast furnace, or enter a user-specific value, in tonnes C/tonne coal/biochar.
4. Column |Cl|: input the carbon content of limestone, in tonnes C/tonne limestone.
5. Column |Cd|: input the carbon content of dolomite, in tonnes C/tonne dolomite.
6. Column |Cce|: input the carbon content of electrodes, in tonnes C/tonne electrode.
7. Column |PM|: select the edit box to open the sub-table associated with Column |PM|. In Column |CC| input the carbon content of each material selected, in tonnes C/tonne material.
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 must 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|: input the carbon content of steel, in tonnes C/tonne steel.
10. Column |Cip|: input the carbon content of iron production not converted to steel, 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 must 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,** data are input, as applicable, row by row, as follows:

1. Column |Ccbr|: input the carbon content of coke breeze/ biochar, in tonnes C/tonne coke breeze or biochar, in tonnes.
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 must 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 must 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|: select the edit box to open the sub-table associated with Column |OPM|. In Column |CC| input the carbon content of each material selected, in tonnes C/tonne material.
4. Column |Csog|: input the carbon content of sinter off-gas, in tonnes C/unit (as indicated in Column |U|).

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,** data are input, as applicable, row by row, as follows:

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 must 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|: input the carbon content of coke breeze/biochar, in tonnes C/GJ coke breeze or biochar.

3. Column |Ccm|: input the carbon content of metallurgical coke/biochar, in tonnes C/GJ 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 are reported in the Energy sector (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**

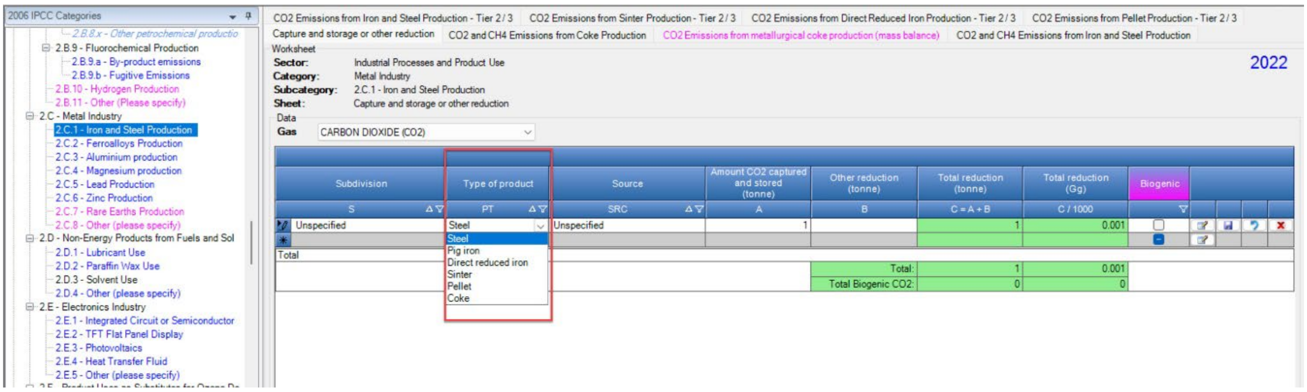
For both coke production and iron and steel production, where the user has indicated use of biochar in production in the *Software*, CO_2 emissions are totalled including and excluding biogenic CO_2.

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 |PT|: select from the drop-down menu the category where capture/reduction is taking place (e.g. steel, coke, etc).
2. Column |SRC|: 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).
3. Column |A|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
4. Column |B|: 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.*
5. Column |Biogenic|: indicate with a check if the reducing agent/fuel is of biogenic origin. *Note that consistent with 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

Section 4.3 in Volume 3, Chapter 4 of the *2006 IPCC Guidelines* provides guidance for estimation of CO_2 and CH_4 emissions from Ferroalloy Production.

There are three methodological Tiers: Tier 1 for CO_2 and CH_4 applies an EF method, Tier 2 is a mass-balance method using national / country-specific data for carbon content and EF for reducing agents, and the Tier 3 mass-balance method is based on plant-specific data and carbon content of input and output materials, including reducing agents. Tier 2 and Tier 3 methods apply 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 was 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.

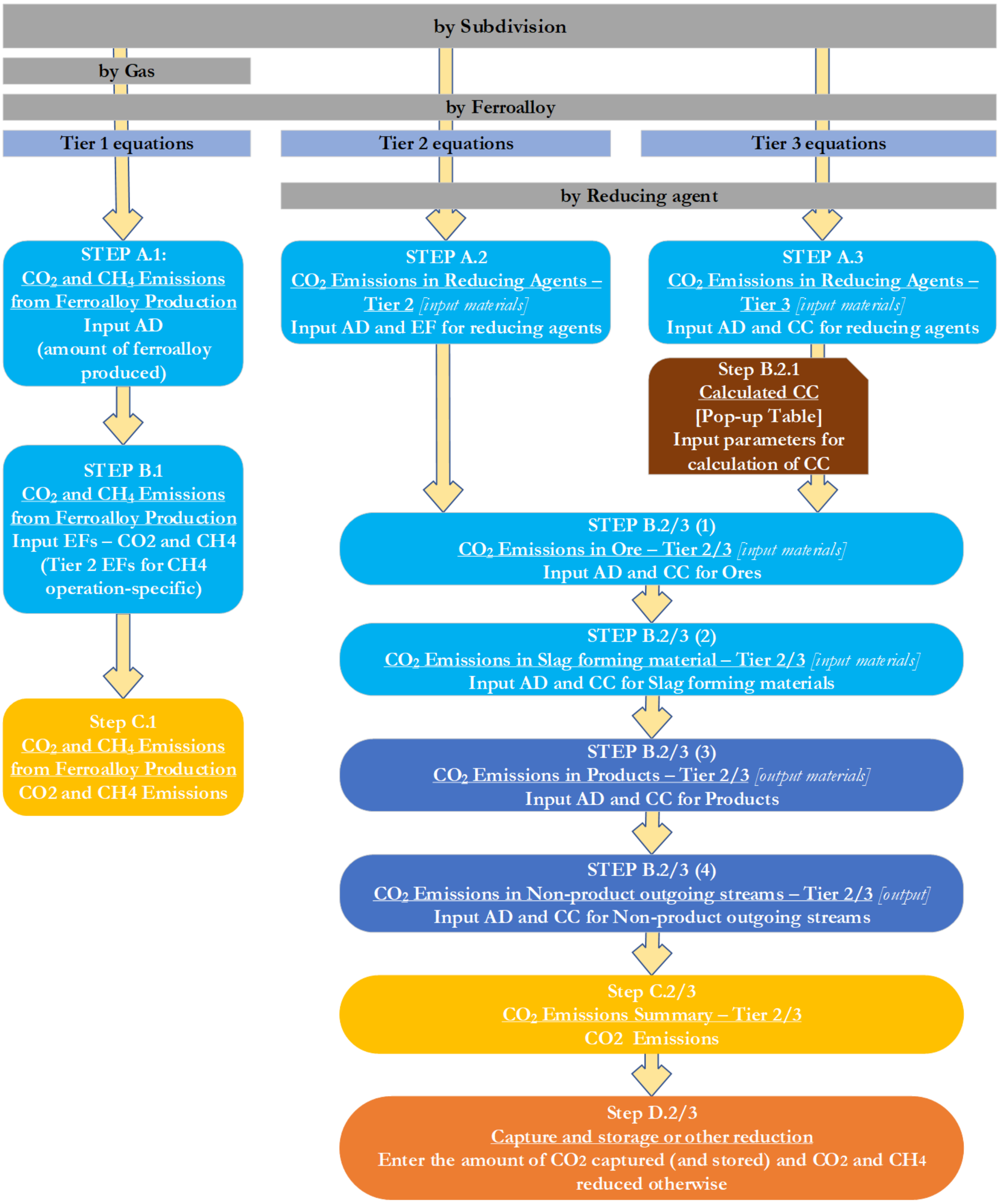
User's Work Flowchart

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 worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production,** for 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 worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production**, for 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 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 worksheet **CO_2 Emissions in Reducing Agents – Tier 2,** for 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 worksheet **CO_2 Emissions in Reducing Agents – Tier 3,** for 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 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 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 worksheet **CO_2 Emissions Summary – Tier 2/3**, for each 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:

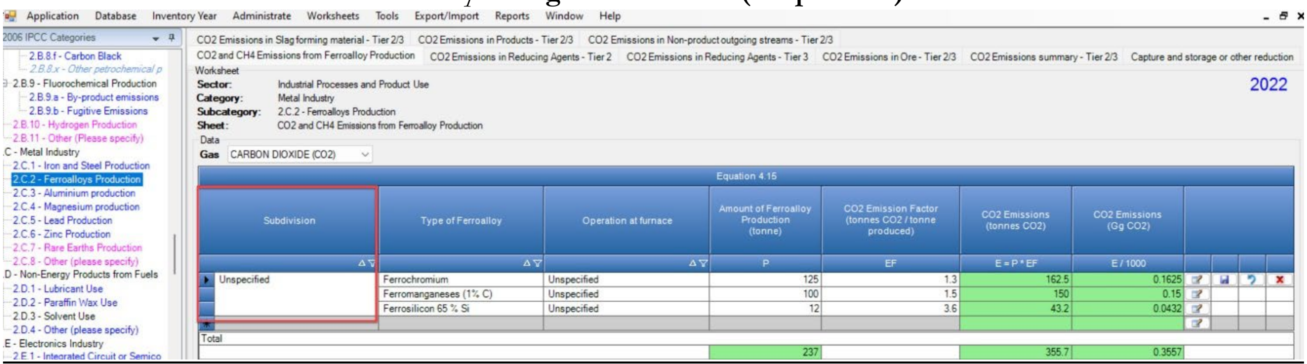
Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) and reduction of CH_4, , not otherwise captured in the worksheets above.

Activity Data Input

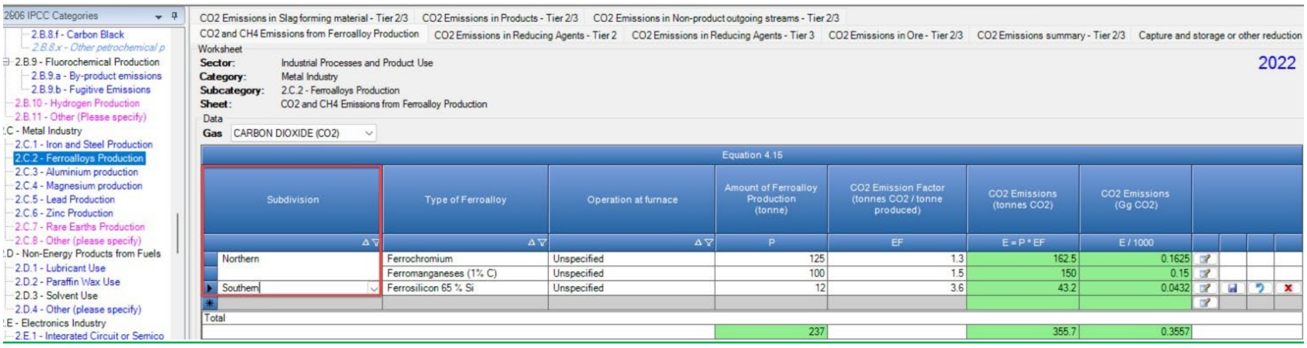
Section 4.3.2.3 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Ferroalloy Production.

Input of AD for Ferroalloy 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**

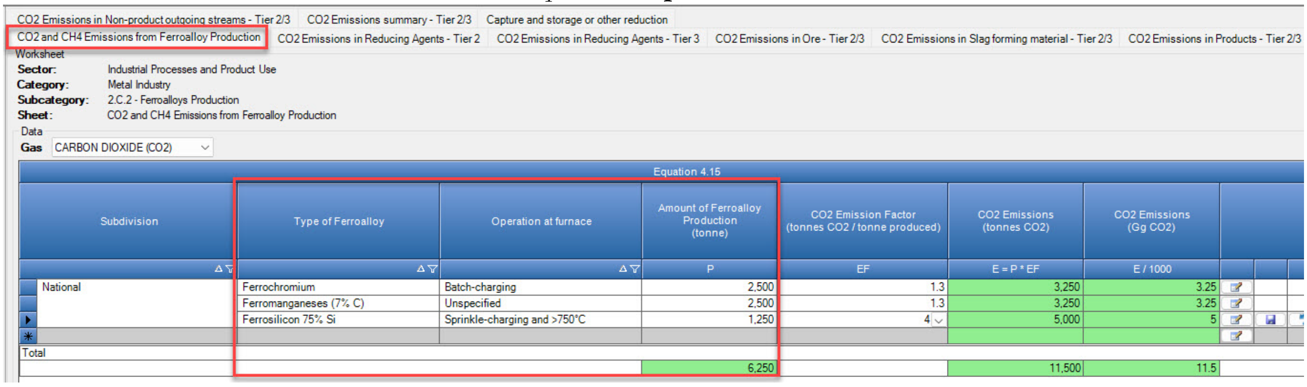


When Tier 1 Equations are applied:

For each subdivision in Column |Subdivision|, data are input 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.

Example: **AD input– Tier 1**



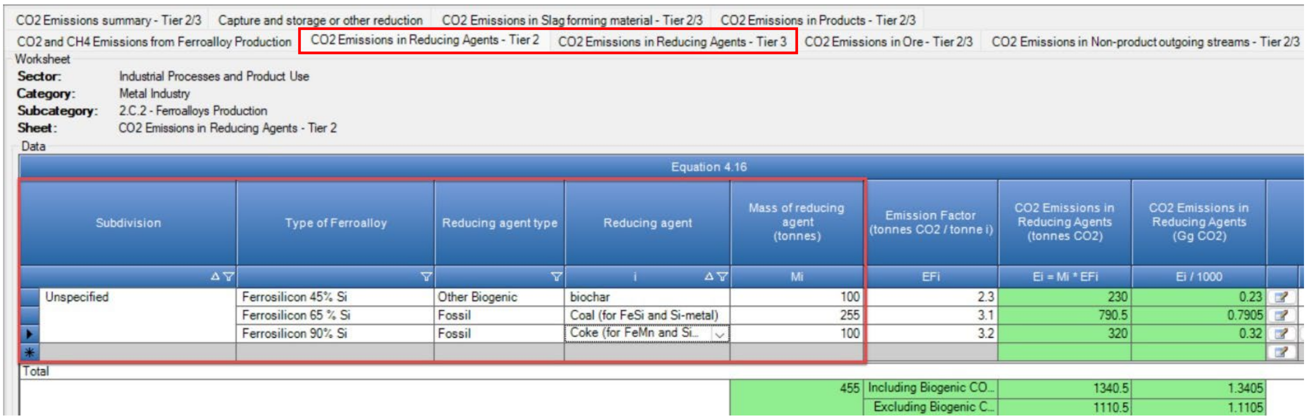
When Tier 2/Tier 3 Equations are applied:

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 input 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 are necessarily relevant, and are to be used, as applicable.

1. Column |Type of Ferroalloy|: select from the drop-down menu the 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 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 type of 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**

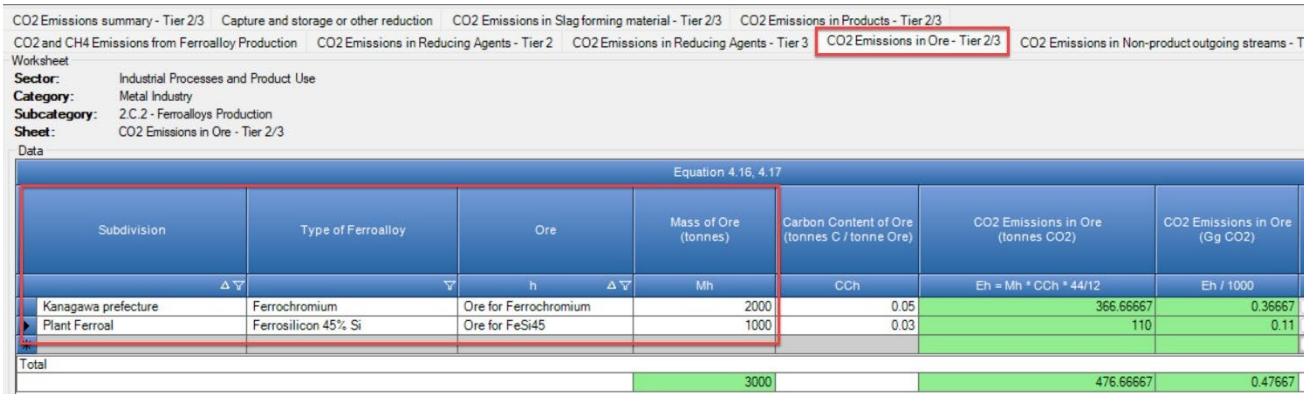


Then, for both Tier 2 and Tier 3

For each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 Emissions in Ore – Tier 2/3,** row by row, as follows:

1. Column |Type of Ferroalloy|: select from the drop-down menu the type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. Column |h|: input manually the name of the ore used for ferroalloy production.
3. Column |Mh|: input the amount/mass of ore used, in tonnes.

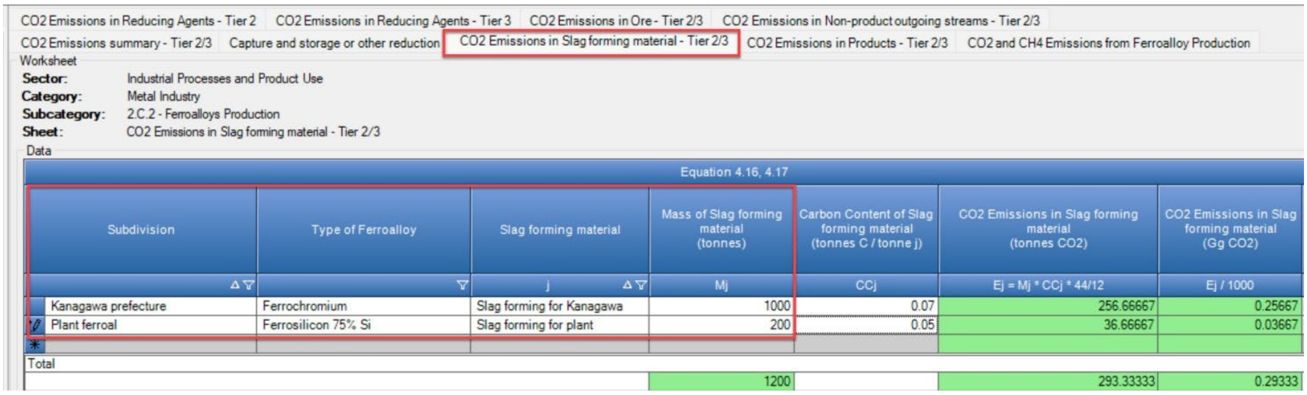
Example: **AD input for ore – Tier 2/3**



Then, for each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 Emissions in Slag forming materials – Tier 2/3,** row by row, as follows:

1. Column |Type of Ferroalloy|: select from the drop-down menu the type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. Column |j|: input manually the name of the slag forming material used for ferroalloy production.
3. Column |Mj|: input the amount/mass of slag forming material used, in tonnes.

Example: **AD input for slag forming materials – Tier 2/3**



CO2 Emissions in Reducing Agents - Tier 2 | CO2 Emissions in Reducing Agents - Tier 3 | CO2 Emissions in Ore - Tier 2/3 | CO2 Emissions in Non-product outgoing streams - Tier 2/3
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 and CH4 Emissions from Ferroalloy Production

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.2 - Ferroalloys Production
Sheet: CO2 Emissions in Slag forming material - Tier 2/3
Data

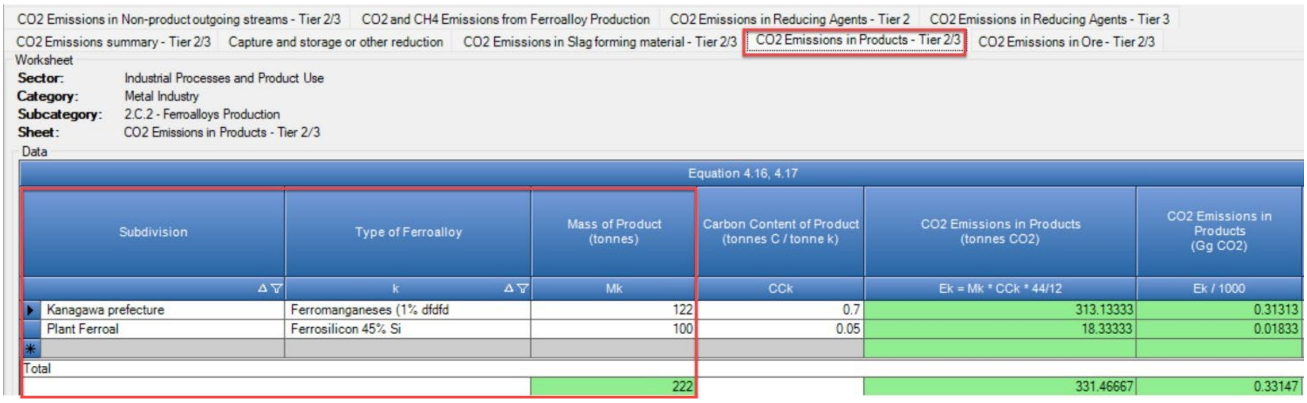
Equation 4.16, 4.17

Subdivision	Type of Ferroalloy	Slag forming material	Mass of Slag forming material (tonnes)	Carbon Content of Slag forming material (tonnes C / tonne j)	CO2 Emissions in Slag forming material (tonnes CO2)	CO2 Emissions in Slag forming material (Gg CO2)
		j	Mj	CCj	Ej = Mj * CCj * 44/12	Ej / 1000
Kanagawa prefecture	Ferrochromium	Slag forming for Kanagawa	1000	0.07	256.66667	0.25667
Plant ferroal	Ferrosilicon 75% Si	Slag forming for plant	200	0.05	36.66667	0.03667
Total			1200		293.33333	0.29333

Then, for each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions in Products – Tier 2/3,** row by row, as follows:

1. <u>Column |Type of Ferroalloy|:</u> select from the drop-down menu the type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. <u>Column |Mk|</u>: input the amount/mass of ferroalloy produced, in tonnes.

Example: **AD input for products (ferroalloys) – 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 in Products - Tier 2/3
Data

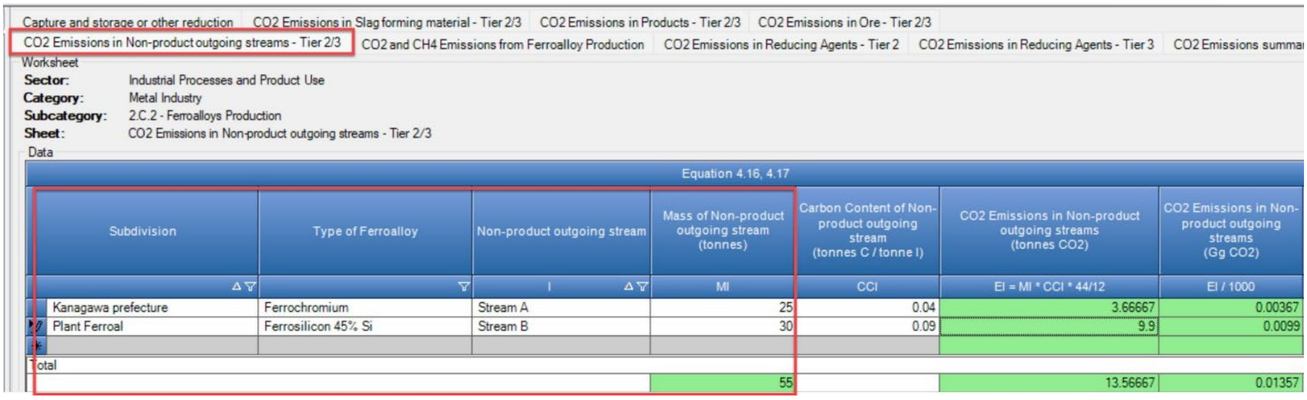
Equation 4.16, 4.17

Subdivision	Type of Ferroalloy	Mass of Product (tonnes)	Carbon Content of Product (tonnes C / tonne k)	CO2 Emissions in Products (tonnes CO2)	CO2 Emissions in Products (Gg CO2)
	k	Mk	CCk	Ek = Mk * CCk * 44/12	Ek / 1000
Kanagawa prefecture	Ferromanganeses (1% dfdfd	122	0.7	313.13333	0.31313
Plant Ferroal	Ferrosilicon 45% Si	100	0.05	18.33333	0.01833
Total		222		331.46667	0.33147

Then, for each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **CO_2 Emissions in Non-product outgoing streams – Tier 2/3,** row by row, as follows:

1. <u>Column |Type of Ferroalloy|:</u> select from the drop-down menu the type of ferroalloy produced or input manually a country-specific type of ferroalloy produced.
2. <u>Column |l|</u>: input manually the name of the non-product outgoing stream from ferroalloy production.
3. <u>Column |Ml|</u>: input the amount/mass of non-product outgoing stream, in tonnes.

Example: **AD input for non-product outgoing streams – 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
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 summa

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.2 - Ferroalloys Production
Sheet: CO2 Emissions in Non-product outgoing streams - Tier 2/3
Data

Equation 4.16, 4.17

Subdivision	Type of Ferroalloy	Non-product outgoing stream	Mass of Non-product outgoing stream (tonnes)	Carbon Content of Non-product outgoing stream (tonnes C / tonne l)	CO2 Emissions in Non-product outgoing streams (tonnes CO2)	CO2 Emissions in Non-product outgoing streams (Gg CO2)
		l	Ml	CCl	El = Ml * CCl * 44/12	El / 1000
Kanagawa prefecture	Ferrochromium	Stream A	25	0.04	3.66667	0.00367
Plant Ferroal	Ferrosilicon 45% Si	Stream B	30	0.09	9.9	0.0099
Total			55		13.56667	0.01357

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:

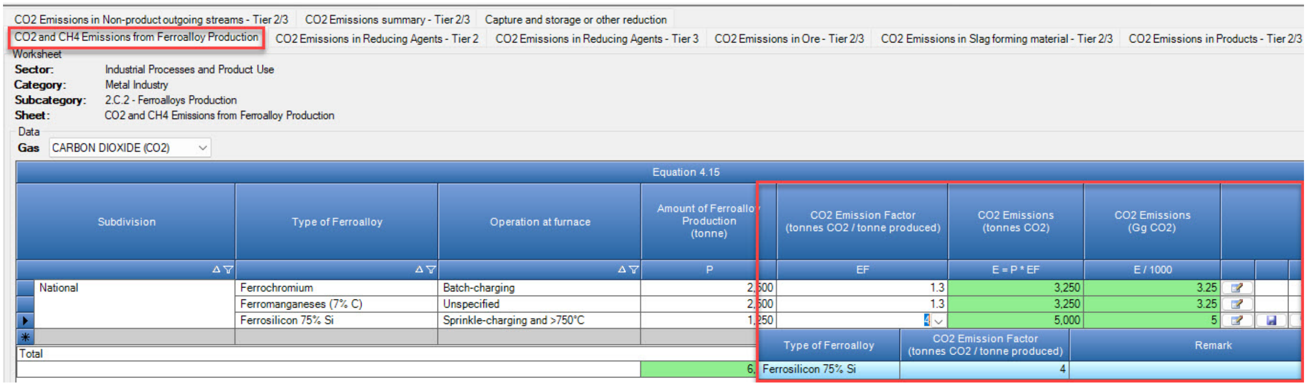
- ✓ Tier 1 EFs for CO_2 (Table 4.5)
- ✓ Tier 2 EFs for CO_2 (Table 4.6)
- ✓ Tier 1 EFs for CH_4 (Table 4.7)
- ✓ Tier 2 EFs for CH_4 (Table 4.8)

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, EF information is input in worksheet **CO_2 and CH_4 Emissions from Ferroalloy Production,** row by row, as follows:

1. Column |EF|: select from the drop-down menu the default EF (based on the process selected in Column |Operation of furnace| or manually input a user specific value.
   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: **ferroalloy production – Tier 1 EFs for CO_2**



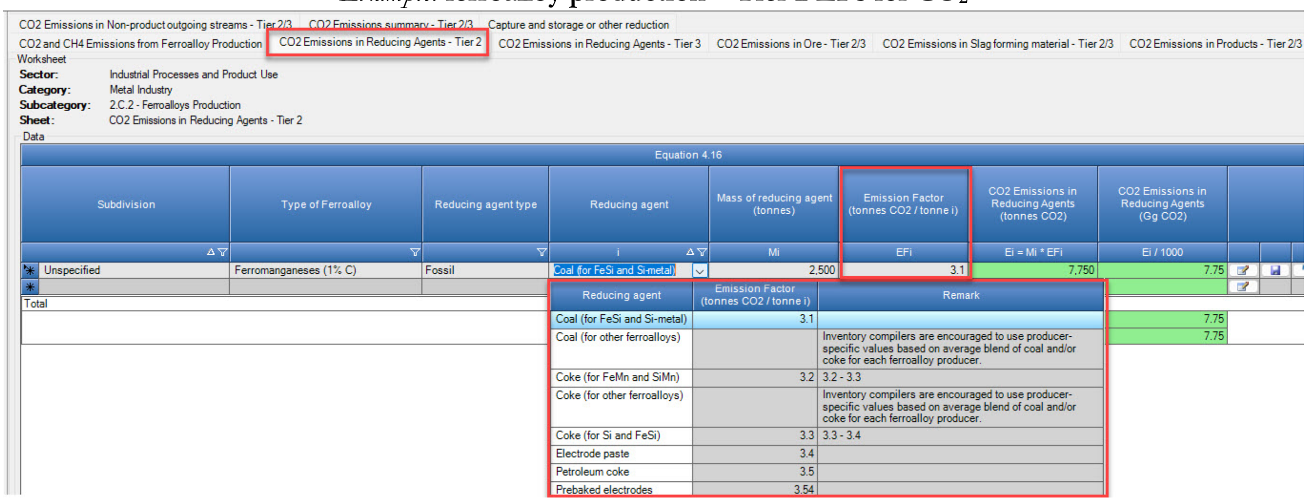
When Tier 2 /3 Equations are applied:

When estimating CO2 emissions from use of reducing agents, the user may apply a Tier 2 or a Tier 3 method as follows:

For Tier 2, for each subdivision in Column |Subdivision|, EF information is input in worksheet **CO_2 Emissions in Reducing Agents – Tier 2,** row by row, as follows:

1. Column |EFi|: the IPCC default value is automatically inserted in this column based on the reducing agent selected in column i, or the user may manually input a user specific value, in tonnes CO_2/tonne reducing agent.

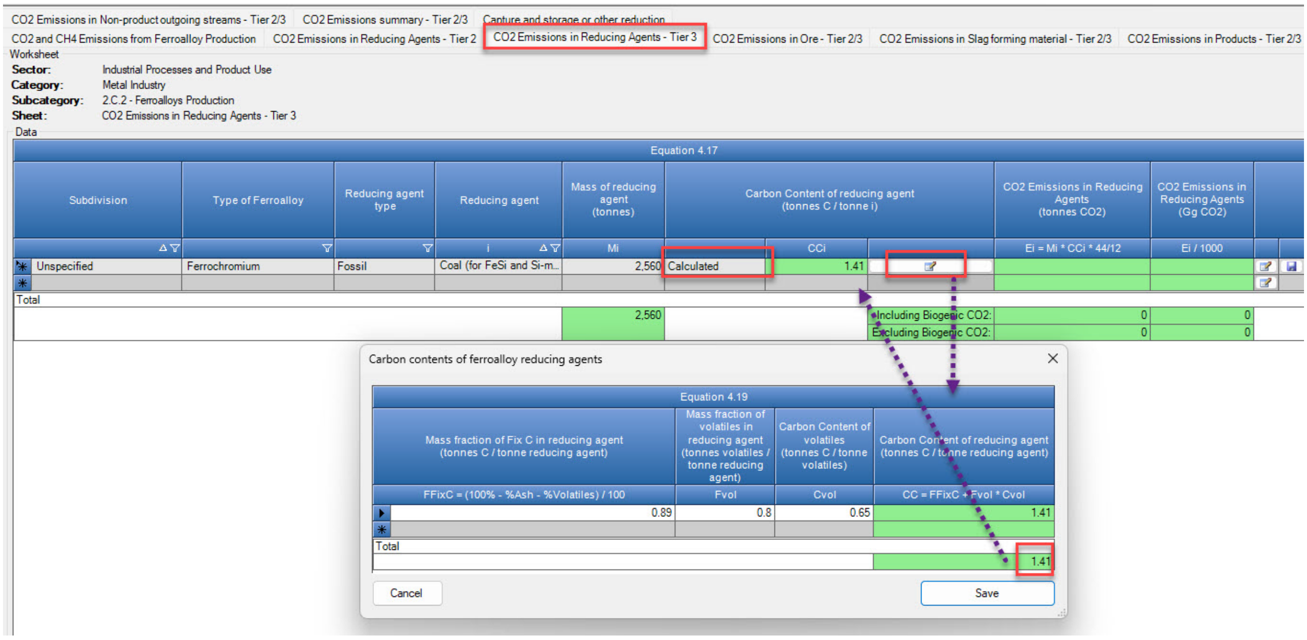
Example: **ferroalloy production – Tier 2 EFs for CO_2**



For Tier 3, in worksheet **CO_2 Emissions in Reducing Agents – Tier 3,** for each subdivision/reducing agent, input information, row by row, as follows:

1. Column |CCi|: indicate whether the carbon content is to be *specified* or *calculated.* If specified, directly input the carbon content, in tonnes C/tonne reducing agent. When calculated, select the edit box and input the following information for the reducing agent,
    a. Column |FFixC|: collect and input the mass fraction of fixed C in the reducing agent, in tonnes of carbon/ tonne of reducing agent.
    b. Column |Fvol|: collect and input the mass fraction of volatiles in reducing agent, in tonnes volatiles/ tonne reducing agent.
    c. Column |Cvol|: 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)**



Then, for both Tier 2 and Tier 3, the user completes the following worksheets, by subdivision/type of ferroalloy as applicable.

In worksheet **CO_2 Emissions in Ore – Tier 2/3,** input a user-specific EF in Column |CCh|, in tonnes C/tonne ore.

Then, in worksheet **CO_2 Emissions in Slag forming material – Tier 2/3** input a user-specific EF in Column |CCj|, in tonnes C/tonne slag forming material.

Then, in worksheet **CO_2 Emissions in Products – Tier 2/3** input a user-specific EF in Column |CCk|, in tonnes C/tonne ferroalloy product.

Then, in worksheet **CO_2 Emissions in Non-product outgoing streams – Tier 2/3** input a user-specific EF in Column |CCl|, in tonnes C/tonne outgoing stream.

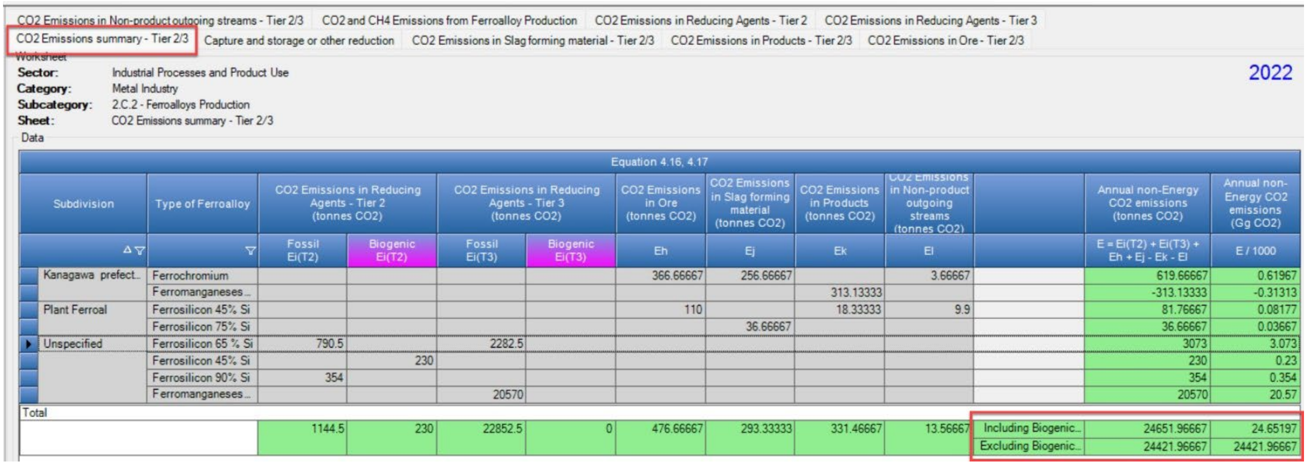
Results

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. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO_2 capture and storage.

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
2022

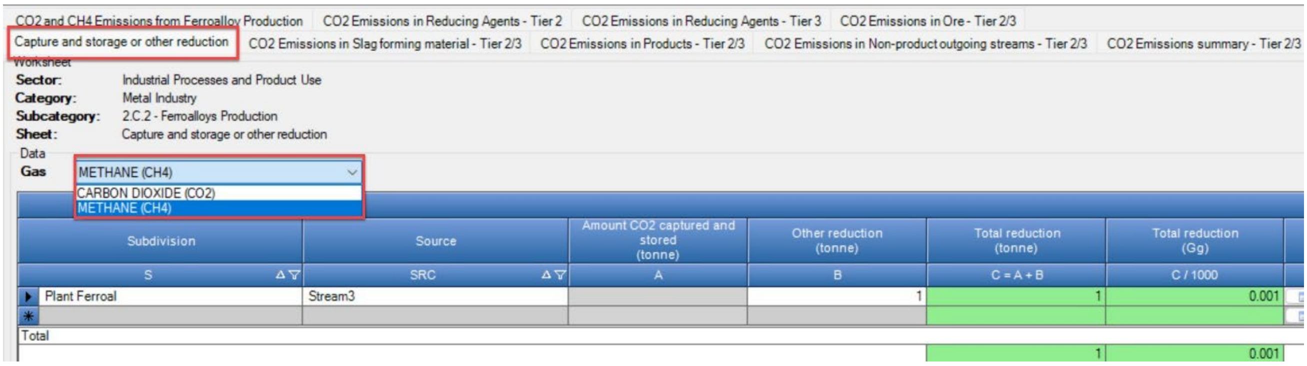
Data
Equation 4.16, 4.17

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>: 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>: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. <u>Column |B|</u>: collect and input information on any other long-term reduction of CO_2, in tonnes.
   Note that: <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.
4. <u>Column |Biogenic|</u>: indicate with a check if the reductant is of biogenic origin.
   Note that consistent with 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**



CO2 and CH4 Emissions from Ferroalloy Production | CO2 Emissions in Reducing Agents - Tier 2 | CO2 Emissions in Reducing Agents - Tier 3 | CO2 Emissions in Ore - 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 Non-product outgoing streams - Tier 2/3 | CO2 Emissions summary - Tier 2/3

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.2 - Ferroalloys Production
Sheet: Capture and storage or other reduction

Data
Gas METHANE (CH4)
CARBON DIOXIDE (CO2)
METHANE (CH4)

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 Ferroal	Stream3		1	1	0.001
Total				1	0.001

2.C.3 Aluminium Production

Information

Section 4.4 in the *2006 IPCC Guidelines* provides guidance for estimation of CO_2 and PFC (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 methods are calculated using a mass balance approach. The choice between the Tier 2 and Tier 3 method will depend on whether anode or paste composition data are available at the plant level.

For PFCs, the Tier 1 method uses technology-based default EFs 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 utilize 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 plant-specific measurement 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

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 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:

- ✓ **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.

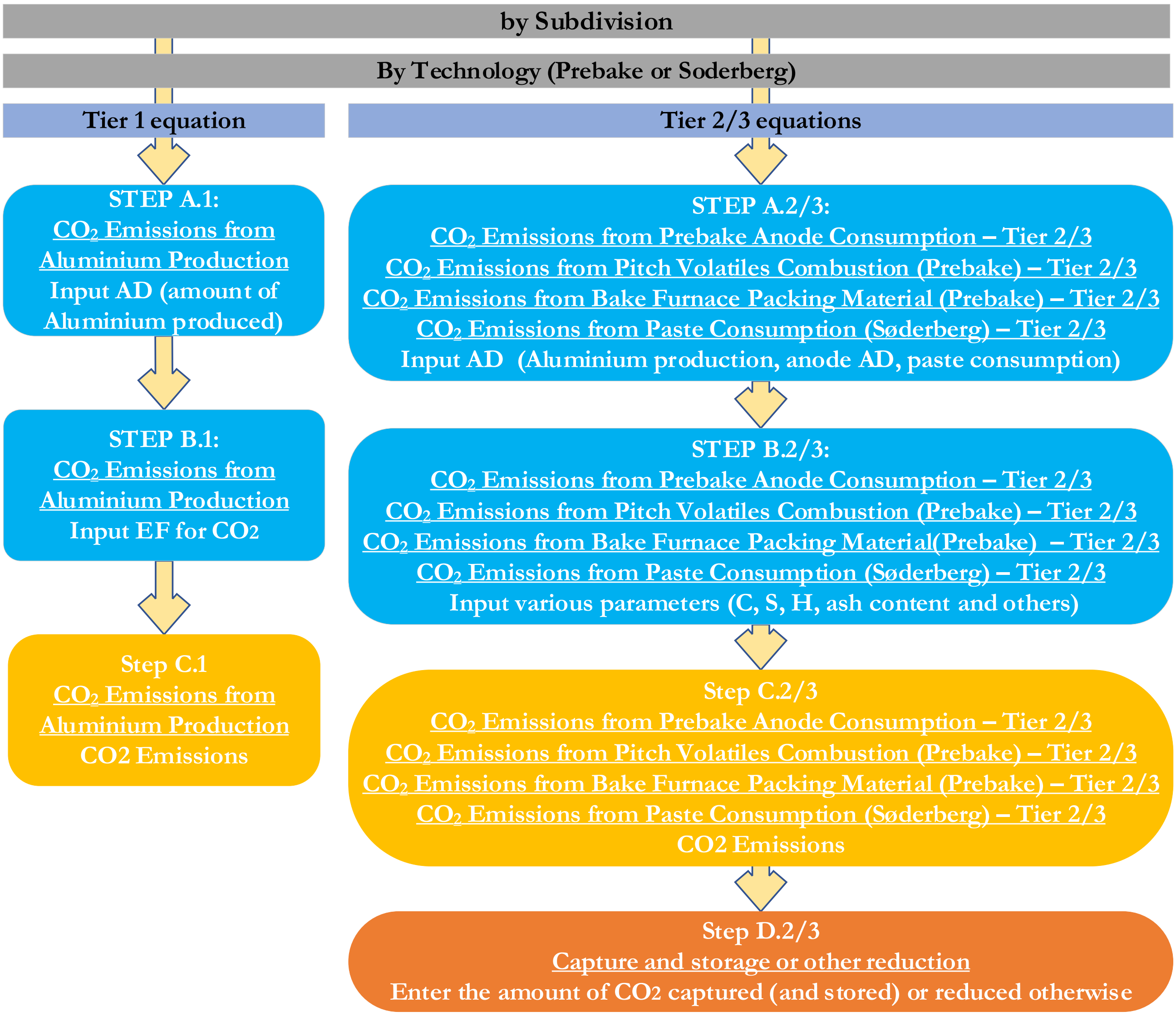
User's Work Flowchart

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 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 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 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 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 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 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 worksheet **CO_2 Emissions from Prebake Anode Consumption – Tier 2/3,** users collect and input sulphur and ash content in baked anodes; in 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 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 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 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.

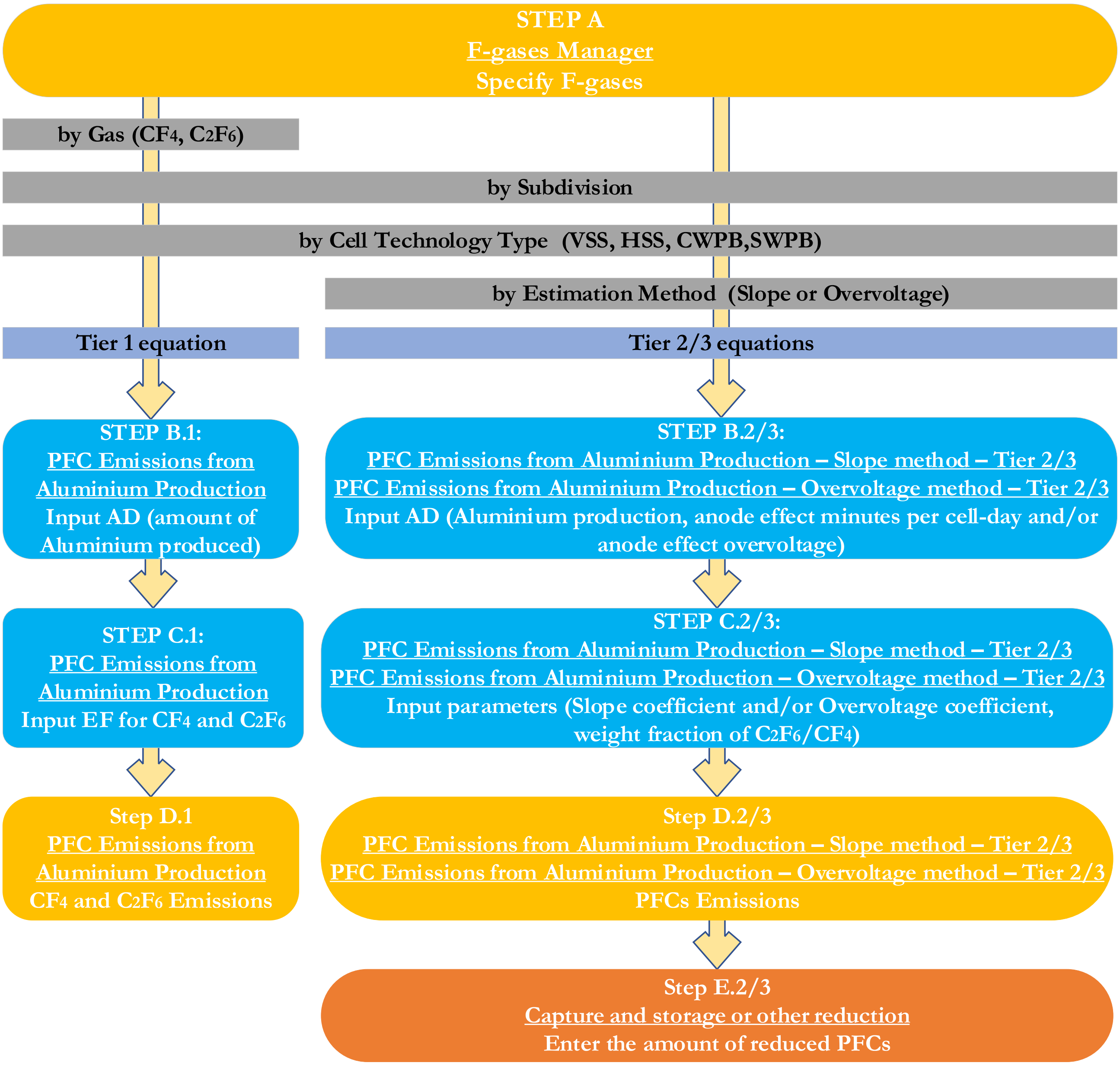
Step B.2/3, in worksheet **CO_2 Emissions from Paste Consumption (Søderberg) – Tier 2/3**, users collect and input emissions of cyclohexane soluble matter, binder content in paste, sulphur, hydrogen and ash content in pitch, sulphur and ash content in calcined coke, and carbon in skimmed dust from Soderberg cells.

Step C.2/3, in 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 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, **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 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 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 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 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 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 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 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 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 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 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

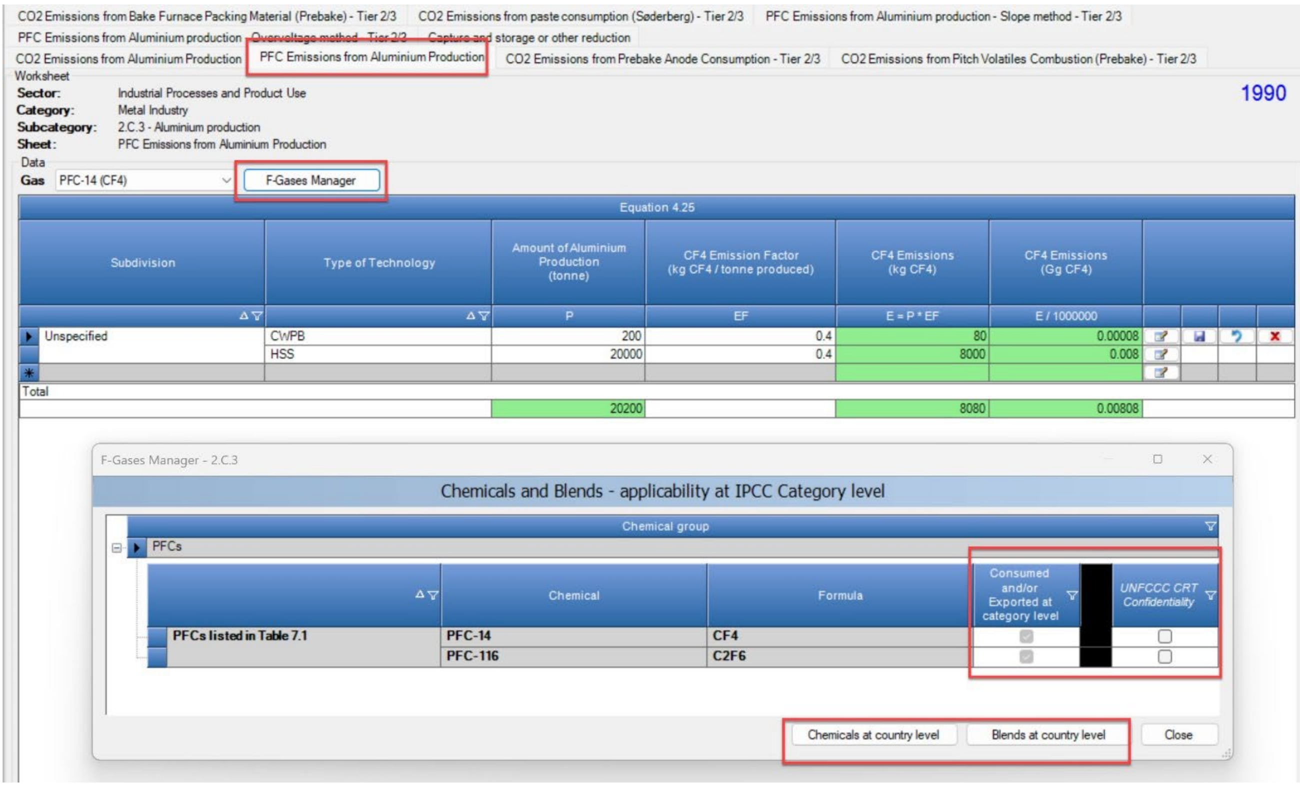
Section 4.4.2.5 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Aluminium Production.

As a **starting step**, users must ensure that the **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 these gases should be automatically selected from the F-Gases Manager for this category. If these 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 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. For more information, refer to populating the F-Gases Manager, in the section above.*

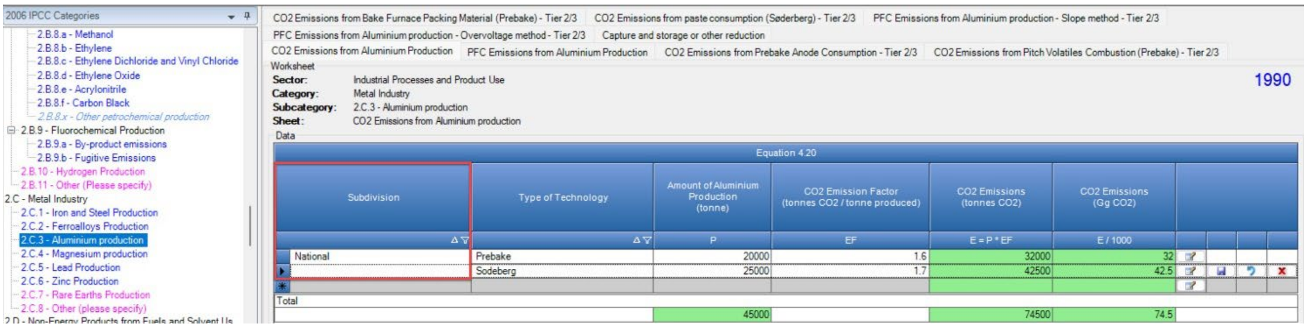
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the 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**

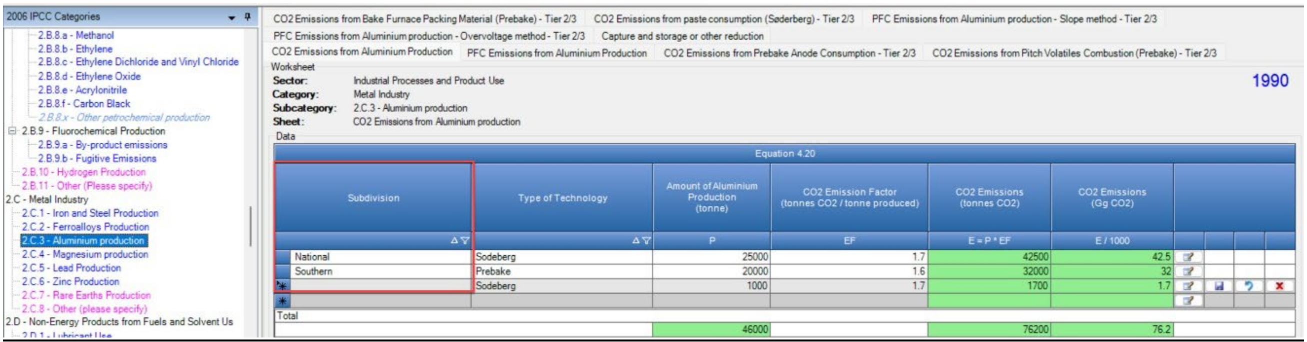


Second, input of AD for Aluminium Production requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or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

Example: **single subdivision**



Example: **multiple subdivisions**

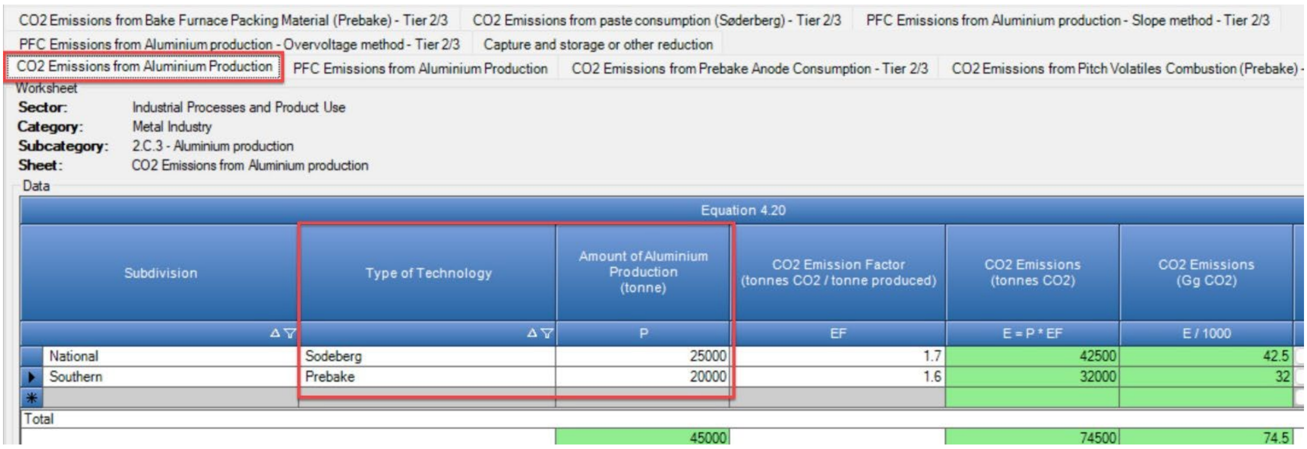


When Tier 1 Equations are applied:

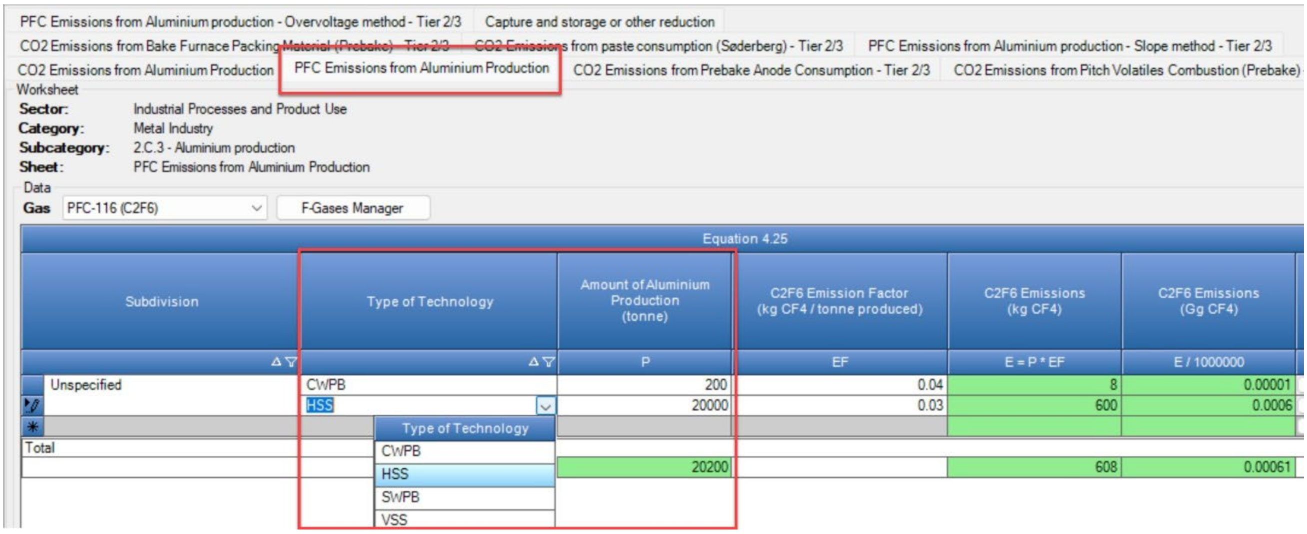
For each subdivision in Column |Subdivision|, data are input in worksheets **CO_2 Emissions from Aluminium Production** and **PFC Emissions from Aluminium Production,** row by row, as follows:

1. Column |Type of Technology|: select from the drop-down menu the default type of technology or input manually user-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 CO_2 emissions, the choice of worksheet depends on if the technology type is Prebake or Søderberg. For PFC emissions, the choice of worksheet depends on if the slope or overvoltage method is selected.

Instructions below are presented first for CO_2 emissions, followed by PFC emissions.

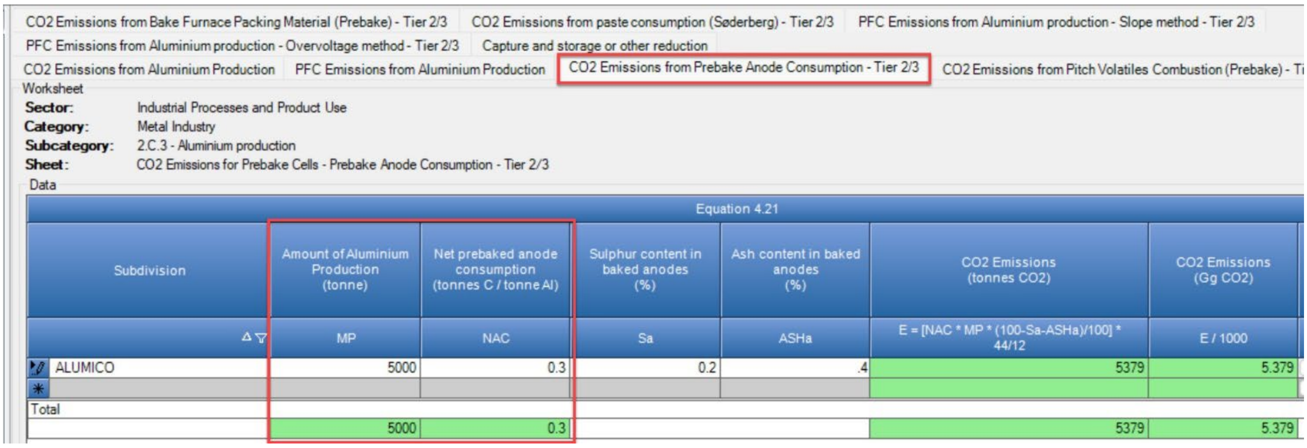
i. CO_2 Emissions

Prebake:

For each subdivision in Column |Subdivision|, data are input 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**

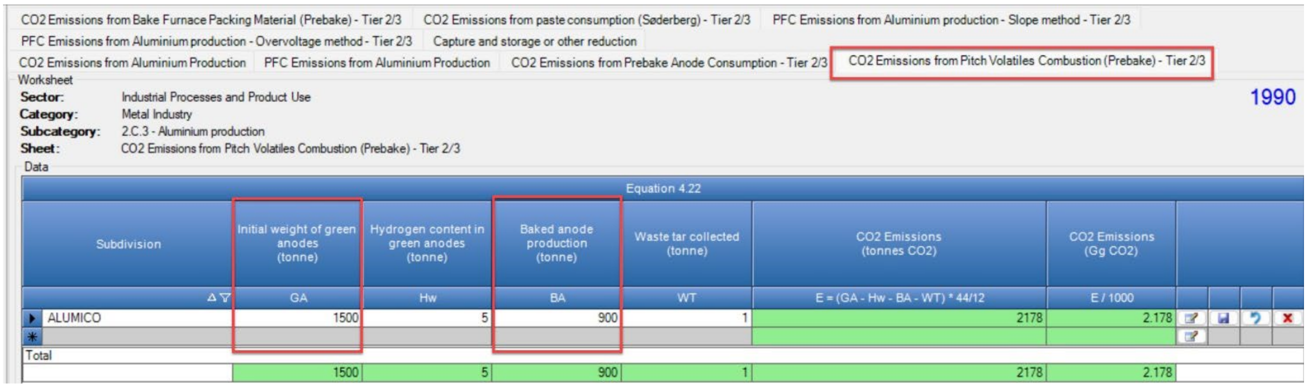


Subdivision	Amount of Aluminium Production (tonne)	Net prebaked anode consumption (tonnes C / tonne Al)	Sulphur content in baked anodes (%)	Ash content in baked anodes (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	MP	NAC	Sa	ASHa	E = [NAC * MP * (100-Sa-ASHa)/100] * 44/12	E / 1000
ALUMICO	5000	0.3	0.2	4	5379	5.379
Total	5000	0.3			5379	5.379

Then, data are input 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**

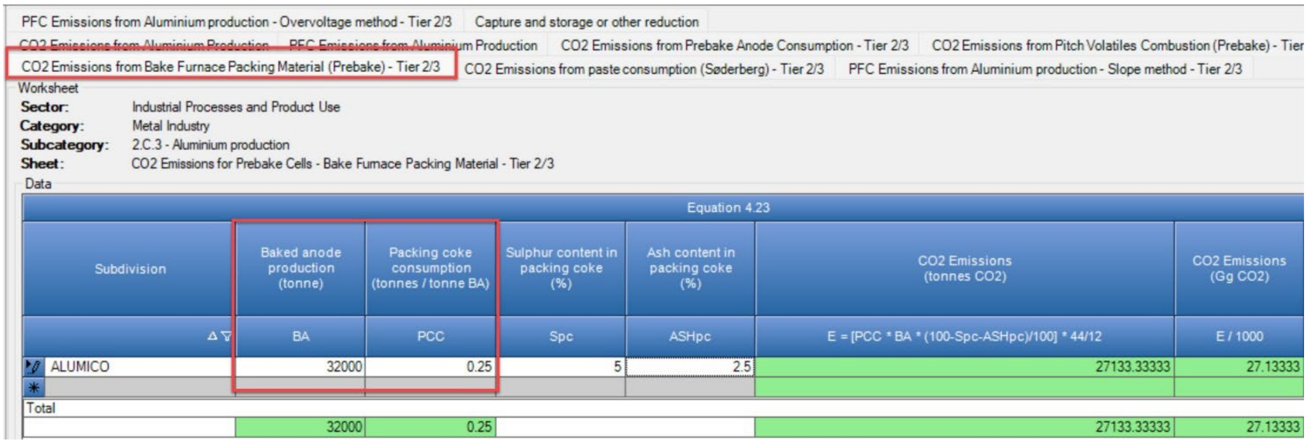


Subdivision	Initial weight of green anodes (tonne)	Hydrogen content in green anodes (tonne)	Baked anode production (tonne)	Waste tar collected (tonne)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	GA	Hw	BA	WT	E = (GA - Hw - BA - WT) * 44/12	E / 1000
ALUMICO	1500	5	900	1	2178	2.178
Total	1500	5	900	1	2178	2.178

Then, data are input 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**

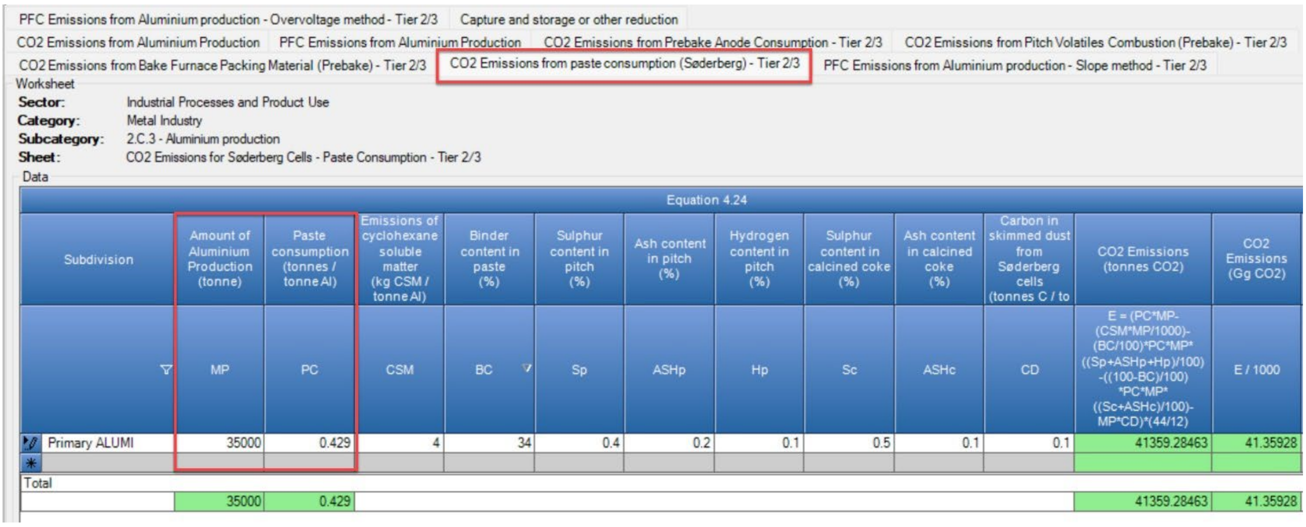


Søderberg:

For each subdivision in Column |Subdivision|, data are input 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**



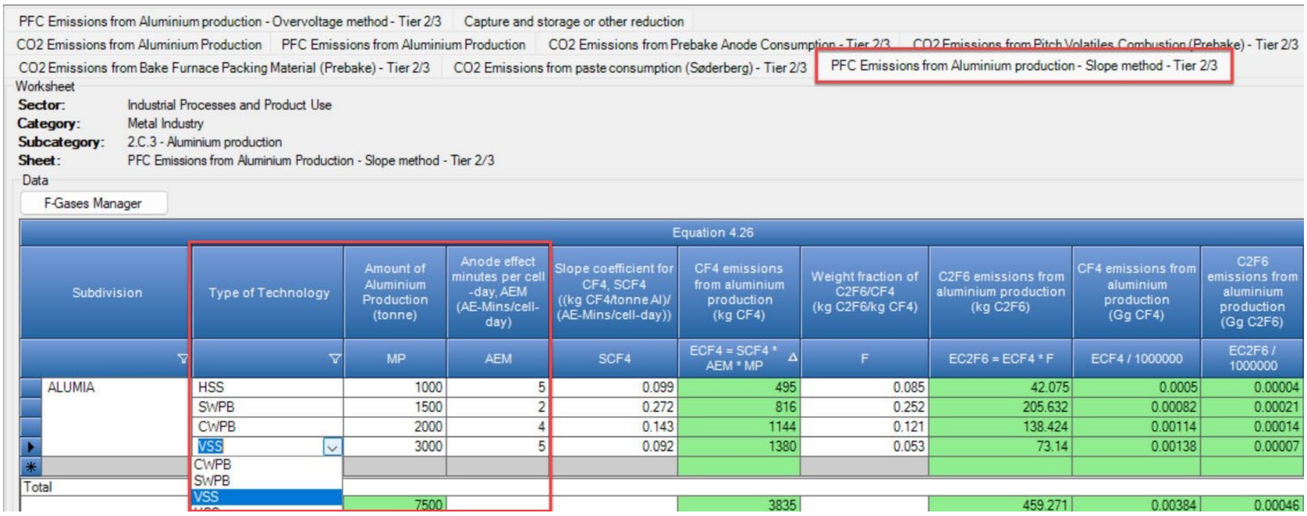
ii. PFC Emissions

Slope method

For each subdivision in Column |Subdivision|, data are input in worksheet **PFC Emissions from Aluminium Production – Slope method – Tier 2/3,** row by row, as follows:

1. Column |Type of Technology|: select 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**


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

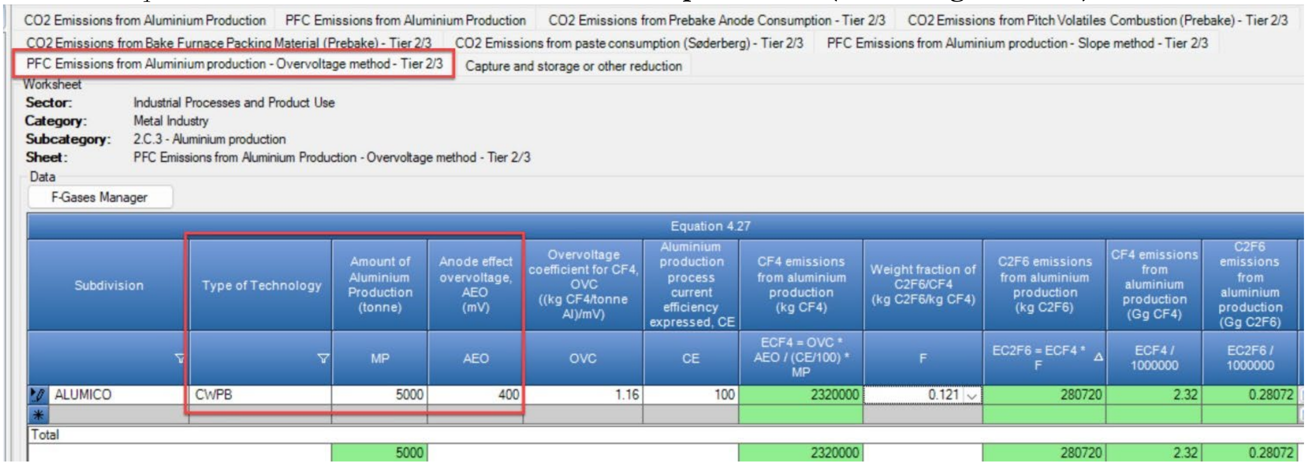
Subdivision	Type of Technology	Amount of Aluminium Production (tonne)	Anode effect minutes per cell-day, AEM (AE-Mins/cell-day)	Slope coefficient for CF4, SCF4 ((kg CF4/tonne Al)/(AE-Mins/cell-day))	CF4 emissions from aluminium production (kg CF4)	Weight fraction of C2F6/CF4 (kg C2F6/kg CF4)	C2F6 emissions 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	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
	CWPB	2000	4	0.143	1144	0.121	138.424	0.00114	0.00014
	VSS	3000	5	0.092	1380	0.053	73.14	0.00138	0.00007
	CWPB								
	SWPB								
Total	VSS	7500			3835		459.271	0.00384	0.00046

Overvoltage method

For each subdivision in Column |Subdivision|, data are input 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**


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
Total		5000				2320000		280720	2.32	0.28072

Emission Factor Input

Sections 4.4.2.2 and 4.4.2.4 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:

- ✓ Tier 1 EFs for CO_2 (Table 4.10)
- ✓ Tier 2/3 EFs for CO_2 (Tables 4.11, 4.12, 4.13 and 4.14)
- ✓ Tier 1 EFs for PFCs (Table 4.15)
- ✓ Tier 2/3 EFs for PFCs (Table 4.16)

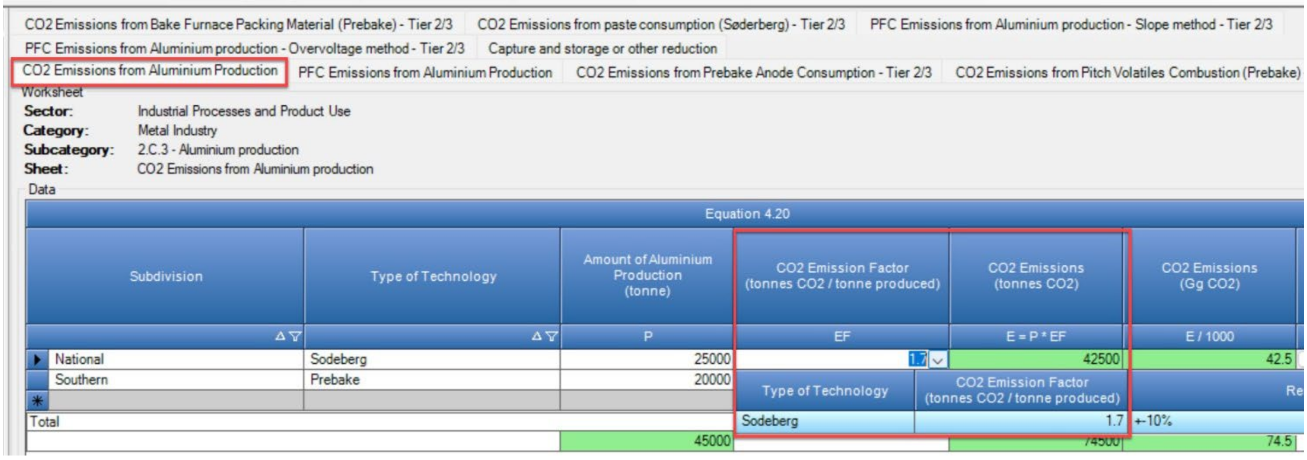
The default EFs are embedded in the *Software*. Users may manually over-write EFs with country-specific values. See examples of input of EFs for CO_2 emissions, followed by PFCs emissions, for different Tiers below.

When Tier 1 Equations are applied:

i. CO_2 Emissions

For each subdivision in Column |Subdivision|, data are input 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 input manually a user-specific EFs, in tonne of CO_2 per tonne of aluminium produced.

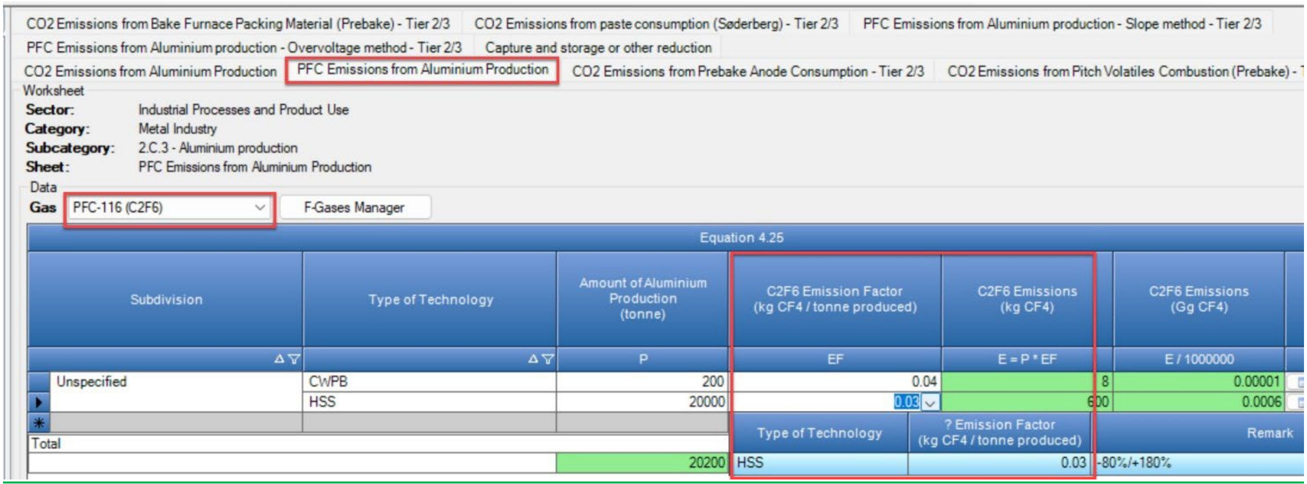
Example: **Tier 1 EFs for CO_2**



ii. PFC Emissions

For each combination of subdivision, gas and type of technology, data are input 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 inputs manually user-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:

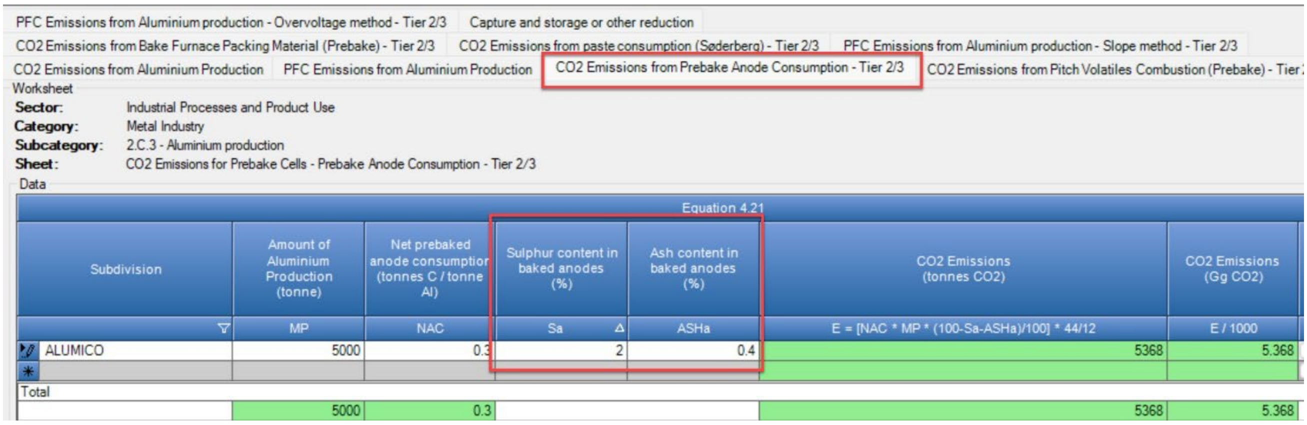
i. CO_2 Emissions

Prebake

For each subdivision, data are input in worksheet **CO_2 emissions from Prebake Anode Consumption – Tier 2/3,** row by row, as follows:

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**



PFC Emissions from Aluminium production - Overvoltage method - Tier 2/3 | Capture and storage or other reduction
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
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

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.3 - Aluminium production
Sheet: CO2 Emissions for Prebake Cells - Prebake Anode Consumption - Tier 2/3

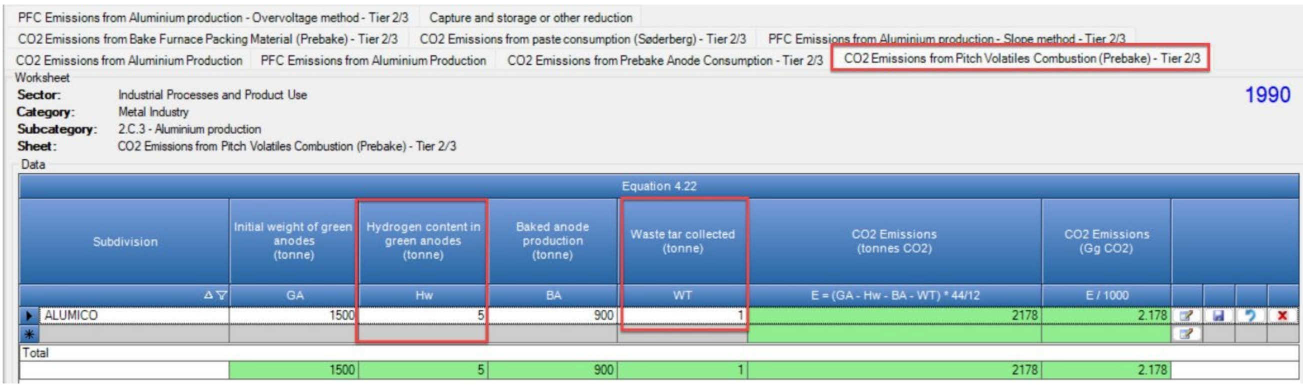
Data

Subdivision	Amount of Aluminium Production (tonne)	Net prebaked anode consumption (tonnes C / tonne Al)	Sulphur content in baked anodes (%)	Ash content in baked anodes (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
			Equation 4.21			
	MP	NAC	Sa	ASHa	E = [NAC * MP * (100-Sa-ASHa)/100] * 44/12	E / 1000
ALUMICO	5000	0.3	2	0.4	5368	5.368
Total	5000	0.3			5368	5.368

Then, for each subdivision in worksheet **CO_2 Emissions from Pitch Volatiles Combustion (Prebake) – Tier 2/3,** data are input, row by row, as follows:

1. Column |Hw|: the user has the option to specify the hydrogen content in green anodes directly, in tonnes, or calculate it, as follows:
   a. Specified: User inputs 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.
   b. Calculated (to be added in a future release): 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:
   a. Specified: User inputs 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.
   b. Calculated (to be added in a future release): 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.

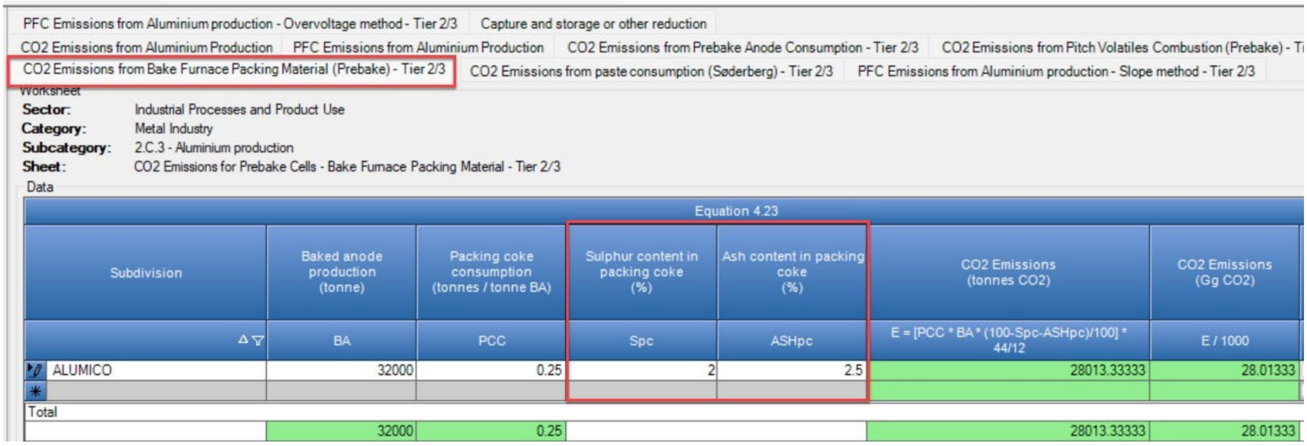
Example: **Tier 2/3 EFs (parameters) input for pitch volatiles combustion for CO_2**



Then, for each subdivision in worksheet **CO_2 Emissions from Bake Furnace Packing Materials (Prebake) – Tier 2/3** data are input, row by row, as follows:

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**



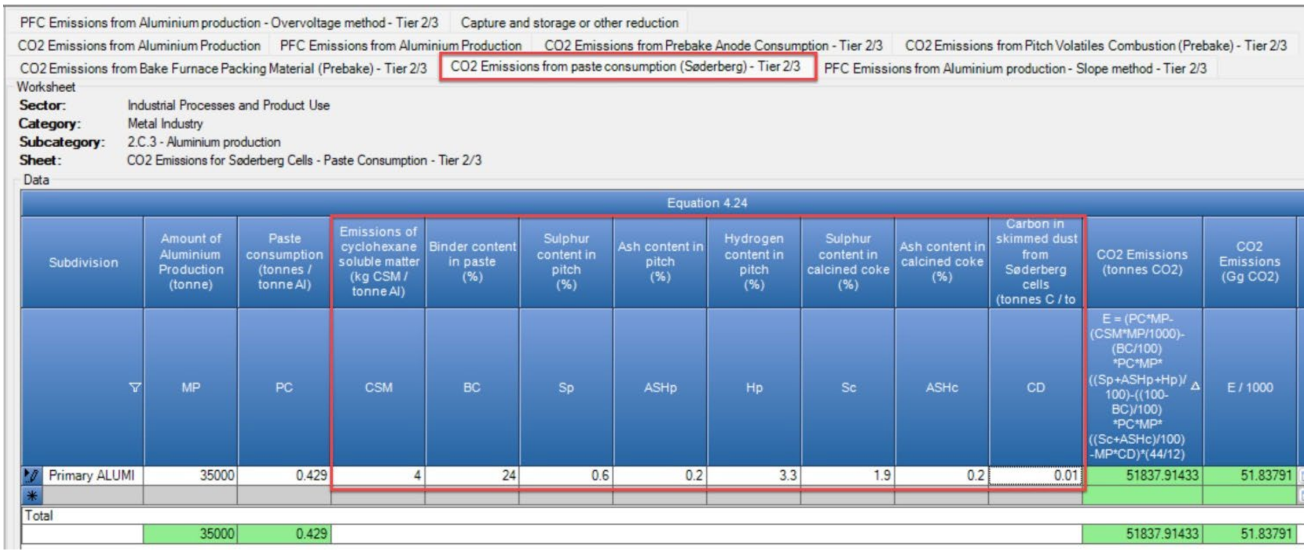
Søderberg

Then, for each subdivision in worksheet **CO_2 Emissions from paste consumption (Soderberg) – Tier 2/3** data are input row by row, as follows:**:**

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**


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: CO2 Emissions for Søderberg Cells - Paste Consumption - Tier 2/3

Data

Equation 4.24

Subdivision	Amount of Aluminium Production (tonne)	Paste consumption (tonnes / tonne Al)	Emissions of cyclohexane soluble matter (kg CSM / tonne Al)	Binder content in paste (%)	Sulphur content in pitch (%)	Ash content in pitch (%)	Hydrogen content in pitch (%)	Sulphur content in calcined coke (%)	Ash content in calcined coke (%)	Carbon in skimmed dust from Søderberg cells (tonnes C / to	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	MP	PC	CSM	BC	Sp	ASHp	Hp	Sc	ASHc	CD	E = (PC*MP-(CSM*MP/1000)-(BC/100)*PC*MP*((Sp+ASHp+Hp)/100)-((100-BC)/100)*PC*MP*((Sc+ASHc)/100)-MP*CD)*(44/12)	E / 1000
Primary ALUMI	35000	0.429	4	24	0.6	0.2	3.3	1.9	0.2	0.01	51837.91433	51.83791
Total												
	35000	0.429									51837.91433	51.83791

ii. PFC Emissions

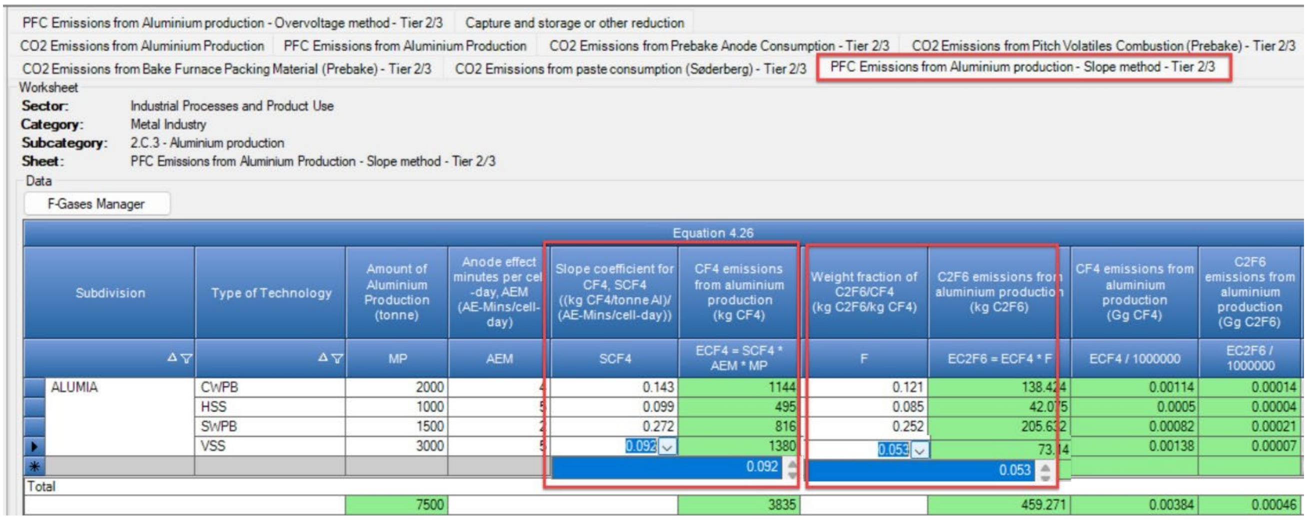
Slope method

For each subdivision and type of technology (CWPB, SWPB, VSS and HSS) data are input in worksheet **PFC Emissions from Aluminium Production – Slope Method – Tier 2/3**, row by row, as follows:

1. Column |SCF_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

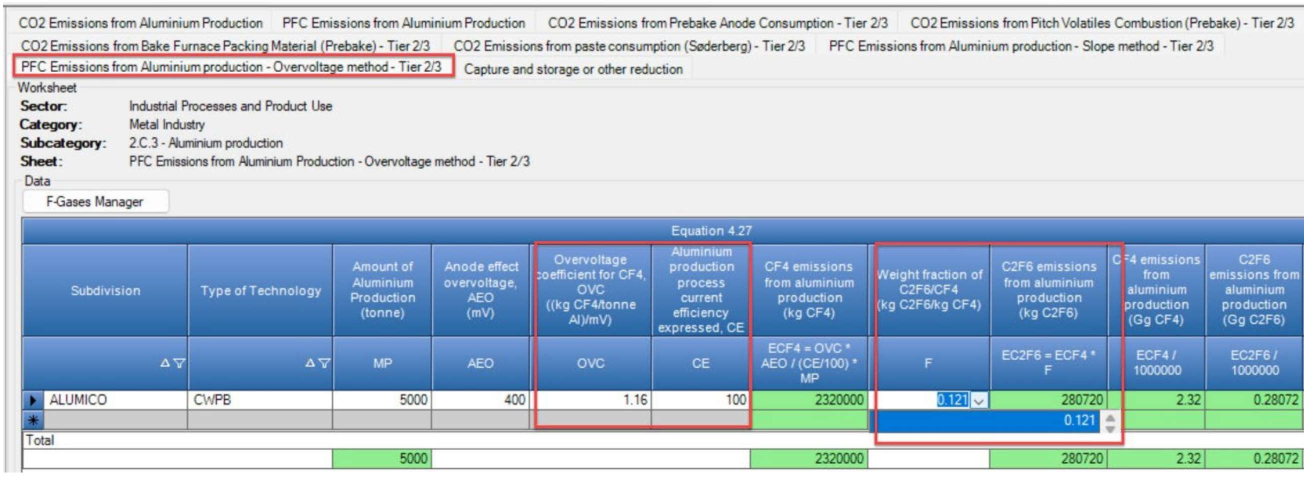
Subdivision	Type of Technology	Amount of Aluminium Production (tonne)	Anode effect minutes per cel -day, AEM (AE-Mins/cell-day)	Slope coefficient for CF4, SCF4 ((kg CF4/tonne Al)/(AE-Mins/cell-day))	CF4 emissions from aluminium production (kg CF4)	Weight fraction of C2F6/CF4 (kg C2F6/kg CF4)	C2F6 emissions fro aluminium productio (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	138.4[illegible]4	0.00114	0.00014
	HSS	1000	5	0.099	495	0.085	42.0[illegible]5	0.0005	0.00004
	SWPB	1500	2	0.272	816	0.252	205.6[illegible]2	0.00082	0.00021
	VSS	3000	5	0.092	1380	0.053	73.[illegible]4	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|: input the 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.

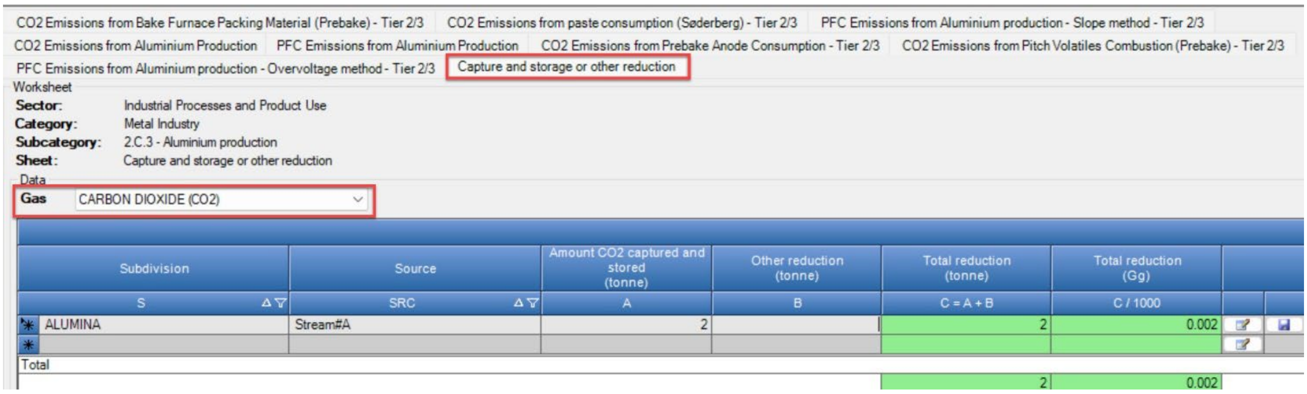
In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.

3. <u>Column |B|:</u> 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.4 Magnesium Production

Information

Section 4.5 in the *2006 IPCC Guidelines* provides 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 and default EFs, while Tier 2 is an EF method and 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 method relies on national statistics 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 allow 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

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 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:

- ✓ **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.
- ✓ **F-Gases 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.

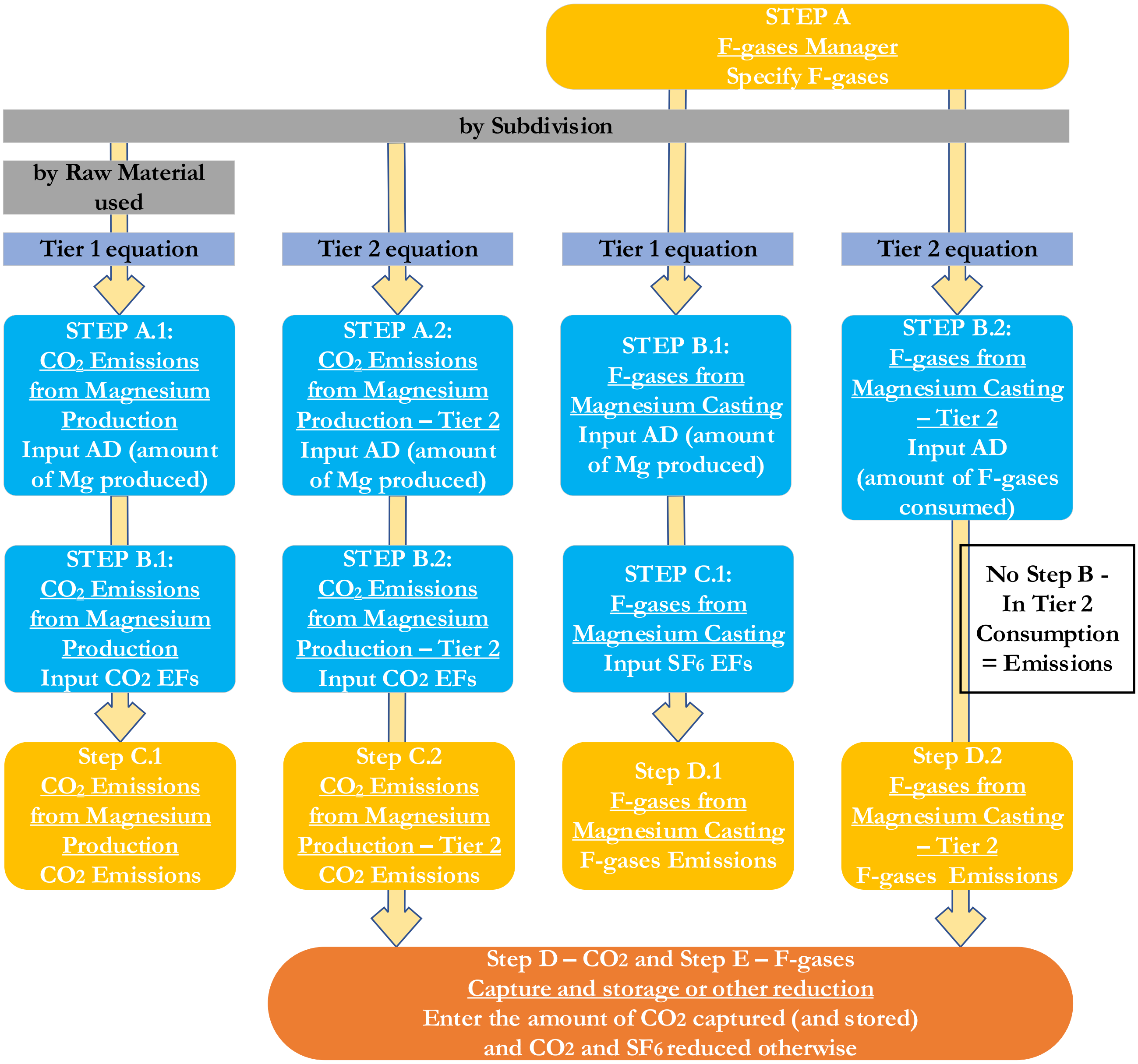
User's Work Flowchart

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:

Step A, 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 Tier 1 Equations are applied:

<u>i. CO_2 emissions</u>

Step A.1, in 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 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 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 B.1, in 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 worksheet **F-Gases from Magnesium Casting**, users input respective EFs (default EF available for SF_6 only).

Step D.1, in 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 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 worksheet **CO_2 Emissions from Magnesium Production – Tier 2**, users input country/plant-specific CO_2 EFs.

Step C.2, in 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 B.2, in 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 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 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

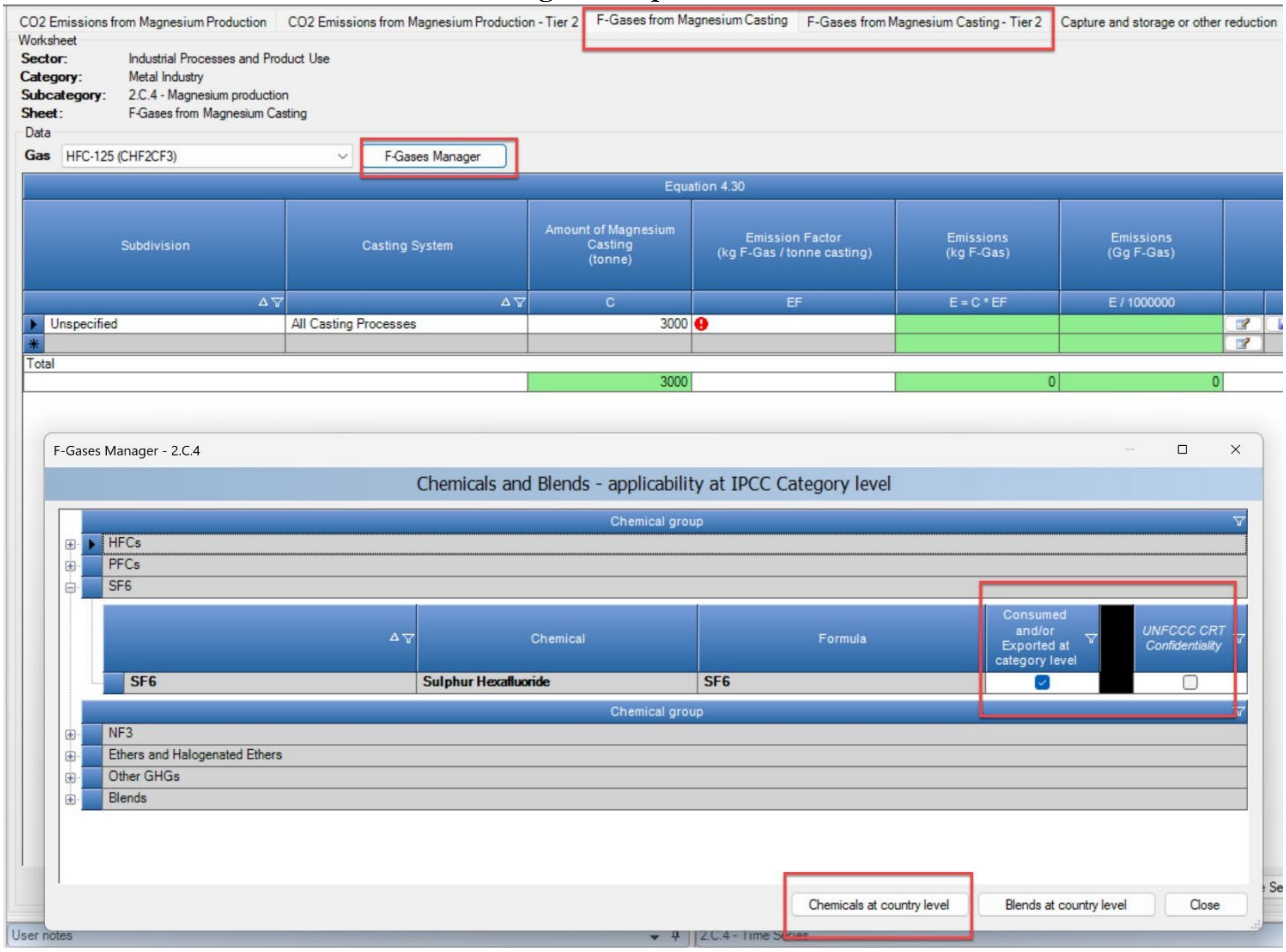
Section 4.5.2.3 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Magnesium Production. Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

As a **starting step**, users must ensure that the **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. For more information, refer to populating the F-Gases Manager, in the section above.*

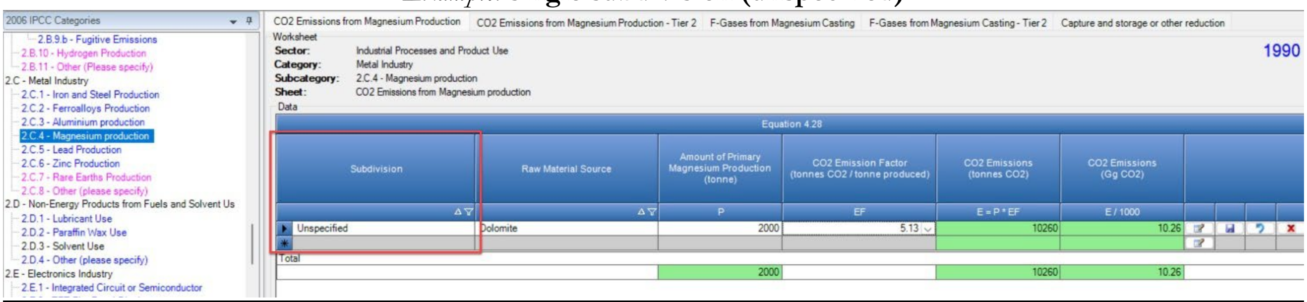
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the CRT. 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**

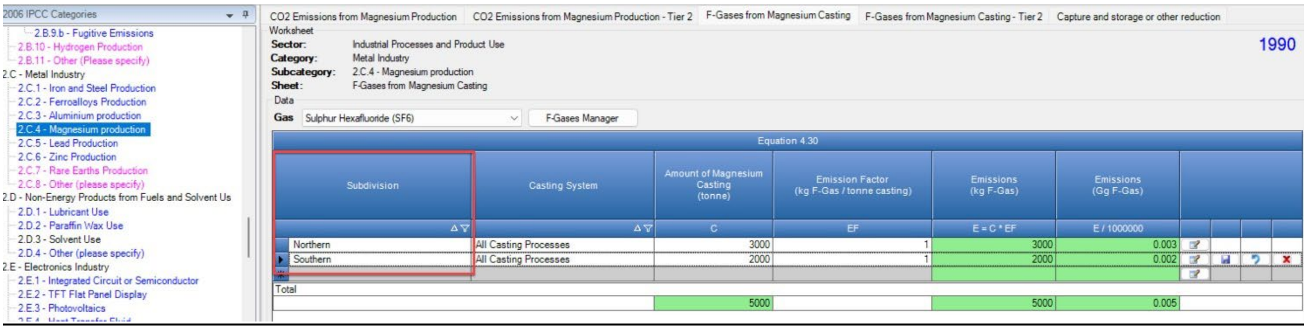


Second, input of AD for Magnesium Production requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in <u>Column |Subdivision|</u> [e.g. "country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

Example: **single subdivision (unspecified)**



Example: **multiple subdivisions**

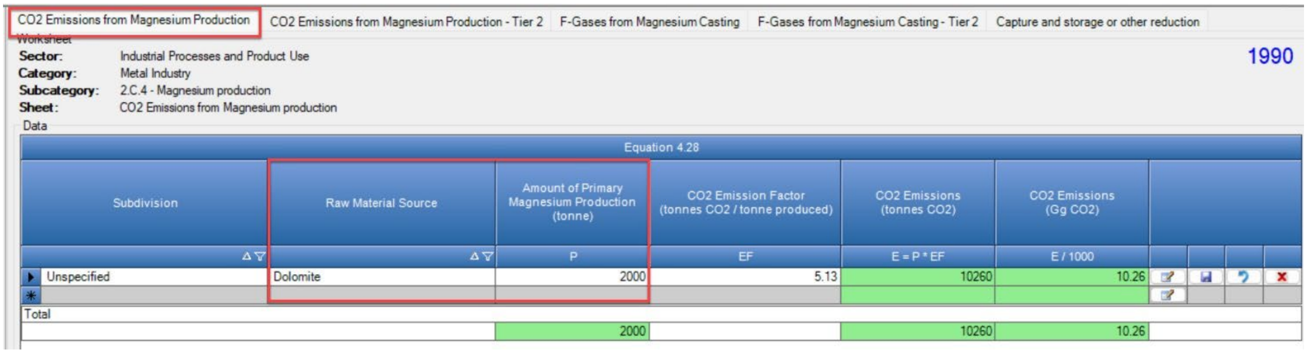


When Tier 1 Equations are applied

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|:select from the drop-down menu the default type of raw material used (dolomite or magnesite) or input manually the user-specific raw material used.
2. Column |P|: input the amount/mass of magnesium produced, in tonnes.

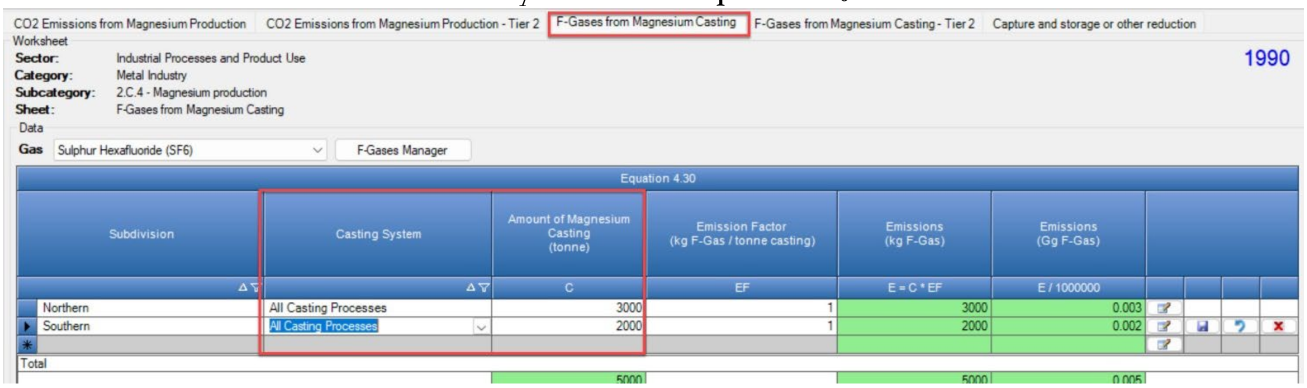


ii. F-gas emissions

For each subdivision in Column |Subdivision|, data are input in worksheet **F-Gases from Magnesium Casting** row by row, as follows:

1. Column |Casting System|: select from the drop-down menu the default type of casting system or input manually a user-specific system.
2. Column |C|: input the amount/mass of magnesium casting, in tonnes.

Example: **Tier 1 AD input for SF_6**



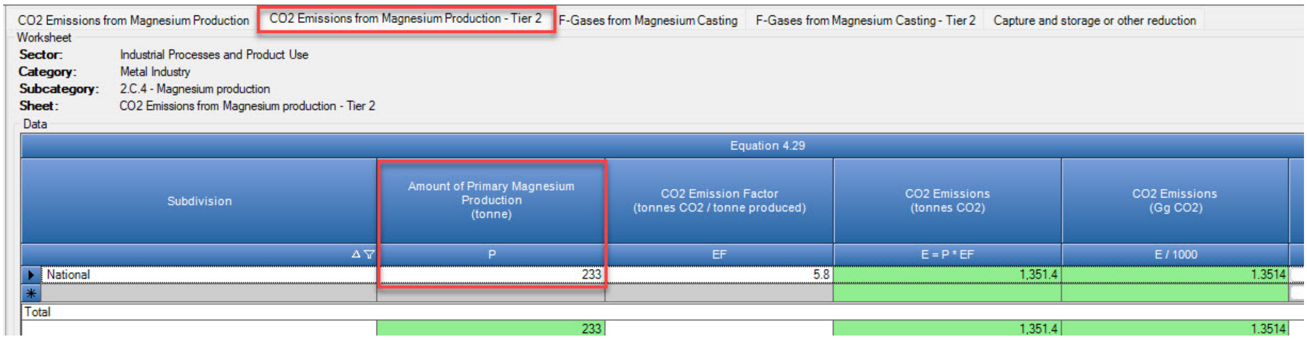
When Tier 2 Equations are applied

i.CO_2 emissions

For each subdivision in Column |Subdivision|, data are input 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**

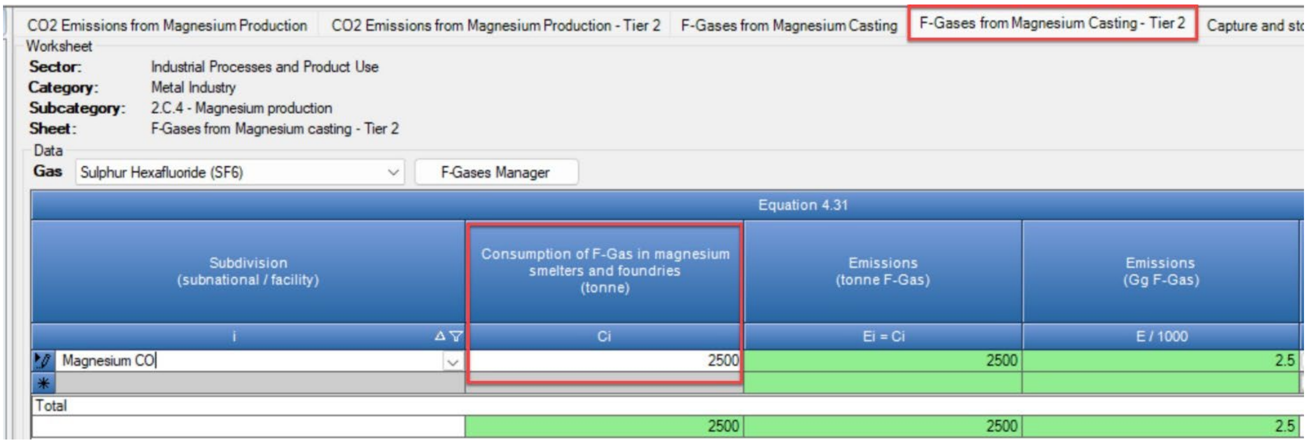


ii. F-gas emissions

For each subdivision in Column |Subdivision|, data are input in worksheet **F-Gases from Magnesium Casting – Tier 2** row by row, by gas, 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:

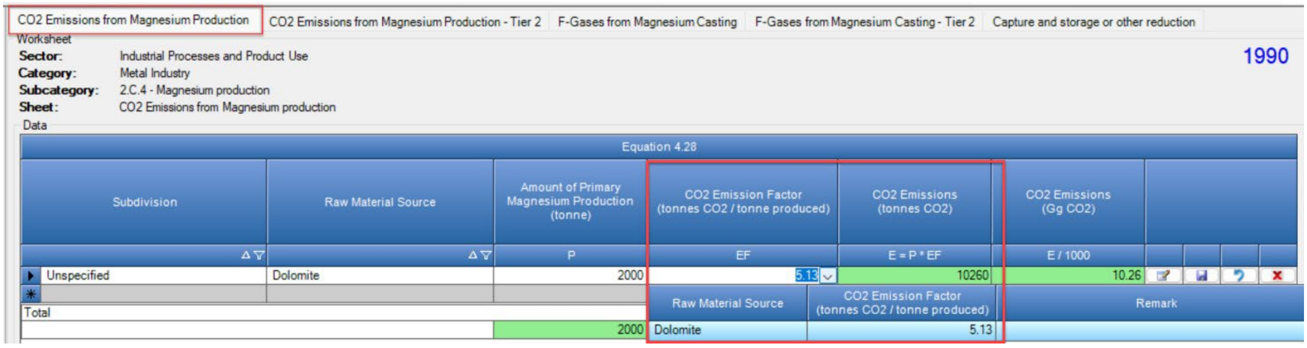
- ✓ Tier 1 EFs for CO_2 (Table 4.19)
- ✓ Tier 1 EFs for SF_6 (Table 4.20)

When the Tier 1 Equations are applied:

i. CO_2 emissions

For each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 Emissions from Magnesium Production,** row by row in Column |EF|. The user selects either default CO_2 EFs from the drop-down menu or inputs manually user-specific EFs, in tonne of CO_2 per tonne of magnesium produced.

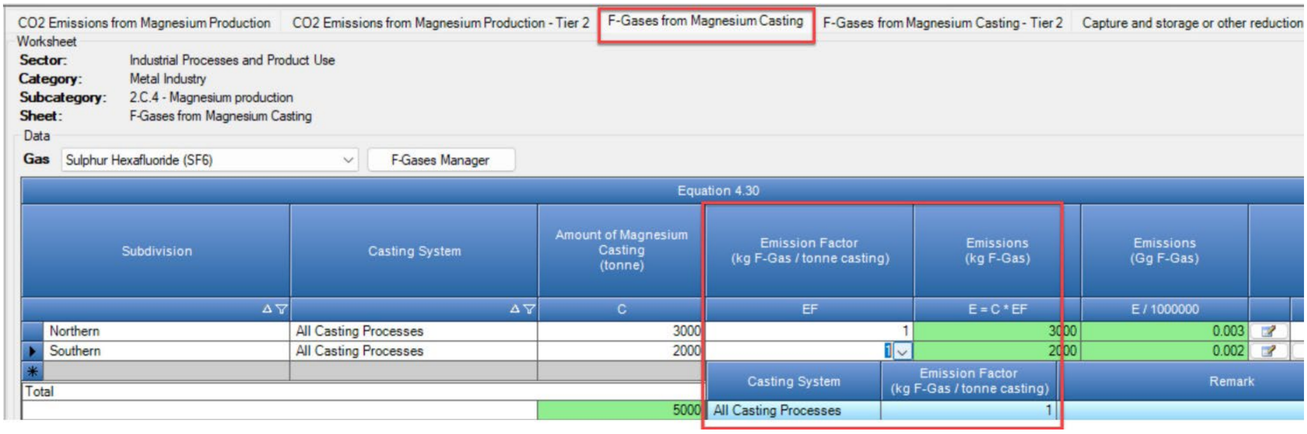
Example: **Tier 1 EFs for CO_2**



ii. F-gas emissions

For each gas and each subdivision in Column |Subdivision|, data are input in worksheet **F-Gases from Magnesium Casting,** row by row in Column |EF|. The user selects either default EFs from the drop-down menu (available for SF_6 only) or inputs manually user-specific EFs, in kg F-gas per tonne of magnesium casting. *Note that the user shall select 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:

i. CO_2 emissions

For each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 Emissions from Magnesium Production – Tier 2,** row by row in Column |EF|. For Tier 2, the user must input a company or plant-specific EF, in tonnes of CO_2 / tonne of magnesium produced.

ii. F-gas emissions

The Tier 2 approach for estimating F-gases assumes that consumption equals emissions. There is no user entry of an EF 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**

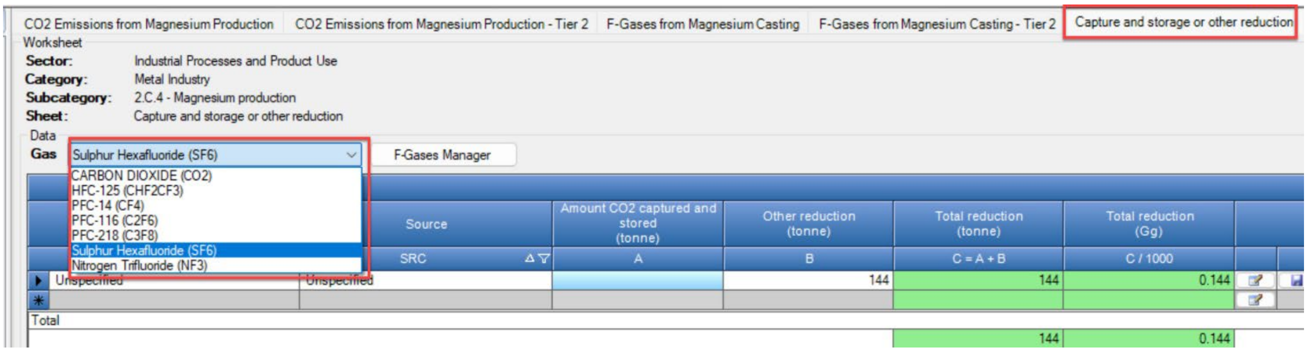
Total CO_2 and F-gas emissions from magnesium production is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate these reductions.

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

1. Column |SRC|: 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 owing to their common methodological approaches applied in the *Software*:

- ✓ **2.C.5 Lead Production**
- ✓ **2.C.6 Zinc Production**

Section 4.6 (Lead Production) and Section 4.8 (Zinc Production) of 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 the Lead Production source category are estimated using the following three worksheets:

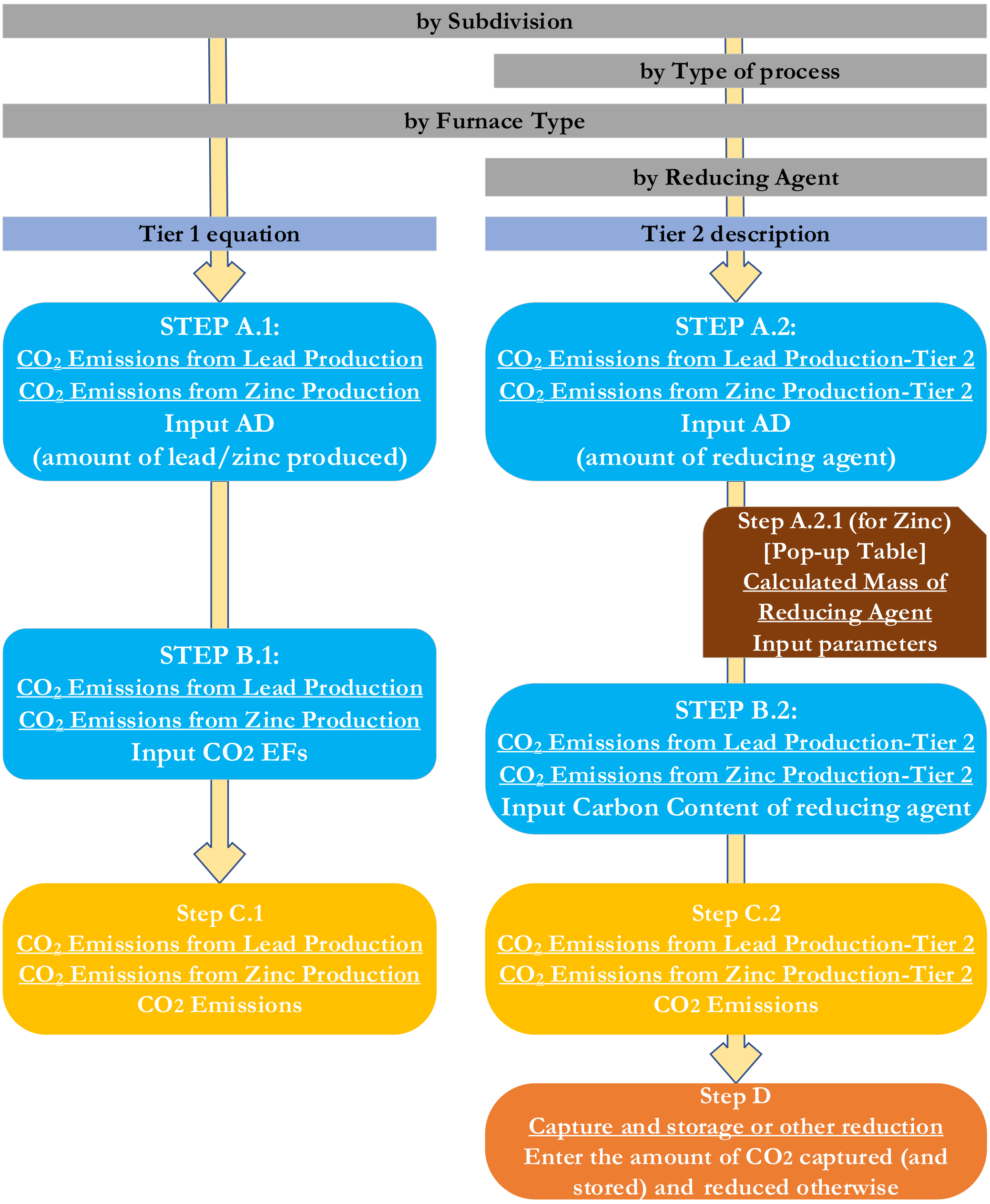
- ✓ **CO_2 Emissions from Lead Production** and **CO_2 Emissions from Zinc Production:** contains for each subdivision and each type of furnace/source/process, if known (e.g. direct smelting, imperial smelting furnace, from secondary materials, Waelz Kiln) information on the amount of lead or zinc produced 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 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 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 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 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 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 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.

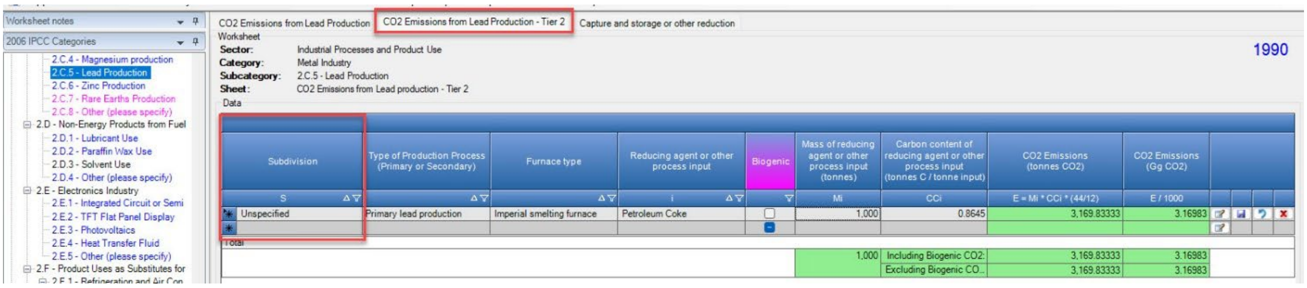
Activity Data Input

The following sections in Chapter 4, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of AD:

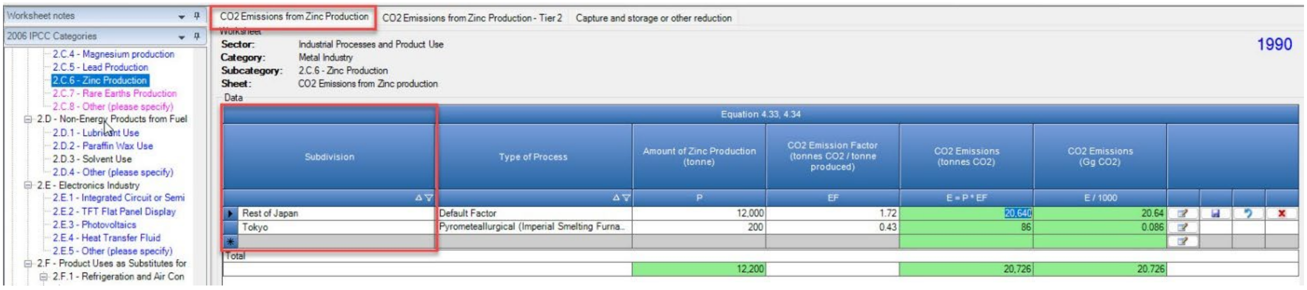
- ✓ Section 4.6.2.3 contains information on the choice of AD for Lead Production.
- ✓ Section 4.7.2.3 contains information on the choice of AD for Zinc Production.

Input of AD for Lead Production and Zinc 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision (unspecified) – lead production**



Example: **multiple subdivisions – zinc production**

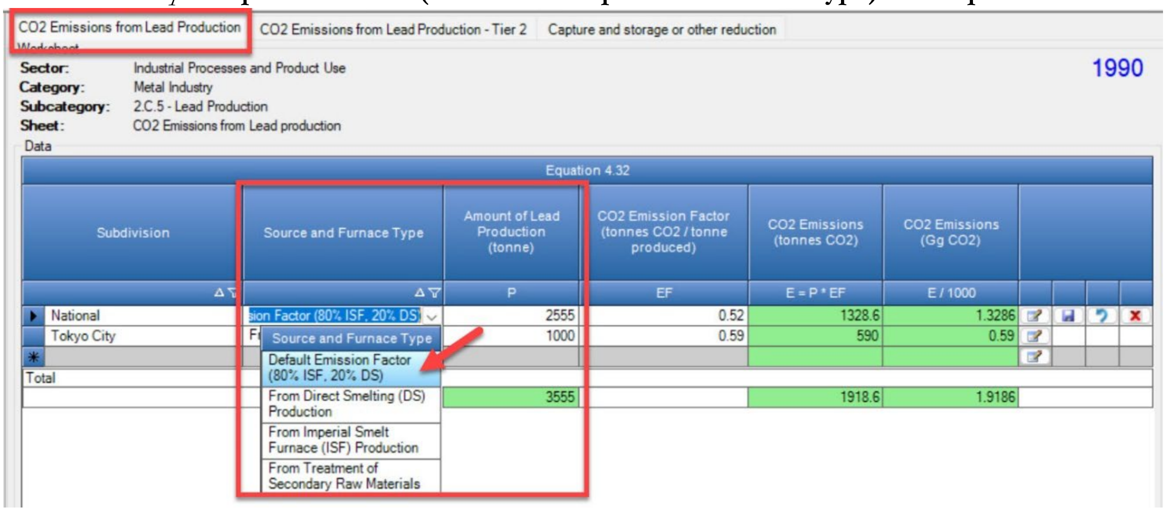


When the Tier 1 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO_2 Emissions from Lead Production,** or **CO_2 Emissions from Zinc Production** row by row, as follows:

1. <u>Column |Source and Furnace Type|</u> (Lead only) and <u>Column |Type of Process|</u> (Zinc): 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.
   <u>Note that</u> 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.
2. <u>Column |P|</u>: input the amount/mass of lead or zinc produced, in tonnes.

Example: **Input Tier 1 AD (default assumption for furnace type) – lead production**



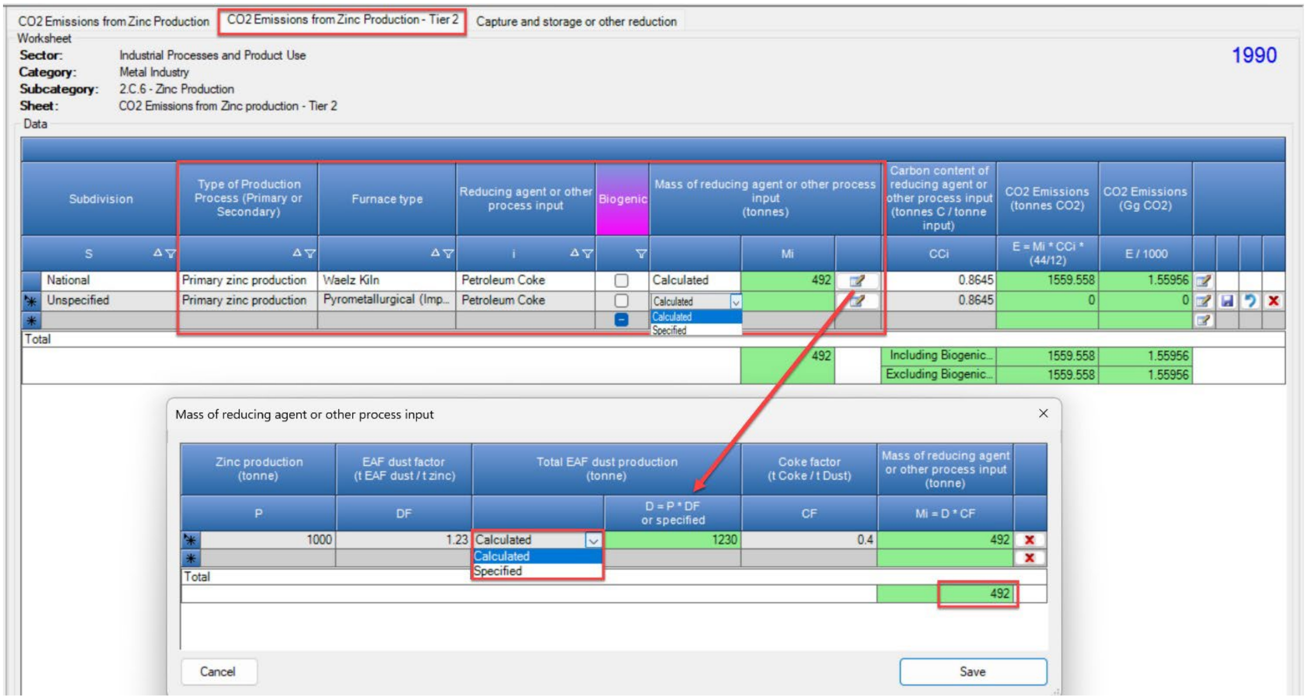
When the Tier 2 Equation is applied:

For each subdivision in 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, as follows:

1. Column |Type of Production (Primary or Secondary)|: select from the drop-down menu whether emissions are estimated for primary production or secondary production.
2. Column |Furnace type|: select from the drop-down menu the default type of furnace or input manually a user-specific type of furnace.
3. Column |i|: select from the drop-down menu the default type of reducing agent or input manually a user-specific type of carbon input.
   Note that 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 Column |CCi|. If a user-specific reducing agent or process fuel is input, the user will be required to manually enter Column |CCi|. See section ***Fuel Manager*** *for more information on how to populate the Fuel Manager.*
4. Column |Biogenic|: indicate with a check if the reducing agent or other process input is of biogenic origin.
5. Column |Mi|: input the amount/mass of reducing agent or other process input consumed, in tonnes. Note that 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 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, select **Calculated** and the corresponding **pop-up table**, and then:
   a. Column |D|: first, indicate whether the total amount of EAF dust produced is to be **Specified** (thus input directly) or **Calculated**.
      i. If Column |D| is *Specified*, Column |P| and Column |DF| are grayed out and the user inputs the amount of EAF dust production in Column |D|.
      ii. If Column |D| is *Calculated*, input the amount of zinc produced, in tonnes in Column |P|. Select or insert the IPCC default EAF dust factor of 1.23 t EAF dust/t zinc in Column |DF|, or input a user-specific value.
   b. Column |CF|: A factor of 0.4 tonne coke used per tonne of dust produced is automatically populated; or the user may manually enter in a user 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:

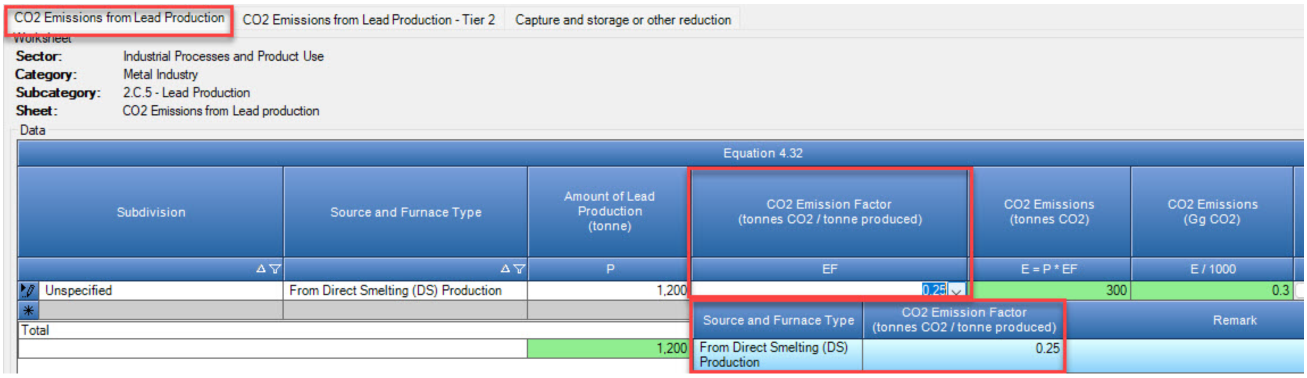
- ✓ Section 4.6.2.2 contains information on the choice of EFs for Lead Production. Tier 1 CO_2 EFs are presented in Table 4.21. Tier 2 default carbon contents for input materials are presented in Table 4.22, but are to be used only if the compiler does not have user-specific information.
- ✓ Section 4.7.2.2 contains information on the choice of EFs for Zinc Production. Tier 1 CO_2 EFs are presented in Table 4.24.

When the Tier 1 Equation is applied:

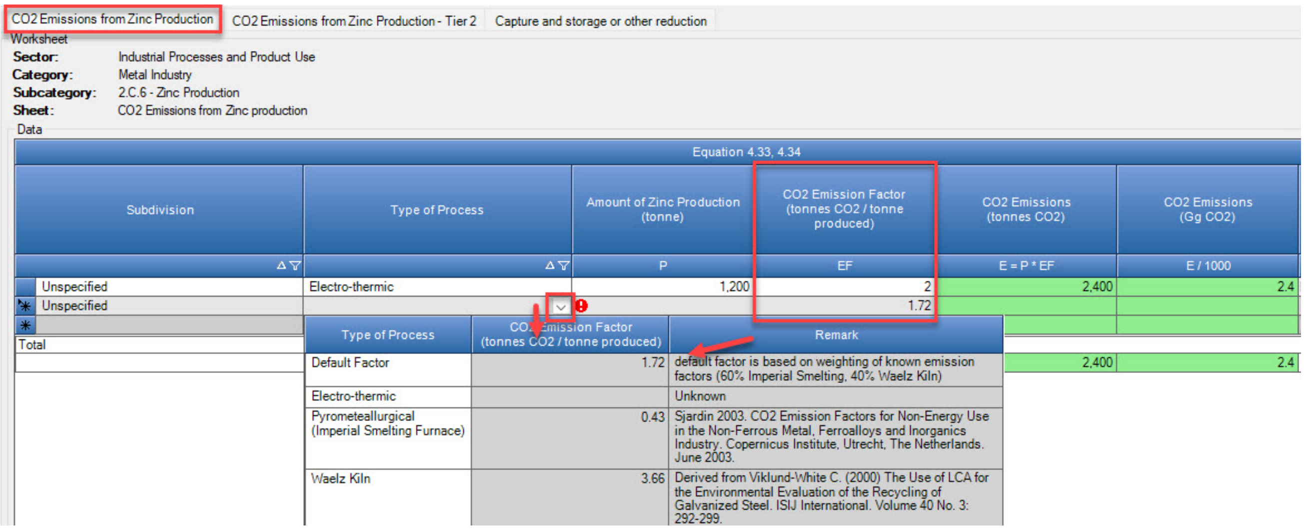
For each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 Emissions from Lead Production** or **CO_2 Emissions from Zinc Production,** row by row, as follows:

1. Column |EF|: Select from the drop-down menu or manually overwrite the EFs with user-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 user-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:

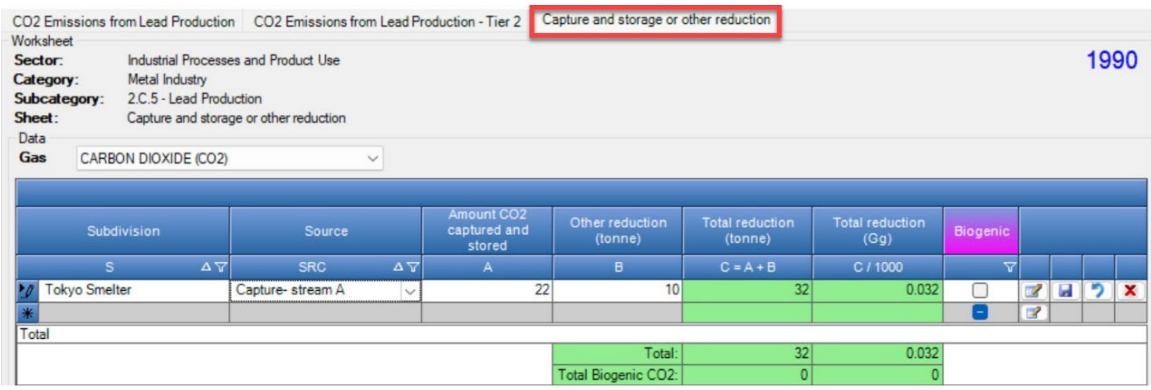
- ✓ **CO_2 Emissions from Zinc Production**
- ✓ **CO_2 Emissions from Zinc Production – Tier 2**

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. Column |SRC|: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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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 CO_2 emissions from use are included elsewhere in the GHG inventory.*
4. Column |Biogenic|: indicate with a check if the reductant/process input material is of biogenic origin. *Note that consistent with 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 in Chapter 4, Volume 3 of the *2019 IPCC Guidelines* provides methods to estimate CO_2 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 the 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

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 worksheets:

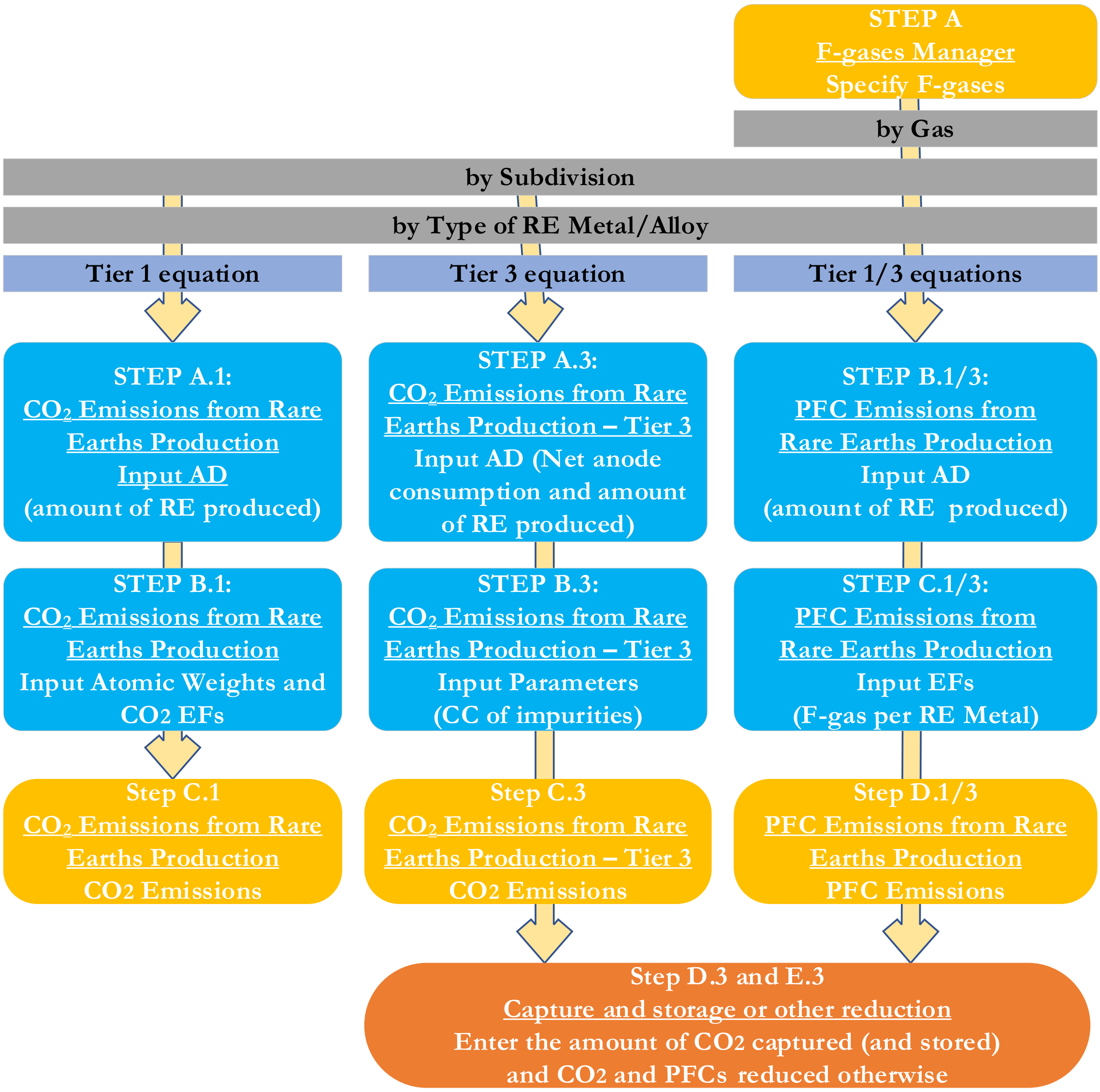
- ✓ **CO_2 Emissions from Rare Earths Production:** contains for each subdivision and each type of RE metal/alloy, information on the amount of the metal/alloy produced and default CO_2 EFs. The worksheet calculates the associated CO_2 emissions.
- ✓ **CO_2 Emissions from Rare Earths Production – Tier 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.
- ✓ **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 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 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 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 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 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 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

When the Tier 1 Equation is applied:

Step B.1/3, in 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 worksheet **PFC Emissions from Rare Earths Production**, users collect and input the EF for each F-gas.

Step D.1/3, in 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 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

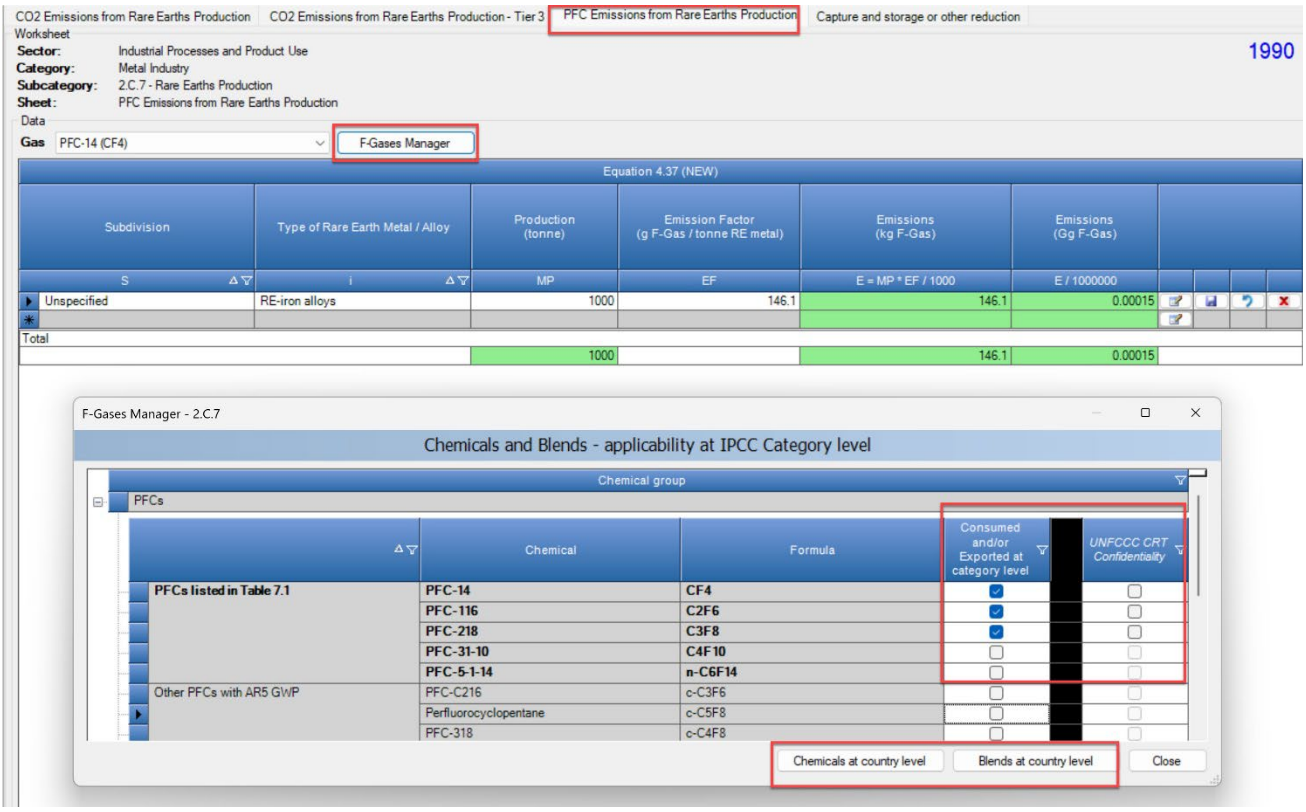
Section 4.8.2.5 in Chapter 4 Volume 3 of the *2019 Refinement* contains information on the choice of AD for Rare Earths Production.

As a **starting step**, for estimation of PFC emissions, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category Rare Earths Production.

*Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. 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. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager. For more information, refer to populating the F-Gases Manager, in the section above.*

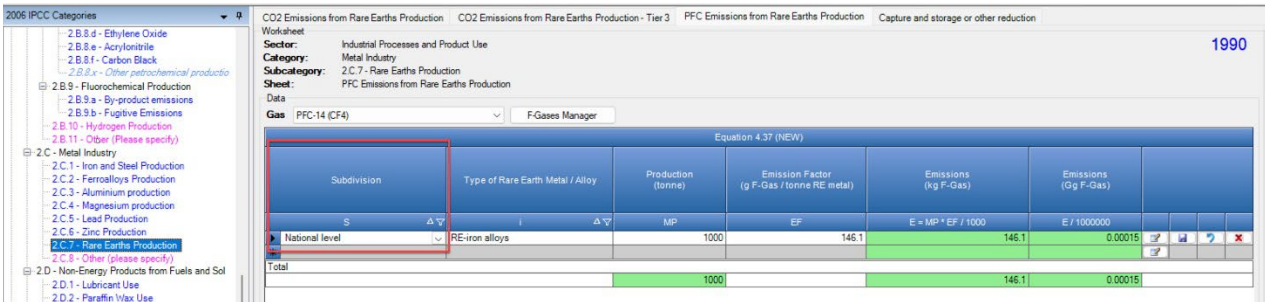
<u>For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool:</u> If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the CRT; 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**

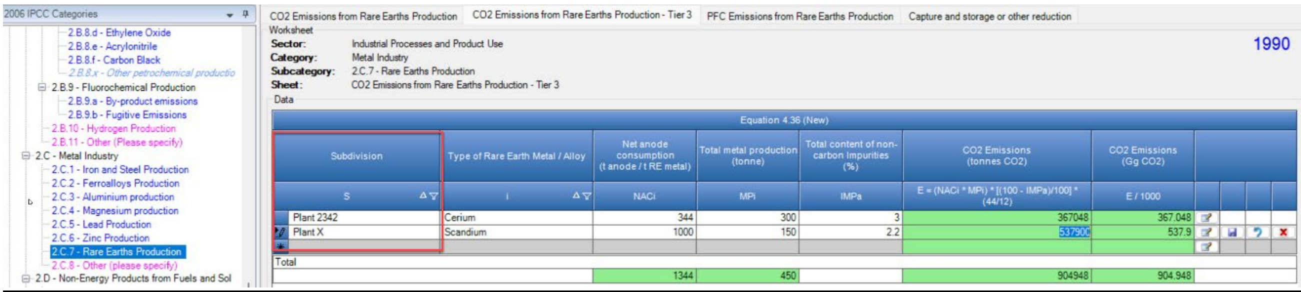


Second, input of AD for the Rare Earths Production requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in <u>Column |Subdivision|</u> [e.g. "country name" or "Unspecified" as selected from the drop-down menu] or where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> for each subdivision.

Example: **single subdivision**



Example: **multiple subdivisions**



2006 IPCC Categories
2.B.8.d - Ethylene Oxide
2.B.8.e - Acrylonitrile
2.B.8.f - Carbon Black
2.B.8.x - Other petrochemical productio
2.B.9 - Fluorochemical Production
2.B.9.a - By-product emissions
2.B.9.b - Fugitive Emissions
2.B.10 - Hydrogen Production
2.B.11 - Other (Please specify)
2.C - Metal Industry
2.C.1 - Iron and Steel Production
2.C.2 - Ferroalloys Production
2.C.3 - Aluminium production
2.C.4 - Magnesium production
2.C.5 - Lead Production
2.C.6 - Zinc Production
2.C.7 - Rare Earths Production
2.C.8 - Other (please specify)
2.D - Non-Energy Products from Fuels and Sol

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

1990

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)

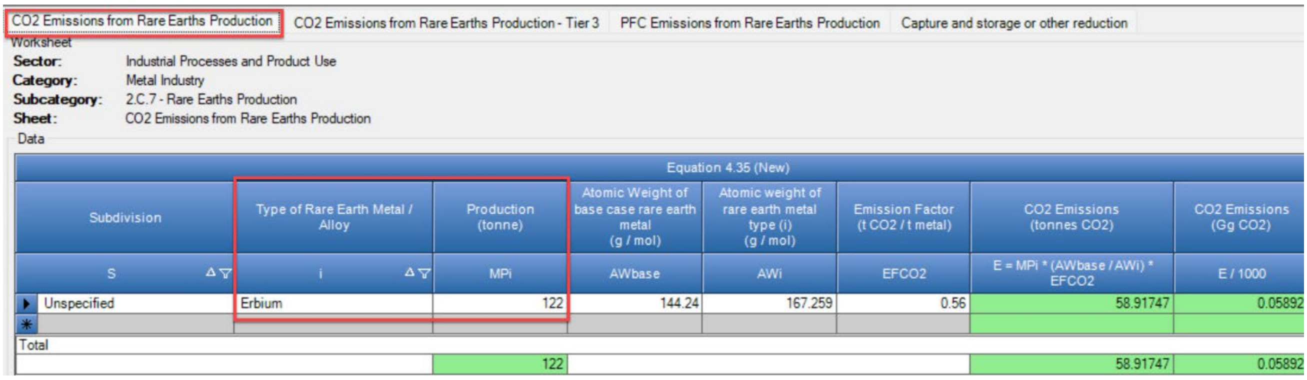
Subdivision	Type of Rare Earth Metal / Alloy	Net anode consumption (t anode / t RE metal)	Total metal production (tonne)	Total content of non-carbon Impurities (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
S	i	NACi	MPi	IMPa	E = (NACi * MPi) * [(100 - IMPa)/100] * (44/12)	E / 1000
Plant 2342	Cerium	344	300	3	367048	367.048
Plant X	Scandium	1000	150	2.2	537900	537.9
Total		1344	450		904948	904.948

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

For each subdivision in Column |Subdivision|, 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, or manually input a user-specific RE metal/alloy.
2. Column |MPi|: input the amount/mass of RE metal/alloy produced, in tonnes.

Example: **AD input for CO_2 – Tier 1**



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)

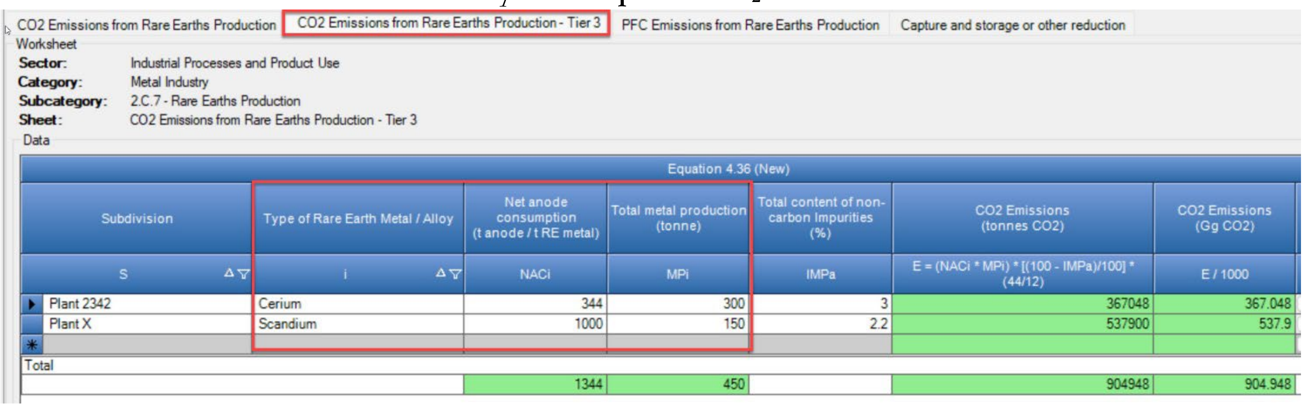
Subdivision	Type of Rare Earth Metal / Alloy	Production (tonne)	Atomic Weight of base case rare earth metal (g / mol)	Atomic weight of rare earth metal type (i) (g / mol)	Emission Factor (t CO2 / t metal)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
S	i	MPi	AWbase	AWi	EFCO2	E = MPi * (AWbase / AWi) * EFCO2	E / 1000
Unspecified	Erbium	122	144.24	167.259	0.56	58.91747	0.05892
Total		122				58.91747	0.05892

When the Tier 3 Equation is applied (CO_2):

For each subdivision in Column |Subdivision|, 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, or manually input a user-specific RE metal/alloy.
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 user-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 |Subdivision|, 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; 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

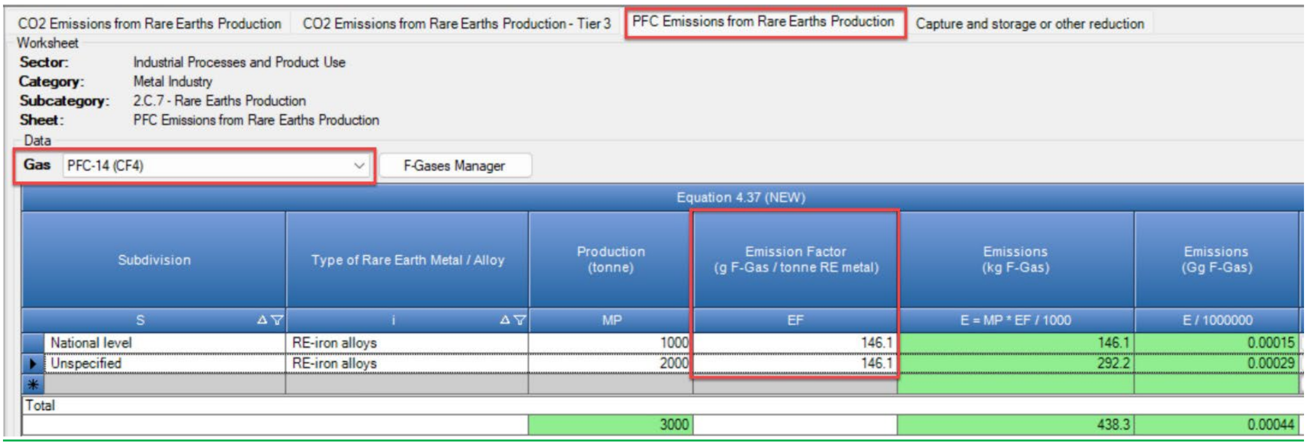
Data

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 |Subdivision|, 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 when either "RE-iron alloys" or "All other RE metals/alloys" is selected, or the user may manually input a user-specific value. 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

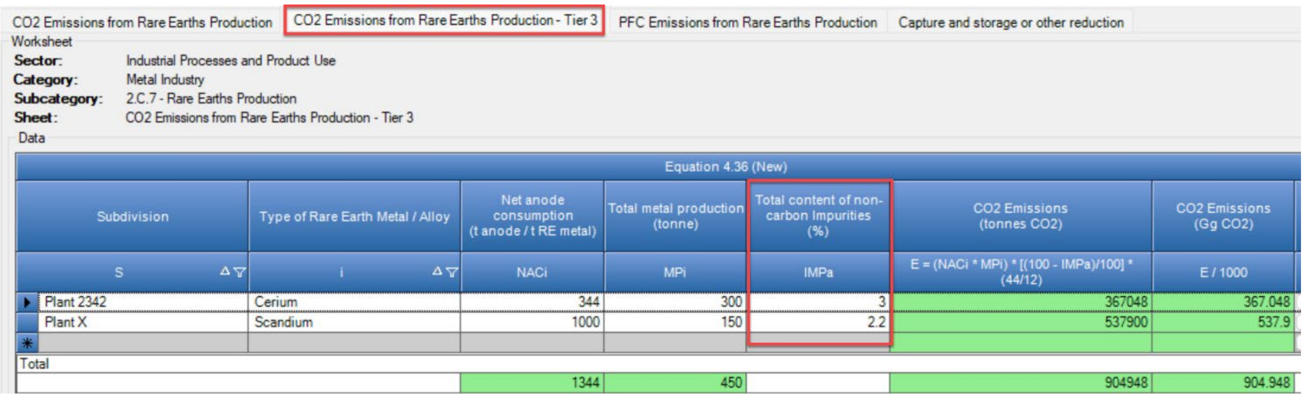
Equation 4.37 (NEW)

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 |Subdivision|, 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:

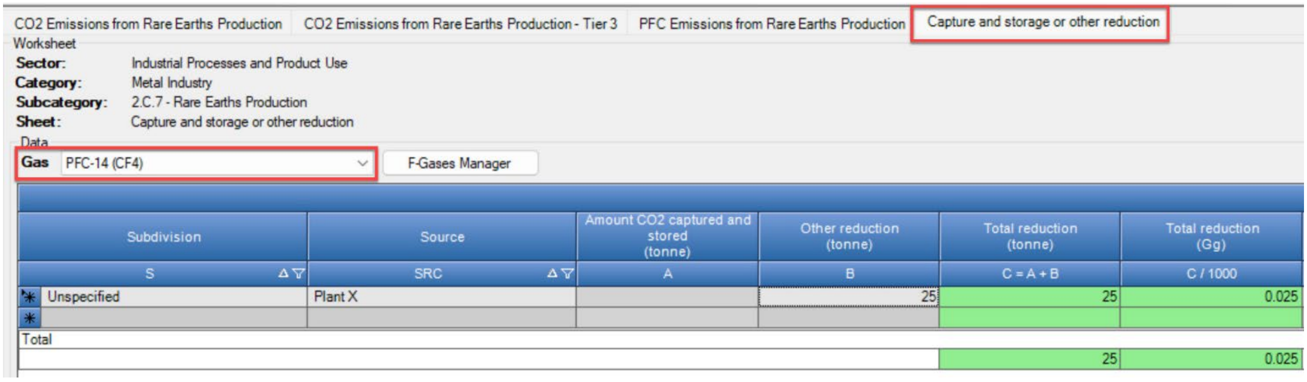
- ✓ **PFC Emissions from Rare Earths Production**

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. Column |SRC|: 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|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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.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

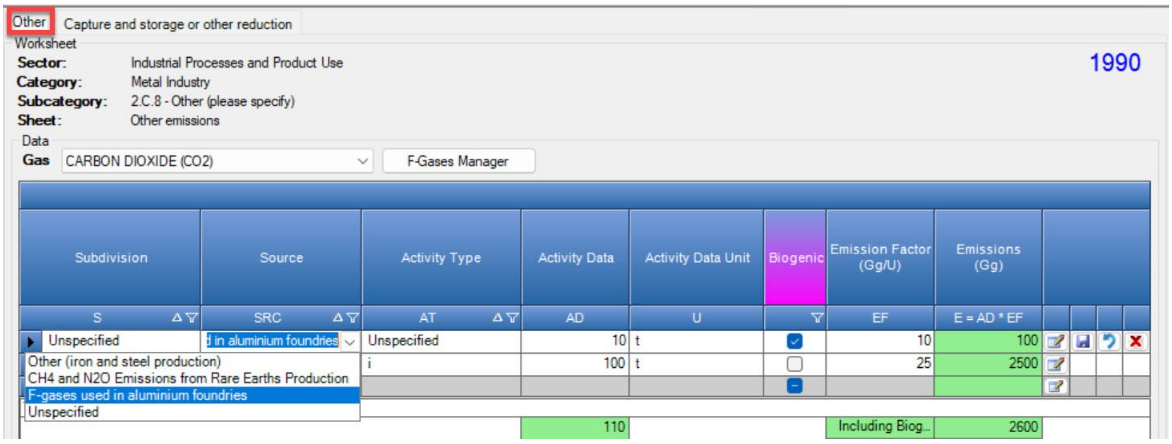
GHGs

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 guidance on inputting 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 those 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 used for energy purposes. 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 chapter 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 CRT 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 owing to their common methodological approaches applied in the *Software*:

- ✓ **2.D.1 Lubricant Use**
- ✓ **2.D.2 Paraffin Wax Use**

Section 5.2 (Lubricant Use) and Section 5.3 (Paraffin Wax Use) of 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 an oxidised during use (ODU) factor that represents the fraction of fossil carbon oxidized during use. The Tier 2 method relies on detailed data on the lubricants and greases consumed or paraffin waxes produced and user-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 section **2.D.4 Other**.

IPCC Equations

- ✓ 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.

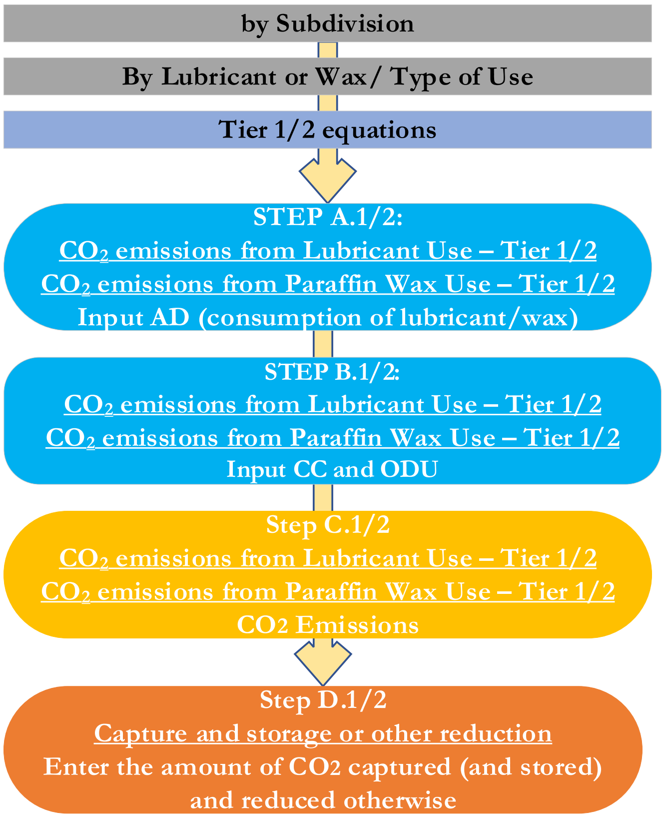
User's Work Flowchart

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.

[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:

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 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 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 worksheet **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.

Step D.1/2, in 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

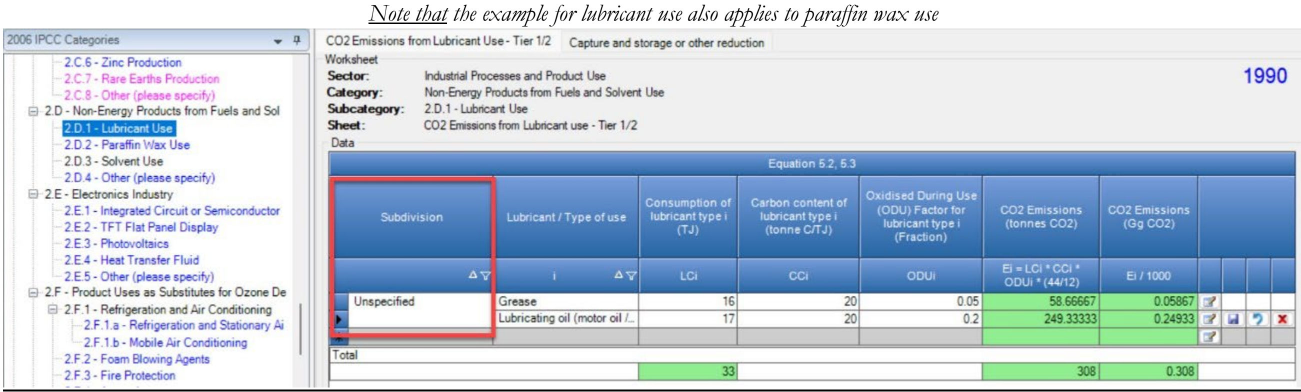
The following sections in Chapter 3, Volume 5 of the *2006 IPCC Guidelines* contain information on the choice of AD:

- ✓ 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 Lubricant Use and Paraffin Wax Use 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

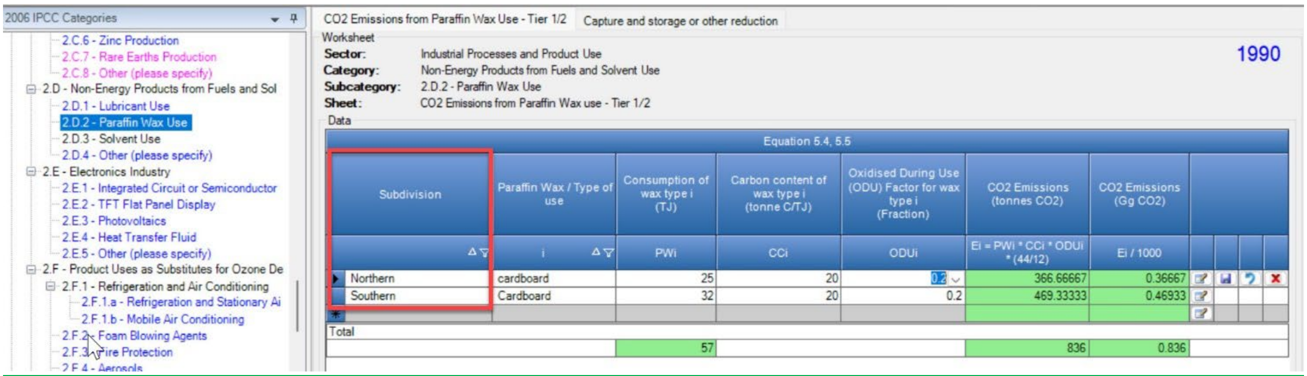
Example: **single subdivision (unspecified)**

Note that the example for lubricant use also applies to paraffin wax use



Example: **multiple subdivisions**

Note that the example for paraffin wax use also applies to lubricant use

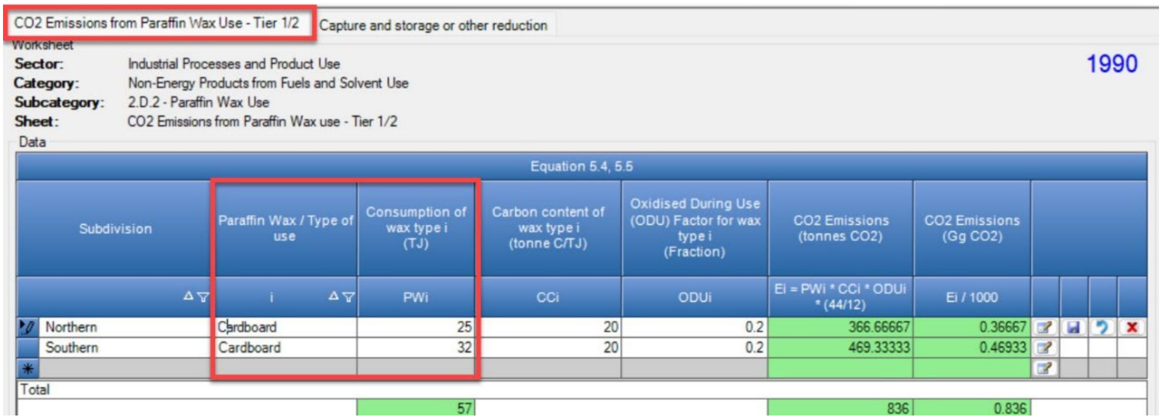


Then, for each subdivision in Column |Subdivision|, data are input in worksheet **CO_2 Emissions from Lubricant Use – Tier 1/2** or **CO_2 Emissions from Paraffin Wax Use – Tier 1/2,** row by row, as follows:

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 user-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:

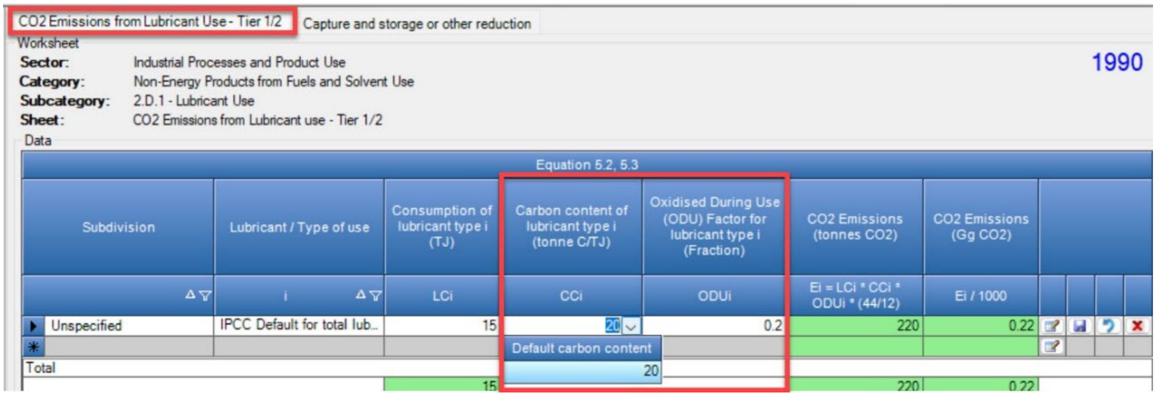
- ✓ Section 5.2.2.2 contains information on the choice of EF for Lubricant Use. Default values are presented in Table 5.2.
- ✓ Section 5.3.2.2 contains information on the choice of EF for Paraffin Wax Use.

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 input 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 input 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

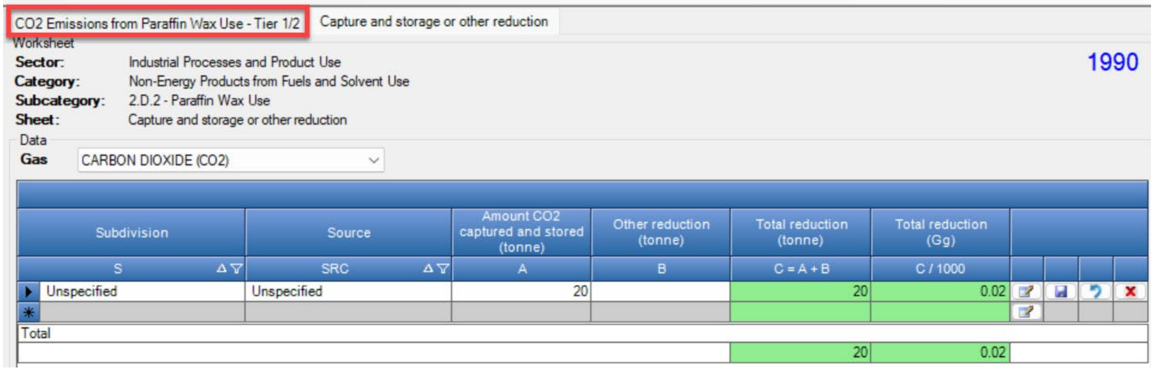
CO_2 emissions from Lubricant Use are estimated in mass units (tonnes and Gg) by each subdivision and total in the *Software* in the worksheets **CO_2 emissions from Lubricant Use – Tier 1/2** or **CO_2 Emissions from Paraffin Wax Use – Tier 1/2.**

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. <u>Column |SRC|</u>: 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. <u>Column |A|</u>: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO_2, in tonnes. *<u>Note that</u>: 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 CRT 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 from 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 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 CRT 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

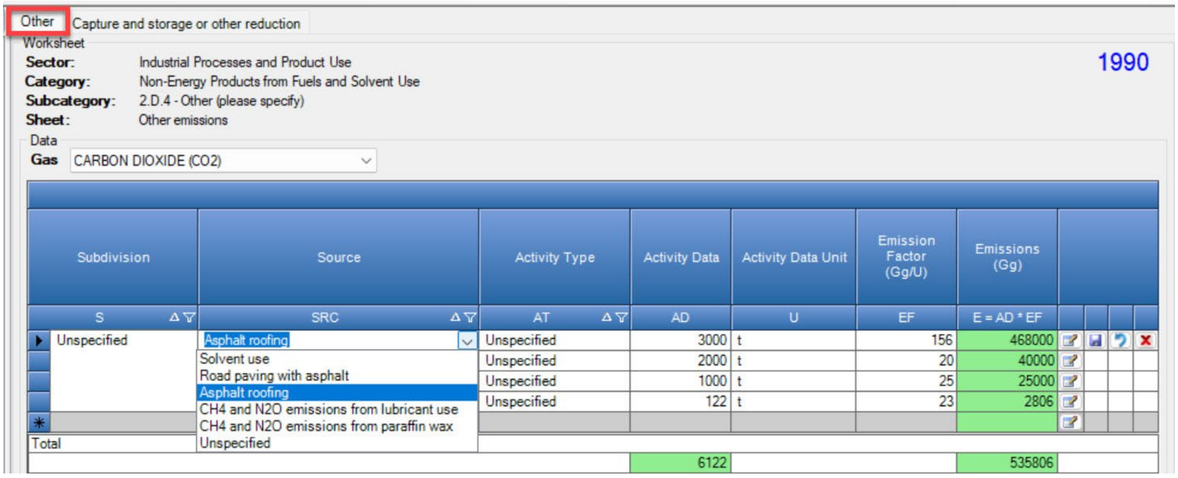
GHGs

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.E Electronics Industry

Several advanced electronics manufacturing processes utilise fluorinated compounds (FC) and N_2O for plasma etching intricate patterns, cleaning reactor chambers, and temperature control. The specific electronic industries discussed in this section include integrated circuit or semiconductors (semiconductors) (2.E.1), thin-film-transistor flat panel displays (TFT-FPD) (2.E.2), photovoltaic (PV) manufacturing (2.E.3), heat transfer fluids (2.E.4) and other electronics industry emissions, including FC emissions from manufacturing of microelectromechanical systems (MEMs) (2.E.5).

Section 6.2.1.1 in Chapter 6 Volume 3 of the *2006 IPCC Guidelines* provides single methodological guidance for the three sub-categories: 2.E.1 Semiconductors, 2.E.2 TFT-FPD and 2.E.3 PVs. Section 6.2.1.2 provides methodological guidance for the sub-category 2.E.4 Heat Transfer Fluids. Because the UNFCCC ETF Reporting Tool includes reporting of emissions from MEMs, and a method for MEMS is specifically introduced in the *2019 Refinement*, Section 6.2.1.1 of those Guidelines is used for this component of the electronics industry (only a Tier 1 method provided).

2.E.1, 2.E.2 and 2.E.3 Integrated Circuit or Semiconductor, TFT Flat Panel Display and Photovoltaics

Information

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

- ✓ 2.E.1 Integrated Circuit or Semiconductor
- ✓ 2.E.2 TFT Flat Panel Display
- ✓ 2.E.3 Photovoltaics

Section 6.2.1.1 of the *2006 IPCC Guidelines* provide three Tiers for estimation of GHG emissions from Semiconductors, TFT-FPD and PVs, with differentiation between Tier 2a and Tier 2b.

The Tier 1 method for calculating emissions relies on a fixed set of generic EFs for fluorinated compounds depending on the sector (or class) of electronic products being manufactured (Semiconductors, TFT-FPDs or PV cells). EFs are expressed as an average emissions per unit of substrate area (e.g., silicon, TFT-FPD panels and PV-cells). The Tier 1 method includes only emissions of F-gases, consistent with the methods in the *2006 IPCC Guidelines*. When applying a Tier 2 or Tier 3 method, the *Software* also allows the user to estimate GHG emissions for N_2O.

The Tier 2a method calculates emissions for each compound based on company-specific gas consumption and emission control technologies. Tier 2a method does not distinguish between process types (etching versus cleaning), individual processes or tools. The default EFs represent weighted averages, formed separately for each gas, over all etching and Chemical Vapour Deposition (CVD) cleaning processes. This method recognizes that individual gases tend to be used predominantly in particular process types (CVD or etch) throughout each industry. However, in countries with companies or plants that depart significantly from the industry-wide pattern of usage (e.g., by using a gas primarily in etch while others primarily use it in CVD), inventory compilers should evaluate the potential to introduce error by using the Tier 2a method rather than the Tier 2b method.

The Tier 2b method uses company-specific data on the proportion of gas used in etching versus cleaning and the proportion of gas used in processes with emission control technology and relies on default values for some or all of the other parameters.

The Tier 3 method also uses equations of Tier 2b, however this method requires company- or plant-specific values for all the parameters used in those equations for each individual process or for each of small sets of processes (e.g., silicon nitride etching or plasma enhanced chemical vapour deposition (PECVD) tool chamber cleaning).

GHGs

The *Software* includes the following GHGs for the Semiconductors, TFT-FPD and PV source categories:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	X (only for Tier 2/3 and categories 2.E.1 and 2.E.2)	X	X	X	X

IPCC Equations

- ✓ Tier 1: Equation 6.1
- ✓ Tier 2a: Equations 6.2, 6.3, 6.4, 6.5 and 6.6
- ✓ Tier 2b: Equations 6.7, 6.8, 6.9, 6.10 and 6.11.
- ✓ Tier 3: Apply the Tier 2b equations, using company-specific or plant-specific values for all parameters for each induvial process or for each small set of processes.

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 (2.E.1, 2.E.2 and 2.E.3) are estimated using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Emissions from Electronics Industry:** contains for each subdivision and each FC gas, information on the annual manufacturing design capacity (m^2 of substrate area processed, e.g. silicon, TFT-FPD panel and PV-cell), utilisation fraction of annual plant production capacity and default EFs. The worksheet calculates the associated FC emissions for Tier 1.
- ✓ **AD Gas – Tier 2/3:** contains for each subdivision, each plant and each gas (FC and N_2O) information on the Tier used (Tier 2a and Tier 2b (or Tier 3)), amount of heel, total consumption of gas, fraction of gas used in processes with control technologies and fraction destroyed (totals for Tier 2a and by etching and cleaning for Tier 2b/3).
- ✓ **AD By-product Manager – Tier 2/3:** in addition to subdivisions, plants and Tiers which are automatically transferred from **AD Manager – Tier 2/3,** contains information on the amount of by-product gas destroyed by the emission control technologies (total for Tier 2a and by etching and cleaning for Tier 2b/3).
- ✓ **Emissions from gases used in production processes – Tier 2a[1]:** in addition to information on subdivision/plant/gas consumption/heels/fraction of gas utilized in processes with emissions controlled/destroyed, which are automatically transferred from **AD Gas- Tier 2/3,** contains information on the use rate of the gas, defined as the fraction destroyed/transformed in the process. The worksheet calculates the associated emissions from the process.
- ✓ **By-product emissions from gases used in production processes – Tier 2a[2]:** in addition to information on subdivision/plant/possible by-products/gas consumption/heels/fraction of gas utilized in processes with emission controls/destroyed, which are automatically transferred from **AD Gas-Tier 2/3 and AD By-product Manager- Tier 2/3,** contains information on by-product EFs. The worksheet calculates the associated by-product emissions.
- ✓ **Emissions from gases used in production processes – Tier 2b/Tier 3[3]:** in addition to information on heels, gas consumption and utilization factors for each subdivision/plant/gas, which are automatically transferred from **AD Gas -Tier 2/3** to this worksheet (for Tier 2b/Tier 3) with differentiation between etching and cleaning processes, contains information on the use rate of gas for etching and cleaning. The worksheet calculates the associated emissions used in the process.
- ✓ **By-product emissions from gases used in production processes – Tier 2b/Tier 3[4]:** in addition to information on heels, gas consumption and fraction of gas used in processes with control technologies for each subdivision/plant/gas, which are automatically transferred from **AD Gas – Tier 2/3** to this worksheet (for Tier 2b/Tier 3) and fraction of by-product gas destroyed by the ECT, which is transferred from **AD By-product- Tier 2/3**, contains information on by-product EFs. The AD and EFs are differentiated for etching and cleaning processes. The worksheet calculates the associated by-product emissions.
- ✓ **Capture and storage or other reduction** contains information on reduction of F-gases, not accounted previously in the worksheets for different Tiers.

---

[1] For category 2.E.3, all references to this worksheet should replace "gases" with "F-gases". Category 2.E.3 is limited to F-gases, as N_2O is not included for photovoltaics.

[2] Ibid.

3 Ibid.

4 Ibid.

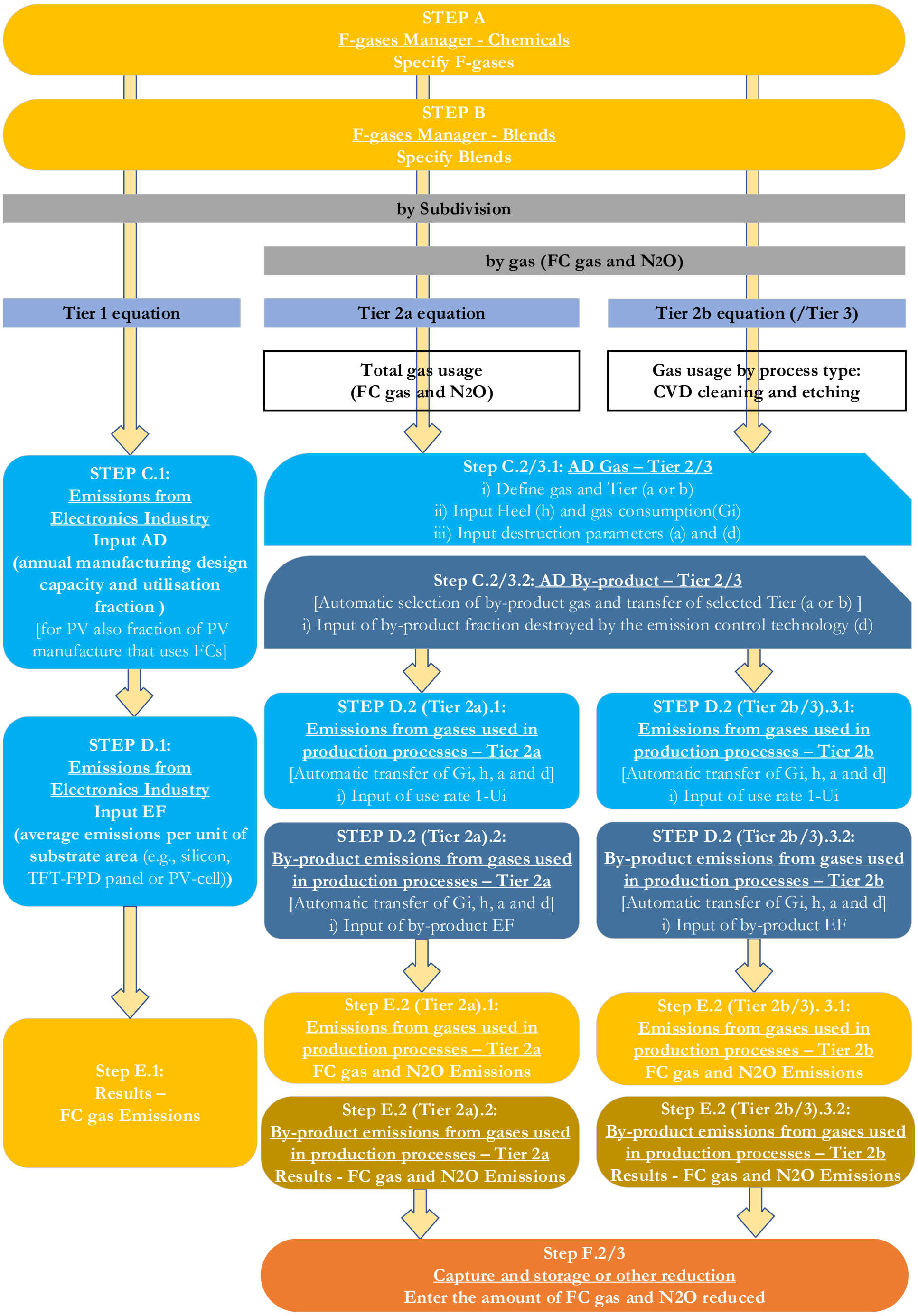
User's Work Flowchart

Consistent with the key category analysis and the decision tree in Figure 6.1 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 source categories 2.E.1 Integrated Circuit or Semiconductor, 2.E.2 TFT Flat Panel Display, and 2.E.3 Photovoltaics.

Electronics Manufacturing - flowchart

(Etching and CVD Cleaning for 2.E.1 Integrated Circuit or Semiconductor, 2.E.2 TFT Flat Panel Display, and 2.E.3 Photovoltaics)



[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 each relevant source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends 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 C.1, in worksheet **Emissions from Electronics Industry**, users collect and input in the *Software* information on the annual manufacturing design capacity (m^2 of substrate area processed, e.g. silicon, TFT-FPD panel and PV-cell) and utilisation fraction of annual plant production capacity.

Step D.1, in worksheet **Emissions from Electronics Industry**, for each subdivision and each FC gas, users input EFs in kg/g FC per m^2 of substrate processed (silicon, glass, PV substrate). Users may overwrite manually default EFs with country-specific EFs.

Step E.1, in worksheet **Emissions from Electronics Industry** the *Software* calculates the associated emissions for FC gas used in metric tonnes and Gg of CO_2 equivalent.

When the Tier 2 Equations are applied:

Note that: *Tier 3 can be applied in all worksheets applicable for Tier 2b; thus the user will notice that this Guidebook refers in several places to worksheet names appended with "Tier 2/3", to denote that the worksheet also accommodates the Tier 3 methods.*

First,

Step C.2/3.1, in worksheet **AD Gas – Tier 2/3**, users collect and input in the *Software* information on the amount of heel, consumption of gas, fraction of gas used in processes with ECT and fraction gas destroyed (total for Tier 2a and by etching and cleaning for Tier 2b/3).

Step C.2/3.2, in worksheet **AD By-product– Tier 2/3**, the information on subdivisions/plants/Tiers is automatically transferred from **AD Gas Manager- Tier 2/3**. For each subdivision/ plant users collect and input in the *Software* information on the amount of by-product gas destroyed by the ECT (total for Tier 2a and by etching and cleaning for Tier 2b/3).

Then,

For Tier 2a

Step D.2(Tier 2a).1, in worksheet **Emissions from gases used in production processes – Tier 2a**, for each subdivision and each FC gas users input the use rate of FC gas.

Step D.2(Tier 2a).2, in worksheet **By-product emissions from gases used in production processes – Tier 2a**, for each subdivision and each gas users input by-product EFs in kg of by-product created per kg of gas used.

Step E.2(Tier 2a)1 and E.2(Tier 2a).2, in worksheets **Emissions from gases used in production processes – Tier 2a** and **By-product emissions from gases used in production processes – Tier 2a** the *Software* calculates the associated emissions for the gas used, and by-products created from that gas, respectively, in kg and Gg.

For Tier 2b

Step D.2(Tier 2b/3)/3.1, in worksheet **Emissions from gases used in production processes – Tier 2b/ 3,** for each subdivision and each gas, users input information on the use rate of gas for etching and cleaning, separately.

Step D.2(Tier 2b/3)/3.2, in worksheet **By-product emissions from gases used in production processes – Tier 2b/ 3**, for each subdivision and each gas, users input by-product EFs for etching and cleaning, separately, in kg of by-product created per kg of gas used.

Step E.2(Tier 2b/3)/3.1 and **E.2(b)/3.2**, in worksheets **Emissions from gases used in production processes – Tier 2b/Tier 3** and **By-product emissions from gases used in production processes – Tier 2b/Tier 3,** the *Software* calculates the associated emissions for gas used and by-products created from that gas, respectively, in kg and Gg.

Then, for each tier, and each gas, as appropriate:

Step F.2/3, in the worksheet **Capture and storage or other reduction**, users collect and input information on the amount of GHG captured or otherwise reduced and not otherwise captured in the worksheets above.

Activity Data Input

Section 6.2.3 in Chapter 6 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for source categories: 2.E.1 Integrated Circuit or Semiconductor, 2.E.2 TFT Flat Panel Display, and 2.E.3 Photovoltaics.

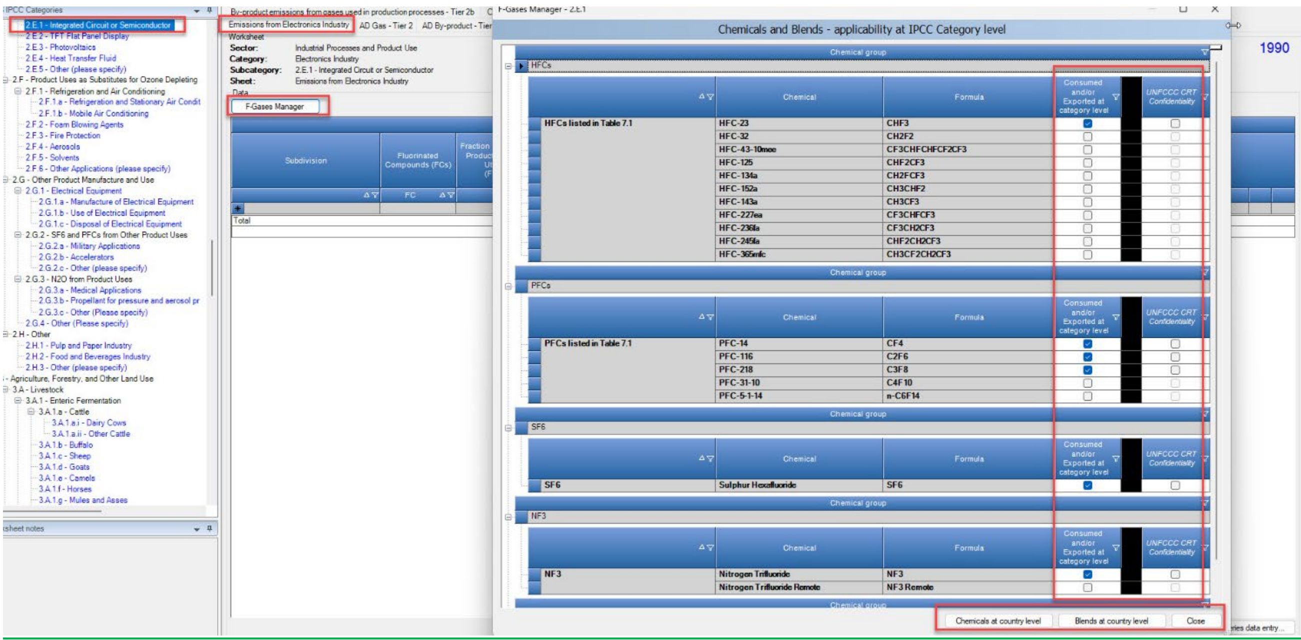
As a **starting step**, users must ensure that the **F-gases Manager** has been populated for all F-gases to be reported for the different activities. When considering the F-gases to add, note that the Tier 1 method for these categories must include estimates for a basket of gases, so all the following gases as shown in Table 6.2 must be selected from the F-gases Manager if the source category is applicable.

- ✓ 2.E.1. Integrated Circuit or Semiconductor: HFC-23, CF_4, C_2F_6, C_3F_8, NF_3, and SF_6
- ✓ 2.E.2 TFT Flat Panel Display: CF_4, NF_3 and SF_6
- ✓ 2.E.3 Photovoltaics: CF_4, and C_2F_6

*Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the **F-Gases Manager** in any worksheet. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. 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 more information, refer to populating the F-Gases Manager, in the section above.*

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: Integrated Circuit or Semiconductor**



Adding an F-gas in one worksheet (e.g. **Emissions from Electronics Industry** or **AD-Gas-Tier 2**) automatically adds it to the other worksheets, except the worksheet **AD By-product-Tier 2/3**. For Tier 2, the user must also separately check off those gases that are emitted as by-products in worksheet **AD-By-product – Tier 2/3.**

The following three tables illustrate the by-products that are to be reported under the Tier 2a and 2b approaches for the given process gas, i, and thus selected in worksheet **AD By-product – Tier 2/3.**

Important: Although the *Software* allows the user to check any F-gas and N_2O as being emitted as a by-product, the *2006 IPCC Guidelines* list only four gases emitted as by-products: CF_4, C_2F_6, C_3F_8 and HFC-23. The *2019 Refinement* adds C_4F_6, C_4F_8, C_5F_8, CH_3F and HFC-32. By-products beyond these listed are not expected and, if exist, their evolution should be documented.

Example: **List of By-products to be selected in AD By-product – Tier 2 for source category 2.E.1 Integrated Circuit or Semiconductor**

2.E.1: Semiconductor manufacturing- Relevant by-products for each input gas (from Table 6.3)

Process gas,	C_2F_6	HFC-23	HFC-32	C_3F_8	c-C_4F_8	NF_3-Remote	NF_3	perfluorobuta-1,3 diene*	c-C_5F_8**	C_4F_8O***	F_2***	COF_2***
Tier 2a (By-products)												
CF_4	√	√	√	√	√	√	√	√	√	√	√	√
C_2F_6					√			√	√			
C_3F_8										√		
Tier 2b (By-products)												
...Etch												
CF_4	√	√	√	√	√			√	√			
C_2F_6					√			√	√			
...CVD												
CF_4	√				√	√	√		√	√	√	√
C_2F_6												
C_3F_8										√		

* Table 6.3 includes gas C_4F_6. In the AR5 and IPCC Software, C_4F_6 is referred to as perfluorobuta-1,3 diene

** Table 6.3 in the 2006 IPCC Guidelines and 2019 Refinement refer to C_5F_8, but Section 6.1.1.1 in the 2019 Refinement refers to the relevant gas as octafluorocyclopentene (c-C_5F_8). c-C_5F_8 has an AR5 GWP is included in the *Software.*

*** These gases appear under "Other GHGs" in the national-and category-level F-gases Manager

Example: **List of By-products to be selected in AD By-product – Tier 2 for source category 2.E.2 TFT FPD and 2.E.3 Photovoltaics**

2.E.2 LCD Manufacturing: Relevant By-products for each input gas (from Table 6.3)

Process gas, i	HFC-23	c-C_4F_8
Tier 2a (By-products)		
CF4	√	√
HFC-23		√
C2F6	√	
C3F8		
Tier 2b (By-products)		
...Etch		
CF4	√	√
HFC-23		√
C2F6	√	
...CVD		
CF4		
C2F6		
C3F8		

2.E.3: PV Manufacturing- Relevant by-products for each input gas (from Table 6.5)

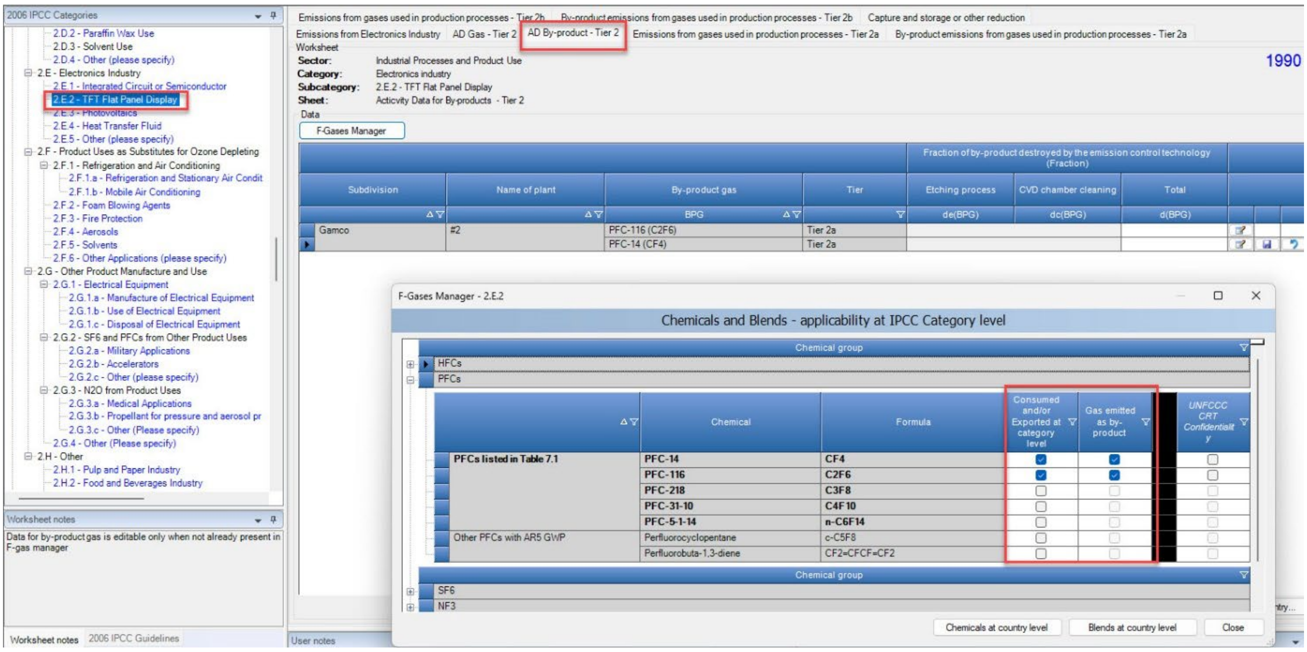
Process gas,	C_2F_6	C_3F_8	c-C_4F_8	NF_3
Tier 2a (By-products)				
CF_4	√	√	√	√
C_2F_6			√	
C_3F_8				
Tier 2b (By-products)				
...Etch				
CF_4	√		√	
C_2F_6			√	
...CVD				
CF_4	√	√	√	
C_2F_6				
C_3F_8				

* Table 6.3 includes gas C_4F_6. In the AR5 and IPCC Software, C_4F_6 is referred to as perfluorobuta-1,3 diene

C_5F_8, but Section 6.1.1.1 in the 2019 Refinement refers to the relevant gas as octafluorocyclopentene (c-C_5F_8). c-C_5F_8 has an AR5 GWP is included in the *Software.*

As an example, the figure below illustrates user input of by-product emissions in the AD By-product Manager for TFT-FPD, when the process gas is HFC-23.

Example: **Populating the AD By-products- Tier 2 in category 2.E.2 with process gas of HFC-23 – Tier 2a**



Then, input of AD for source categories 2.E.1 Integrated Circuit or Semiconductor, 2.E.2 TFT Flat Panel Display, and 2.E.3 Photovoltaics 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] or where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> for each subdivision.

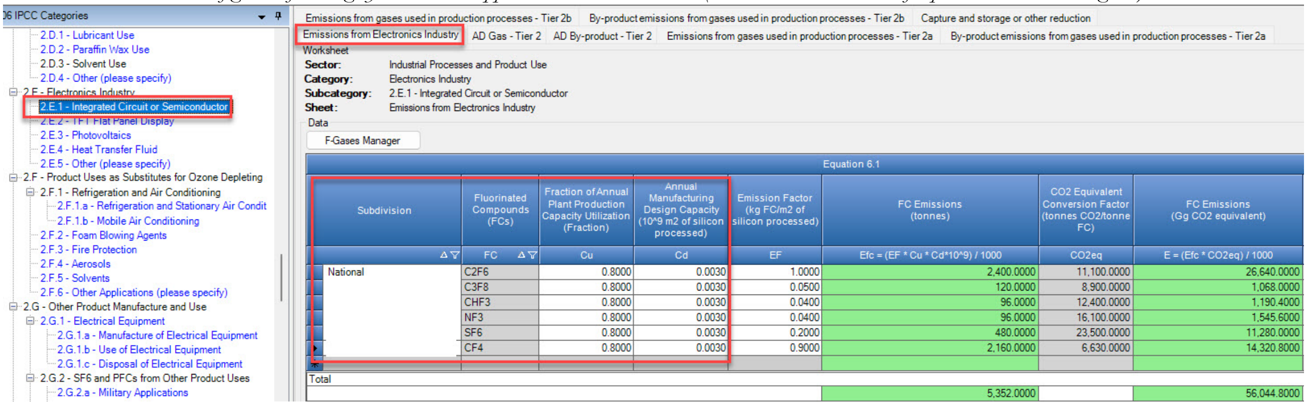
When the Tier 1 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **Emissions from Electronics Industry** row by row, as follows:

1. <u>Column |FC|</u>:for each type of electronic product (Semiconductors, TFT-FPDs and PV cells) select from the drop-down menu all FC gases listed in Table 6.2.
   <u>Note that:</u> In using Tier 1, it is not good practice to modify, in any way, the set of the FCs or the values of the EFs assumed in Table 6.2.
2. <u>Column |Cu|</u>: input the utilisation fraction of annual plant production capacity, fraction.
   <u>Note that:</u> When country-specific capacity utilisation data are not available, the suggested capacity utilisation for semiconductor manufacturing is 80 percent, for TFT-FPD is 80 percent and for PV manufacturing, 86 percent.
3. <u>Column |Cd|</u>: input annual manufacturing design capacity in 10^9 m^2 of substrate processed for Semiconductors and TFT-FPDs and for PV manufacturing in 10^6 m^2.
   <u>Note that:</u> The 2006 IPCC Guidelines contain a Table 6.7 with annual design capacities, however give the pace of technological advances, the 2019 Refinement notes that this table is no longer accurate, and that it is not possible to provide defaults as they would be quickly outdated (see also section 6.2.3 of the 2019 Refinement for further information on acquiring AD).
4. <u>Column |Cpv|</u> (only for PVs): input fraction of PV manufacture that use FCs, fraction.
   <u>Note that:</u> in the absence of country-specific information the IPCC default is 0.5

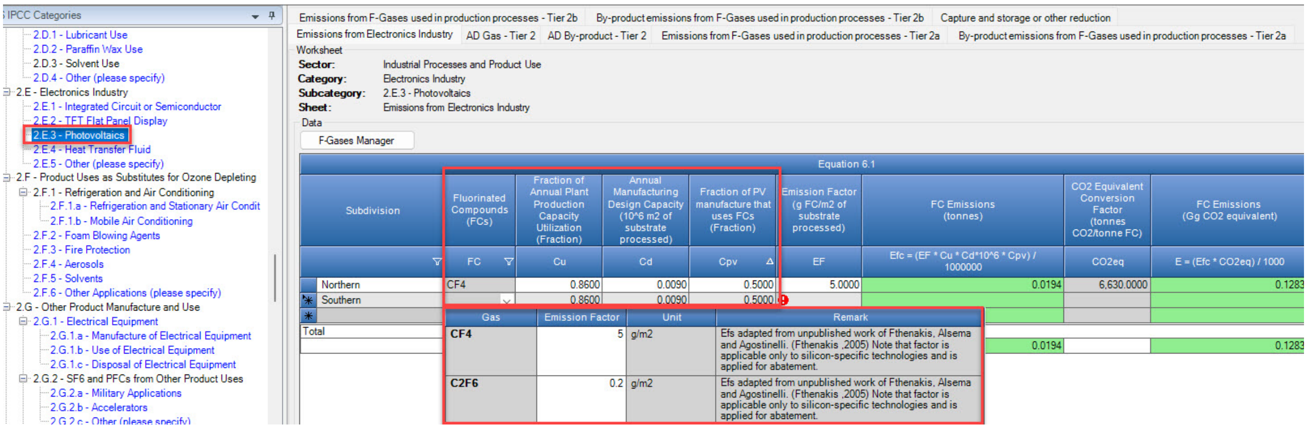
Example: **single subdivision – unspecified (national) and entry of AD- Tier 1**

Note that figure is for category 2.E.1, but applies to 2.E.2 and 2.E.3 (with additional column of Cpv and with relevant gases)



Example: **multiple subdivisions: Tier 1 AD Input**

Note that figure is for category 2.E.3 but applies to 2.E.1 and 2.E.2 (excluding additional column of Cpv and with relevant gases)



When Tier 2 Equations are applied:

For each subdivision in Column |Subdivision|, data are input in worksheet **AD Gas - Tier 2/3,** row by row, as follows:

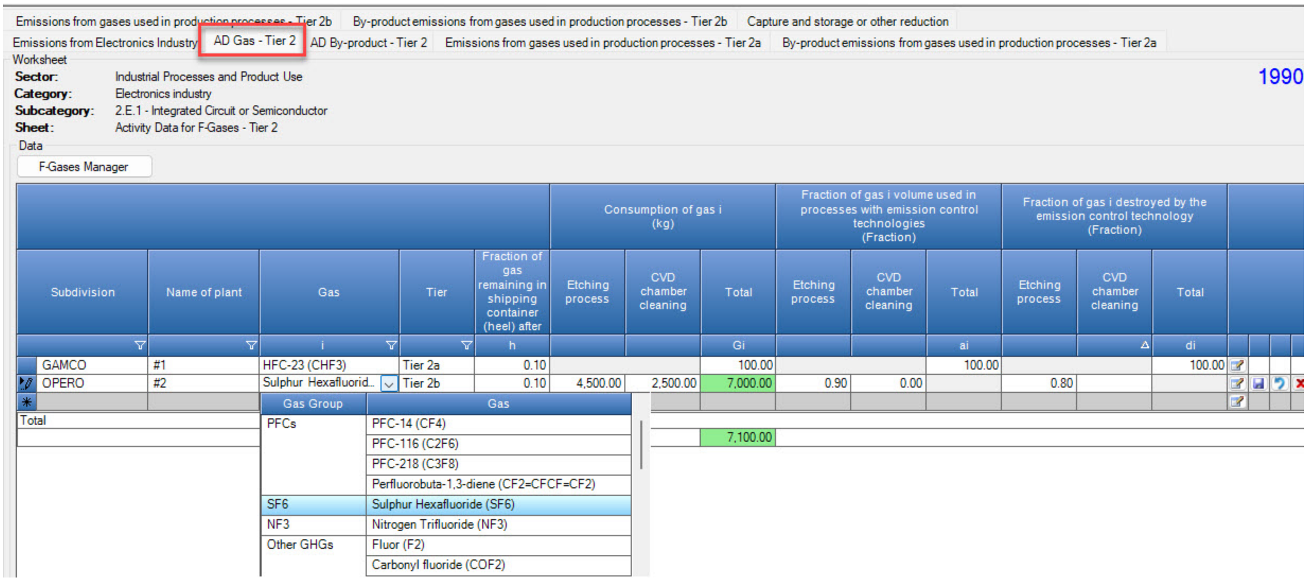
1. Column |Name of Plant|: input name of the plant where FC gases are used for manufacturing.
2. Column |i|: select from the drop-down menu the gas used (either FC, or for Tier 2, N_2O).
   Recall if a gas is not available for selection, it must first be selected from the F-Gases Manager (national and category-specific).
3. Column |Tier|: for each subdivision/plant/gas select the estimation Tier – Tier 2a or Tier 2b/Tier 3.
4. Column |h|: input the amount of heel – i.e. gas remaining in shipping container after use, fraction.
   Note that: in the absence of country-specific information, the IPCC default is 0.1.
5. Column |Gi|: input either total gas consumption (Tier 2a) or mass separated by etching and cleaning (Tier 2b/Tier 3), in kg of gas.
6. Column |ai|: input fraction of gas used in processes with ECT (company- or plant-specific), either as a total fraction (Tier 2a) or separated by etching and cleaning (Tier 2b/Tier 3).
   Note that: Unless ECT are installed, the default value for ai is zero.
7. Column |di|: input fraction of gas destroyed by the ECT, either total fraction (Tier 2a) or by etching and cleaning (Tier 2b/Tier 3).

Important: default values for destruction are presented in Table 6.6. Destruction can only be included for those gases listed in Table 6.6, specifically CF_4, C_2F_6, HFC-23, C_3F_8, c-C_4F_8, NF_3 and SF_6.[1] Destruction factors for

[1] Note that the *2019 Refinement* updated this table to also include C_4F_6, C_4F_8O, C_5F_8, HFC-32 and N_2O. Inclusion of destruction of gases beyond those listed are not expected and should be documented.

all other gases must be set equal to 0. It is important to read all footnotes and conditions for use of destruction technologies.

Example: **AD Gas – Tier 2/3: Input of AD and parameters**

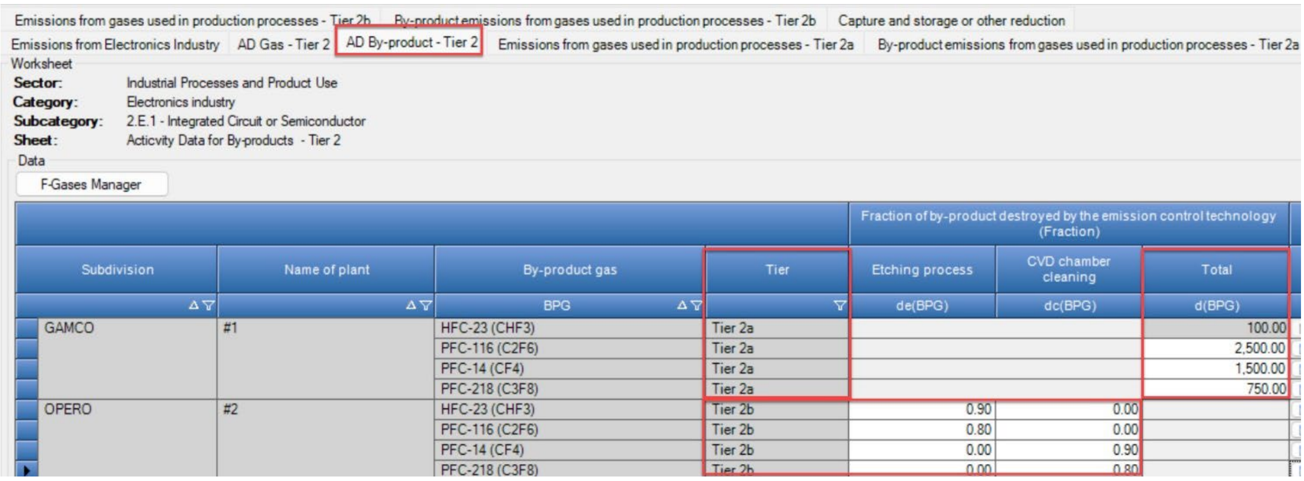


Then, and after selecting the relevant by-products for the process-gas used, as described above, data are input in worksheet **AD By-product - Tier 2/3,** for each subdivision/plant/by-product gas/tier (transferred from worksheet **AD Gas – Tier 2/3,** row by row, as follows:

1. Column |de(BPG)|: (Tier 2b/3 only) input the fraction of by-product gas that is used for the etching process and destroyed by the ECT, fraction.
2. Column |dc(BPG)|: (Tier 2b/3 only) input the fraction of by-product gas that is used for CVD chamber cleaning and destroyed by the ECT, fraction.
3. Column |d(BPG)|: (Tier 2a only) input the total fraction of by-product gas destroyed by the ECT, fraction.

Note that when estimating all fractions above, Table 6.6 and page 21 describe the specific conditions that must apply in order for inclusion of destruction to be considered consistent with *IPCC Good Practice*.

Example: **AD By-products – Tier 2/3: input of destruction fractions- Tier 2a and 2b/3**



Emission Factor Input

Section 6.2.2.1 in Chapter 6 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for source categories 2.E.1, 2.E.2 and 2.E.3. There are four sets of default EFs presented in the *2006 IPCC Guidelines*:

- ✓ Tier 1: Table 6.2: Tier 1 default EFs for semiconductors, TFT-FPDs and PV cells)
- ✓ Tier 2: Default factors (either in total for Tier 2a or differentiated by etching and cleaning for Tier 2b):
  - o Tables 6.3-6.5: EF from use of gas, fraction.
  - o Tables 6.3-6.5: By-product EFs, kg of by-product gas created from gas used.
  - o Table 6.6: Gas destroyed by the ECT, fraction.

Use of Tier 3 methods require company - or plant-specific values for the EFs for each individual process or for each of small sets of processes (e.g., silicon nitride etching or plasma enhanced chemical vapour deposition (PECVD) tool chamber cleaning).

When the Tier 1 Equation is applied:

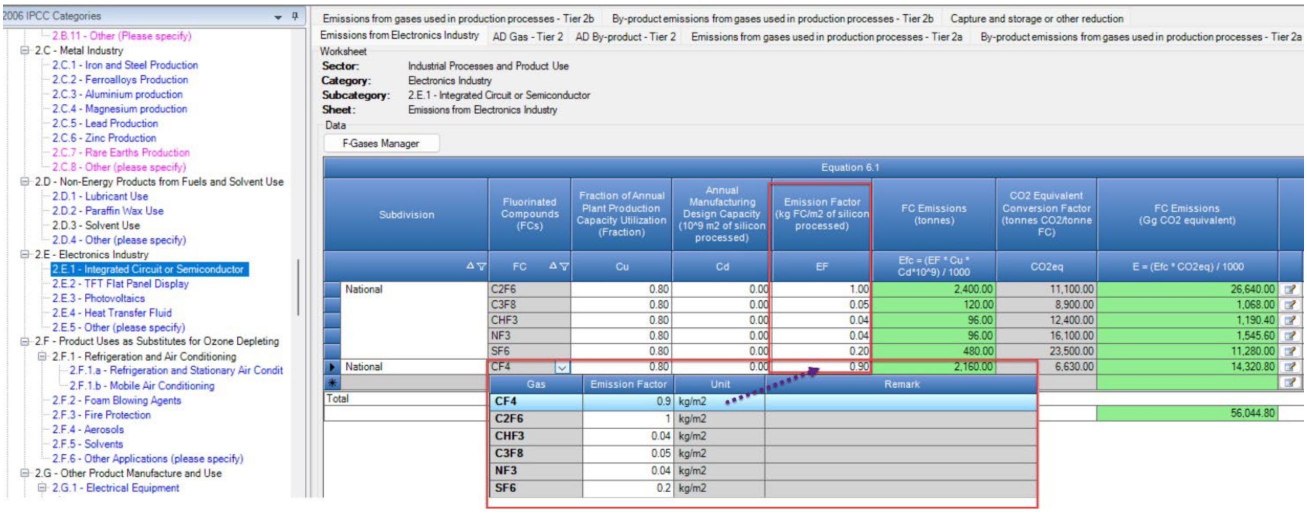
In worksheet **Emissions from Electronics Industry,** the corresponding EF from Table 6.2 is automatically inserted in Column |EF|, in kg FC/m² substrate processed upon selection of the gas in Column |FC|.

Note two critical points in use of the Tier 1 method:

1. The user shall include all F-gases in Table 6.2 in the estimation
2. The user shall not modify the default EF

Example: **Tier 1 EFs**

Note: figure applies to 2.E.1 Semiconductors. Same instructions apply to source categories 2.E.2 and 2.E.3, but with the corresponding gases included in Table 6.2



When Tier 2 Equations are applied:

Tier 2a

In worksheet **Emissions from gases used in production processes – Tier 2a** worksheet, for each gas/subdivision/ plant/ amount of consumption the user selects from the drop-down menu in Column |1-Ui|, the EF from use of the process gas (i.e. 1-the fraction destroyed or transformed in process) (white cells) as a fraction. This value may be manually overwritten.

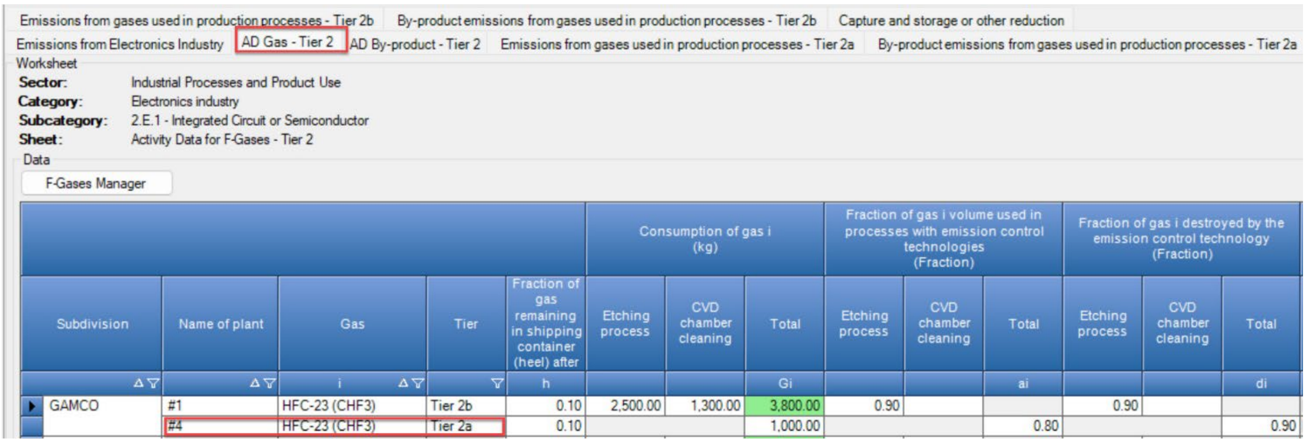
Then, in worksheet **By-product emissions from F-gases used in production processes – Tier 2a** for each gas/subdivision/ plant/ by-product gas the user selects from the drop-down menu in Column |B|, the default EF for the by-products that correspond to the process-gas identified by "Gas" in the worksheet. This value may be manually overwritten.

Full example of estimating GHG emissions from use of HFC-23 in semiconductor manufacturing

An illustration is provided below on how to estimate GHG missions in the case where GAMCO, #4 facility follows the Tier 2a method, and uses the process gas HFC-23.

Step 1. Enter AD in worksheet **AD Gas – Tier 2/3,** including the name of the plant, process gas used, Tier, fraction of gas remaining in the heal, and the corresponding amount of gas consumed, the fraction used in processes with ECT, and the fraction of gas destroyed in those processes.

Example: **Tier 2a AD entry for HFC-23**



Emissions from gases used in production processes - Tier 2b | By-product emissions from gases used in production processes - Tier 2b | Capture and storage or other reduction

Emissions from Electronics Industry | AD Gas - Tier 2 | AD By-product - Tier 2 | Emissions from gases used in production processes - Tier 2a | By-product emissions from gases used in production processes - Tier 2a

Worksheet

Sector: Industrial Processes and Product Use
Category: Electronics industry
Subcategory: 2.E.1 - Integrated Circuit or Semiconductor
Sheet: Activity Data for F-Gases - Tier 2

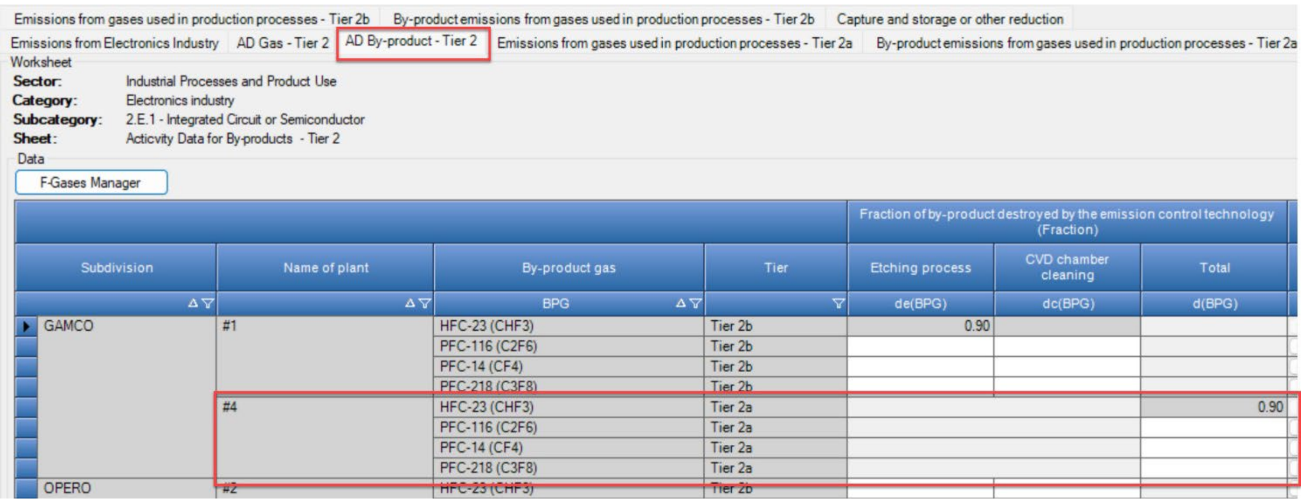
Data

F-Gases Manager

					Consumption of gas i (kg)			Fraction of gas i volume used in processes with emission control technologies (Fraction)			Fraction of gas i destroyed by the emission control technology (Fraction)		
Subdivision	Name of plant	Gas	Tier	Fraction of gas remaining in shipping container (heel) after	Etching process	CVD chamber cleaning	Total	Etching process	CVD chamber cleaning	Total	Etching process	CVD chamber cleaning	Total
		i		h			Gi			ai			di
GAMCO	#1	HFC-23 (CHF3)	Tier 2b	0.10	2,500.00	1,300.00	3,800.00	0.90			0.90		
	#4	HFC-23 (CHF3)	Tier 2a	0.10			1,000.00			0.80			0.90

Step 2. In worksheet **AD By-product- Tier 2/3** no further additions are needed. According to Table 6.3 the only possible by-product emission when HFC-23 is the process gas, is CF_4. The destruction factor for CF_4 was already entered in **AD Gas – Tier 2/3** worksheet, so it carries over below in the by-product worksheet. Since the other by-products listed under the GAMCO #4 facility are not applicable when HFC-23 is the process gas, destruction factors do not need to be input.

Example: **Tier 2a By-product entry for HFC-23**



Emissions from gases used in production processes - Tier 2b | By-product emissions from gases used in production processes - Tier 2b | Capture and storage or other reduction

Emissions from Electronics Industry | AD Gas - Tier 2 | AD By-product - Tier 2 | Emissions from gases used in production processes - Tier 2a | By-product emissions from gases used in production processes - Tier 2a

Worksheet

Sector: Industrial Processes and Product Use
Category: Electronics industry
Subcategory: 2.E.1 - Integrated Circuit or Semiconductor
Sheet: Acticvity Data for By-products - Tier 2

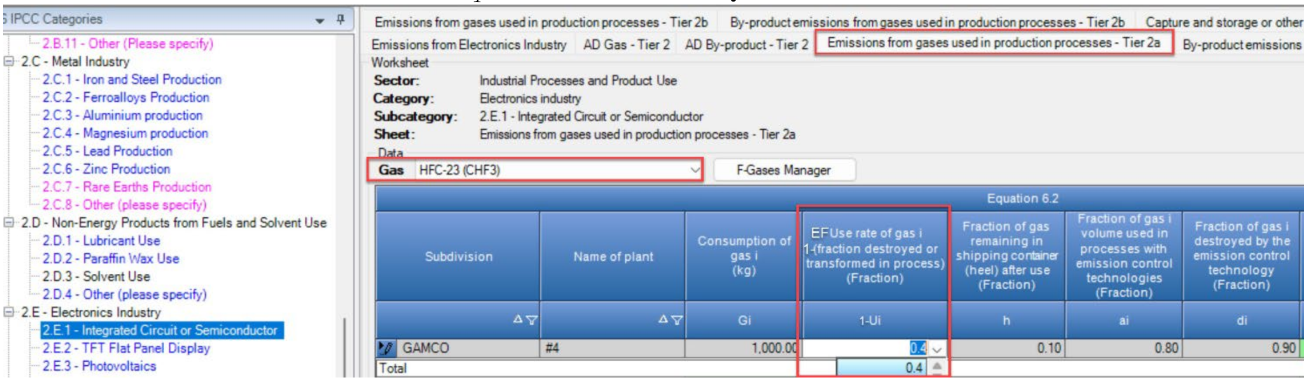
Data

F-Gases Manager

				Fraction of by-product destroyed by the emission control technology (Fraction)		
Subdivision	Name of plant	By-product gas	Tier	Etching process	CVD chamber cleaning	Total
		BPG		de(BPG)	dc(BPG)	d(BPG)
GAMCO	#1	HFC-23 (CHF3)	Tier 2b	0.90		
		PFC-116 (C2F6)	Tier 2b			
		PFC-14 (CF4)	Tier 2b			
		PFC-218 (C3F8)	Tier 2b			
	#4	HFC-23 (CHF3)	Tier 2a			0.90
		PFC-116 (C2F6)	Tier 2a			
		PFC-14 (CF4)	Tier 2a			
		PFC-218 (C3F8)	Tier 2a			
OPERO	#2	HFC-23 (CHF3)	Tier 2b			

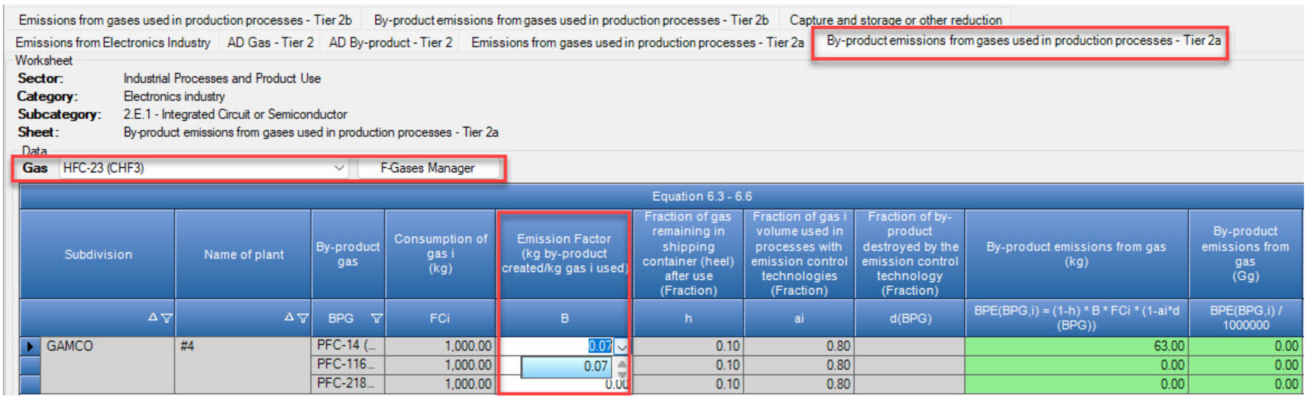
Step 3. Estimate the HFC-23 emissions in worksheet **Emissions from gases used in production processes – Tier 2a.** According to Table 6.3, the default EF (1-Ui) = 0.4 for HFC-23 is 0.4, available in the drop-down menu.

Example: **Tier 2a EFs- entry for HFC-23**



Step 4. Estimate the by-product emissions when HFC-23 is the process gas in worksheet **By-product emissions from gases used in production processes- Tier 2a.** When HFC-23 is the process gas, according to Table 6.3, for semiconductor manufacturing, the only possible by-product is CF_4. The user selects from the drop-down menu the default by-product EF for CF_4. An EF of 0 is added for the other gases since these are not applicable for a process gas of HFC-23.

Example: **Tier 2a By-product EFs- entry for HFC-23**



Tier 2b/3

Recall that the Tier 2b separates manufacturing processes, and thus emissions estimation, into etching and CVD chamber cleaning. The Tier 2b worksheets may be used for Tier 3, but in doing so, the user must enter company-specific or plant-specific values for all the parameters used in these equations for each individual process or for each of small sets of processes (e.g., silicon nitride etching or plasma enhanced chemical vapour deposition (PECVD) tool chamber cleaning).

In worksheet **Emissions from gases used in production processes – Tier 2b** worksheet, for each gas/subdivision/ plant/ amount of consumption the user enters information, row by row, as follows:

1. Column |1-Uie|: select from the drop-down menu the EF from the use of the process gas for etching (i.e. 1-the fraction destroyed or transformed in process), as a fraction. This value may be manually overwritten.
2. Column |1-Uic|: select from the drop-down menu the EF from the use of the process gas for CVD chamber cleaning (i.e. 1-the fraction destroyed or transformed in process), as a fraction. This value may be manually overwritten.

Then, in worksheet **By-product emissions from gases used in production processes – Tier 2b** for each gas/subdivision/ plant/ by-product gas the user the user inputs information, row by row, as follows:

1. Column |Be|: select from the drop-down menu the default EF for etching of the by-products that correspond to the process-gas identified by "Gas" in the worksheet. This value may be manually overwritten.
2. Column |Bc|: select from the drop-down menu the default EF for CVD chamber cleaning of the by-products that correspond to the process-gas identified by "Gas" in the worksheet. This value may be manually overwritten.

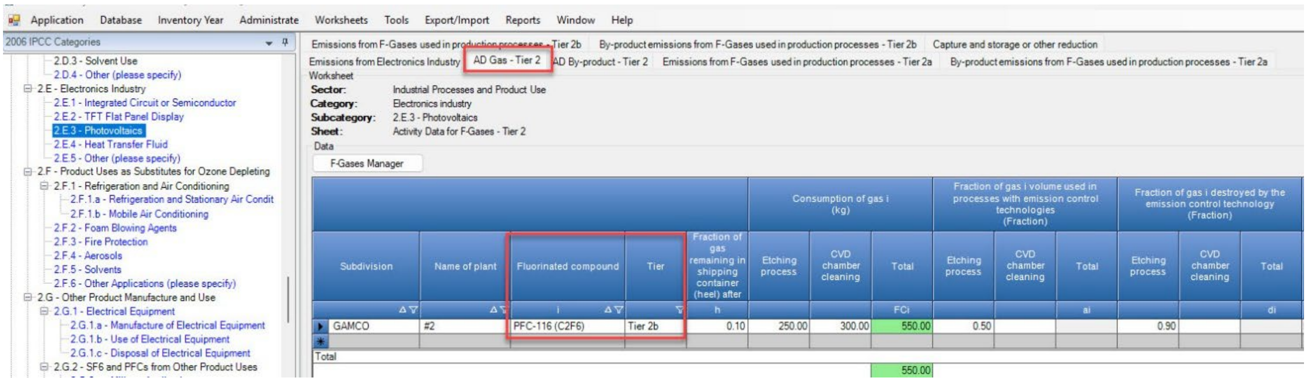
Full example of estimating GHG emissions from use of C_2F_6 in photovoltaics

An illustration is provided below on how to estimate GHG missions in the case where GAMCO, #2 facility follows the Tier 2b method, and uses the process gas C_2F_6 for photovoltaics (category 2.E.3).E.3).

Note that the worksheet names for photovoltaics refer specifically to F-gases (as opposed to just gases as in 2.E.1 and 2.E.2. This is because N_2O is not included as a possible gas for photovoltaics).

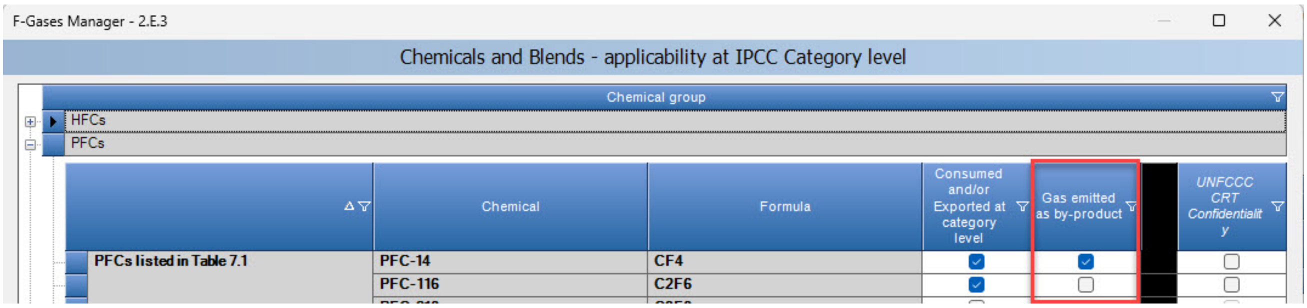
Step 1. Enter AD in worksheet **AD Gas – Tier 2/3,** including the name of the plant, process gas used, Tier, fraction of gas remaining in the heal, and the corresponding amount of gas consumed, the fraction used in processes with ECT, and the fraction of gas destroyed in those processes. In this example, it is assumed that some gas from the etching process is fed into an ECT. Gases used for CVD chamber cleaning processes are not destroyed.

Example: **Tier 2b AD entry for C_2F_6**

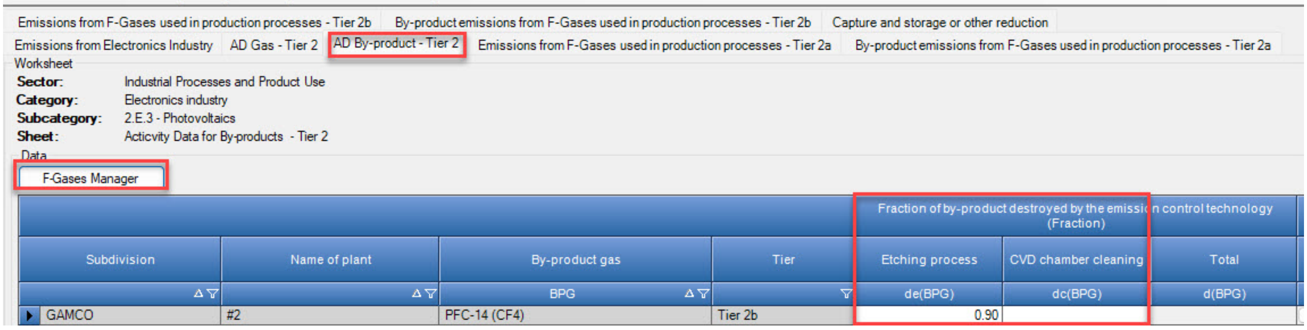


Step 2. In worksheet **AD By-product- Tier 2/3** the user inputs the fraction of by-product gas destroyed. According to Table 6.5 the only possible by-product emission when C_2F_6 is the process gas, is CF_4. After first checking off CF_4 as a by-product in the F-Gases Manager, the user then inputs the destruction factor for CF_4 in this worksheet. For this example, we assume a destruction factor of 0.9 for the etching process; and no destruction for CVD chamber cleaning.

Example: **Tier 2b by-product entry for C_2F_6 – F-Gases Manager**

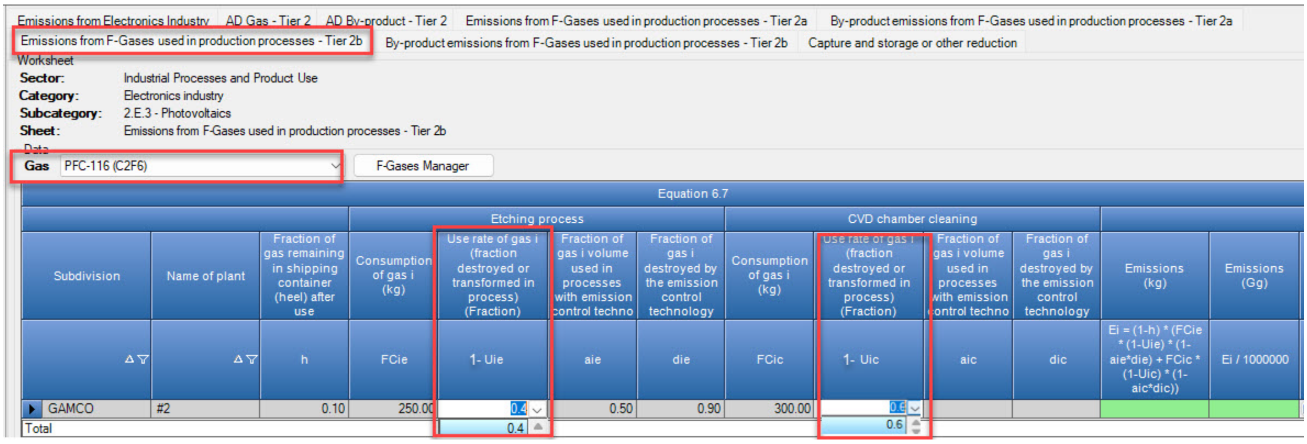


Example: **Tier 2b by-product entry for C_2F_6 – destruction**



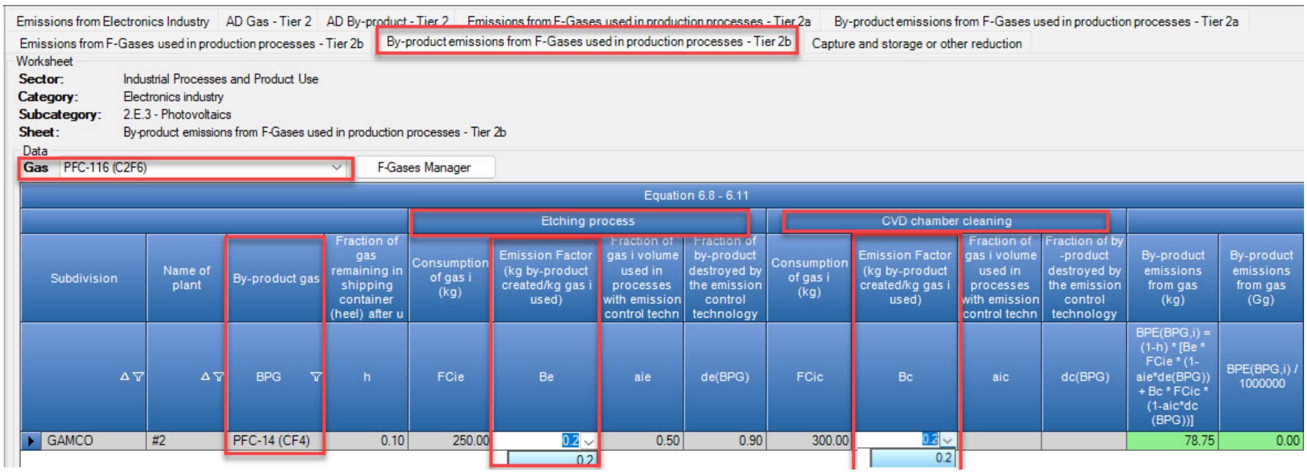
Step 3. Estimate the C_2F_6 emissions in worksheet **Emissions from F-gases used in production processes – Tier 2b.** According to Table 6.5, the default EF (1-Ui) = 0.4 (etching) and 0.6 (CVD chamber cleaning) when C_2F_6 is the process gas. These factors are available in the drop-down menu or may be overwritten by the user.

Example: **Tier 2b EFs- entry for C_2F_6**



Step 4. Estimate the by-product emissions when C_2F_6 is the process gas in worksheet **By-product emissions from F-gases used in production processes- Tier 2b.** When C_2F_6 is the process gas, according to Table 6.5, for photovoltaics, the only possible by-product is CF_4 (for both etching and CVD chamber cleaning). According to Table 6.5, the default EF ($EtchB_{CF4}$) in Column |Be|= 0.2 and the default EF ($CVDB_{CF4}$) in Column |Bc|= 0.2. These factors are available in the drop-down menu or may be overwritten by the user.

Example: **Tier 2b By-product EFs- entry for C_2F**



Results

GHG emissions are estimated separately for source categories 2.E.1 Integrated circuit or Semiconductors, 2.E.2 TFT-Flat Panel Display and 2.E.3 Photovoltaics by the *Software* in the following worksheets:

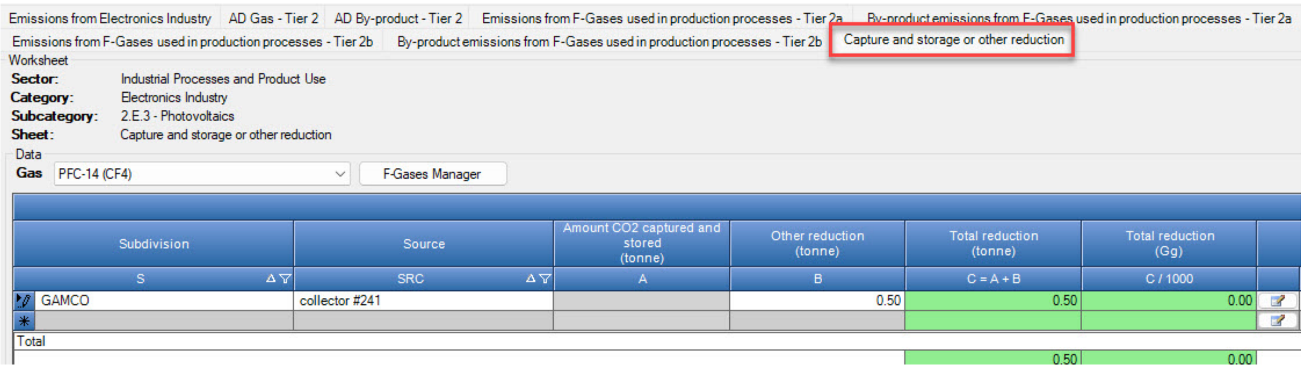
- ✓ **Emissions from Electronics Industry,** in tonnes and GgCO_2 eq.
- ✓ **Emissions from gases used in production processes – Tier 2a**
- ✓ **By-product emissions from gases used in production processes – Tier 2a**
- ✓ **Emissions from gases used in production processes – Tier 2b/Tier 3**
- ✓ **By-product emissions from gases used in production processes – Tier 2b/Tier 3**

Total GHG emissions from each source category is the sum of all emissions in the above worksheets, taking into account any capture and storage or other reduction not otherwise accounted for in these worksheets. 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|: 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|: not applicable for this category.
3. Column |B|: collect and input information on any other long-term reduction of F-gas emissions, in tonnes.
   Note that: any destruction estimated in the Tier 2 worksheet should not be included in Column |B|. This worksheet is not expected to be used for this category however has been retained owing to the rapid development in this industry and to provide any needed flexibility to users.

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



2.E.4 Heat Transfer Fluids

Information

Section 6.2.1.2 of the *2006 IPCC Guidelines* provides two Tiers for estimation of GHG emissions from Heat Transfer Fluids (HTF). The Tier 1 calculation relies on a generic EF that expresses the average aggregate emissions per unit of silicon consumed during semiconductor manufacturing. It is used when company-specific data are not available and expresses consumption of all liquid fluorinated compounds (FCs) used as HTF, as C_6F_{14}.

Tier 2 is a mass-balance approach that accounts for liquid FCs usage as HTF over an annual period, taking into account the beginning/end of year inventory and liquid FCs used to fill newly purchased equipment and to replace FC fluid loss from equipment operation through evaporation.

GHGs

The *Software* includes the following GHG for the Heat Transfer Fluid source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

- ✓ Tier 1:Equation 6.12
- ✓ Tier 1:Equation 6.13
- ✓ 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

GHG emissions from the Heat Transfer Fluid source category are estimated using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ✓ **Emissions from Heat Transfer Fluid:** contains for each subdivision, information on the annual design capacity of semiconductor manufacturing facilities, average capacity utilisation for these, and a default EF assuming consumption is of C_6F_{14}. The worksheet calculates the associated emissions for Tier 1.
- ✓ **Emissions from Heat Transfer Fluid – Tier 2:** [mass-balance] contains for each subdivision, each plant and each FC fluid, information on the amount of liquid at the end of the previous period and the end of the current period, net purchases of liquid, total charge of newly installed, and retired or sold equipment, and the amount of liquid recovered and sent offsite from retired equipment. The worksheet calculates the F-gas emissions for Tier 2.
- ✓ **Capture and storage or other reduction** contains information on reduction of F-gases, not accounted previously in the worksheets for different Tiers.

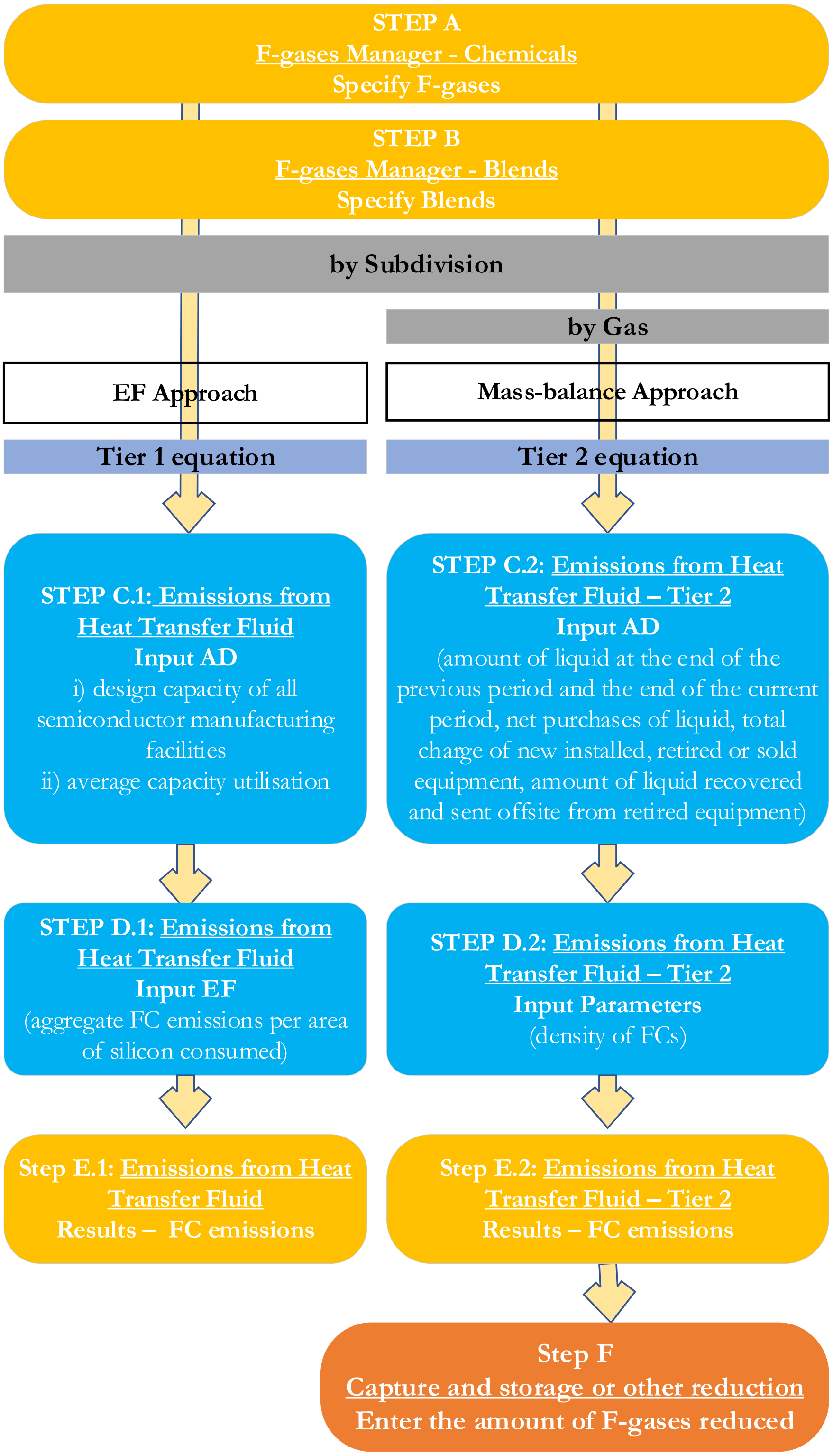
User's Work Flowchart

Consistent with the key category analysis and the decision tree in Figure 6.1 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 Heat Transfer Fluid.

[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.

Heat Transfer Fluid- flowchart



Thus, for the source-category:

Step A and B, F-gases Manager, users ensure that all F-gases/blends 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. The only F-gas applicable for Tier 1 is C_6F_{14}.

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 C.1, in worksheet **Emissions from Heat Transfer Fluid**, users collect and input in the *Software* information on the annual design capacity of all semiconductor manufacturing facilities in the country (m^2 of silicon consumed) and their average capacity utilisation.

Step D.1, in worksheet **Emissions from Heat Transfer Fluid**, users input an EF (aggregate FC emissions per Gm^2 of silicon consumed expressed as the mass of C_6F_{14} in Mt C_6F_{14}/Gm^2).

Step E.1, in worksheet **Emissions from Heat Transfer Fluid**, the *Software* calculates the associated emissions in metric tonnes and Gg of CO_2 equivalent.

When the Tier 2 Equation is applied:

Step C.2, in worksheet **Emissions from Heat Transfer Fluid – Tier 2**, users collect and input in the *Software* information on the amount of liquid at the end of the previous period of the inventory and the end of the current period, net purchases of liquid, total charge of new installed, retired or sold equipment, amount of liquid recovered and sent offsite from retired equipment.

Step D.2, in worksheet **Emissions from Heat Transfer Fluid – Tier 2**, as it is a mass-balance approach, no EFs are applied. The only parameter needed is density of FC fluid in kg per litre.

Step E.2, in worksheet **Emissions from Heat Transfer Fluid – Tier 2,** the *Software* calculates the associated emissions in mass units (kg and Gg).

Step F, in worksheet **Capture and storage or other reduction,** users collect and input in the *Software* information on the amount of reduced F-gases not accounted in the other worksheet.

Activity Data Input

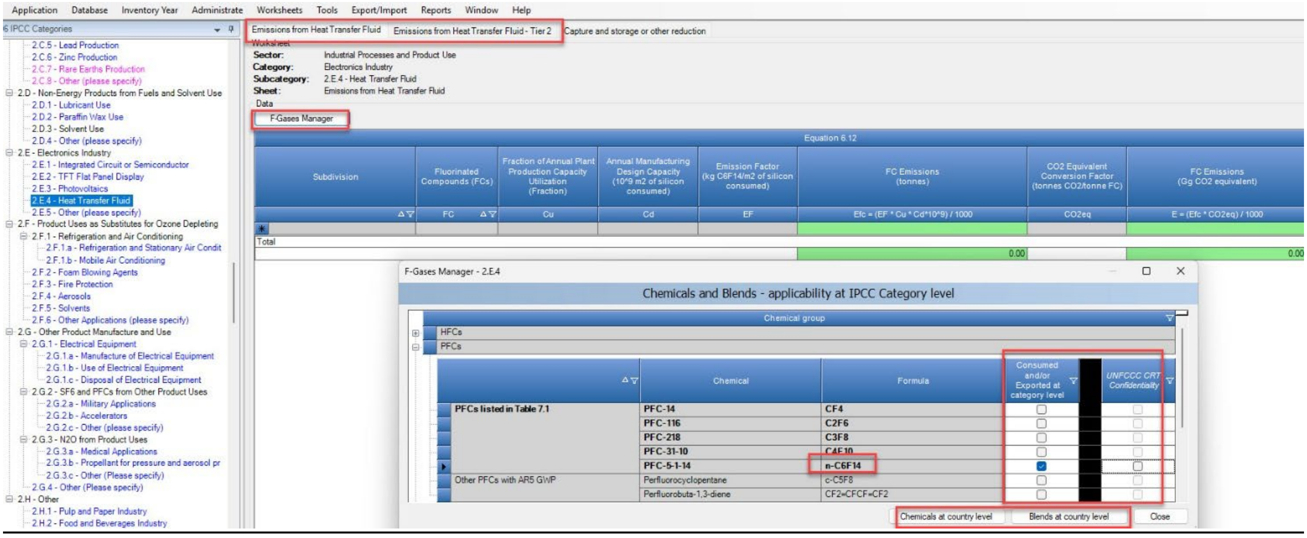
Section 6.2.3 in Chapter 4 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for the Heat Transfer Fluid source category.

As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category Heat Transfer Fluid. For Tier 1, the user must select n-C_6F_{14}, as the Tier 1 method expresses all HTF as n-C_6F_{14}. For Tier 2, the user must select all relevant gases.

*Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the **F-Gases Manager** in either the Tier 1 or Tier 2 worksheet. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager. For more information, refer to populating the F-Gases Manager, in the section above.*

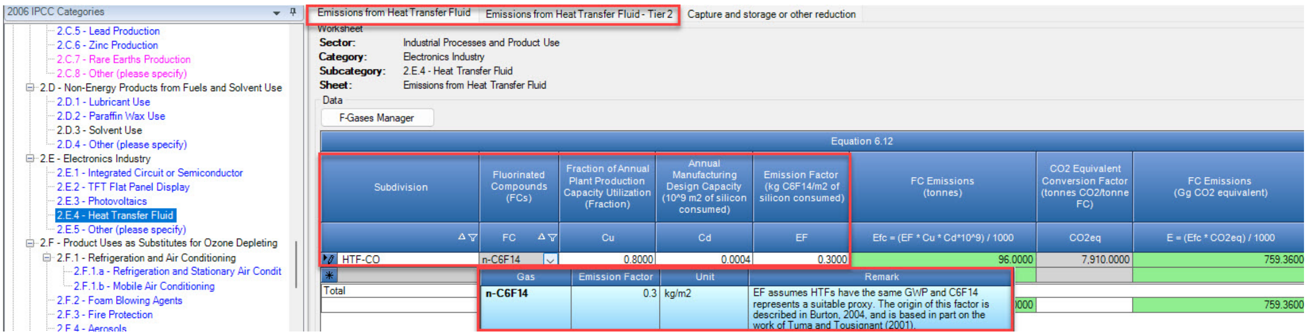
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the 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: heat transfer fluid**



Second, input of AD for Heat Transfer Fluids 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision and AD and EF entry- Tier 1**



When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, data are input in worksheet **Emissions from Heat Transfer Fluid** row by row, as follows:

1. Column |FC|: select from the drop-down menu the default FC fluid (C_6F_{14}).
2. Column |Cu|: input the average capacity utilisation, fraction.
   Note that: when country-specific capacity utilisation data are not available, the suggested capacity utilisation for semiconductor manufacturing is 80 percent.
3. Column |Cd|: input the annual manufacturing design capacity in 10^9 m^2 of silicon consumed for all semiconductor manufacturing facilities in the country.
   Note that: the 2006 IPCC Guidelines contain Table 6.7 with annual design capacities, however give the pace of technological advances, the 2019 Refinement notes that this table is no longer accurate, and that it is not possible to provide defaults as they would be quickly outdated (see also section 6.2.3 of the 2019 Refinement for further information on acquiring AD).

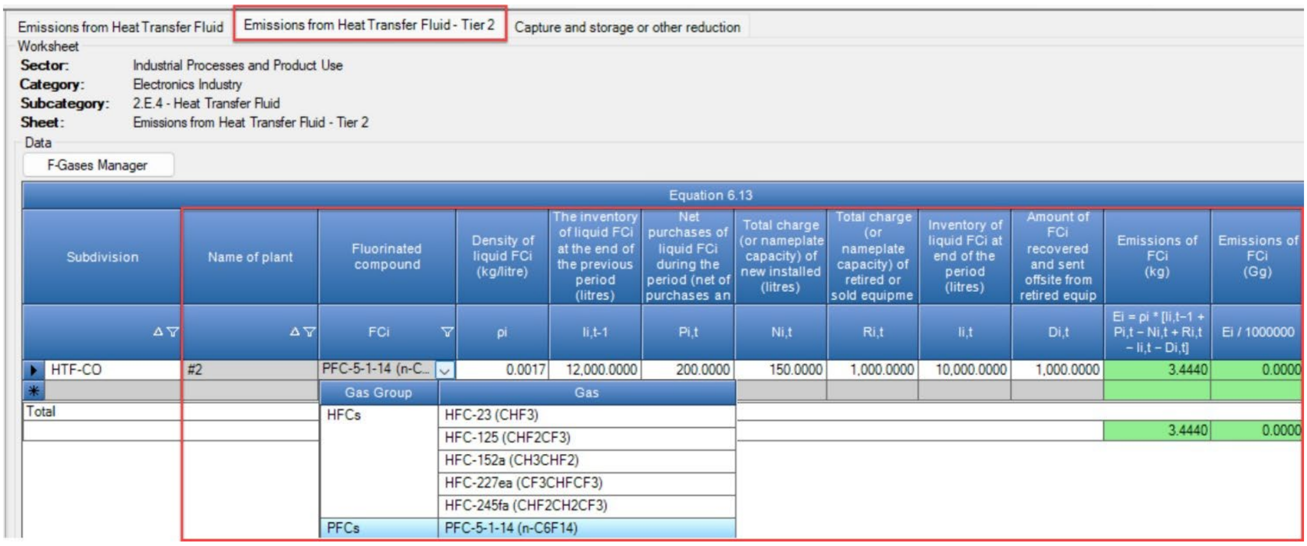
When the Tier 2 Equation is applied:

For each subdivision in Column |Subdivision|, data are input in worksheet **Emissions from Heat Transfer Fluid-Tier 2,** row by row, as follows:

1. Column |Name of Plant|: input the name of the plant where FC fluids are used.

2. Column |FCi|: select from the drop-down menu the FC fluid used (e.g. C_6F_{14}).
   Note that: the drop-down menu includes only those gases selected in the F-Gases Manager. If the desired gas is not available for selection, refer to guidance above for selecting gases from the F-Gases Manager.
3. Column |ρi| input the density of the liquid FC input in Column |FCi|, in kg per litre.
4. Column |$Ii_{,t-1}$|: input the inventory (amount) of liquid FCs at the end of the previous period, in litres.
5. Column |Pi,t |: input net purchases (amount) of liquid FCs during the period (net of purchases and any returns), in litres.
6. Column |Ni,t|: input total charge (or nameplate capacity) of new installed equipment, in litres.
7. Column |Ri,t|: input total charge (or nameplate capacity) of retired or sold equipment in litres.
8. Column |Ii,t |: input the inventory (amount) of liquid FCs at end of the period, in litres.
9. Column |Di,t|: input amount of FC fluid recovered and sent offsite from retired equipment in litres.
   Note that the value entered in Column |Di,t| should be equal to or less than the value entered in Column |Ri,t|.

Example: **Tier 2 AD input**



Emission Factor Input

Sections 6.2.2.2 in Chapter 6 Volume 3 of the *2006 IPCC Guidelines* provides the following information on the choice of EFs for HTF: the EF for the Tier 1 method is presented in Table 6.2. There are no EFs for the Tier 2 method for estimating emissions from evaporation of HTF.

When the Tier 1 Equation is applied:

For each subdivision/plant/fluorinated compound, data are input in worksheet **Emissions from Heat Transfer Fluid**, row by row, as follows:

1. Column |EF|: the IPCC default EF 0.30 kg C_6F_{14}/m^2 of silicon consumed is automatically populated in this column upon selection of the FC. The user may manually overwrite this value with user-specific information.

See above *Example:* **single subdivision and AD and EF entry- Tier 1** for an illustration of data entry.

When the Tier 2 Equation is applied:

The Tier 2 mass balance approach does not rely on the use of EFs.

Results

GHG emissions from the Heat Transfer Fluid source category are estimated in mass units (metric tonnes/kg and Gg) by the *Software* in the following two worksheets:

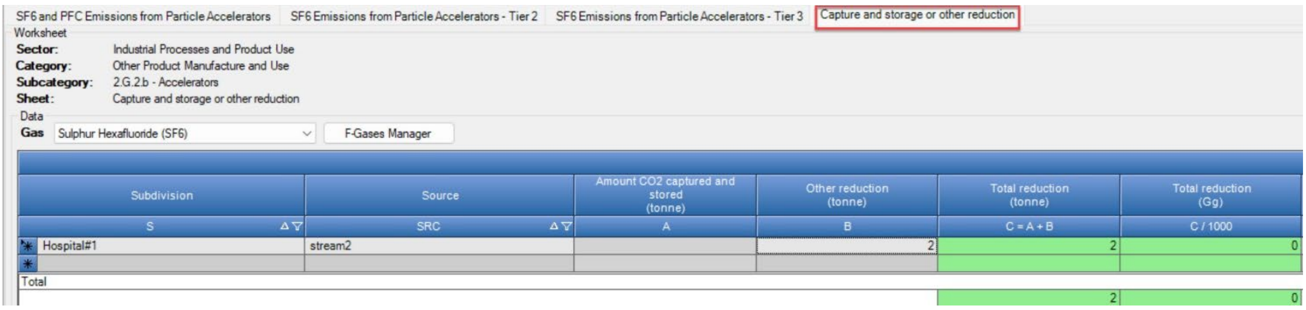
- ✓ **Emissions from Heat Transfer Fluid**
- ✓ **Emissions from Heat Transfer Fluids – Tier 2**

Total F-gas emissions from HTF 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|: 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|: not applicable for this category.
3. Column |B|: users collect and input information on any other long-term reduction of F-gas emissions, in tonnes.
   Note that: any recovery estimated in the Tier 2 worksheet should not be included in Column |B|.

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



2.E.5 Other

Information

This section describes calculation of emissions from other electronics industries not included in source categories 2.E.1, 2.E.2, 2.E.3 or 2.E.4 above.

Section 6.2.4 of the *2006 IPCC Guidelines* references other sources or products/processes resulting in emissions. Specifically, FCs may be released during gas handling (e.g. distribution) and by sources such as research and development (e.g. university) scale plants and tool suppliers. These emissions are not believed to be significant (e.g., less than 1 percent of this industry's total emissions). FC use has also been identified in the electronics industry in emissive applications, including micro-electro-mechanical systems (MEMS), hard disk drive manufacturing, device testing (FC liquids), vapour phase reflow soldering, and precision cleaning.

The *Software* allows users to estimate GHG emissions from these other electronics industry sources. Because the UNFCCC CRT includes reporting from MEMs, the Tier 1 method from Section 6.2.1.1 of the *2019 Refinement* has been added as a separate worksheet in source category 2.E.5 Other (Electronics Industry) to allows users to calculate these emissions.

GHGs

Emissions from the Other (Electronics 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

IPCC Equations

Other (electronics industry)

Given that there are no specific equations in the *2006 IPCC Guidelines* for 2.E.5 Other (Electronics Industry) a generic worksheet is provided to enable calculation of other sources of emissions from the industry.

- ✓ 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*.

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.

MEMS

The Tier 1 method from the *2019 Refinement* has been included in the *Software* to allow users to estimate GHG emissions from MEMS for interoperability with the UNFCCC ETF GHG Reporting Tool.

- ✓ Tier 1: Equation 6.1 (Updated)

Although Tier 2 and Tier 3 equations exist for MEMs in the *2019 Refinement*, these higher-tiered methods have not yet been introduced into the *Software*. Introducing the Tier 2 and Tier 3 methods for MEMs would require methodological changes for the entirety of electronics industry and structural changes to the category tree (heat transfer fluids are not a separate category in the *2019 Refinement*). Users wishing to apply higher tiered methods for MEMS can estimate and report these emissions using worksheet **Other**, as described below.

Software Worksheets

The *Software* calculates emissions from Other (Electronics Industry) using worksheets:

- ✓ **Other**: contains source, AD (type, amount and unit), and EF for each GHG, and calculates associated emissions for all other electronics industry sources. For users estimating emissions from MEMS, these emissions can be reported directly using the Tier 1 method in the worksheet below. Since the MEMS worksheet accommodates only the Tier 1 method, users applying higher tiered methods can report emissions from MEMS in this **Other** worksheet.

Note that for users intending to report emissions to the UNFCCC ETF Reporting Tool, if "Other emissions from MEMs" is selected in this worksheet in Column |SRC| any calculated emissions will map to the category of MEMS in the UNFCCC ETF Reporting Tool, along with any emissions estimated in worksheet FC Emissions from manufacturing of microelectromechanical systems.

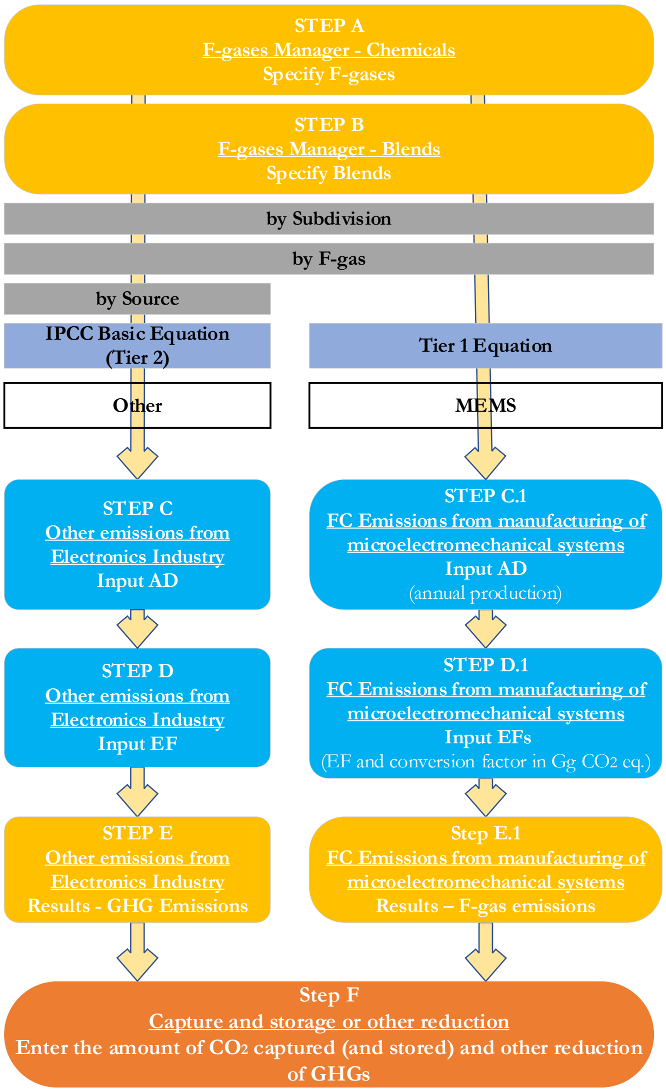
- ✓ **FC Emissions from manufacturing of microelectromechanical systems:** contains for each subdivision and each gas, information on the annual production (m^2 of substrate used) and EFs. The worksheet calculates the associated F-gas emissions for Tier 1 for MEMS.
- ✓ **Capture and storage or other 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 (Electronics Industry).

Other (Electronics Industry) – 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 source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends 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:

Other

Step C, in worksheet **Other**, users collect and input in the *Software* information on the source of emissions and AD.

Step D, in worksheet **Other**, users collect and input the associated EF.

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

MEMS

Step C.1, in worksheet **FC Emissions from manufacturing of microelectromechanical systems**, users collect and input information in the *Software* on the annual production of electronic devices, measured by the surface area of substrate used.

Step D.1, in worksheet **FC Emissions from manufacturing of microelectromechanical systems**, users collect and input in each row the associated EF, by gas.

Step E.1, in worksheet **FC Emissions from manufacturing of microelectromechanical systems**, for each row of data, the *Software* calculates the emissions in mass units (kg) and Gg CO_2 eq. In addition, total emissions are calculated.

Then, for each tier, and each gas, as appropriate:

Step F in the worksheet **Capture and storage or other reduction**, users collect and input information on the amount of GHG captured or otherwise reduced and not otherwise captured in the worksheets above.

Activity data input

As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases (or, if applicable, blends) to be reported. For worksheet **Other,** users must populate the F-Gases Manager with all relevant F-gases. For worksheet **FC Emissions from manufacturing of microelectromechanical systems,** the user need only add c-C4F8 (first at the national level, and then at the category level). The other gases are automatically populated. *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 more information, refer to populating the F-Gases Manager, in the section above.*

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.

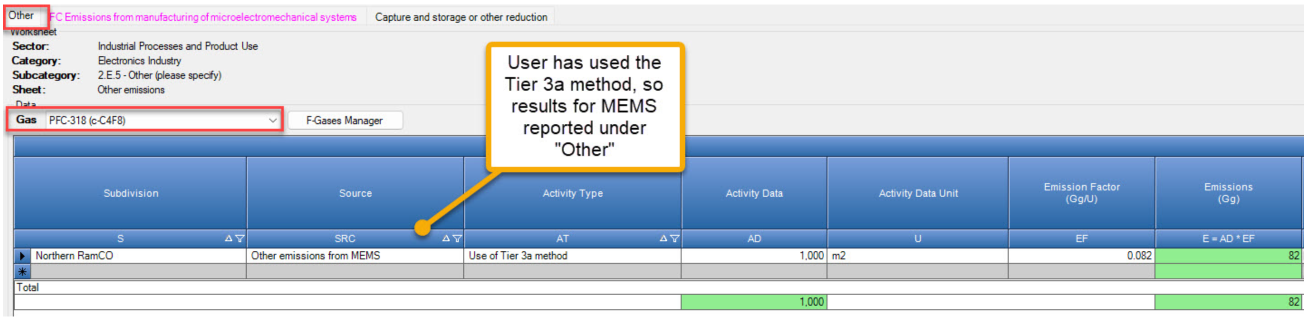
Second, input of AD for Other (Electronics Industry) requires the user first to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "*country name*" or "*unspecified*" as selected from the drop-down menu], or with subnational aggregations, and for each of those the univocal name/code entered in Column |Subdivision|.

Then, for each subdivision in Column |Subdivision|, data are input in worksheet **Other**, row by row, as follows:

1. Column |SRC|: describe the type of activity emitting GHG emissions from this category. The user may select from the drop-down (which includes *other emissions from MEMs* in the case where higher tiered methods are used to estimate emissions from MEMs) 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 a gas is not relevant for the input category, 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.

   Note that for users intending to report emissions to the UNFCCC ETF Reporting Tool, if "Other emissions from MEMs" is selected in this worksheet in Column |SRC| any calculated emissions will map to the category of MEMS in the UNFCCC ETF Reporting Tool, along with any emissions estimated in worksheet FC Emissions from manufacturing of microelectromechanical systems.
2. Column |AT|: input the activity type corresponding to the source selected.
3. Column |AD|: input AD (quantity of the activity type input in Column |AT| and following the units in Column |U|).
4. Column |U|: input unit of the AD.
5. Column |Biogenic|(CO_2 only): indicate with a check, and if applicable, if the process feedstock is of biogenic origin.

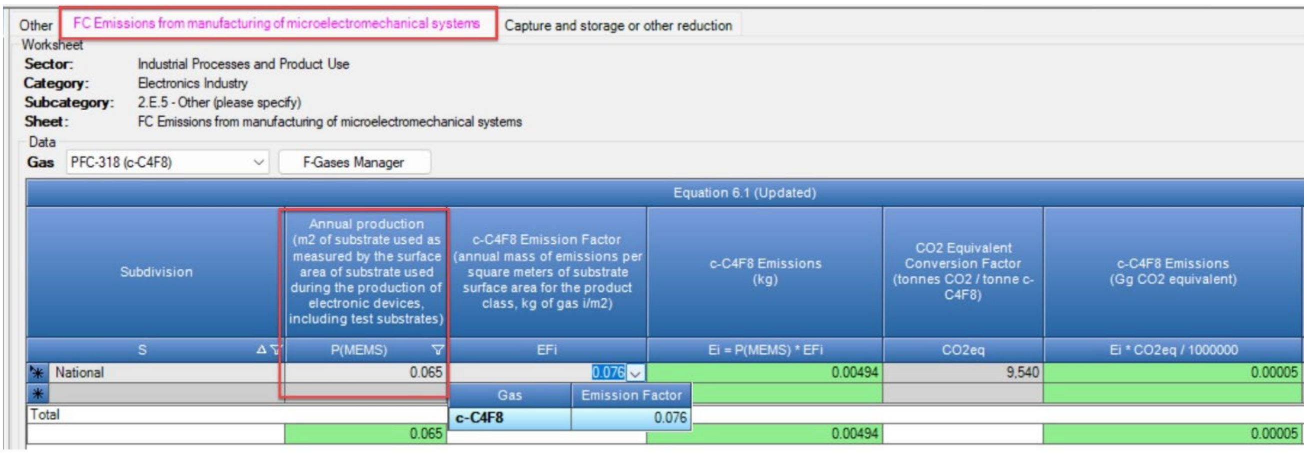
Example: **single subdivision- data entry for Other (Electronics Industry)**



Then, for each subdivision in Column |Subdivision|, data are entered in worksheet **FC Emissions from manufacturing of microelectromechanical systems**, row by row, as follows:

1. Column |P(MEMS)|: input total production of electronic devices, as determined by the total surface area of electronic substrates used during the production of those devices, in m^2.

Example: **AD entry for MEMS – Tier 1**



Emission Factor Input

Section 6.2.2.1 of the *2006 IPCC Guidelines* provides specific guidance for choice of EFs for semiconductors, TFT-FPD, photovoltaics and heat transfer fluids. Information is not available for Other (Electronics Industry).

Section 6.2.2.1 in the *2019 Refinement* provides the IPCC default EF for MEMS in Table 6.6 (Updated). Recall, when using the Tier 1 method for Electronics in worksheet **FC Emissions from manufacturing of microelectromechanical systems**, it is not good practice to modify, in any way, the set of GHGs or the values of the EFs assumed in Table 6.6. Thus, users reporting MEMS in this table must calculate emissions for CF_4, c-C_4F_8 and SF_6, consistent with the gases included in Table 6.6.

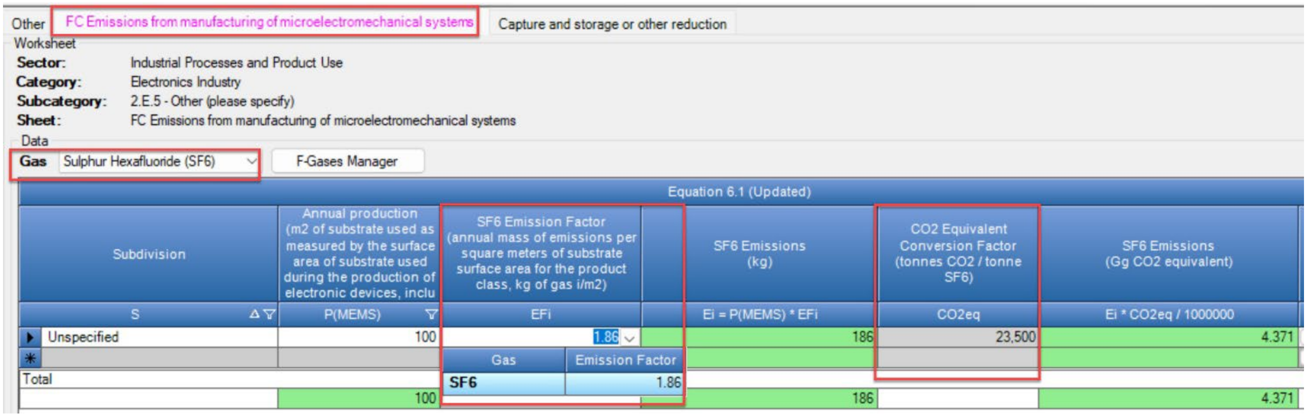
So, in worksheet **Other,** for each subdivision in Column |Subdivision|, users input information row by row, as follows:

1. Column |EF|: input EF for each GHG, in Gg/unit. See figure above for worksheet **Other.**
   Note that the 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 a gas is not relevant for the category input, the user should leave the EF column blank.

In worksheet **FC Emissions from manufacturing of microelectromechanical systems**, for each subdivision in Column |Subdivision|, and each gas, input information, row by row, as follows:

1. Column |EFi|: input EF for each GHG, in Gg/unit.
   Note that user shall select the relevant gas in the "Gas" bar at the top, to enter data for each GHG one by one. Recall that emissions estimates must be included for CF_4, c-C_4F_8 and SF_6
2. Column |CO_2eq|: this column is automatically populated with the GWP of the gas in the drop-down menu Gas.

Example: **EF entry for MEMS – Tier 1**



Results

Total GHG emissions from Other (Electronics Industry) is the sum of all subdivisions in the above worksheets, 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.

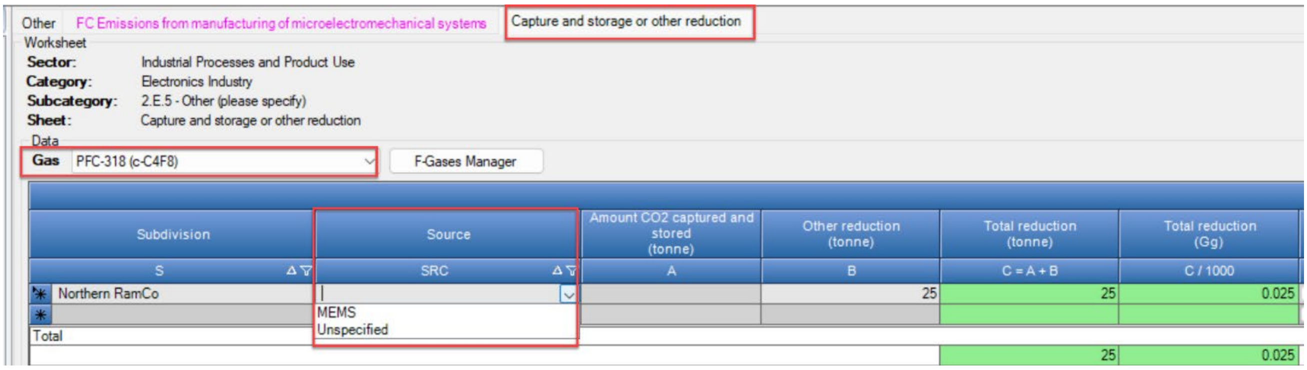
In the worksheet **Capture and storage or other reduction** for each subdivision and each gas:

1. Column |SRC|: 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).
   Note that the drop-down menu includes a single choice of MEMS. This source includes all capture/recovery/destruction for MEMS, regardless of which worksheet the MEMS were reported under (recognizing that it is not expected that capture/recovery/destruction would be reported if only the Tier 1 method were used). This is because, although MEMS are reported in two separate worksheets, for users reporting to the UNFCCC ETF Reporting Tool, all emissions (and reductions) from MEMS are reported together.

2. Column |A|: collect and input information on the amount of CO_2 captured (with subsequent storage), in tonnes.
3. Column |B|: 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|: (visible only when gas = CO_2) indicate with a check if the reductant is of biogenic origin.

   Note that consistent with 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.F Product Uses as Substitutes for Ozone Depleting Substances

Chapter 7 of Volume 3 of the *2006 IPCC Guidelines* provides guidance for the estimation of F-gases from the use of alternatives to ozone depleting substances being phased out under the Montreal Protocol.

Applications covered by the *2006 IPCC Guidelines,* and thus the *Software,* comprise:

- ✓ Refrigeration and air conditioning
- ✓ Foam blowing agents
- ✓ Fire protection
- ✓ Aerosols
- ✓ Solvent cleaning
- ✓ Other applications

Use of fluorinated compounds in these various applications lead to emissions over the course of the lifetime of use of these products.

Important note on collection of consumption data for F-gases

Users should review carefully consumption data on F-gases used in categories 2.F (Product Uses as Substitutes for Ozone Depleting Substances), as well as any F-gases used in other categories, particularly in the 2.C Metals Industry (e.g. magnesium production), 2.E Electronics Industry (e.g. semiconductors), 2.G Other Product Manufacture and Use (e.g. electrical equipment) and 2.H Other to ensure there is no double counting of consumption across multiple applications.

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 a given category (e.g. a given quantity of HFC-134a should not be added into worksheets for both domestic and commercial refrigeration and air conditioning) or across source categories (e.g. the same given quantity should not be included in both refrigeration and air conditioning (category 2.F.1) and fire protection (category 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 input, 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 several categories (e.g. refrigeration and air conditioning) to assess if the data input are consistent with the fundamental principle of mass conservation of the gases (see for example the QA/QC for refrigeration and air conditioning).

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.*

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

This section groups guidance for the following source categories owing 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 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 2.F.1 Refrigeration and Air Conditioning only. Emissions are estimated by sub-application (e.g. commercial and domestic refrigeration are estimated separately), using a Tier 2a and/or Tier 2b method. Both methods require information on the chemical used (including manufacturing, import and export (bulk and in equipment), year of introduction of the chemical, growth rate and lifetime.

In addition, the Tier 2a method is an EF approach and requires EFs for each stage of operation, including:

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).

And the Tier 2b method is a mass-balance approach and requires information on the flow of refrigerants across the industry, including:

i) Total charge of new equipment
ii) Original total charge of retiring equipment

iii) 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** and **Fire Protection,** using the following worksheets:

- ✓ **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 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 to apply 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

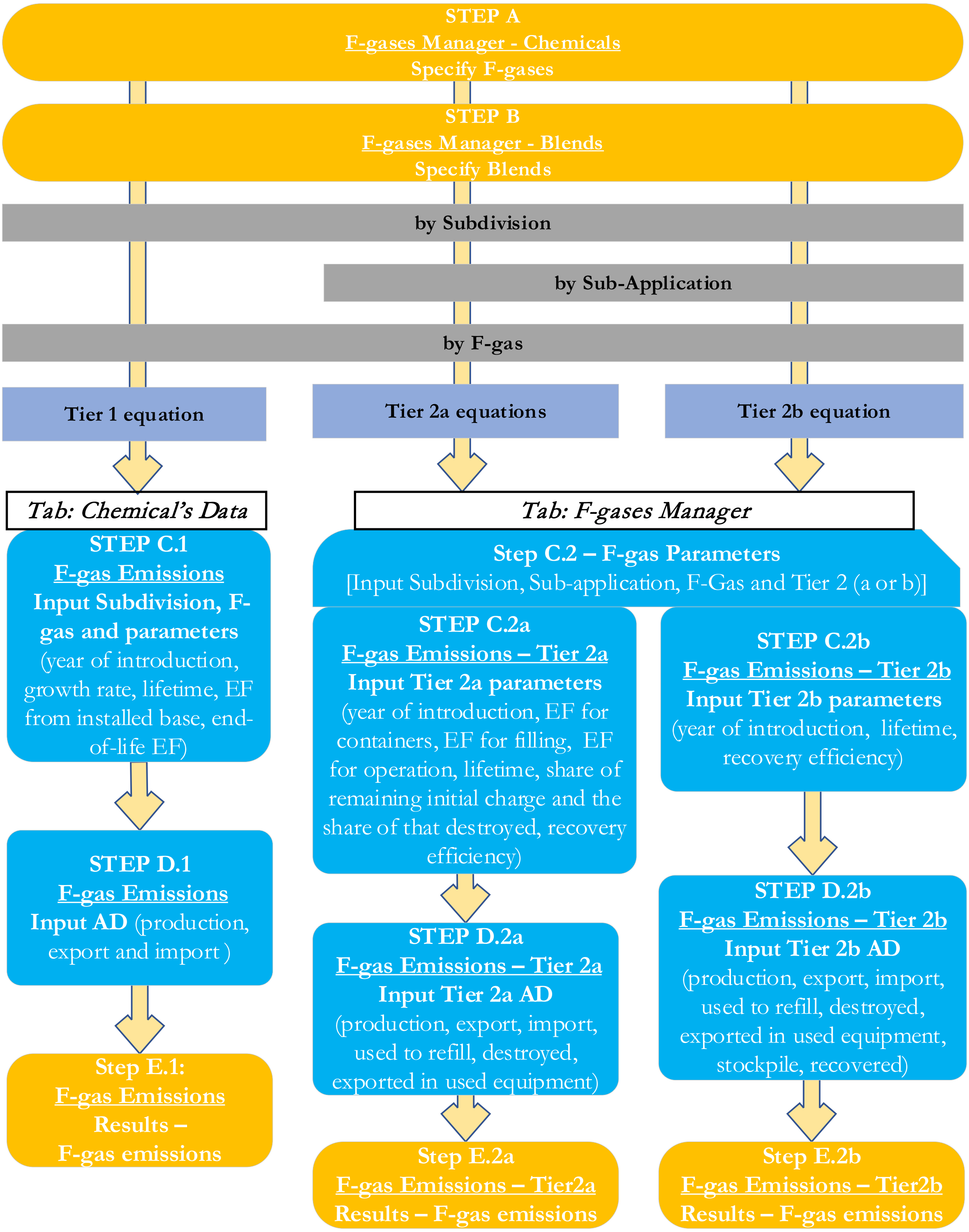
For Refrigeration and Air Conditioning, consistent with the key category analysis and the decision tree in Figure 7.6 of the *2006 IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific[1] EFs or direct measurements.

For Fire Protection, GHG estimates are calculated following the decision tree in Figure 7.9.

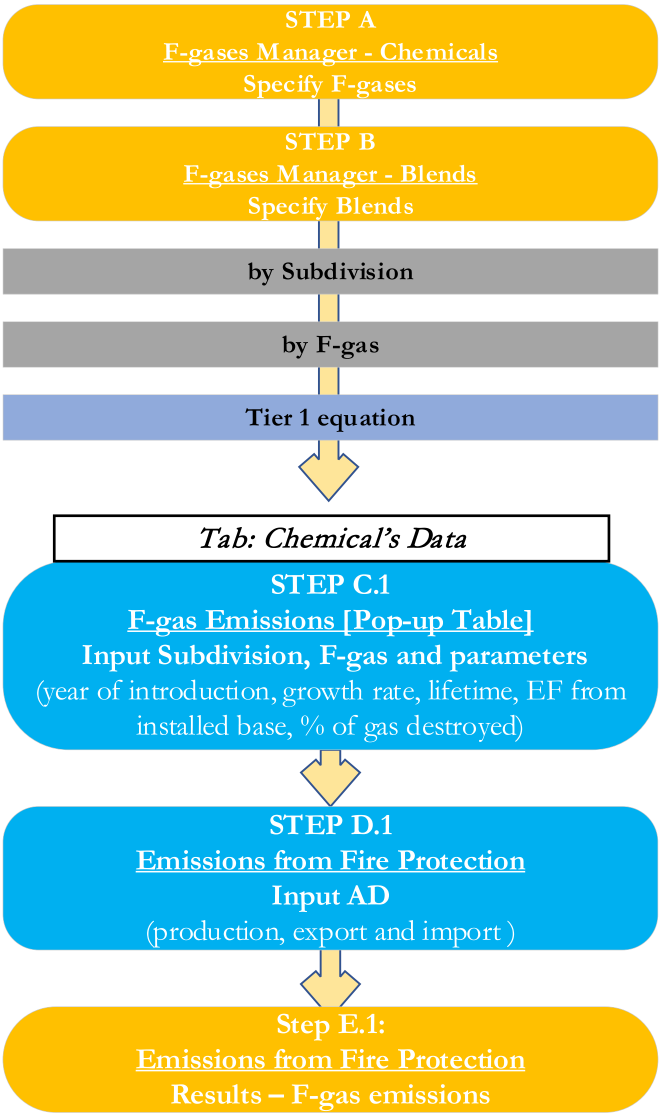
To ease the use of the *Software* as well as to avoid its misuse, the user follows the following flowcharts for Refrigeration and Air Conditioning and Fire Protection, respectively.

[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.

Refrigeration and Air Conditioning– flowchart



Fire Protection – flowchart



Thus, for the relevant source-category:

Steps A and B, **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 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 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 worksheet **F-Gas Emissions** or **Emissions from Fire Protection,** the *Software* calculates the associated emissions for each F-gas, in tonnes and Gg.

When Tier 2 Equations are applied (Refrigeration and Air Conditioning only)**:**

Step C.2, in worksheet **F-Gas Parameters – Tier 2**, users collect and input in the *Software* information on subdivisions, sub-applications and Tier 2 methods (Tier 2a and/or Tier 2b). For Tier 2a, users collect and input 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)**. Users may also identify in this worksheet if gases are confidential (for reporting to the UNFCCC ETF Reporting Tool).

Then for Tier 2a:

Step D.2a, in 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 all reporting years).

Step E.2a in 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 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 all reporting years).

Step E.2b, in worksheet **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

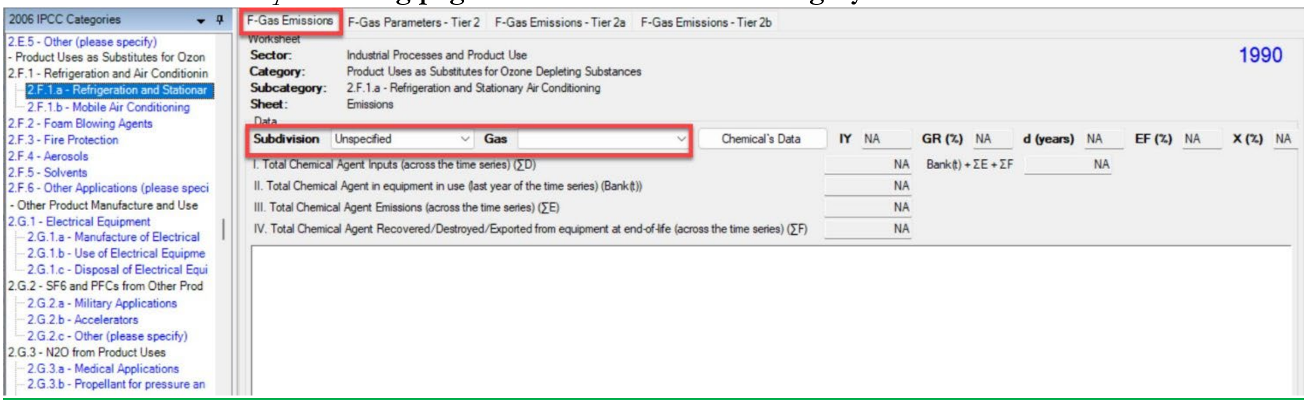
For both the Tier 1 and Tier 2 methods, users must first identify the applicable subdivision/sub-application/F -gases/blends applicable to the chosen method that will be used to estimate GHG emissions.

When the Tier 1 Equation is applied:

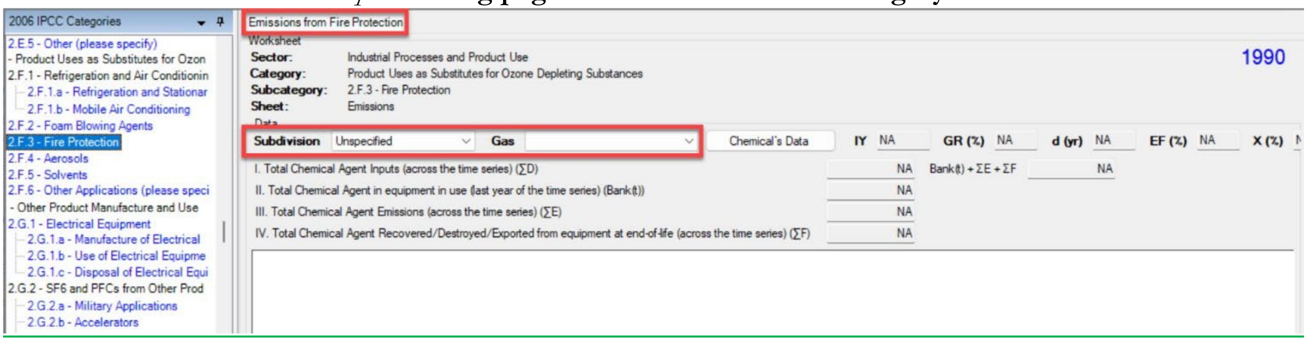
For the Tier 1 method, the user customizes the *Software* to identify the relevant subdivision(s) and F-gases used. There are no sub-applications for the Tier 1 method for either Refrigeration and Air Conditioning or Fire Protection. *Note that for users that apply a Tier 1 method for Refrigeration and 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) only. Users reporting a Tier 1 method for Refrigeration and Air Conditioning will 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**

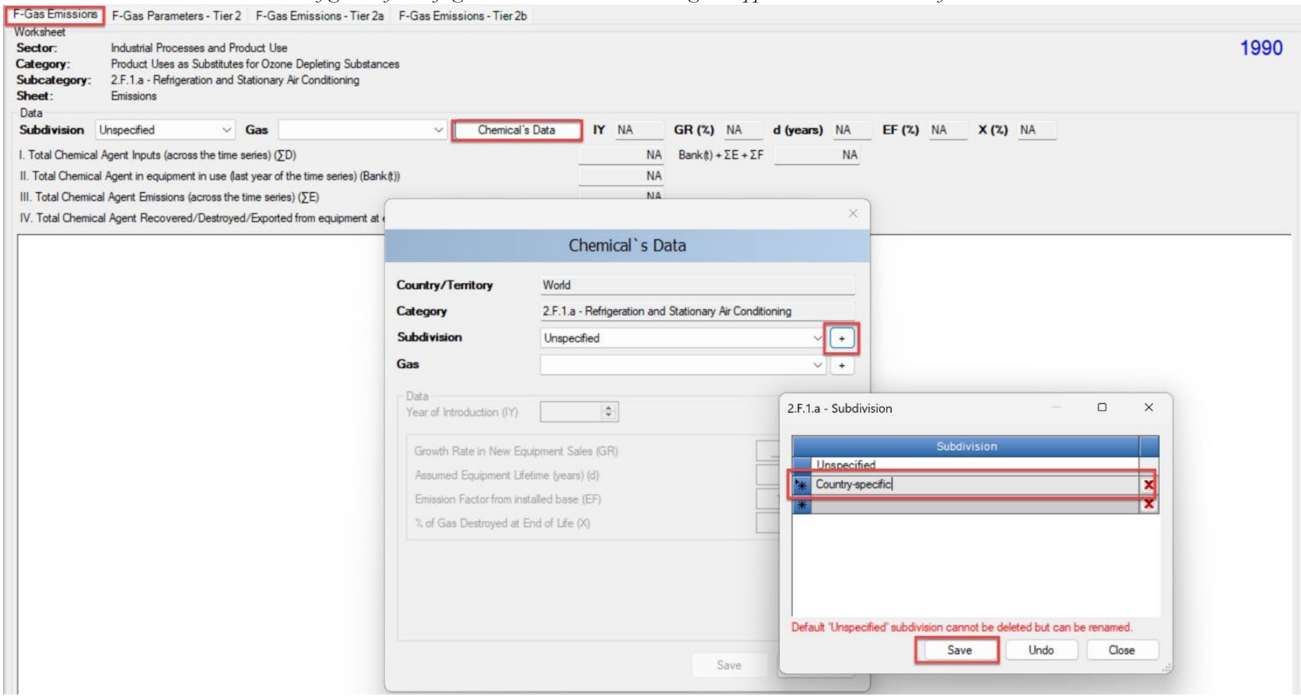


Entering subdivision(s)

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>

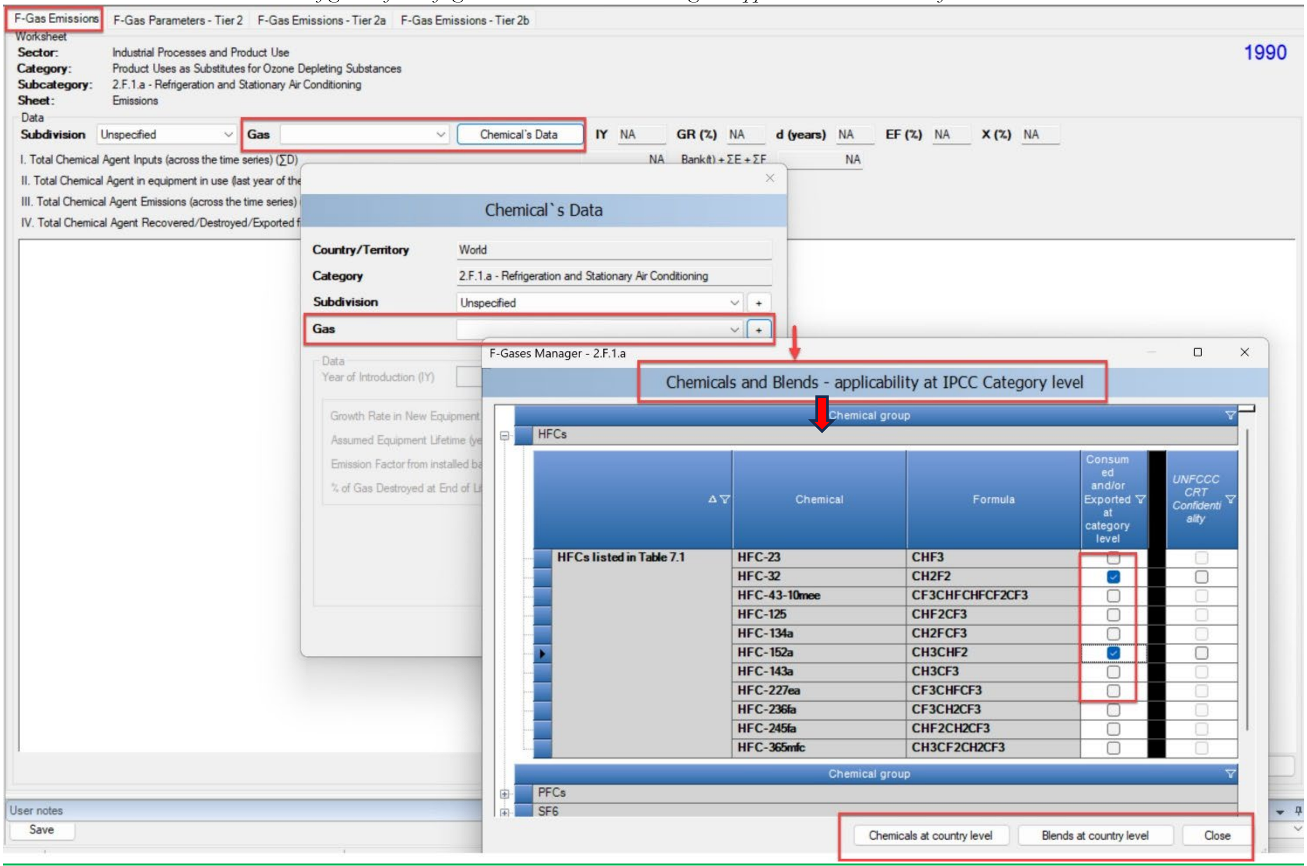
Upon first entering the *Software* and selecting **Gas** in the worksheet **F-Gas Emissions** or **Emissions from Fire Protection,** the user will not see any F-gases (or blends) pre-populated in the drop-down menu. This is because users must first identify the specific F-gases /blends consumed for each relevant source category; selected from all F-gases/blends that have already been identified by the user at the national level in the **F-Gases Manager**.

To select the F-gases used in this IPCC category (see also <u>here</u>):

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 RAC and for fire protection.
   *<u>Note that:</u> 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 country level** or **Blends at country 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 (RAC 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).

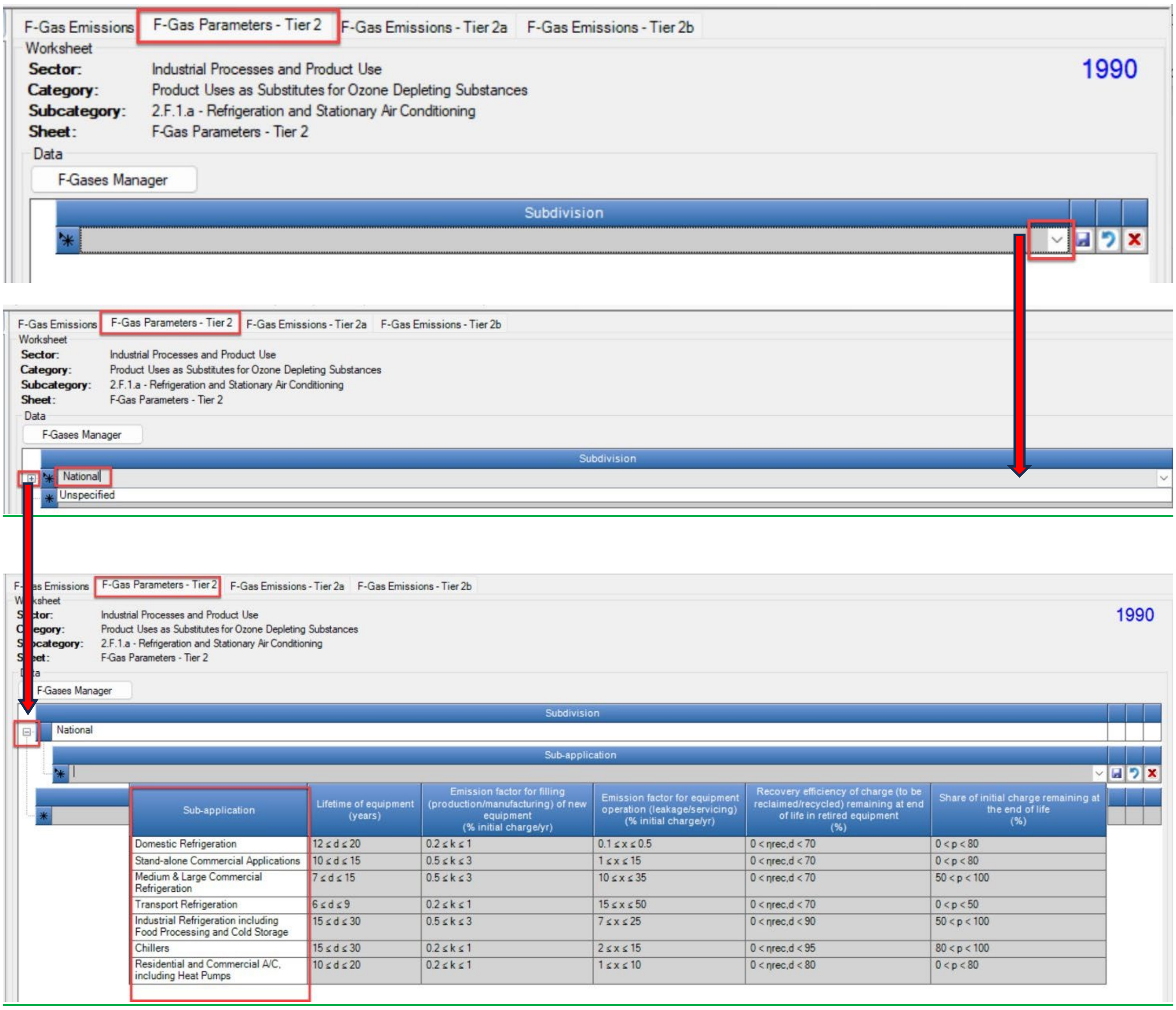
Entering subdivision(s) and sub-application(s)

Upon first opening the *Software*, the worksheet is empty and users must input subdivision(s) in the gray 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 manually input 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 select from the drop-down menu the relevant sub-application(s) (domestic, commercial, etc.) (select the [+] sign again to add multiple sub-applications. 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>

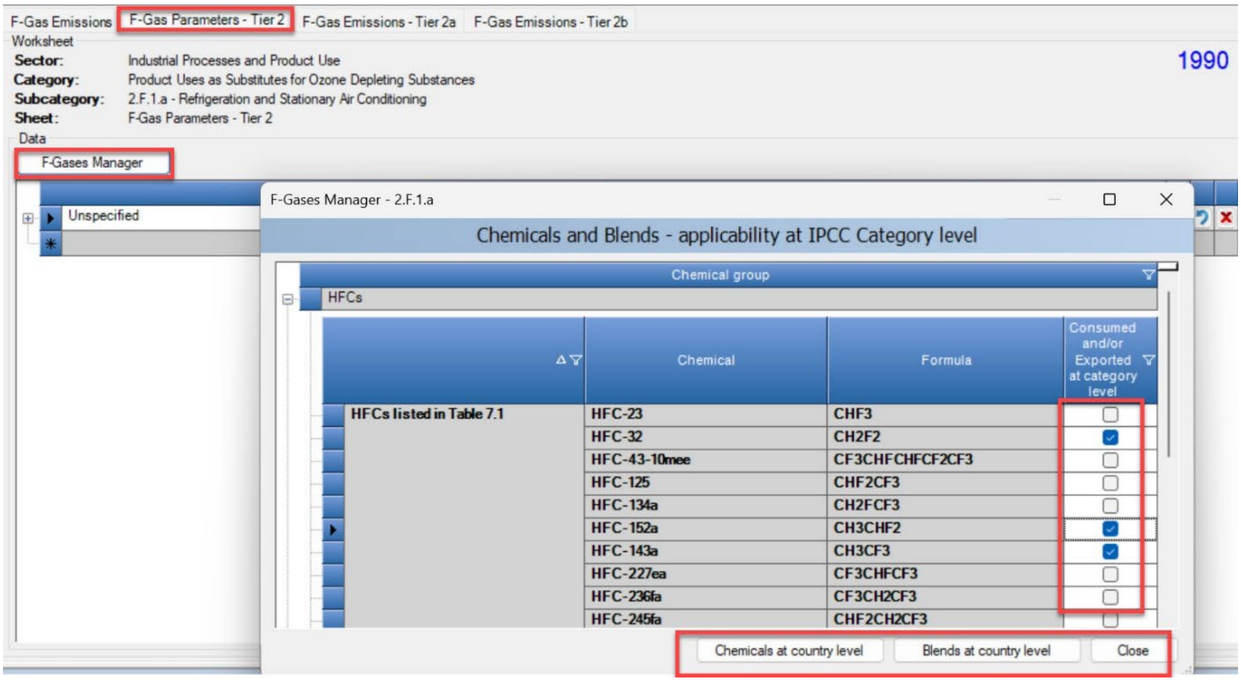
After identifying the subdivision(s) and sub-application(s), users must then identify the specific F-gases /blends consumed for RAC; selected from all F-gases/blends that have already identified by the user at the national level in the **F-Gases Manager**. Selection of F-gases/blends may also be done in worksheet **F-Gas Parameters – Tier 2.**

To select the F-gas(es)/blends used in this IPCC category:

1. Select **F-Gases Manager** and check all F-gas(es)/blends consumed for RAC.
   <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.*

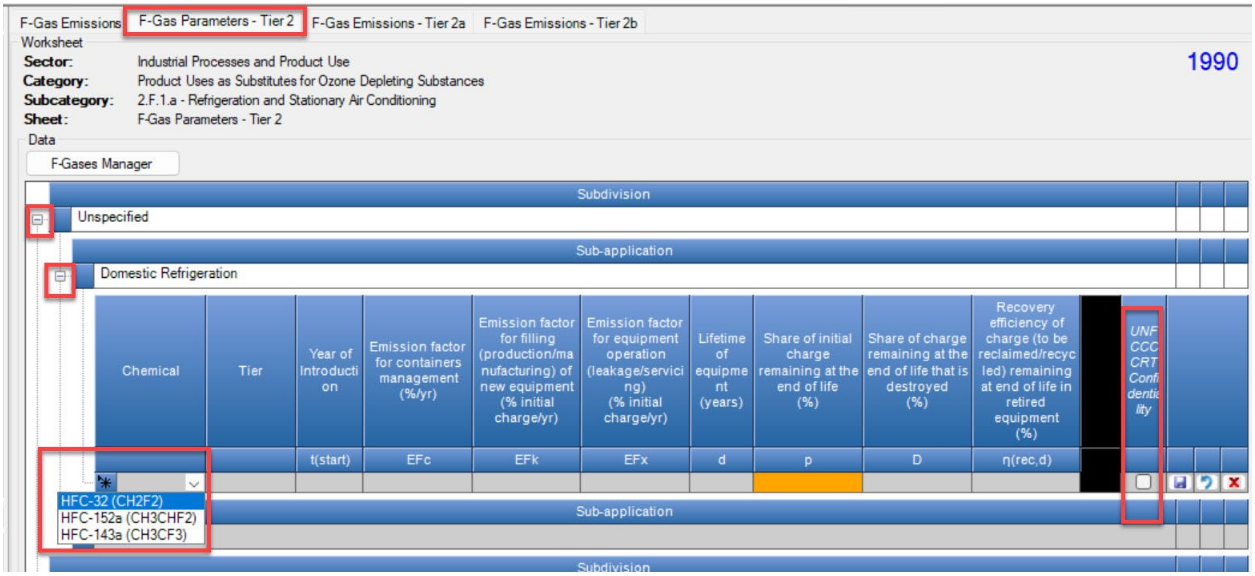
2. After identifying the subdivision, selecting a specific sub-application (e.g. Domestic Refrigeration in the second image below), and ensuring the F-gases Manager includes all gases/blends consumed in the category, the user selects the [+] plus sign to select the F-gas(es)/blends for which emissions 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. <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 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**).
<u>Note that:</u> 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:

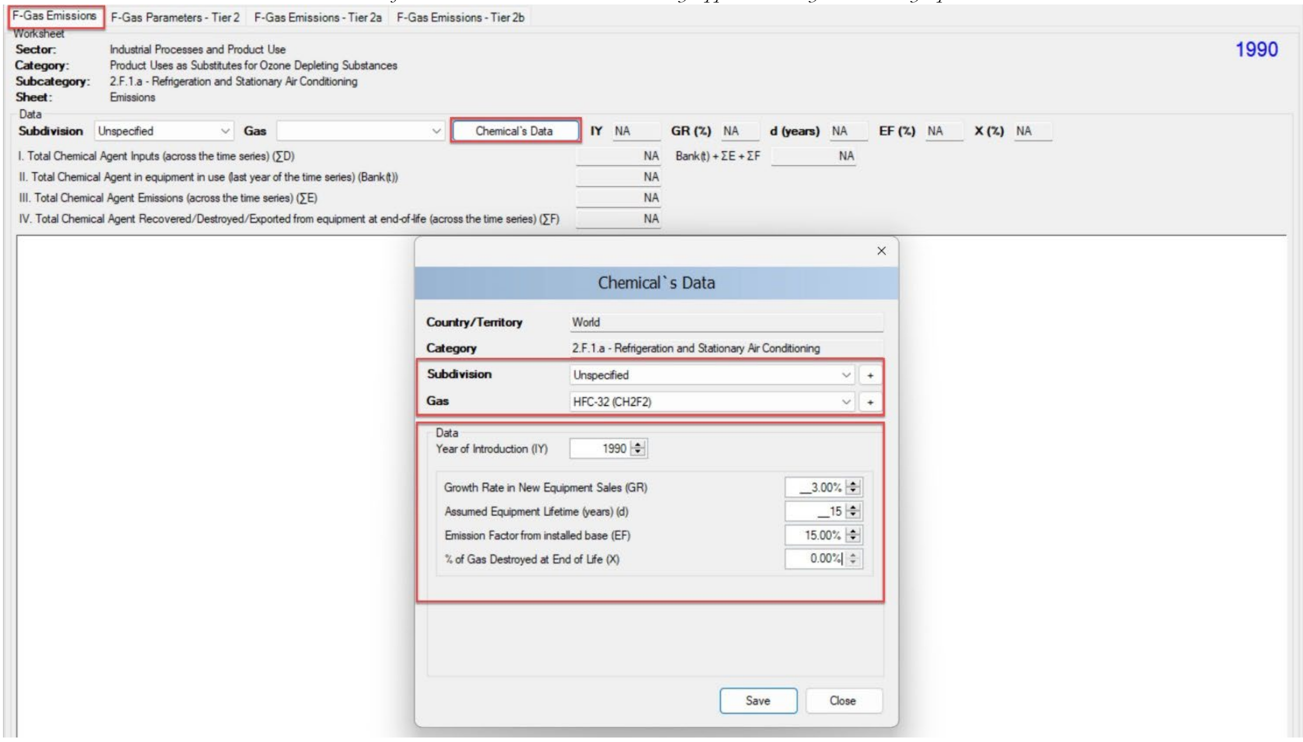
- ✓ Section 7.5.2.2 contains information on the choice of EFs/parameters for RAC.
- ✓ Section 7.6.2.2 contains information on the choice of EFs/parameters for Fire Protection.

When the Tier 1 Equation is applied:

1. In worksheet **F-Gas Emissions** or **Emissions from Fire Protection,** 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:** select the relevant F-gas/blend from the drop-down menu (refer here if additional F-gases or blends needs to be added to the drop-down menu).
3. Window |Year of Introduction|: input the year of introduction of the agent in the country for use in RAC (e.g., 1990).
4. Window |Growth Rate in New Equipment Sales|: input the growth rate in sales of new equipment, usually assumed linear across the period of assessment (e.g. 3%).
5. Window |Assumed Equipment Lifetime|: input the 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|: input the 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|: input the agent destroyed at the end-of-life, percent.
   Note that the default assumption of 0% means no F-gas is destroyed at the end-of-life, thus all gases in retired equipment are emitted.

Example: **entering EF/parameter information- Tier 1**

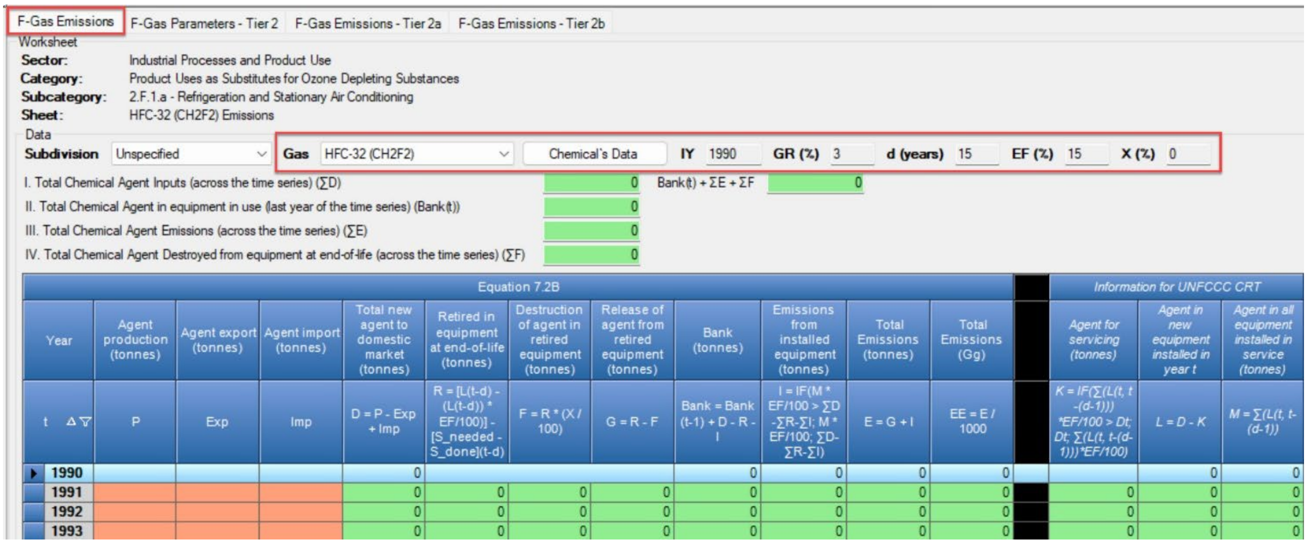
Note that this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet. The IPCC default values for Fire Protection, will automatically appear but may be manually updated.



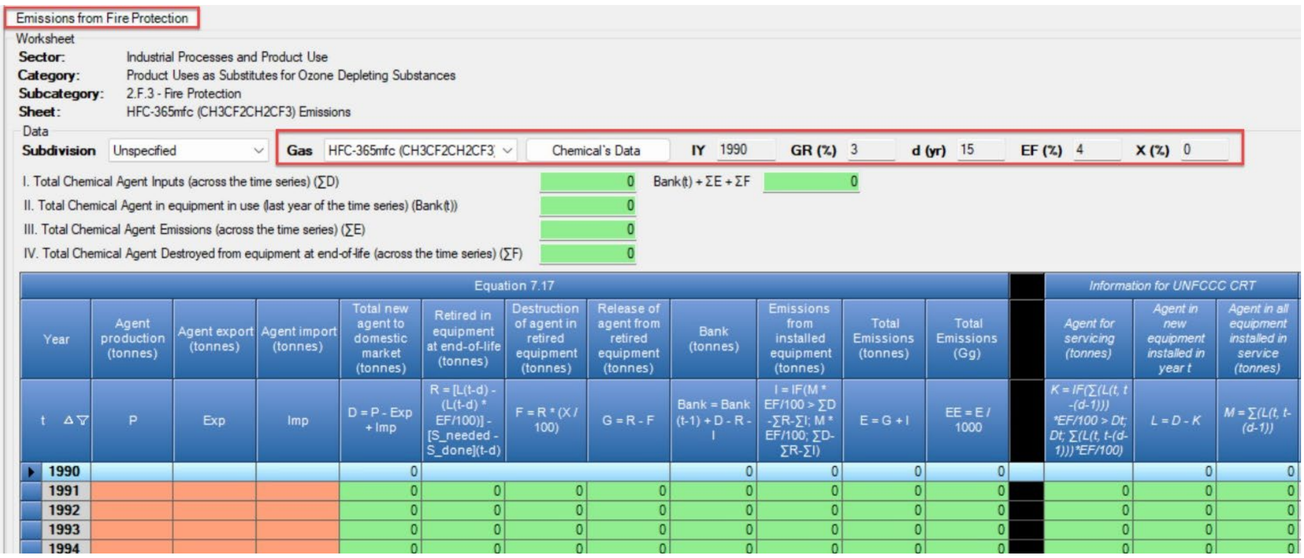
[1] Unlike other source categories in the IPCC sector, this Users' Guidebook explains first the input of EF/parameter inputs, then AD inputs, due to the structure of the *Software*.

8. Then, **Save and Close** the pop-up window **Chemical's Data** to return to the worksheet and to input 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 (RAC only)**:**

1. In worksheet **F-Gas Parameters-Tier 2,** use the [+] plus sign to input data for each subdivision/ sub-application.
2. <u>Column |Chemical|</u>: select the relevant F-gas/blend from the drop-down menu (refer to previous section on <u>customizing the *Software*</u> if an additional F-gas or blend needs to be added to the drop-down menu).
3. <u>Column |Tier|</u>: After selecting the F-gas/blend, the specific Tier 2 method applied (i.e. either Tier 2a or Tier 2b) should be selected.

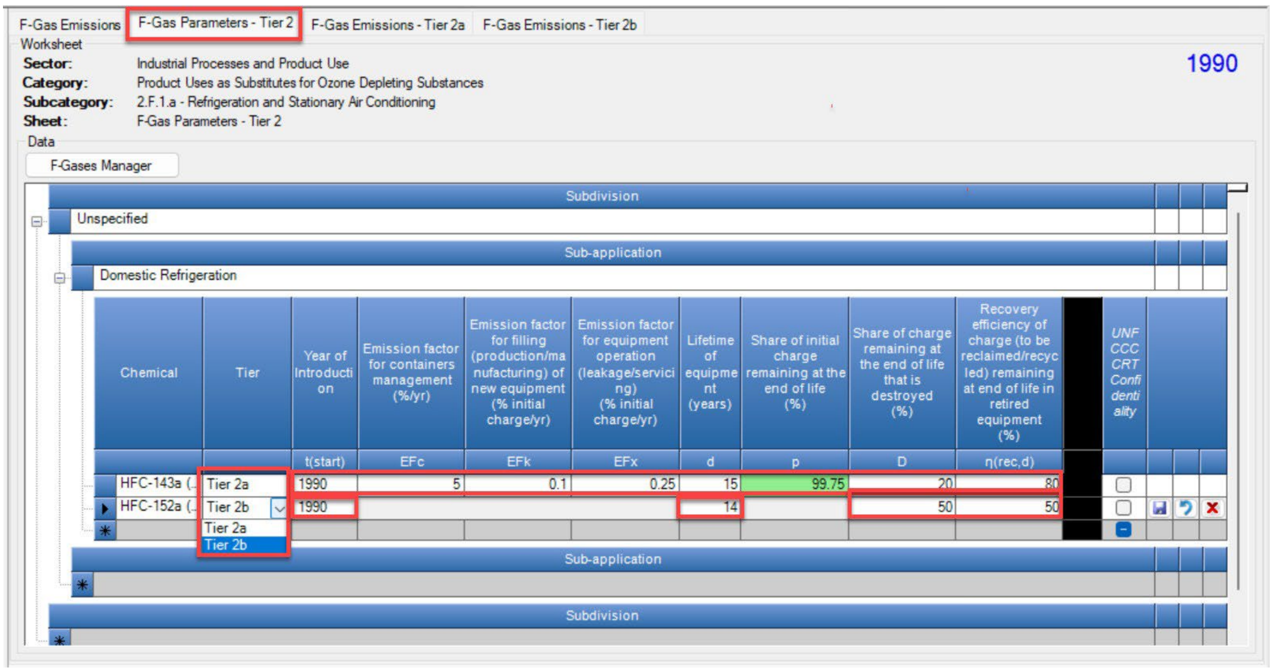
Then, for different Tiers (Tier 2a and/or Tier 2b) input the following EFs/parameters (consult Table 7.9 Chapter 7 Volume 3 of the *2006 IPCC Guidelines* for IPCC default values, if needed).

4. For Tier 2a, for each subdivision, sub-application and each F-gas/blend, enter the following information:
   a. Window |t (start)|: input the year of introduction of refrigerant (F-gas/blend).
   b. Window |EFc|: input the EF for containers management (percent per year).
   c. Window |EFk|: input the EF for filling new equipment (percent of initial charge per year).
   d. Window |EFx|: input the EF for equipment operation (percent of initial charge per year).
   e. Window |d|: input the lifetime of equipment, years.
   f. Window |p|: input the share of initial (full) charge remaining at end-of-life, percent.
   Note that: this cell requires direct entry. By default, users should input 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 user-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 the annual losses. A red colour means that p estimates a quantity of charge that is larger than the initial charge minus the annual loss. 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. Window |D|: input the share of charge remaining at the end of life that is destroyed, percent.
   h. Window |η (rec,d)|: input the 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, input the following information:
   a. Column |t (start)|: input the year of introduction of refrigerant (F-gas/blend).
   b. Column |d|: input the lifetime of equipment, years.
   c. Column |D|: input the share of charge remaining at the end of life that is destroyed, percent.
   d. Column |η (rec,d)|: input the 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.

Please note that all EFs are based on the initial (full) charge.

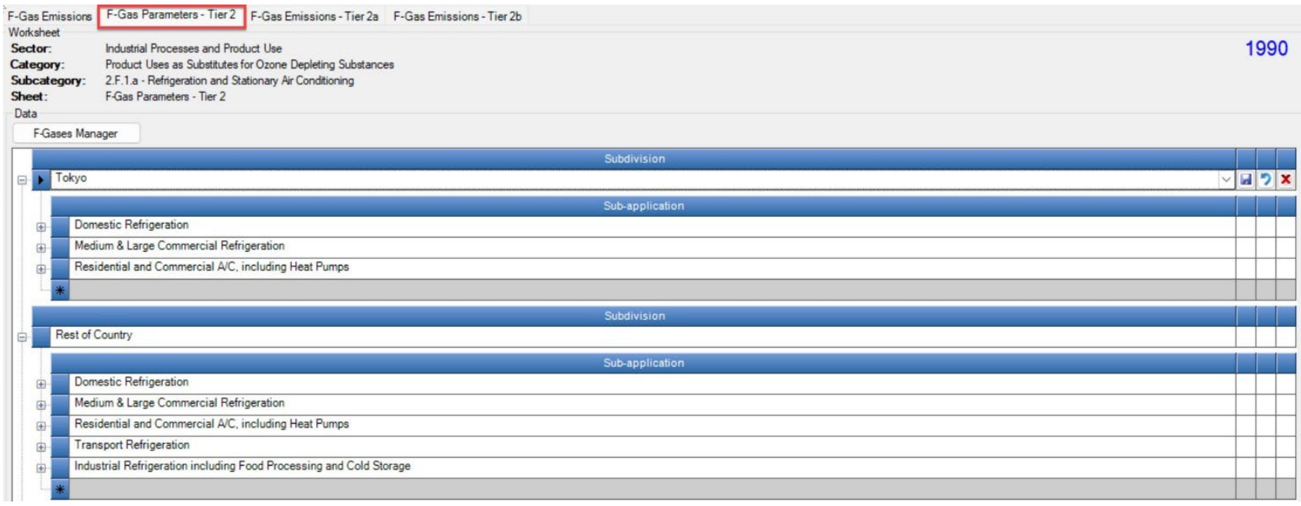
Example: **entering EF/parameter information- Tier 2**



6. The same procedure is to be applied for all subdivisions/sub-applications.

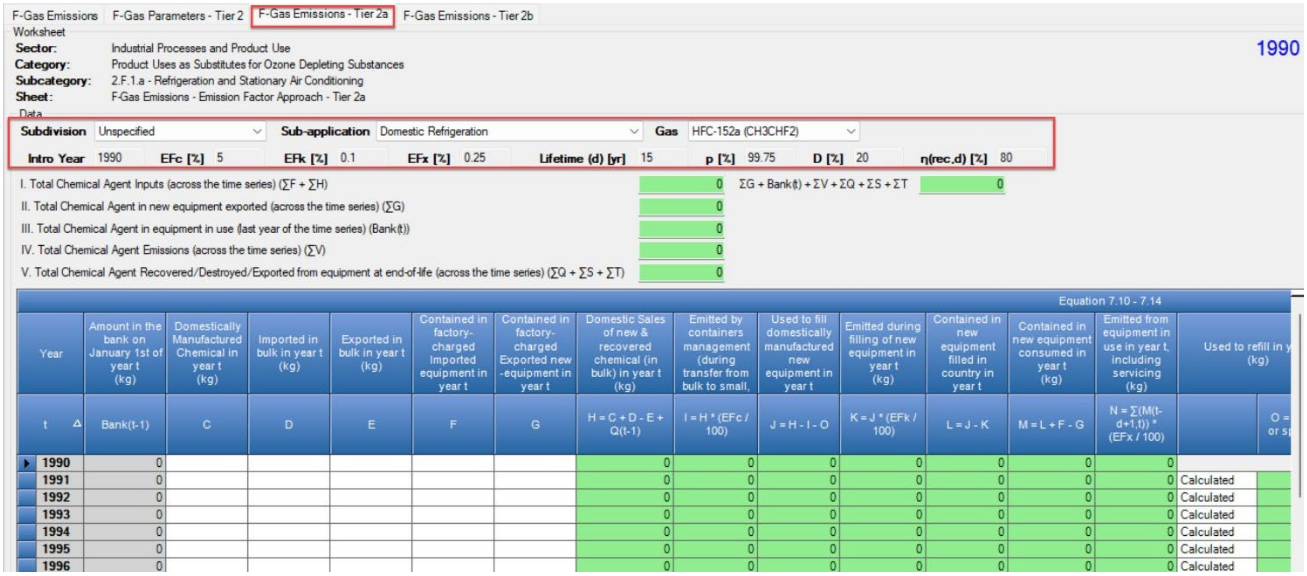
Example: **subdivisions and sub-applications entered for the entire category 2.F.1.a**

Note that the same table structure applies to category 2.F.1.b



7. After EF and parameter information is entered for all subdivisions /sub-applications/ F-gases/blends, navigate to the worksheet **F-Gas Emissions – Tier 2a** and/or **F-Gas Emissions – Tier 2b** and input the corresponding AD. The user can see parameters input 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: estimates in a Tier 2a/Tier 2b worksheet may be for individual F-gas species, or blends. When emissions are calculated for a blend in a worksheet, the blend will be disaggregated into 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.

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions.

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|: input the amount of the respective chemical identified in **Gas** produced for consumption in the designated subdivision.
3. Column |Exp|: input the amount of the respective chemical identified in **Gas** that was produced for consumption in the designated subdivision, and exported, in tonnes. This amount will not be considered in the calculation of emissions.
   Note that: exports should be equal to or less than the amount produced plus imported for a given year.
4. Column|Imp|: input 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. Entry of "0" will be read as a zero for purposes of any interpolation/extrapolation, so be sure to enter "0" only for true zero.

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 years for which data are known.
   *Note that this cell is based on the parameters entered in the tab **Chemical's Data** (specifically the equipment growth rate).*
2. Column |D|: 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 previous step), 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**

Information for CRT			HIDDEN CALCULATION					
agent for servicing (tonnes)	agent in new equipment installed in year t (tonnes)	agent in all equipment installed in service (tonnes)	needed agent across lifetime		actual agent used across time			
			S_neeeded	(tonnes)			S_done	(tonnes)
$K = \sum_{t-(d-1)}^{t-1} L * \frac{EF\%}{100} > D_t, D_t, \sum_{t-(d-1)}^{t-1} L * \frac{EF\%}{100}$	L=D-K	$M = \sum_{t-(d-1)}^{t} (L)$	for equipment	L_{t-1}*(d-1)*EF/100		is to be equal to K	for equipment X installed in a year Y	$\sum_{1}^{d-1} (S\_done)$
NO	10,000.000	10,000.000	installed in year t-20	9,000.000	year t-20	NO	installed in year t-20	6,000.000
1,000.000	9,000.000	19,000.000	installed in year t-19	8,100.000	year t-19	1,000.000	installed in year t-19	4,600.000
1,900.000	8,100.000	27,100.000	installed in year t-18	7,290.000	year t-18	1,900.000	installed in year t-18	3,340.000
2,710.000	7,290.000	34,390.000	installed in year t-17	6,561.000	year t-17	2,710.000	installed in year t-17	2,287.000
3,439.000	6,561.000	40,951.000	installed in year t-16	5,904.900	year t-16	3,439.000	installed in year t-16	1,412.200
4,095.100	5,604.900	46,555.900	installed in year t-15	5,044.410	year t-15	4,095.100	installed in year t-15	660.490
0.000	0.000	46,555.900	installed in year t-14	0.000	year t-14	0.000	installed in year t-14	0.000
0.000	0.000	46,555.900	installed in year t-13	0.000	year t-13	0.000	installed in year t-13	0.000
0.000	0.000	46,555.900	installed in year t-12	0.000	year t-12	0.000	installed in year t-12	0.000
4,655.590	5,344.410	51,900.310	installed in year t-11	4,809.969	year t-11	4,655.590	installed in year t-11	400.000
100.000	0.000	41,900.310	installed in year t-10	0.000	year t-10	100.000	installed in year t-10	0.000
100.000	0.000	32,900.310	installed in year t-9	0.000	year t-9	100.000	installed in year t-9	0.000
100.000	0.000	24,800.310	installed in year t-8	0.000	year t-8	100.000	installed in year t-8	0.000
100.000	0.000	17,510.310	installed in year t-7	0.000	year t-7	100.000	installed in year t-7	0.000
100.000	0.000	10,949.310	installed in year t-6	0.000	year t-6	100.000	installed in year t-6	0.000
100.000	0.000	5,344.410	installed in year t-5	0.000	year t-5	100.000	installed in year t-5	0.000
100.000	0.000	5,344.410	installed in year t-4	0.000	year t-4	100.000	installed in year t-4	0.000
100.000	0.000	5,344.410	installed in year t-3	0.000	year t-3	100.000	installed in year t-3	0.000
100.000	0.000	5,344.410	installed in year t-2	0.000	year t-2	100.000	installed in year t-2	0.000
0.000	100.000	100.000	installed in year t-1	90.000	year t-1	0.000	installed in year t-1	10.000
10.000	90.000	190.000						
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 litetime of equipment X installed in the relevant year Y		amount of chemical serviced in a year t		cumulated amount of chemical actually serviced across litetime of equipment X installed in the relevant year Y

to calculate actual servicing occurred in each year subsequent to the installation of the equipment installed in a year:

installed in year	t-20	t-19	t-18	t-17	t-16	t-15	t-14	t-13	t-12	t-11	t-10	t-9	t-8	t-7	t-6	t-5	t-4	t-3	t-2	t-1
servicing in year	**6,000.000**	**4,600.000**	**3,340.000**	**2,287.000**	**1,412.200**	**660.490**	**0.000**	**0.000**	**0.000**	**400.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**10.000**
t-19	1,000.000																			
t-18	1,000.000	900.000																		
t-17	1,000.000	900.000	810.000																	
t-16	1,000.000	900.000	810.000	729.000																
t-15	1,000.000	900.000	810.000	729.000	656.100															
t-14	0.000	0.000	0.000	0.000	0.000	0.000														
t-13	0.000	0.000	0.000	0.000	0.000	0.000	0.000													
t-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000												
t-11	1,000.000	900.000	810.000	729.000	656.100	560.490	0.000	0.000	0.000											
t-10		100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000										
t-9			100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000									
t-8				100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000								
t-7					100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000							
t-6						100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
t-5							0.000	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000					
t-4								0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000				
t-3									0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
t-2										100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
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	10.000

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 than is needed (S_needed) then this cell is equal to the amount of agent available for servicing.

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, in tonnes.
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 several categories to ensure that the data, EFs and parameters entered by users are consistent with 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, last year of the time series (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) 224,053.265215 Bank(t) + ΣE + ΣF 224,053.265215
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 45,610.02406
III. Total Chemical Agent Emissions (across the time series) (∑E) 178,443.241156
IV. Total Chemical Agent Destroyed from equipment at end-of-life (across the time series) (∑F) 0

Demonstration of conservation of mass:
Total inputs =
bank+emissions+recovery/destruction

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(∑(L(t, t -(d-1))) *EF/100 > Dt; Dt; ∑(L(t, t-(d-1)))*EF/100)*	*L = D - K*	*M = ∑(L(t, t-(d-1))*
2009	0	0	7,224.21277	7,224.21277	0	0	0	31,632.230…	5,582.1584	5,582.1584	5.58216	5,292.38411	1,931.82866	37,214.389…
2010	0	0	7,440.93915	7,440.93915	0	0	0	33,212.194…	5,860.97552	5,860.97552	5.86098	5,582.1584	1,858.78074	39,073.170…
2011	0	0	7,664.16732	7,664.16732	0	0	0	34,744.907…	6,131.45429	6,131.45429	6.13145	5,860.97552	1,803.19181	40,876.361…
2012	0	0	7,894.09234	7,894.09234	0	0	0	36,243.149…	6,395.85	6,395.85	6.39585	6,131.45429	1,762.63806	42,638.999…
2013	0	0	8,130.91511	8,130.91511	4,436.08626	0	4,436.08626	33,947.282…	5,990.69682	10,426.783…	10.42678	5,613.01124	2,517.90387	39,937.978…
2014	0	0	8,374.84257	8,374.84257	3,903.75591	0	3,903.75591	32,655.613…	5,762.7553	9,666.51121	9.66651	5,301.79872	3,073.04384	38,418.368…
2015	0	0	8,626.08784	8,626.08784	3,455.26759	0	3,455.26759	32,152.468…	5,673.96504	9,129.23263	9.12923	5,153.0022	3,473.08565	37,826.433…
2016	0	0	8,884.87048	8,884.87048	3,078.16477	0	3,078.16477	32,265.298…	5,693.87614	8,772.04091	8.77204	5,130.7595	3,754.11098	37,959.174…
2017	0	0	9,151.41659	9,151.41659	2,761.86299	0	2,761.86299	32,856.623…	5,798.22776	8,560.09075	8.56009	5,206.48856	3,944.92804	38,654.851…
2018	0	0	9,425.95909	9,425.95909	2,497.36916	0	2,497.36916	33,817.431…	5,967.78209	8,465.15125	8.46515	5,357.51556	4,068.44353	39,785.213…
2019	0	0	9,708.73786	9,708.73786	2,277.04298	0	2,277.04298	35,061.757…	6,187.36901	8,464.41199	8.46441	5,565.95097	4,142.78689	41,249.126…
2020	0	0	10,000	10,000	2,094.39411	0	2,094.39411	36,522.259…	6,445.10454	8,539.49865	8.5395	5,817.77005	4,182.22995	42,967.3636
2021	0	0	10,300	10,300	1,943.90979	0	1,943.90979	38,146.596…	6,731.75239	8,675.66218	8.67566	6,102.06164	4,197.93836	44,878.349…
2022	0	0	10,609	10,609	1,820.90836	0	1,820.90836	39,894.485…	7,040.20328	8,861.11164	8.86111	6,410.41562	4,198.58438	46,934.688…

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, 224,053 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)**

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) 138,529.523276 Bank(t) + ΣE + ΣF 138,529.523276
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 45,767.65362
III. Total Chemical Agent Emissions (across the time series) (∑E) 92,761.869656
IV. Total Chemical Agent Destroyed from equipment at end-of-life (across the time series) (∑F) 0

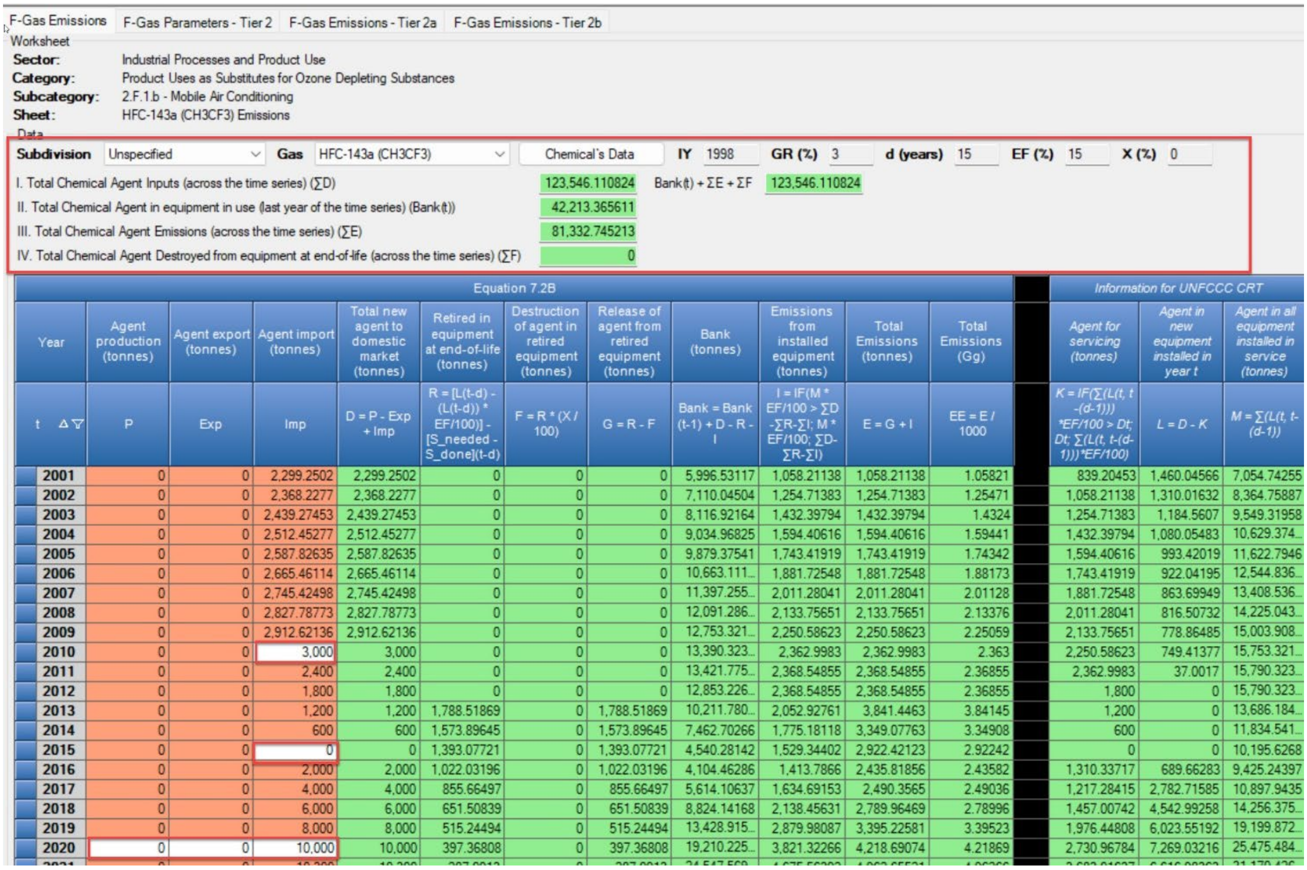
Equation 7.2B												Information for UNFCCC CRT		
Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (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(∑(L(t, t -(d-1))) *EF/100 > Dt; Dt; ∑(L(t, t-(d-1)))*EF/100)*	*L = D - K*	*M = ∑(L(t, t-(d-1))*
2000	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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	0	0	3,000	3,000	0	0	0	10,410.389…	1,837.12761	1,837.12761	1.83713	1,631.91484	1,368.08516	12,247.517…
2011	0	0	3,400	3,400	0	0	0	11,738.831…	2,071.55847	2,071.55847	2.07156	1,837.12761	1,562.87239	13,810.389…
2012	0	0	3,800	3,800	0	0	0	13,208.006…	2,330.8247	2,330.8247	2.33082	2,071.55847	1,728.44153	15,538.831…
2013	0	0	4,200	4,200	1,036.69168	0	1,036.69168	13,915.617…	2,455.69724	3,492.38892	3.49239	2,147.87911	2,052.12089	16,371.314…
2014	0	0	4,600	4,600	912.28868	0	912.28868	14,962.829…	2,640.49936	3,552.78803	3.55279	2,294.70513	2,305.29487	17,603.329…
2015	0	0	5,000	5,000	807.47915	0	807.47915	16,282.047…	2,873.30258	3,680.78173	3.68078	2,498.00304	2,501.99696	19,155.350…
2016	0	0	6,000	6,000	719.35206	0	719.35206	18,328.291…	3,234.40438	3,953.75645	3.95376	2,746.3581	3,253.6419	21,562.6959
2017	0	0	7,000	7,000	645.43388	0	645.43388	20,980.428…	3,702.42864	4,347.86253	4.34786	3,120.50429	3,879.49571	24,682.857…
2018	0	0	8,000	8,000	583.62297	0	583.62297	24,137.285…	4,259.5209	4,843.14387	4.84314	3,599.43636	4,400.56364	28,396.806…
2019	0	0	9,000	9,000	532.13382	0	532.13382	27,714.3786	4,890.77269	5,422.90651	5.42291	4,165.61494	4,834.38506	32,605.1513
2020	0	0	10,000	10,000	489.44967	0	489.44967	31,641.1896	5,583.73934	6,073.18901	6.07319	4,804.39922	5,195.60078	37,224.928…

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, 138,529 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.



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(∑(L(t, t -(d-1))) *EF/100 > Dt; Dt; ∑(L(t, t-(d-1)))*EF/100)*	*L = D - K*	*M = ∑(L(t, t-(d-1))*
2001	0	0	2,299.2502	2,299.2502	0	0	0	5,996.53117	1,058.21138	1,058.21138	1.05821	839.20453	1,460.04566	7,054.74255
2002	0	0	2,368.2277	2,368.2277	0	0	0	7,110.04504	1,254.71383	1,254.71383	1.25471	1,058.21138	1,310.01632	8,364.75887
2003	0	0	2,439.27453	2,439.27453	0	0	0	8,116.92164	1,432.39794	1,432.39794	1.4324	1,254.71383	1,184.5607	9,549.31958
2004	0	0	2,512.45277	2,512.45277	0	0	0	9,034.96825	1,594.40616	1,594.40616	1.59441	1,432.39794	1,080.05483	10,629.374...
2005	0	0	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	0	0	2,665.46114	2,665.46114	0	0	0	10,663.111...	1,881.72548	1,881.72548	1.88173	1,743.41919	922.04195	12,544.836...
2007	0	0	2,745.42498	2,745.42498	0	0	0	11,397.255...	2,011.28041	2,011.28041	2.01128	1,881.72548	863.69949	13,408.536...
2008	0	0	2,827.78773	2,827.78773	0	0	0	12,091.286...	2,133.75651	2,133.75651	2.13376	2,011.28041	816.50732	14,225.043...
2009	0	0	2,912.62136	2,912.62136	0	0	0	12,753.321...	2,250.58623	2,250.58623	2.25059	2,133.75651	778.86485	15,003.908...
2010	0	0	3,000	3,000	0	0	0	13,390.323...	2,362.9983	2,362.9983	2.363	2,250.58623	749.41377	15,753.321...
2011	0	0	2,400	2,400	0	0	0	13,421.775...	2,368.54855	2,368.54855	2.36855	2,362.9983	37.0017	15,790.323...
2012	0	0	1,800	1,800	0	0	0	12,853.226...	2,368.54855	2,368.54855	2.36855	1,800	0	15,790.323...
2013	0	0	1,200	1,200	1,788.51869	0	1,788.51869	10,211.780...	2,052.92761	3,841.4463	3.84145	1,200	0	13,686.184...
2014	0	0	600	600	1,573.89645	0	1,573.89645	7,462.70266	1,775.18118	3,349.07763	3.34908	600	0	11,834.541...
2015	0	0	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	0	0	2,000	2,000	1,022.03196	0	1,022.03196	4,104.46286	1,413.7866	2,435.81856	2.43582	1,310.33717	689.66283	9,425.24397
2017	0	0	4,000	4,000	855.66497	0	855.66497	5,614.10637	1,634.69153	2,490.3565	2.49036	1,217.28415	2,782.71585	10,897.9435
2018	0	0	6,000	6,000	651.50839	0	651.50839	8,824.14168	2,138.45631	2,789.96469	2.78996	1,457.00742	4,542.99258	14,256.375...
2019	0	0	8,000	8,000	515.24494	0	515.24494	13,428.915...	2,879.98087	3,395.22581	3.39523	1,976.44808	6,023.55192	19,199.872...
2020	0	0	10,000	10,000	397.36808	0	397.36808	19,210.225...	3,821.32266	4,218.69074	4.21869	2,730.96784	7,269.03216	25,475.484...

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 (RAC only)**:**

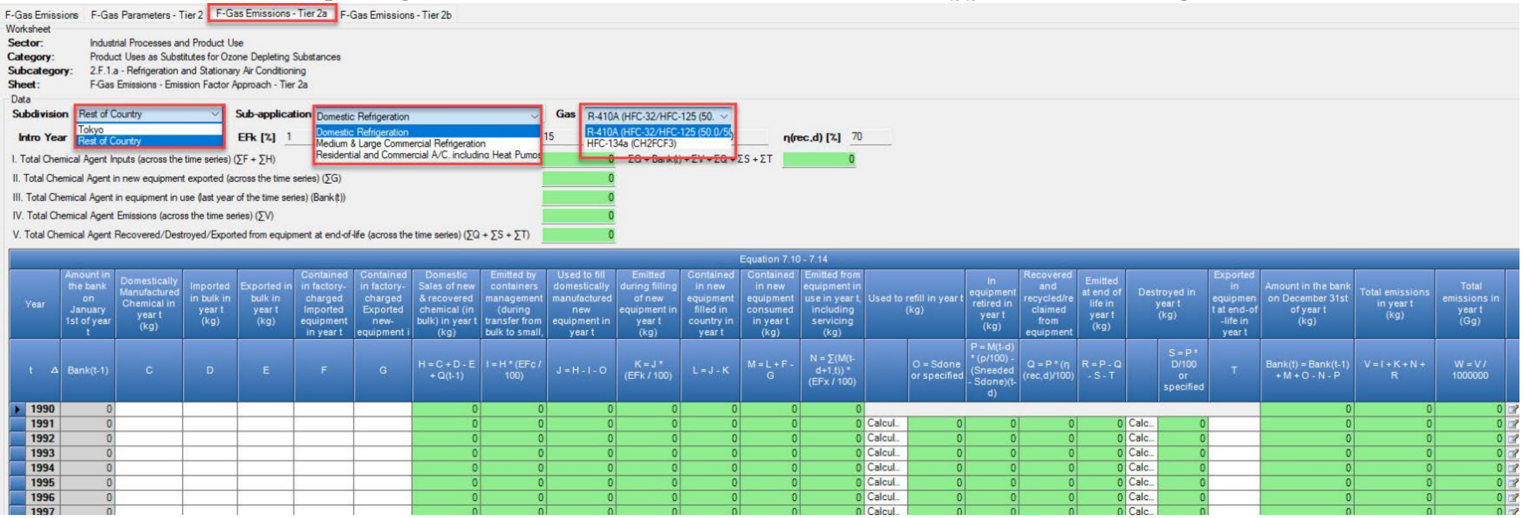
As noted in the section **EF/parameters** above, parameters from the tab **F-Gas Parameters – Tier 2** will be visible in the worksheets **F-Gas Emissions – Tier 2a** and **F-Gas Emissions – Tier 2b**. Next, users need to input AD in the white cells of these worksheets for each year, as applicable.

Tier 2a:

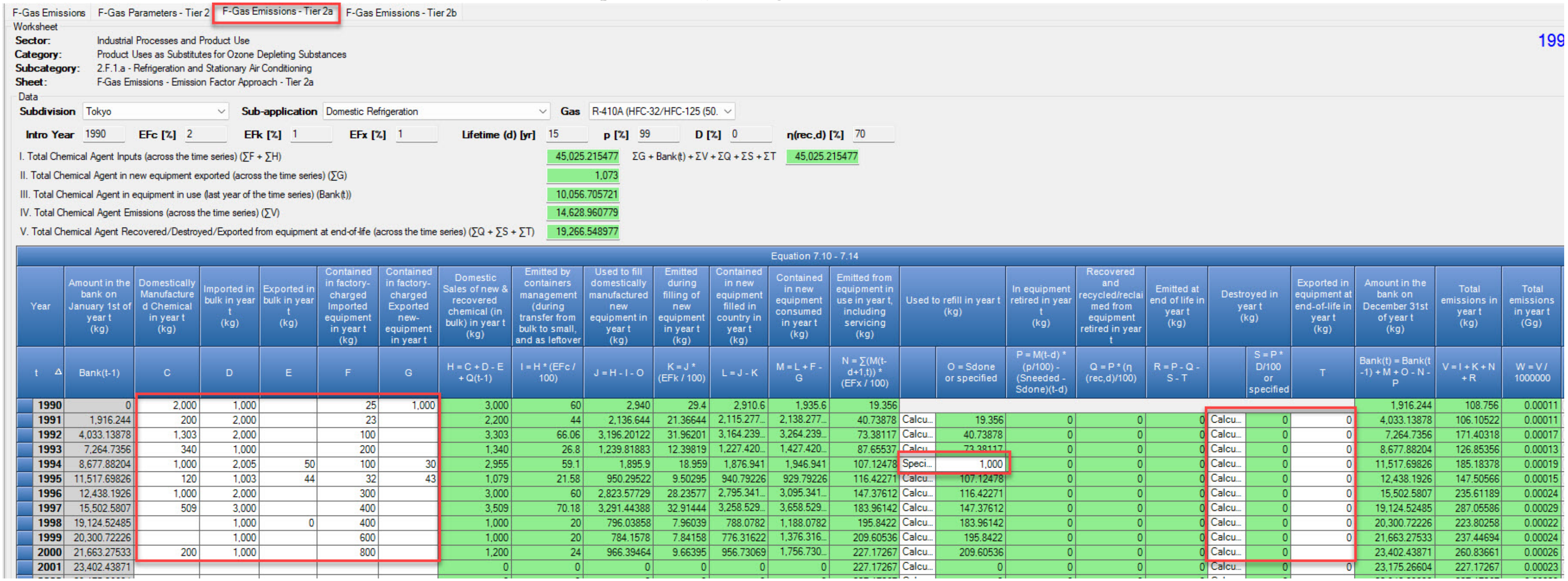
If Tier 2a was specified in the worksheet **F-Gas Parameters – Tier 2**, then worksheet **F-Gas Emissions – Tier 2a** will be active, so that users can select subdivisions, sub-applications and F-gases/blends and estimate emissions. Data are entered as follows:

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 input 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|: input the amount of domestically manufactured F-gas/blend used in that subdivision/sub-application, in year t, kg.
2. Column |D|: input the amount imported in bulk in year t, kg.
3. Column |E|: input the 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|: input the amount contained in factory-charged imported equipment in year t, kg.
5. Column |G|: input the amount contained in factory-charged exported new-equipment in year t, kg.
6. Column |O|: input the amount used to refill equipment in year t, kg. In Column |O| there is a drop-down menu with two options:
   a. *Calculated* (green cell) – the *Software* estimates the amount of gas available for refill of operating equipment. The *Software* calculates the amount needed for servicing as equal to the losses from all installed and operating equipment in the previous year, plus any additional servicing needs for those 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 available).
      - If domestic sales for the year (Column |H|) minus any emissions from containers management during fillings of the domestic sales (Column |I|) 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|) minus any emissions from containers management during fillings of the domestic sales (Column |I|) are less than the servicing needs, all domestic sales are used to refill existing equipment and no gas is used to fill domestically sold new equipment in the current year (Column |J|).
   b. *Specified* (white cell) – users enter user-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| (which takes into account whether that equipment was fully serviced up to the time of retirement), and the share of the remaining charge that is destroyed at disposal, as entered by the user in Column |D| in the worksheet **F-Gas Parameters – Tier 2.**
   b. *Specified* (white cell) – users enter country-specific AD manually.
      Note that: a warning will appear on Column |S| if the values in Columns S +T +Q are greater than the amount in Column |P|.
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 of that equipment.
15. Column |M|: amount contained in new equipment in year t (i.e. amount added 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 for equipment operation in the same worksheet (|EFx|, 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| (99% in this example), taking into account whether there was sufficient agent to fully service the equipment over the course of its lifetime.*
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 out of the subdivision.
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 several categories to ensure that the data, EFs and parameters entered by the users are consistent with 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)

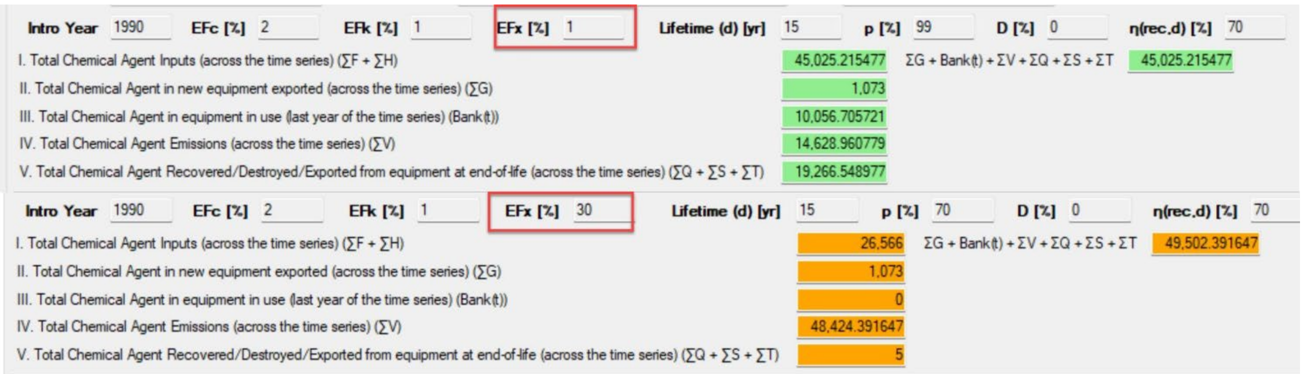
In the case of Tier 2a, mass conservation has been ensured if:

$$\sum F+\sum H = \sum G + Bank(t) + \sum V + \sum Q+\sum S+\sum T$$

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, review 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.

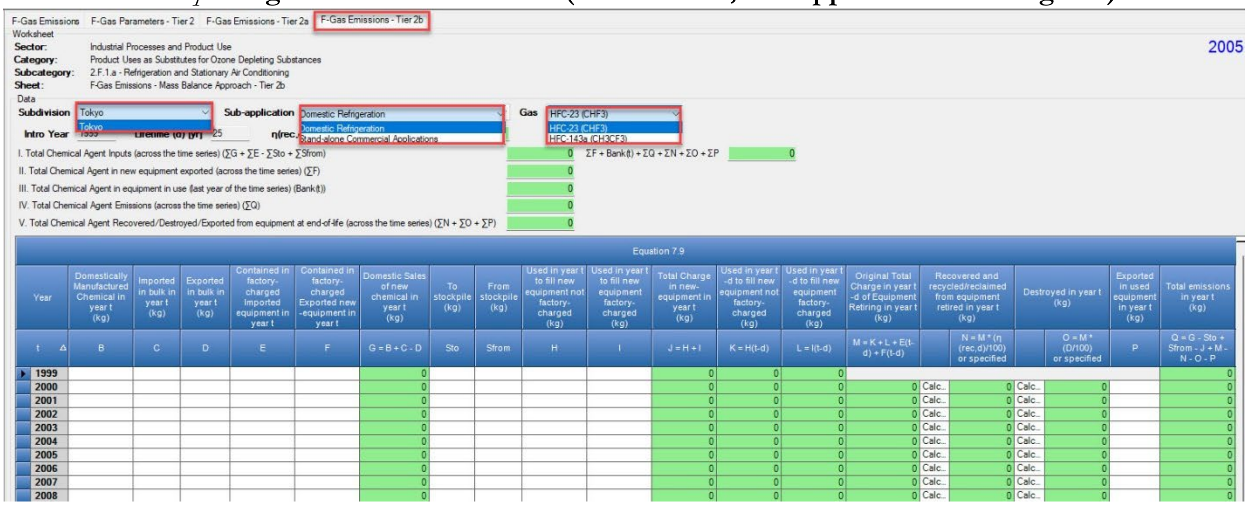


Tier 2b:

If Tier 2b is 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 input, row by row, for each subdivision/sub-application/F-gas/blend, as follows:

1. Users first must select the subdivision/sub-application/ F-gas/blend for which AD are to be input. *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**, 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 input 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.

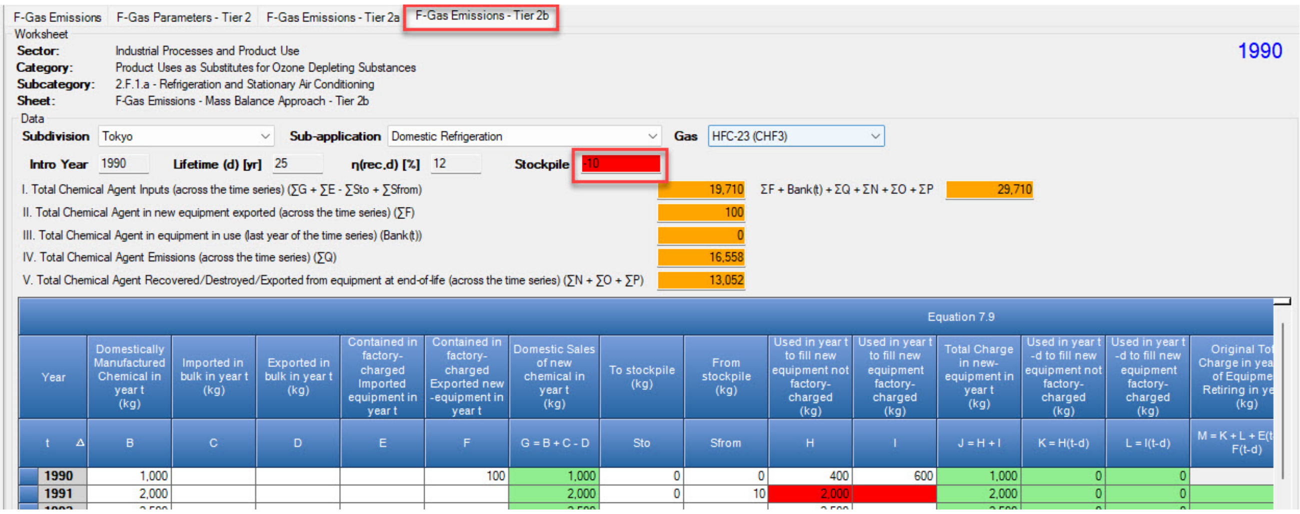
1. Column |B|: input the amount of domestically manufactured F-gas/blend in year t, kg.
2. Column |C|: input the amount imported in bulk in year t, kg.
3. Column |D|: input the amount exported in bulk in year t, kg.
   Note that bulk exports must be equal to or less than the amount produced plus imported 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](#)).

4. <u>Column |E|</u>: input the amount contained in factory-charged imported equipment in year t, kg.
5. <u>Column |F|</u>: input the amount contained in factory-charged exported new-equipment in year t, kg.
   <u>Note that</u> 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. <u>Column $|S_{to}|$:</u> input the amount of F-gas/blend available (from production or import) but not used in year (t), i.e. stockpiled.
   <u>Note that:</u> gas that goes to the stockpile is not available to fill equipment (either factory or non-factory charged) in <u>Column |H|</u> and <u>Column |I|</u>. If an range colour appears in <u>Column |H|</u> and <u>Column |I|</u> confirm that the amount that has gone into stockpile is not double counted.
7. <u>Column $|S_{from}|$:</u> input the amount of F-gas/blend removed from the stockpile in year (t).
   <u>Note that</u> the Software contains a check on the cumulative amount of the stockpile. The cumulated stockpile should always be positive. If the 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. <u>Column |H|</u>: input amount of F-gas/blend used to fill new equipment not factory-charged in year t, kg.
   <u>Note that</u> this column, as well as the subsequent <u>Column |I|</u> 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. <u>Column |I|</u>: input the amount of F-gas/blend used to fill equipment factory-charged in year t, kg (see note above on <u>Column |H|</u>.

Example: **Indicator that stockpile should be reviewed**

<u>Note that</u> the negative stockpile has resulted in overall QA/QC for mass conservation to turn orange.



10. <u>Column |N|:</u> input the amount recovered and recycled/reclaimed from equipment retired in year t, kg. In <u>Column |N|</u> 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 <u>Column |M|</u> 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.
       <u>Note that</u> the amount recovered and recycled/reclaimed plus any values entered in <u>Column |O|</u> plus <u>Column |P|</u> must be equal to or less than the total chemical agent in retired equipment (<u>Column |M|</u>). If the value is Columns N+O+P is greater than the amount in <u>Column |M|</u>, then the QA/QC check will change to orange and the user should check the values entered.
11. <u>Column |O|:</u> input the amount destroyed in year t, kg. In <u>Column |O|</u> 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**.

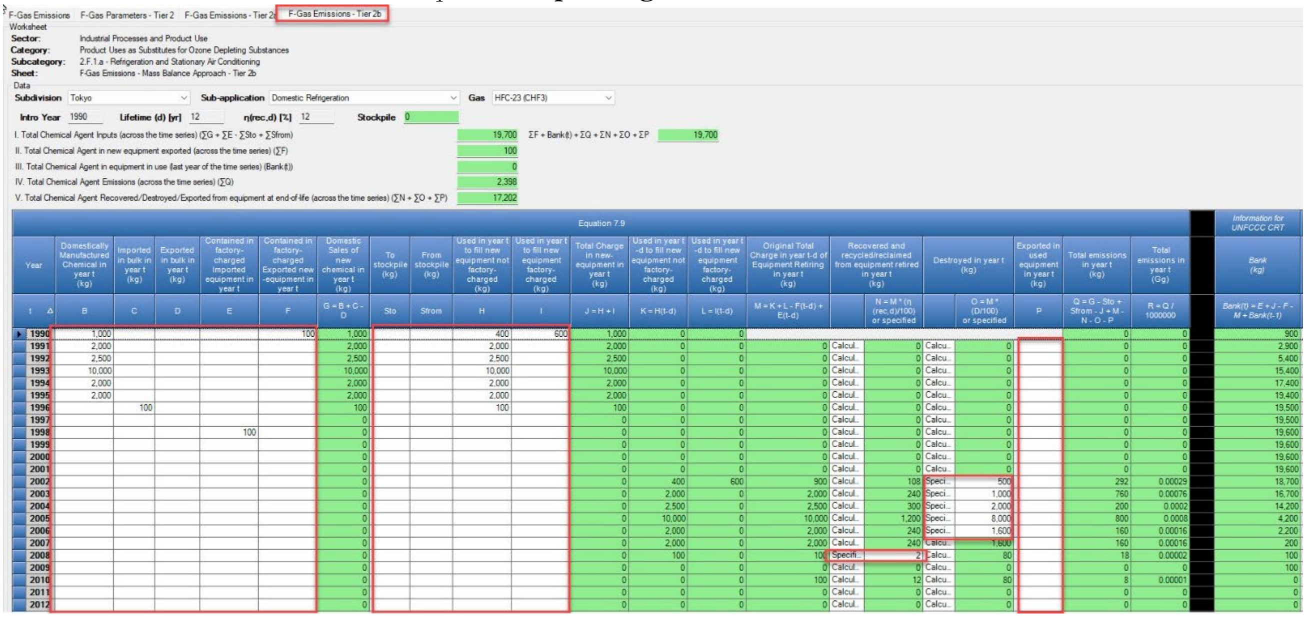
b. Specified (white cell) – users need to enter country-specific AD manually.
Note that the amount destroyed plus any values entered in Column |N| plus Column |P| must be equal to or less than the total chemical agent in retired equipment (Column |M|). If the value is Columns N+O+P is greater than the amount in Column |M|, then the QA/QC check will change to orange and the user should check the values entered.

12. Column |P|: input the 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 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**



<u>**Ensuring mass conservation of gases in Tier 2b**</u>

A QA/QC check has been introduced into the worksheets for several categories to ensure that the data, EFs and parameters entered by the users are consistent with 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:

$$\sum G+\sum E + \sum S_{to} + \sum S_{from} = \sum F + \text{Bank}(t) + \sum Q + \sum N+\sum O+\sum P$$

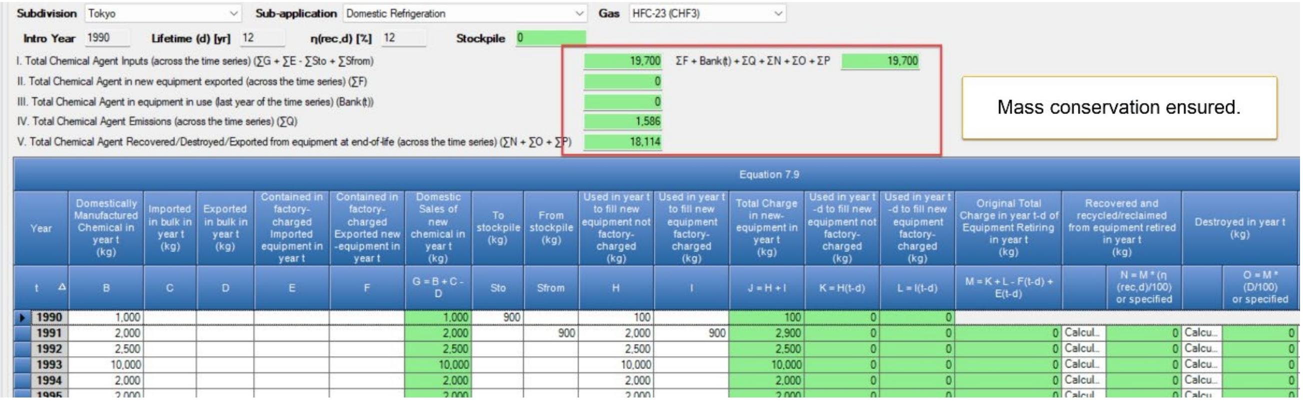
If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading, review 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:

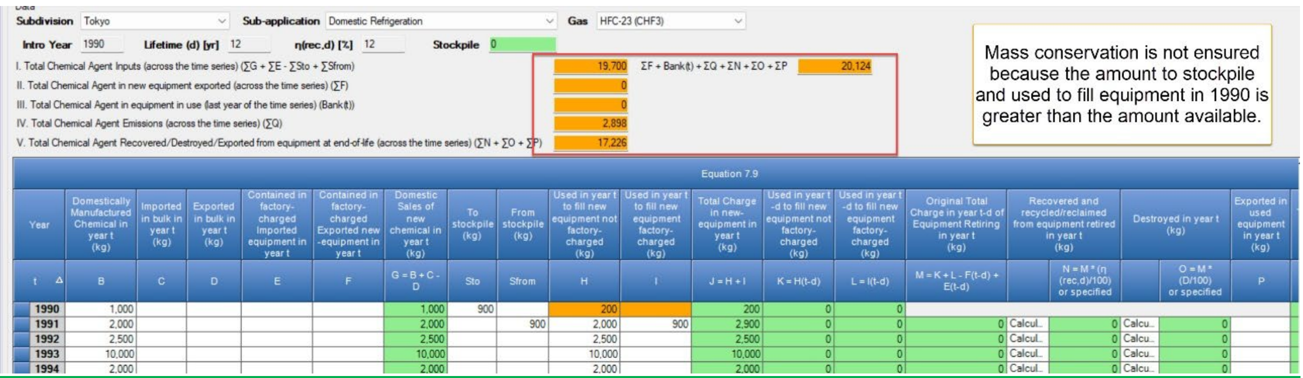
- Agent going to the stockpile (Column S_{to}) for a given year is also included in Column H and/or I as being used to fill new equipment.
- The amount used to fill new equipment (factory charged and non-factory charged) (Columns H and I) is greater than the amount available from domestic sales (Column 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**



Results

GHG emissions from Refrigeration and Air Conditioning are estimated one row for each year of the time series, in the following worksheets:

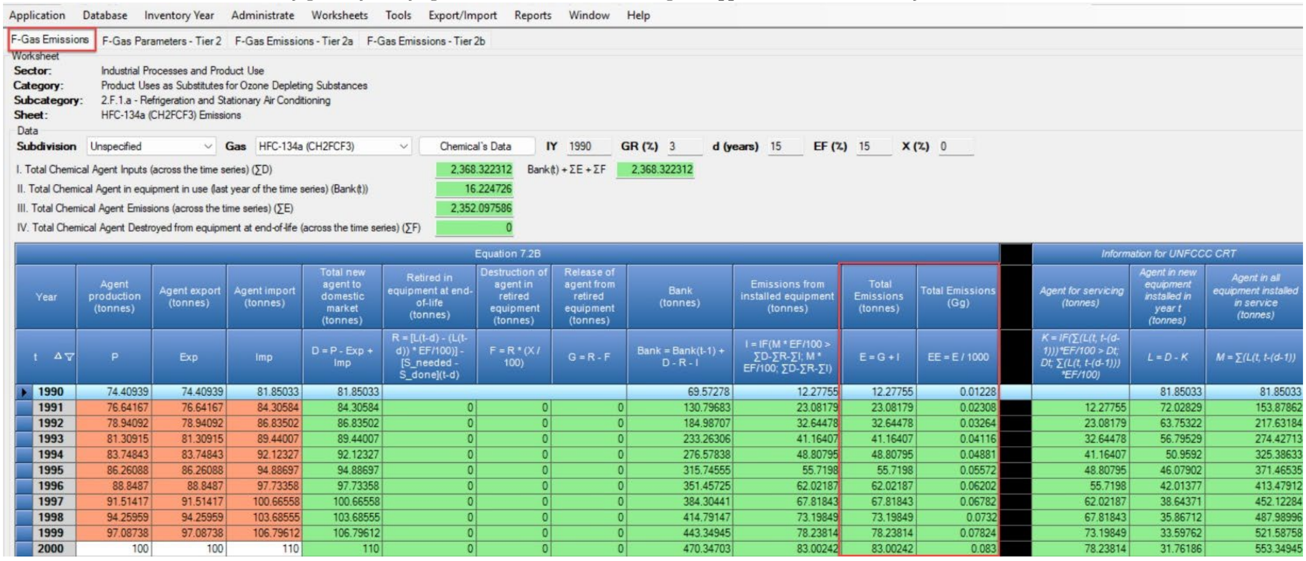
- ✓ **F-Gas Emissions**
- ✓ **F-Gas Emissions – Tier 2a**
- ✓ **F-Gas Emissions – Tier 2b**

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 and Gg; 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.

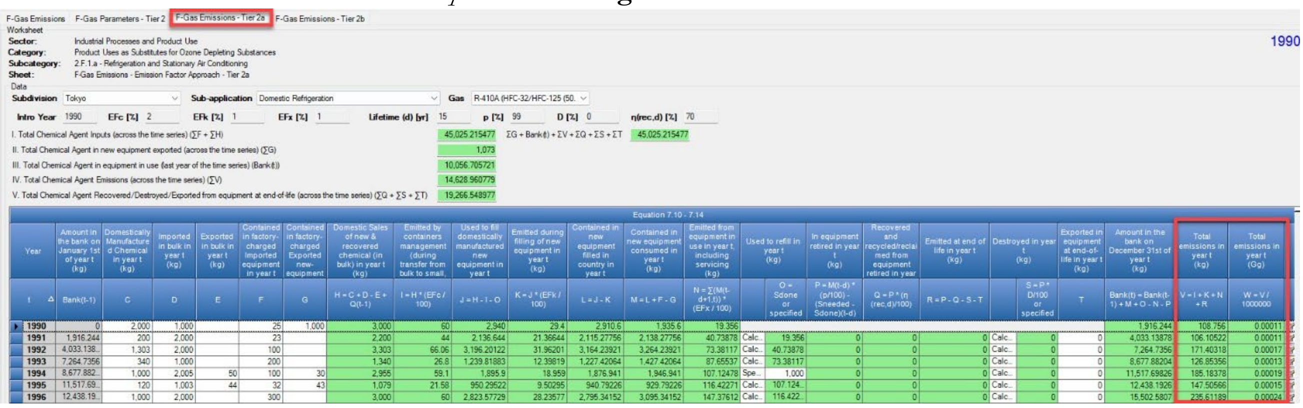
The user will note that Refrigeration and Air Conditioning does not contain a worksheet for **Capture and storage or other reduction.** This is because all capture and other reductions are already accounted for in the worksheets noted above.

Example: results: F-Gas emissions – Tier 1

Note that this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet.



Example: results: F-gas Emissions – Tier 2a

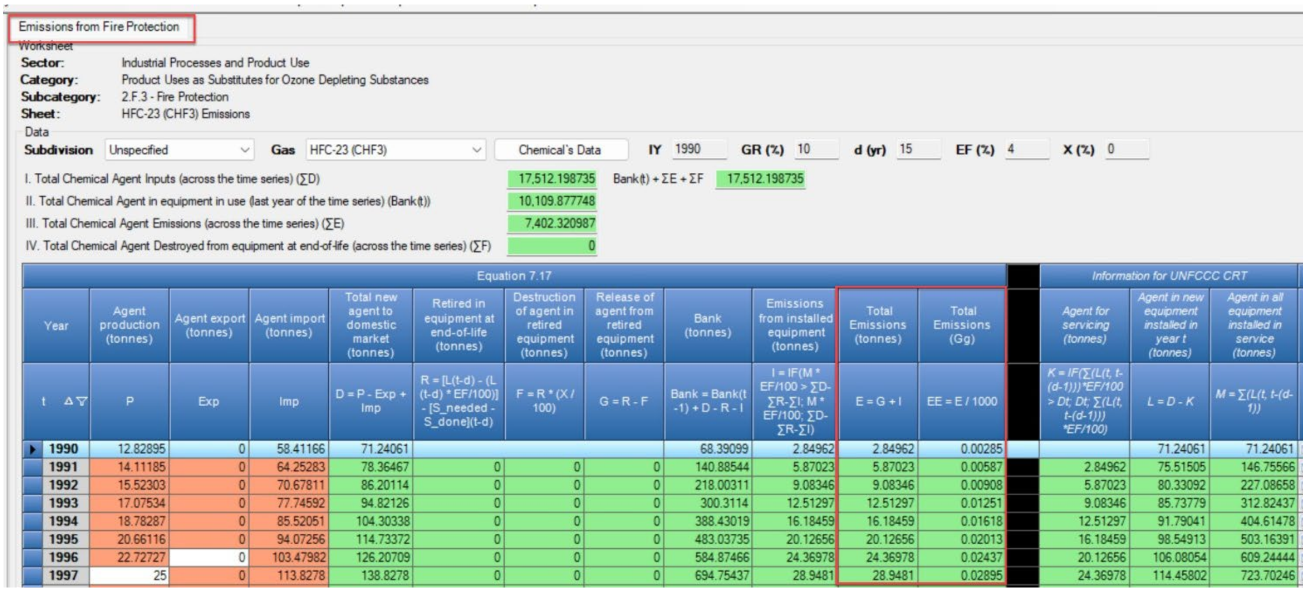


Example: results: F-gas Emissions – Tier 2b

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**



Emissions from Fire Protection

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.3 - Fire Protection
Sheet: HFC-23 (CHF3) Emissions

Data

Subdivision Unspecified **Gas** HFC-23 (CHF3) Chemical's Data **IY** 1990 **GR (%)** 10 **d (yr)** 15 **EF (%)** 4 **X (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑D) 17,512.198735 Bank(t) + ΣE + ΣF 17,512.198735
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 10,109.877748
III. Total Chemical Agent Emissions (across the time series) (∑E) 7,402.320987
IV. Total Chemical Agent Destroyed from equipment at end-of-life (across the time series) (∑F) 0

Equation 7.17												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(∑(L(t, t-(d-1)))*EF/100 > Dt; Dt; ∑(L(t, t-(d-1))) *EF/100)*	*L = D - K*	*M = ∑(L(t, t-(d-1))*
1990	12.82895	0	58.41166	71.24061				68.39099	2.84962	2.84962	0.00285		71.24061	71.24061
1991	14.11185	0	64.25283	78.36467	0	0	0	140.88544	5.87023	5.87023	0.00587	2.84962	75.51505	146.75566
1992	15.52303	0	70.67811	86.20114	0	0	0	218.00311	9.08346	9.08346	0.00908	5.87023	80.33092	227.08658
1993	17.07534	0	77.74592	94.82126	0	0	0	300.3114	12.51297	12.51297	0.01251	9.08346	85.73779	312.82437
1994	18.78287	0	85.52051	104.30338	0	0	0	388.43019	16.18459	16.18459	0.01618	12.51297	91.79041	404.61478
1995	20.66116	0	94.07256	114.73372	0	0	0	483.03735	20.12656	20.12656	0.02013	16.18459	98.54913	503.16391
1996	22.72727	0	103.47982	126.20709	0	0	0	584.87466	24.36978	24.36978	0.02437	20.12656	106.08054	609.24444
1997	25	0	113.8278	138.8278	0	0	0	694.75437	28.9481	28.9481	0.02895	24.36978	114.45802	723.70246

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, F-gases (typically HFCs) are used as blowing agents and emissions 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 emissions 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. In Tier 2, the user may assume longer lifetimes and include estimates for the end-of-life, applying the same calculations as for Tier 2 closed-cell foams.

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 2: Box 7.2 (sub-application level, both closed and open cell foams)
- ✓ 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:

- ✓ **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 annual loss, the maximum potential end-of-life loss, the rate of loss at decommissioning, recovery and destruction, 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- 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. Based on these data, and parameters entered above, the worksheet calculates the associated F-gas emissions for open cell foams for Tier 2.

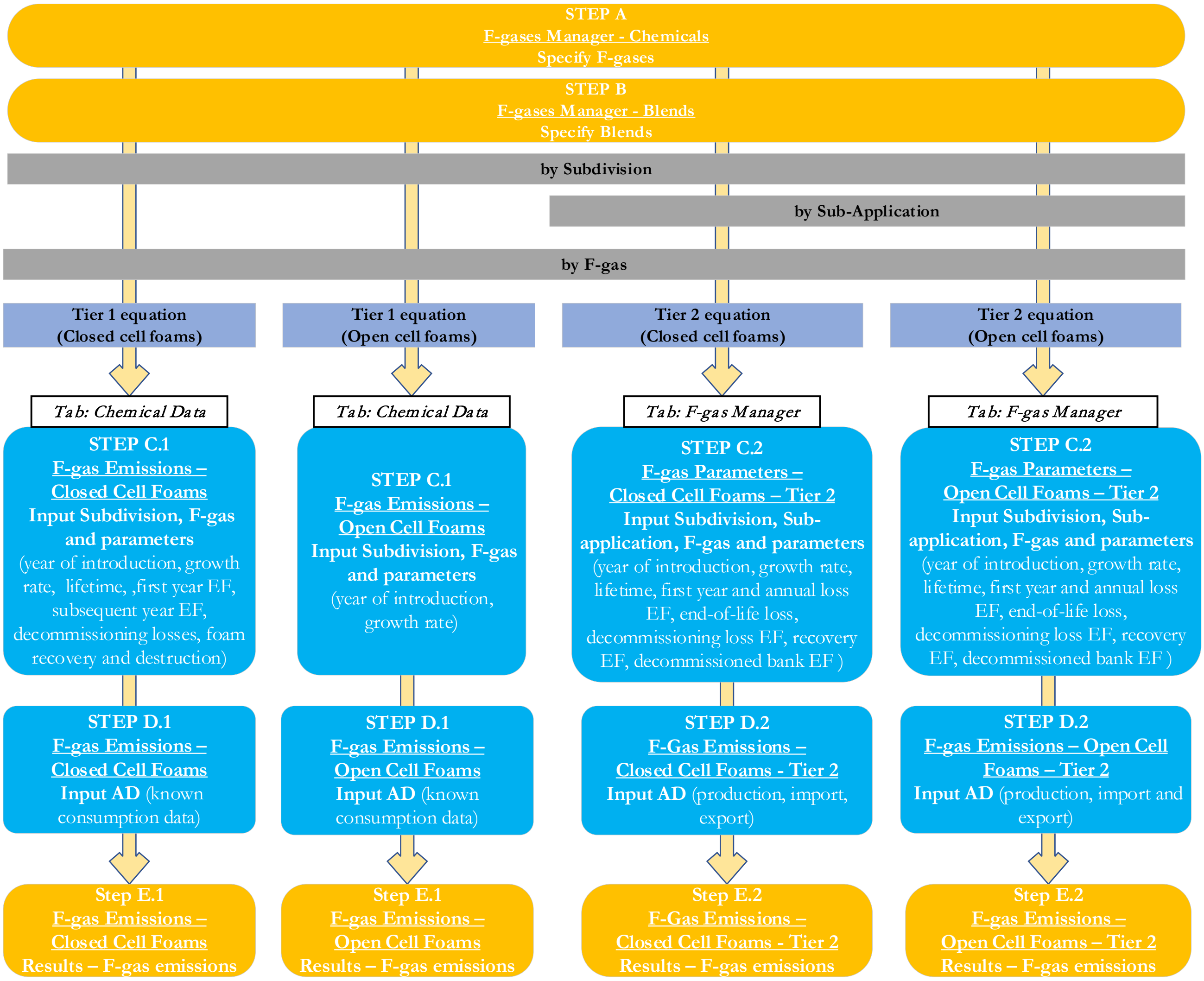
User's Work Flowchart

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[48] 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.

[48] 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, **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 are 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 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 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 worksheet **F-Gas Emissions – Closed Cell Foams** the *Software* calculates the associated emissions for each F-gas, in tonnes and Gg.

<u>**Open Cell Foams**</u>

Step C.1, in 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 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 worksheet **F-Gas Emissions – Open Cell Foams,** the *Software* calculates the associated emissions for each F-gas, in tonnes and Gg.

When the Tier 2 method is applied:

For Tier 2, data entry for **Closed Cell Foams** and **Open Cell Foam** are the same, as follows**:**

Step C.2, in worksheet **F-Gas Parameters – [Closed][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 worksheet **F-Gas Emissions – [Closed][Open] Cell Foams – Tier 2**, for each subdivision and each F-gas, users collect and input information on the amount of F-gas produced separately for closed and open cell foams produced domestically, imported and exported (the worksheets allow the user to enter such information for previous years as well).

Step E.2, in worksheet **F-Gas Emissions – [Closed][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 (Tier 2 only)/F -gases/blends applicable to the chosen method that will be used to estimate GHG emissions.

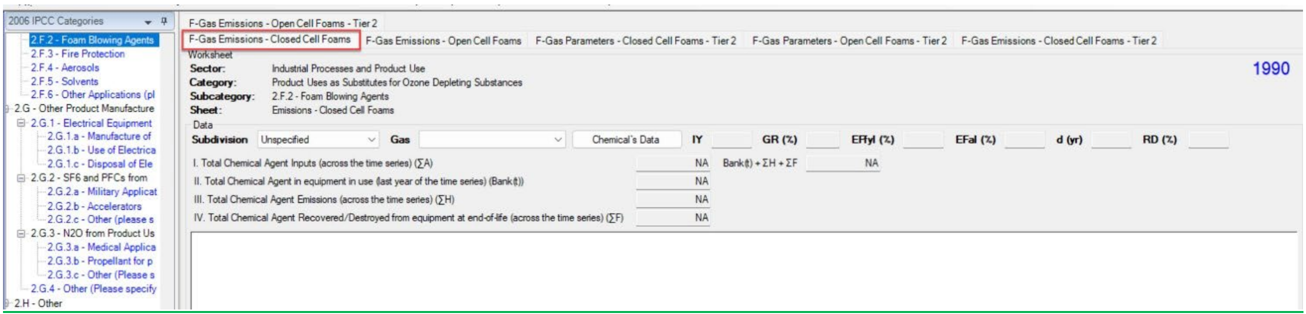
When the Tier 1 Equation is applied:

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 GHG 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.).

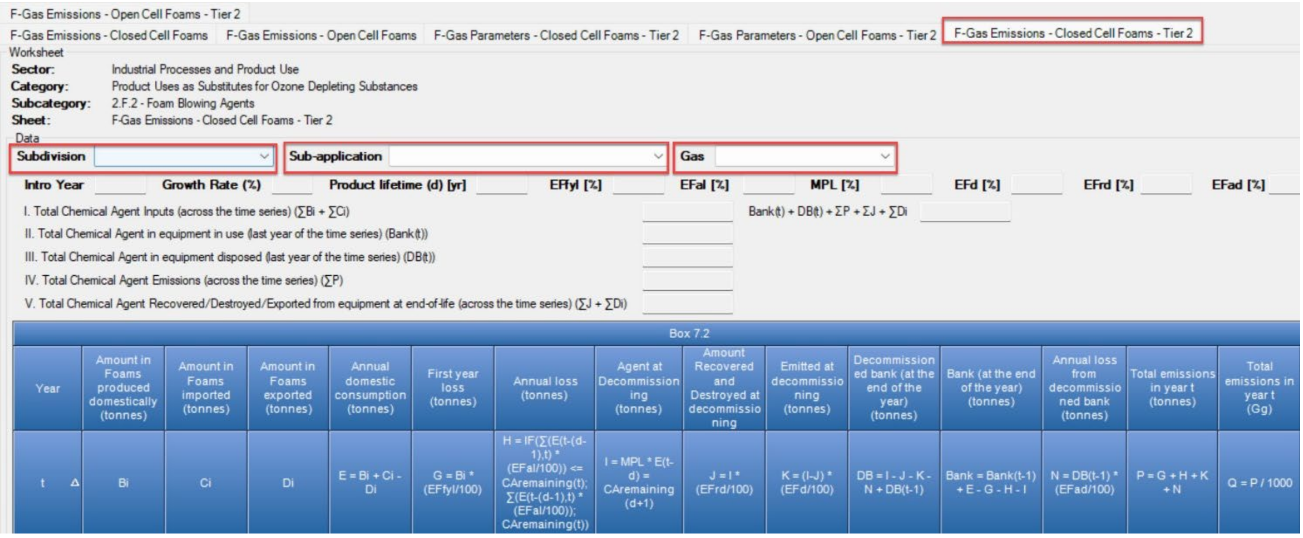
When the Tier 2 method is applied:

Like 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 are no subdivisions, sub-applications or F-gases available for selection for data entry for Foam Blowing Agents. The user must identify subdivisions, sub-applications and 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

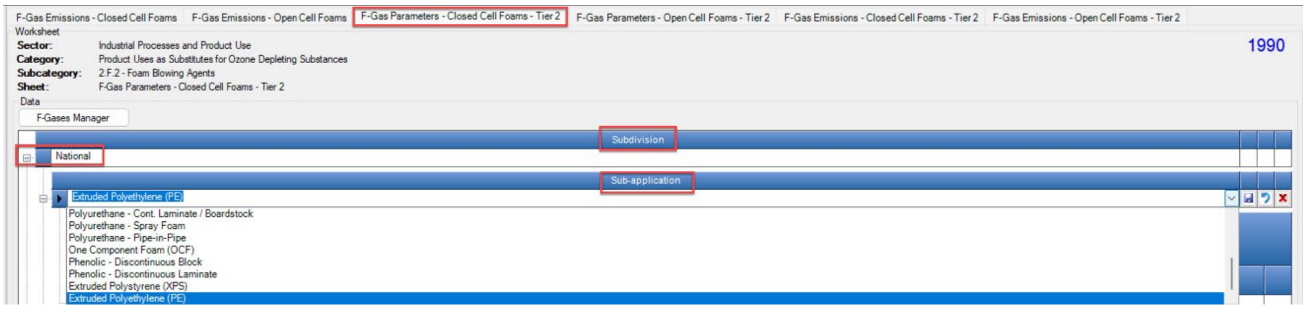


Entering subdivision(s) and sub-application(s)

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.

For foams, any subdivisions entered in worksheet **F-Gas Parameters – Closed Cell Foams- Tier 2** will automatically appear in worksheet **F-Gas Parameters – Open Cell Foams- Tier 2,** and vice versa.

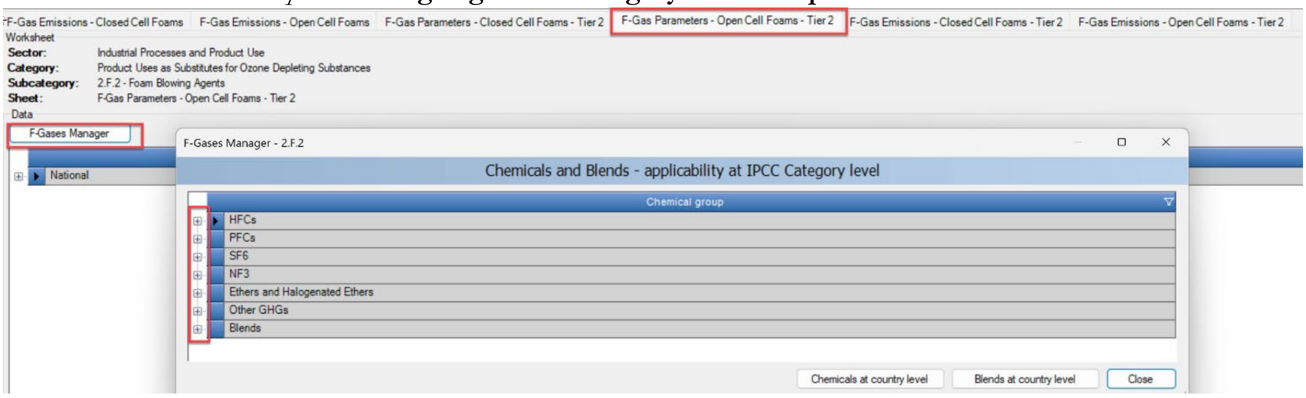
Example: **entering subdivision/sub-application for closed cell foams– Tier 2**



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.

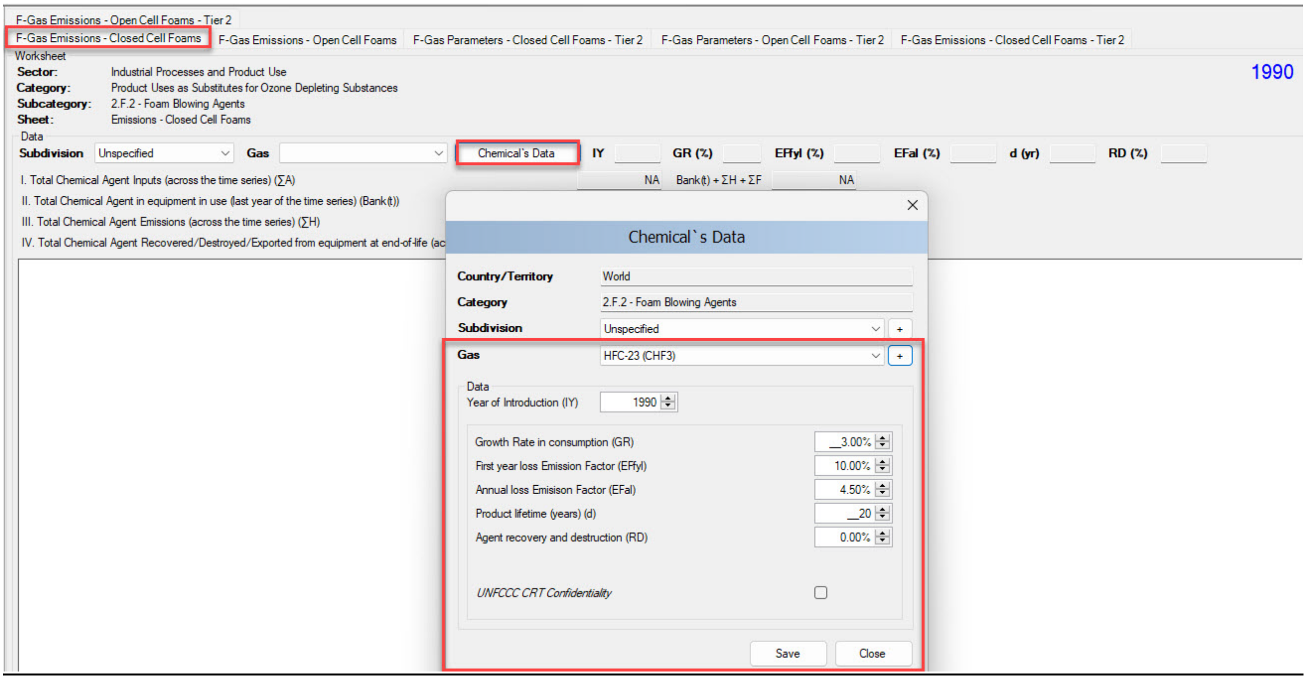
When the Tier 1 Equation is applied:

Closed Cell Foams:

1. In worksheet **F-Gas Emissions- Closed Cell Foams**, 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:** select 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|: input the year of introduction of the agent in the country for use in foam blowing (closed cell) (e.g., 1990).
4. Window |Growth Rate in consumption|: input the growth rate in consumption, usually assumed linear across the period of assessment, in %.
5. Window |First year loss Emission Factor|: input the 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|: input the EF for annual loss in percent of the original charge (IPCC default = 4.5% of the original charge/year).
7. Window |Product lifetime|: input the lifetime of closed cell foams, in years (IPCC default =20 years).
8. Window |Agent recovery and destruction|: input 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

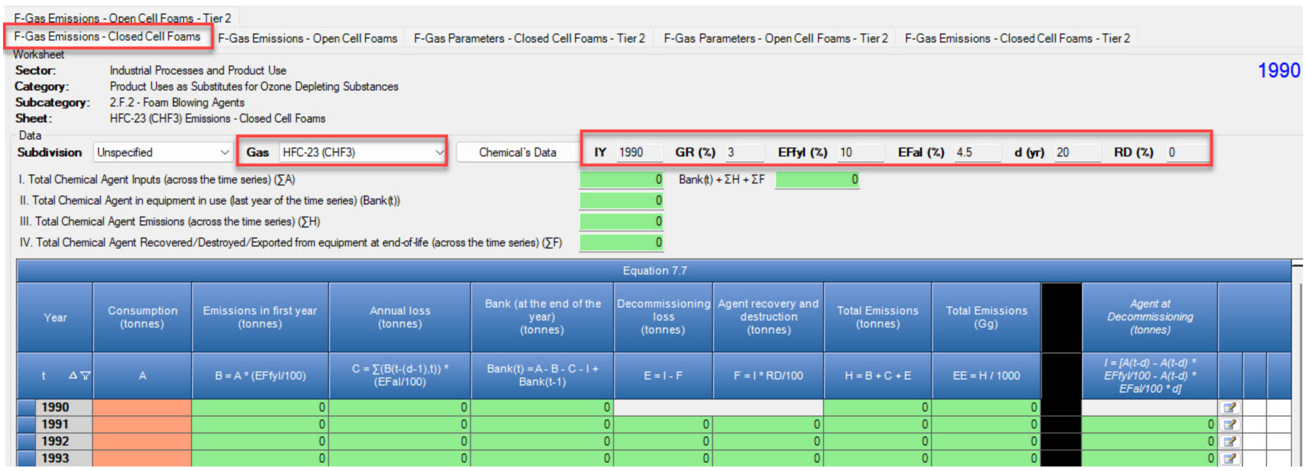
category 2.H in Table2(II).B-Hs2 of the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF_6 or NF_3, as appropriate (for further information, see Annex I).

Example: **entering EFs, parameters information and confidentiality for closed cell foams– Tier 1**



10. Then, **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**

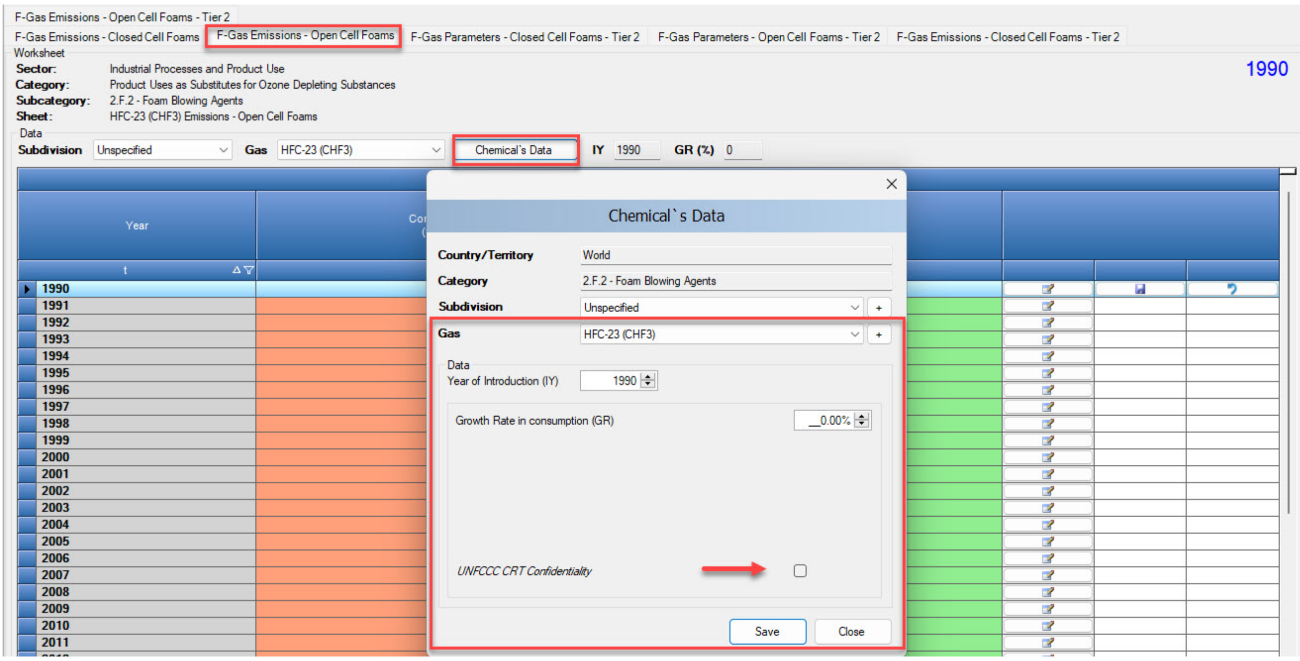


Open Cell Foams:

1. In worksheet **F-Gas Emissions- Open Cell Foams**, 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:** select 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).

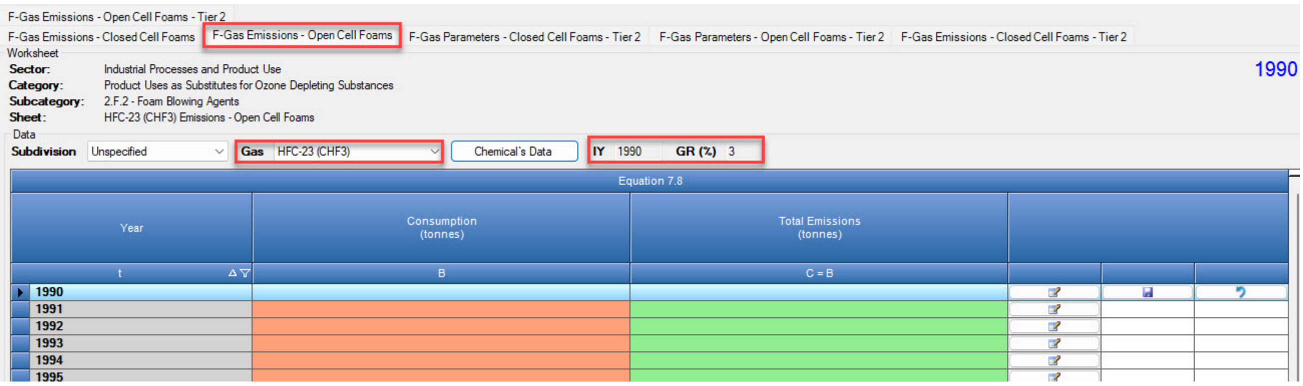
3. Window |Year of Introduction|: input the year of introduction of the agent in the country for use in foam blowing (open cells) (e.g., 1990).
4. Window |Growth Rate in consumption|: input the growth rate in consumption, usually assumed linear across the period of assessment, in %.
5. Window |Confidentiality|: 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, **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 method is applied

Closed Cell Foams

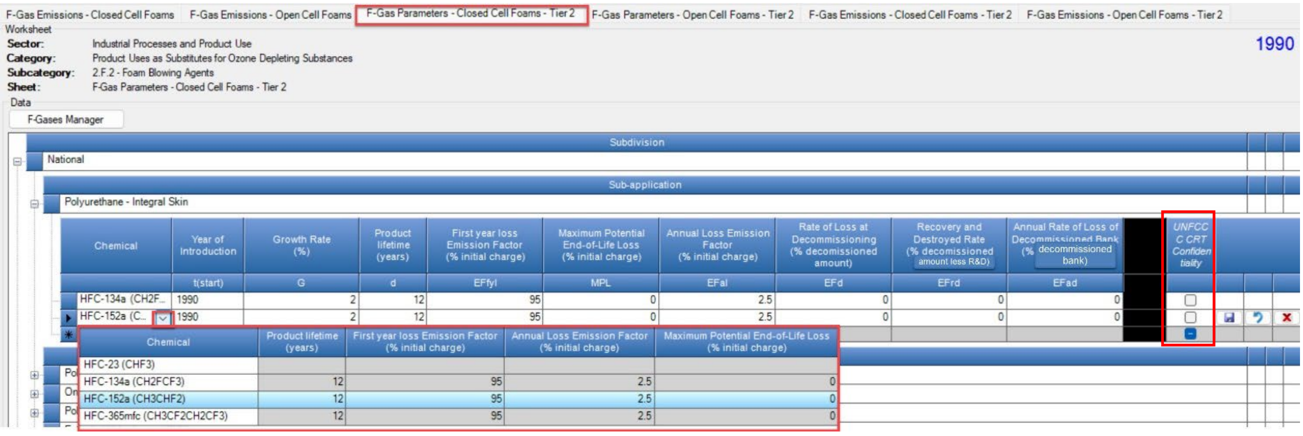
Open Cell Foams

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|: select 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 input 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 each chemical and re-enter it, so that the updated parameters are populated.*
2. Column |t (start)|: input the year of introduction of F-gas/blend for [closed][open] cell foams.
3. Window |G|: input the growth rate in consumption, usually assumed linear across the period of assessment, in %.
4. Column |d|: input the 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|: input the 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|: input the 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|: input the 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|: input the 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|: input the 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|: input the 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 2** 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 the 2.F.2 Foam Blowing Agents source category.

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions.

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, input the AD in the red-orange cells, by subdivision/gas, and for each year, as follows:

1. Column |A|: input all known consumption (production plus imports minus exports) for each subdivision/gas for closed cell foams, 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 extrapolate 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 extrapolation of the time series.
   Note that unlike the Tier 2 worksheets, which allow separate data entry for production, imports and exports, the Tier 1 allows only a single data entry of "consumption". Because of the assumption in foams that all emissions from manufacturing (i.e. first year losses) occur in the country of foam manufacture, if net imports are a significant component of net consumption, the Tier 1 (which attributes first year losses to all production plus imports and excludes exports) will overestimate first year emissions. If a user is a net exporter, the Tier 1 will underestimate first year emissions. For such users, the Tier 2 should be used.
   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* makes several calculations based on the factors added in the Chemical's Data tab:

2. Column |B|: calculates emissions in the first year, in tonnes.
   *Note that 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 all agent currently in foams, 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 **Chemical's Data** tab.*
4. <u>Column |$Bank_{(t)}$|</u>: calculates the bank at the end of 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 entered 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 the first year, plus annual emissions from the bank, plus emissions from decommissioning.
8. <u>Column |EE|</u>: calculates total emissions, in Gg.
9. <u>Column |I|</u>: calculates the amount of agent at decommissioning. This column is shown separately and in italics, as this amount is calculated for the purposes of reporting to the UNFCCC ETF Reporting Tool.
   <u>Note that</u> this cell is calculated based on the amount consumed in the year t minus the lifetime, minus the first-year losses during manufacturing in that first year, minus the sum of the annual losses across the lifetime of that foam.

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**

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 = ∑(A(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	10	4.5	85.5			14.5	0.0145	
1991	125	12.5	10.125	187.875	0	0	22.625	0.02263	0
1992	128.75	12.875	15.91875	287.83125	0	0	28.79375	0.02879	0
1993	132.6125	13.26125	21.88631	385.29619	0	0	35.14756	0.03515	0
1994	136.59088	13.65909	28.0329	480.19507	0	0	41.69199	0.04169	0
1995	140.6886	14.06886	34.36389	572.45093	0	0	48.43275	0.04843	0
1996	144.90926	14.49093	40.88481	661.98445	0	0	55.37573	0.05538	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 several source categories to ensure that the data, EFs and parameters entered by the users are consistent with 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, last year of the time series (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:

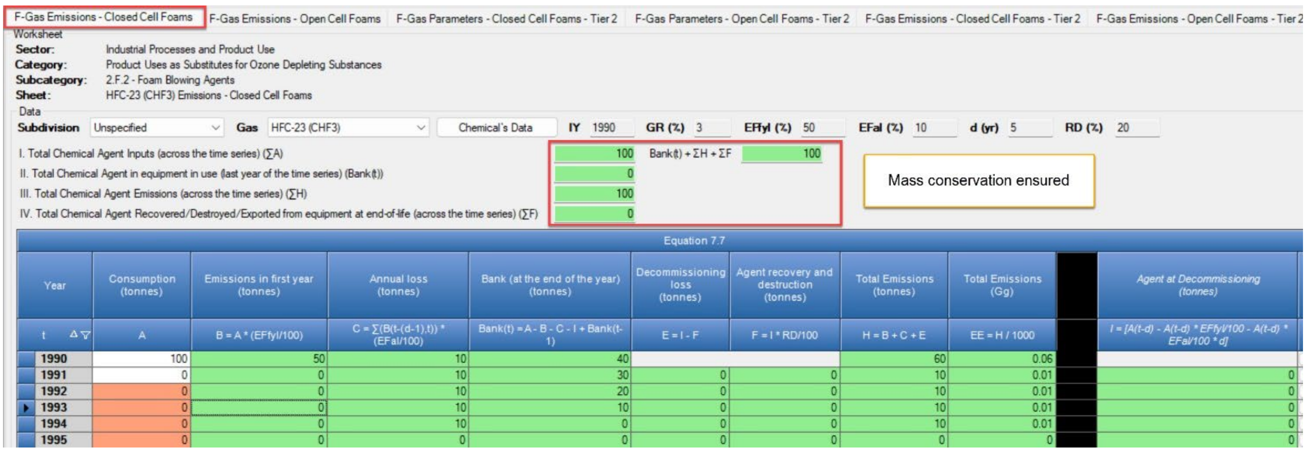
$$\sum A = \text{Bank}(t) + \sum H + \sum F$$

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 the user should review data input to ensure that all parameters are coherent.

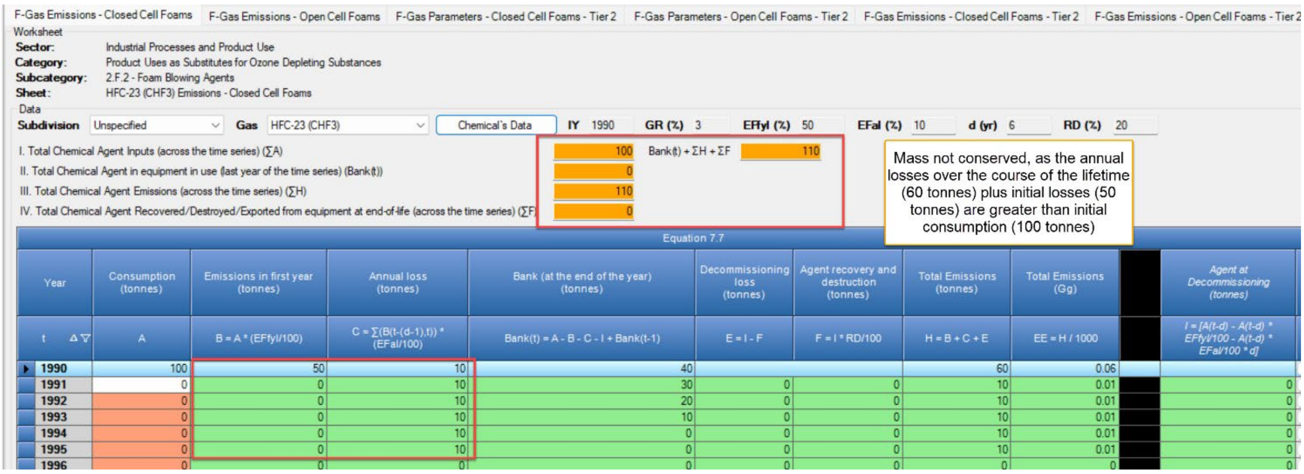
Some common scenarios leading to orange cells (chemical stored in the system and subsequent emissions are greater than inputs) include:

- 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, input the AD in the red-orange cells, by subdivision/gas, and for each year, as follows:

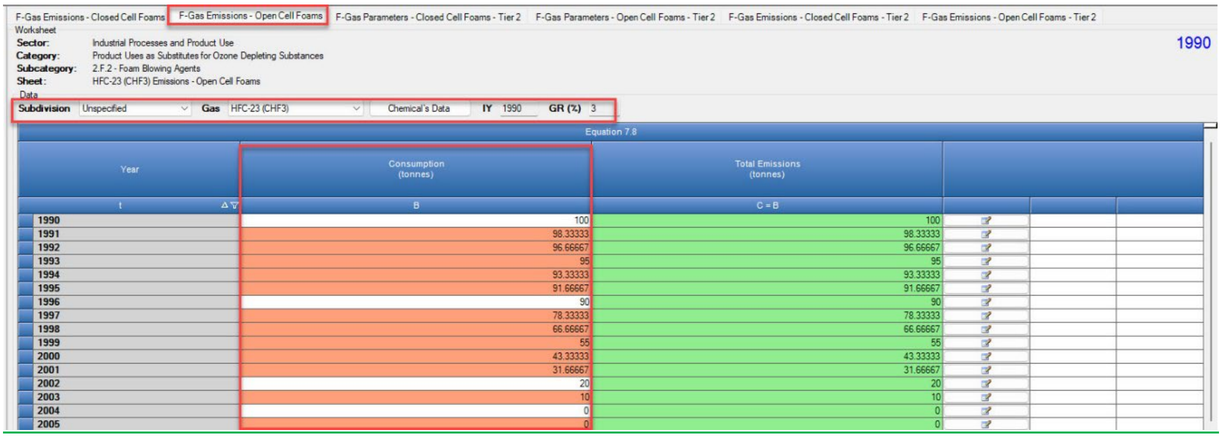
1. Column |B|: input all known consumption (production plus import minus export) for each subdivision/gas for open cell foams, in tonnes. Only those years for which data are known should be entered. Data entered, along with the growth rate entered in the **Chemical's Data** tab, will be used to extrapolate 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 extrapolation of the time series.

   Note that unlike the Tier 2 worksheets, which allow separate data entry for production, imports and exports, the Tier 1 allows only a single data entry of "consumption". Because of the assumption in foams that all emissions from manufacturing (i.e. first year losses) occur in the country of foam manufacture, if net imports are a significant component of net consumption, the Tier 1 (which attributes first year losses to all production plus imports and excludes exports) will overestimate first year emissions. If a user is a net exporter, the Tier 1 will underestimate first year emissions. For such users, the Tier 2 should be used.

   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 method is applied

Closed Cell Foams

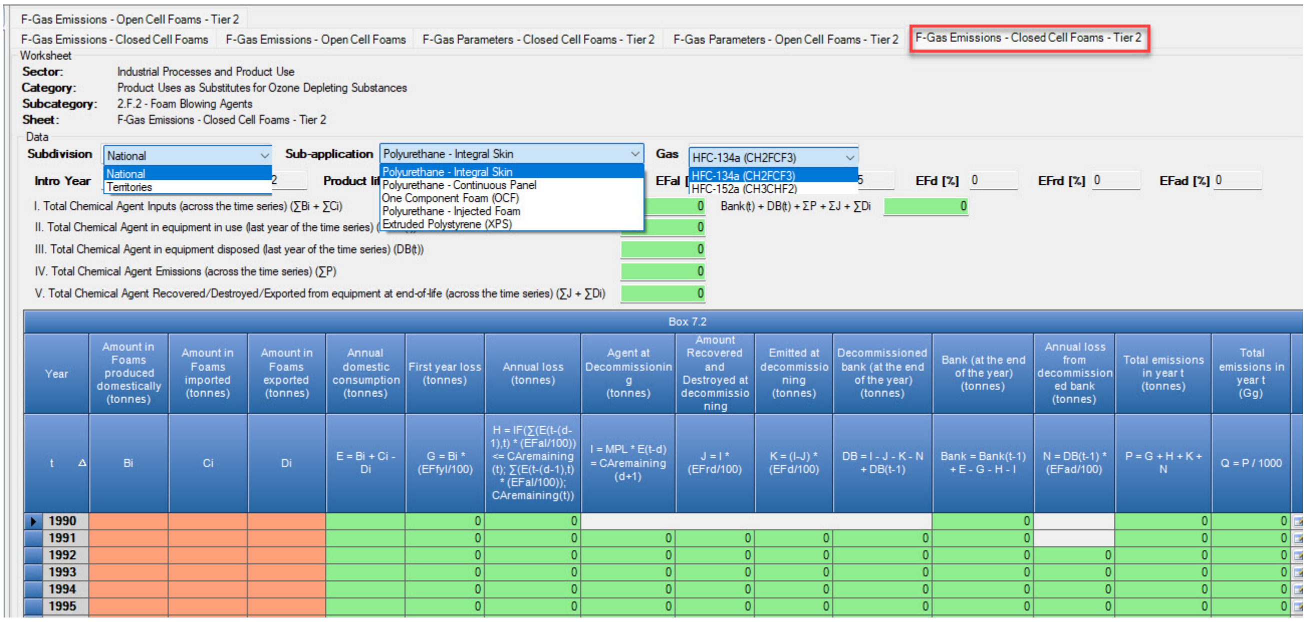
Open Cell Foams

Input 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 as follows:

1. Select the subdivision/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, 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 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)**

Note that 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:

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.

1. Column |Bi|: input the amount of F gases/blends produced domestically, in tonnes.
   Note: 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|: input the amount of F-gas/blend imported in open cell foams, in tonnes.
   Note: 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|: input the amount of F-gas/blend exported in open cell foams, in tonnes.
   Note: 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:

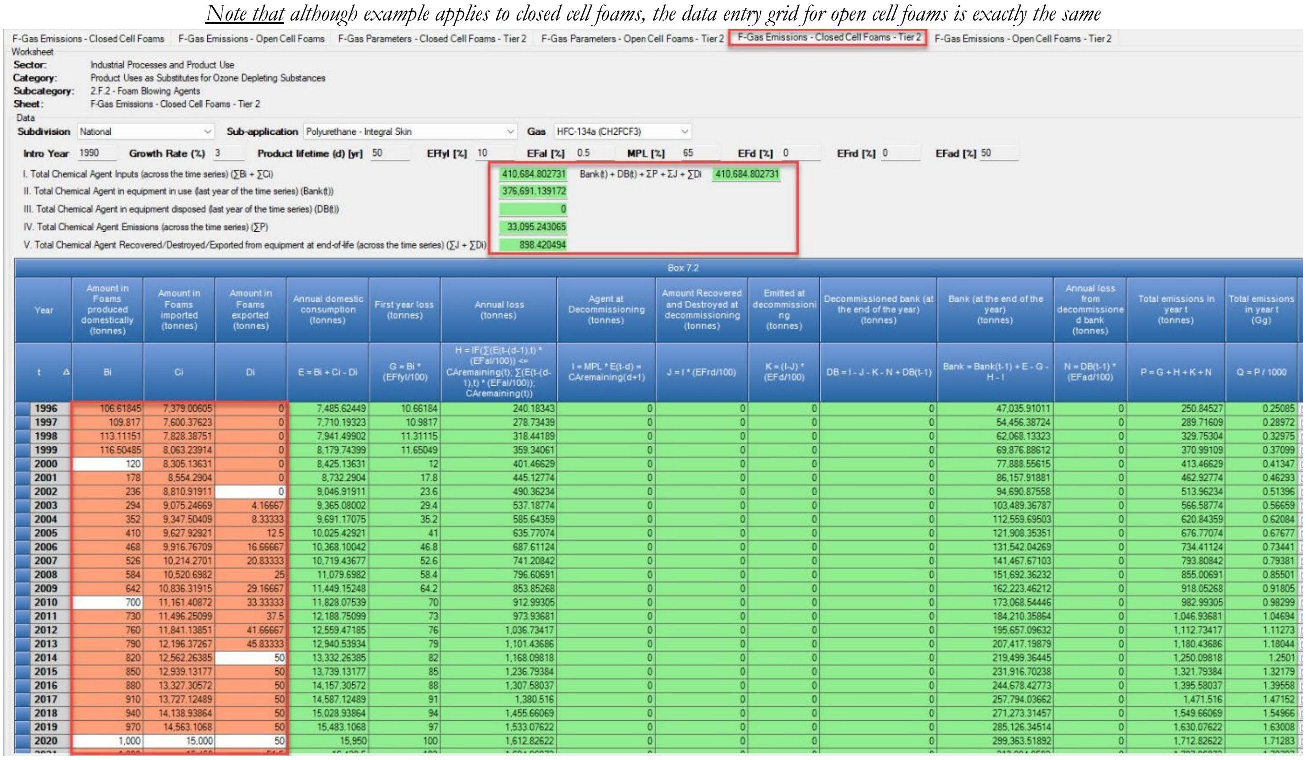
4. Column |E|: total amount of F-gas/blend consumed domestically in year t, in tonnes.
   Note that this cell is calculated as the sum of production (Column |Bi|) plus imports (Column |Ci|) minus exports (Column |Di|).
5. Column |G|: amount of F-gas/blend lost (emitted) in the first year during manufacture 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 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 of foams, in tonnes.
   *Note that this cell is calculated by multiplying the amount of agent in currently used foams 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 multiplied by the 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 for all foams that have reached their designated year of decommissioning based on their lifetime, and multiplying the amount of agent in these foams in their year of origin 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 annual 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 .
    Calculated as the sum of first year and annual losses, as well as losses during decommissioning and from the decommissioned bank.
14. Column |Q|: total emissions in year t, in Gg.

Example: **AD input for closed and open cell foams- Tier 2**

Note that 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 [%]** 0 **EFrd [%]** 0 **EFad [%]** 50

I. Total Chemical Agent Inputs (across the time series) (∑Bi + ∑Ci) 410,684.802731 Bank(t) + DB(t) + ∑P + ∑J + ∑Di 410,684.802731
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 + ∑Di) 898.420494

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 = MPL * E(t-d) = CAremaining(d+1)	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.

Ensuring mass conservation of gases in Closed and Open Cell Foams- Tier 2

A QA/QC check has been introduced into the worksheets for several categories to ensure that the data, EFs and parameters entered by the users are consistent with 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 ($\sum Bi + \sum Ci$)
II. Total chemical agent in equipment in use (last year of the time series) ($\sum Bank_{(t)}$)
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/exported ($\sum J + \sum Di$)

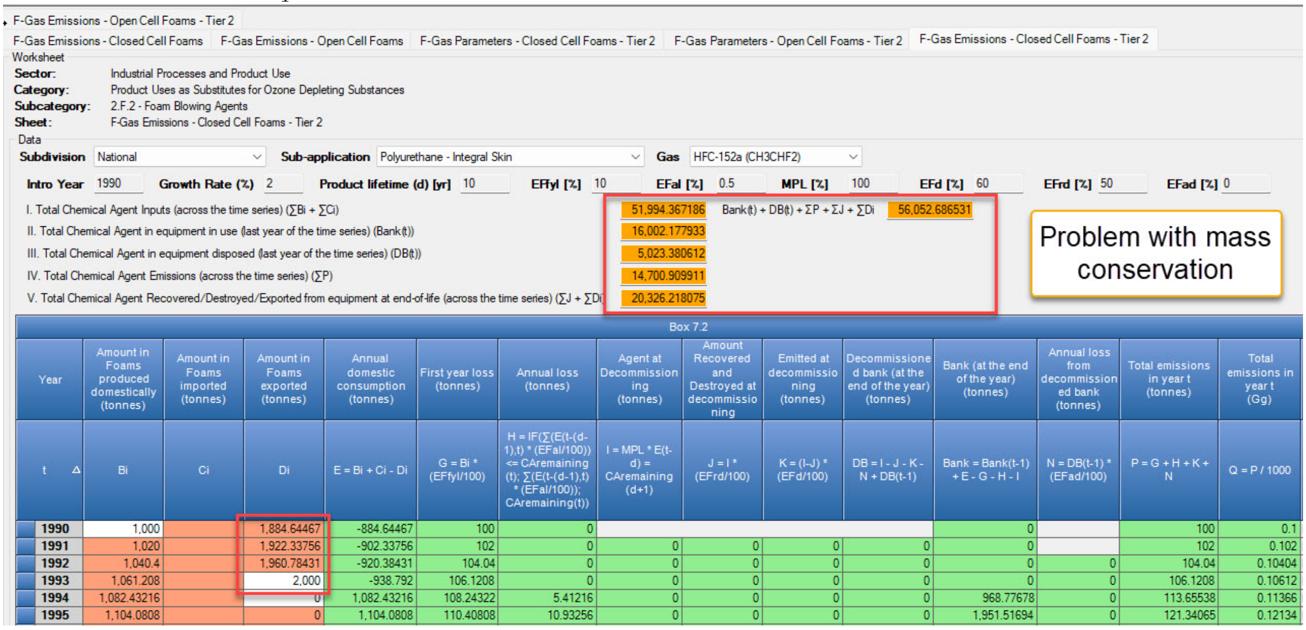
In the case of Tier 2, mass conservation has been ensured if:

$$\sum Bi + \sum Ci = Bank_{(t)} + DB_{(t)} + \sum P + \sum J + \sum Di$$

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.

The first image below, shows a problem with data entry. The user has entered exports of 2,000 tonnes in 1993 but has forgotten to correct the export data for 1990-1992, where 0 was the intended input, so the *Software* automatically extrapolated back exports based on the growth rate. It resulted in a case where the exports were greater than the total of production + imports for these years. In the second image exports, changes exports to "0" for 1990-1992 and the check turns green.

Example: **mass conservation not realized– Tier 2 closed cell foams**


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

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-152a (CH3CHF2)
Intro Year 1990 **Growth Rate (%)** 2 **Product lifetime (d) [yr]** 10 **EFfyl [%]** 10 **EFal [%]** 0.5 **MPL [%]** 100 **EFd [%]** 60 **EFrd [%]** 50 **EFad [%]** 0

I. Total Chemical Agent Inputs (across the time series) (∑Bi + ∑Ci) 51,994.367186 Bank(t) + DB(t) + ∑P + ∑J + ∑Di 56,052.686531
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 16,002.177933
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t)) 5,023.380612
IV. Total Chemical Agent Emissions (across the time series) (∑P) 14,700.909911
V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑J + ∑Di) 20,326.218075

Problem with mass conservation

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	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 = MPL * E(t-d) = CAremaining (d+1)	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	1,000		1,884.64467	-884.64467	100	0					0		100	0.1
1991	1,020		1,922.33756	-902.33756	102	0	0	0	0	0	0		102	0.102
1992	1,040.4		1,960.78431	-920.38431	104.04	0	0	0	0	0	0	0	104.04	0.10404
1993	1,061.208		2,000	-938.792	106.1208	0	0	0	0	0	0	0	106.1208	0.10612
1994	1,082.43216		0	1,082.43216	108.24322	5.41216	0	0	0	0	968.77678	0	113.65538	0.11366
1995	1,104.0808		0	1,104.0808	110.40808	10.93256	0	0	0	0	1,951.51694	0	121.34065	0.12134

Example: **mass conservation confirmed– Tier 2 closed cell foams**

Intro Year 1990 **Growth Rate (%)** 2 **Product lifetime (d) [yr]** 10 **EFfyl [%]** 10 **EFal [%]** 0.5 **MPL [%]** 100 **EFd [%]** 60 **EFrd [%]** 50 **EFad [%]** 0

I. Total Chemical Agent Inputs (across the time series) (∑Bi + ∑Ci)	51,994.367186	Bank(t) + DB(t) + ∑P + ∑J + ∑Di	51,994.367186
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t))	15,893.625133		
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t))	5,366.780612		
IV. Total Chemical Agent Emissions (across the time series) (∑P)	15,317.009911		
V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (∑J + ∑Di	15,416.95153		

Mass conservation confirmed

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	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 = MPL * E(t-d) = CAremaining (d+1)	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	1,000		0	1,000	100	5					895		105	0.105
1991	1,020		0	1,020	102	10.1	0	0	0	0	1,802.9		112.1	0.1121
1992	1,040.4		0	1,040.4	104.04	10.1	0	0	0	0	2,729.16	0	114.14	0.11414
1993	1,061.208		2,000	-938.792	106.1208	10.1	0	0	0	0	1,674.1472	0	116.2208	0.11622
1994	1,082.43216		0	1,082.43216	108.24322	15.51216	0	0	0	0	2,632.82398	0	123.75538	0.12376

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 in metric tonnes and Gg.

The user will note that Foam Blowing Agents 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 – closed cell foams Tier 1**

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

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-134a (CH2FCF3) Emissions - Closed Cell Foams

Data
Subdivision Unspecified **Gas** HFC-134a (CH2FCF3) Chemical's Data **IY** 1990 **GR (%)** 0 **EFfyl (%)** 10 **EFal (%)** 4.5 **d (yr)** 20 **RD (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑A)	66,750	Bank(t) + ∑H + ∑F	66,750
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t))	17,100		
III. Total Chemical Agent Emissions (across the time series) (∑H)	49,650		
IV. Total Chemical Agent Recovered/Destroyed 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 = ∑(A(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	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	0
1992	1,500	150	202.5	3,645	0	0	352.5	0.3525	0
1993	1,500	150	270	4,725	0	0	420	0.42	0
1994	1,500	150	337.5	5,737.5	0	0	487.5	0.4875	0
1995	1,500	150	405	6,682.5	0	0	555	0.555	0
1996	1,550	155	474.75	7,602.75	0	0	629.75	0.62975	0
1997	1,600	160	546.75	8,496	0	0	706.75	0.70675	0
1998	1,650	165	621	9,360	0	0	786	0.786	0
1999	1,700	170	697.5	10,192.5	0	0	867.5	0.8675	0
2000	1,750	175	776.25	10,991.25	0	0	951.25	0.95125	0
2001	1,800	180	857.25	11,754	0	0	1,037.25	1.03725	0
2002	1,850	185	940.5	12,478.5	0	0	1,125.5	1.1255	0
2003	1,900	190	1,026	13,162.5	0	0	1,216	1.216	0
2004	1,950	195	1,113.75	13,803.75	0	0	1,308.75	1.30875	0
2005	2,000	200	1,203.75	14,400	0	0	1,403.75	1.40375	0

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

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) (∑Bi + ∑Ci) 765.5 Bank(t) + DB(t) + ΣP + ΣJ + ∑Di 765.5
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 12
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t)) 414
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 + ∑Di) 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	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 = MPL * E(t-d) = CAremaining (d+1)	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	100	10	0	110	100	0					10		100	0.1
1991	102	10	0	112	102	0	10	0	0	10	10		102	0.102
1992	50	10	0	60	50	0	10	0	0	20	10	0	50	0.05
1993	25	12	0	37	25	0	10	0	0	30	12	0	25	0.025
1994	20.83333	12	0	32.83333	20.83333	0	12	0	0	42	12	0	20.83333	0.02083
1995	16.66667	12	0	28.66667	16.66667	0	12	0	0	54	12	0	16.66667	0.01667
1996	12.5	12	0	24.5	12.5	0	12	0	0	66	12	0	12.5	0.0125
1997	8.33333	12	0	20.33333	8.33333	0	12	0	0	78	12	0	8.33333	0.00833
1998	4.16667	12	0	16.16667	4.16667	0	12	0	0	90	12	0	4.16667	0.00417
1999	0	12	0	12	0	0	12	0	0	102	12	0	0	0
2000	0	12	0	12	0	0	12	0	0	114	12	0	0	0
2001	0	12	0	12	0	0	12	0	0	126	12	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.F.4 (Aerosols), 2.F.5 (Solvents) and 2.F.6: (Other Applications - Emissive)

Information

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

- ✓ **2.F.4 Aerosols**
- ✓ **2.F.5 Solvents**
- ✓ **2.F.6 Other Applications - Emissive**

Section 7.3 (Aerosols) and Section 7.2 (Solvents) in Chapter 7 Volume 3 of the *2006 IPCC Guidelines* provide two Tiers for estimation of GHG emissions from aerosols and solvents. Tier 1 relies on AD at the application level and default assumptions on the amount of gas released in the first and second years (i.e. emissions are prompt). Tier 2 is applied at the sub-application level and accommodates national circumstances, providing for cases where emissions are released after the first two years. As the *2006 IPCC Guidelines* provide for the possibility that recovery and subsequent recycling or destruction of agents takes place (e.g. when there are stockpiled materials that are out-of-date), the *Software* includes factors to account for recovery/recycling. Where data are available at the sub-application level for aerosols (e.g. metered dose inhalers, personal care products, household products) or solvents (e.g. precision cleaning, electronics cleaning, etc) or where country specific EFs are available, a Tier 2 can be applied.

This guidebook provides users two sets of worksheets that can accommodate both the Tier 1 and Tier 2 methods. Both Tiers can be implemented in either set of worksheets. Users may decide to estimate emissions using worksheet(s):

1. **Emissions from [Aerosols][Solvents] (1/1):** for the purposes of the Guidebook, this set of worksheets below is referred to as **Default method**, and 1/1 denotes that this single worksheet can be used to input the basic assumptions and IPCC defaults, or
2. **F-Gas Parameters (1/2) and F-Gas Emissions (2/2):** for the purposes of the Guidebook, this set of worksheets below is referred to as **Default method with refined assumptions,** and 1/2 and 2/2 denotes that these two worksheets are an alternative means for inputting data. The user has flexibility in these worksheets to further refine assumptions on lifetime and EFs.

Section 7.7 in Chapter 7 Volume 3 of the *2006 IPCC Guidelines* provides methods for other applications that are emissive. For these other emissive applications, it is considered good practice to use a Tier 1a method. The worksheet for **Emissive Applications** follows worksheet **Emissions from [Aerosols][Solvents] (1/1).**

GHGs

The *Software* includes the following GHGs for the Aerosols, Solvents and Other Applications- Emissive source categories:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

- ✓ Tier 1[49]: Equation 7.6 (Aerosols), Equation 7.5 (Solvents), and Equation 7.18 (Other Applications- Emissive)
- ✓ Tier 2: *(Aerosols and Solvents only)* Same as Tier 1 Equation, although at the sub-application level, and user-specific EFs, if available. A lifetime longer than two years can be considered.
- ✓ 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 equations.

[49] Elements have been added to the equations, consistent with the text of the *2006 IPCC Guidelines,* to allow for the possibility of applying recovery and recycling/destruction practices.

Software Worksheets

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

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications** contains for each F-gas, subdivision and sub-application (if applicable), information on the quantity of F-gas contained in the product sold in the current reporting year t and in the previous year t-1 as well as an EF for the current reporting year and the previous year. The amount recovered for recycling and/or destruction may be added, if known. The worksheet calculates the associated F-gas emissions by sub-application, if known, for Tier 1.
- ✓ **F-Gas Parameters (1/2):** *(Aerosols and Solvents only)* 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; growth rate, product lifetime, EFs for the first-year loss and for annual loss, and the fraction of chemical disposed of that is recovered and destroyed and/or recovered and recycled. These parameters are automatically transferred into the calculation of emissions in worksheet **F-Gas Emissions (2/2).**
- ✓ **F-Gas Emissions (2/2):** *(Aerosols and Solvents only)* contains for each subdivision/sub-application/F-gas, information on the amount of F-gas produced consumed/imported in aerosols or solvents. Based on these data, and the parameters above, the worksheet calculates the associated F-gas emissions for Tier 2.

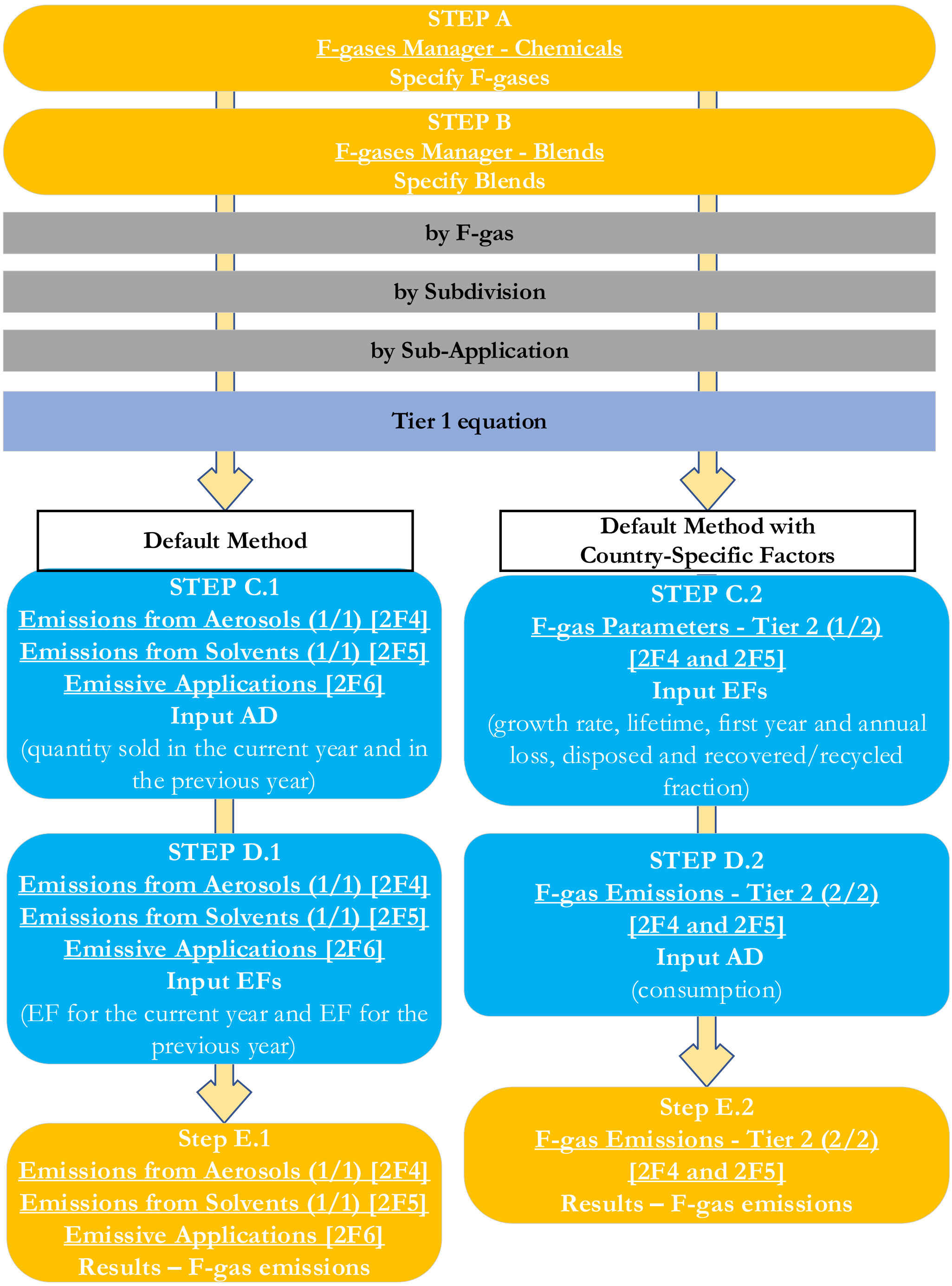
User's Work Flowchart

Consistent with the key category analysis and the decision trees in Figure 7.3 (Aerosols), Figure 7.2 (Solvents) and Figure 7.10 (Other Applications-Emissive) 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[50] 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.

[50] 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.

Aerosols, Solvents and Other Applications - Emissive– flowchart



Thus, for the relevant source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends consumed (including imported for consumption) or produced and exported and related to aerosols, solvents or other applications – emissive (as appropriate) have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager. See the section below on customizing the *Software* to fit the users' needs to designate gases for each 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), and sub-applications, if applicable.

Then, for each subdivision/sub-application, if any:

When the default method is applied:

The first set of steps (Step C.1- Step E.1) explicitly follow the equations in the *2006 IPCC Guidelines*, and may be used as follows, either with default or country-country-specific EFs/sub-applications:

Step C.1, in worksheet **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications,** users collect and input in the *Software* information on the quantity of F-gas/blends contained in products sold in the current reporting year (including in imported products), t, and in the previous year, t-1. If applicable, the quantity of chemical that is recovered and destroyed and/or recovered and recycled at the end of the previous year, t-1, may be entered.

Step D.1, in worksheet **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications**, users input EFs for the current reporting year and for the previous year.

Step E.1, in worksheet **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications,** the *Software* calculates the associated F-gas emissions for each subdivision in mass units (tonnes and Gg). In addition, the total emissions of all subdivisions for the entire source category are shown in the worksheet.

When default method with refined assumptions is applied:

If, for **aerosols and solvents only**, the user wants to further accommodate national circumstances, including sub-applications or a lifetime longer than 2 years, the following Steps/worksheets may be used:

Step C.2, in worksheet **F-Gas Parameters (1/2),** users collect and input in the *Software* information for each subdivision, sub-application, and F-gas on the growth rate of the product, the product lifetime, EFs for the first-year loss and annual loss and the fraction of chemical destroyed and recovered/recycled.

Step D.2, in worksheet **F-Gas Emissions (2/2)**, users input the quantity F-gas/blend contained in aerosols or solvents in the current year, t, the quantity destroyed in the previous year, t-1, and the quantity recovered/recycled in the current inventory year, t.

Step E.2, in worksheet **F-Gas Emissions (2/2),** the *Software* calculates the associated F-gas emissions for each subdivision and sub-application in mass units (tonnes and Gg).

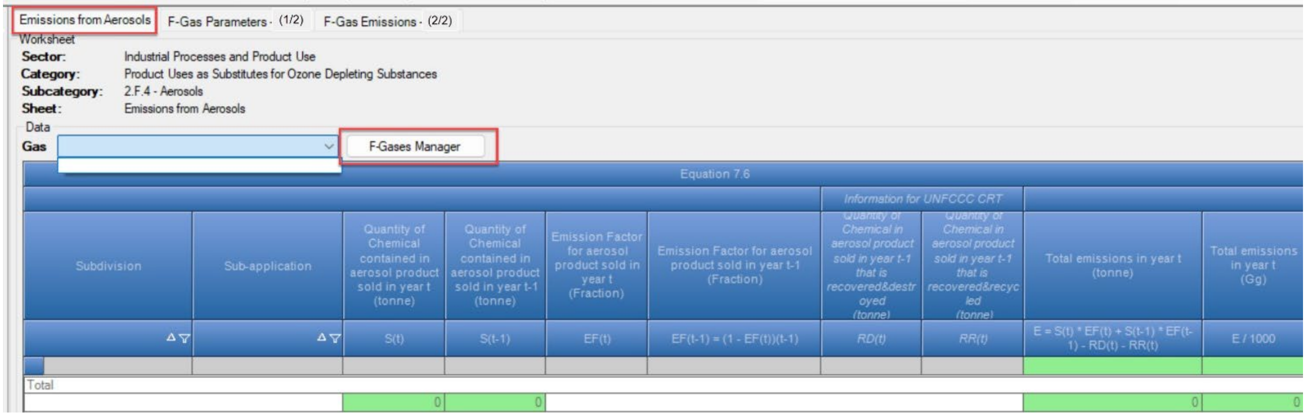
Customizing the *Software* for Aerosols, Solvents and Other Applications- Emissive: subdivision/sub-application/F-gases/blends

For all source categories and all Tiers, users must first identify the relevant F-gases/blends that are consumed in the respective IPCC category and then identify the applicable subdivision(s)/ sub-application(s).

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. The user must identify the relevant F-gas(es)/blends in the worksheet F-gases Manager before entering information on subdivision(s)/sub-applications.

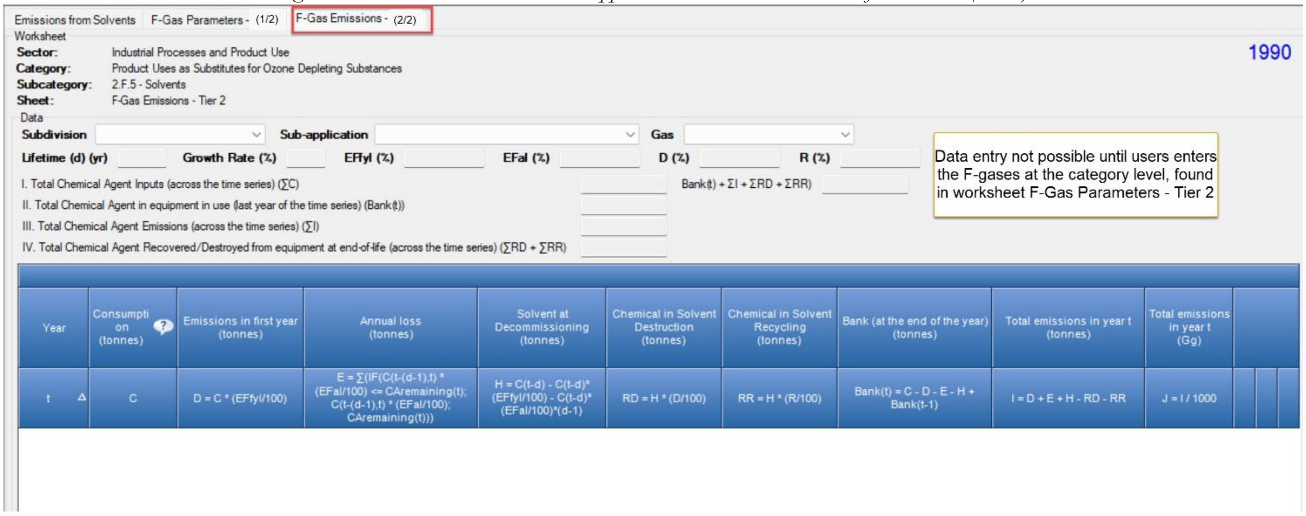
Example: **landing page when user first enters category 2.F.4 Emissions from Aerosols (1/1)**

Figure illustrates aerosols, but the same applies to worksheets Emissions from Solvents (2.F.5) and Emissive Applications (2.F.6)



Example: **landing page when user first enters category 2.F.5 F-Gas Emissions (2/2)**

Figure illustrates solvents, but the same applies to the same named worked for Aerosols (2.F.4)

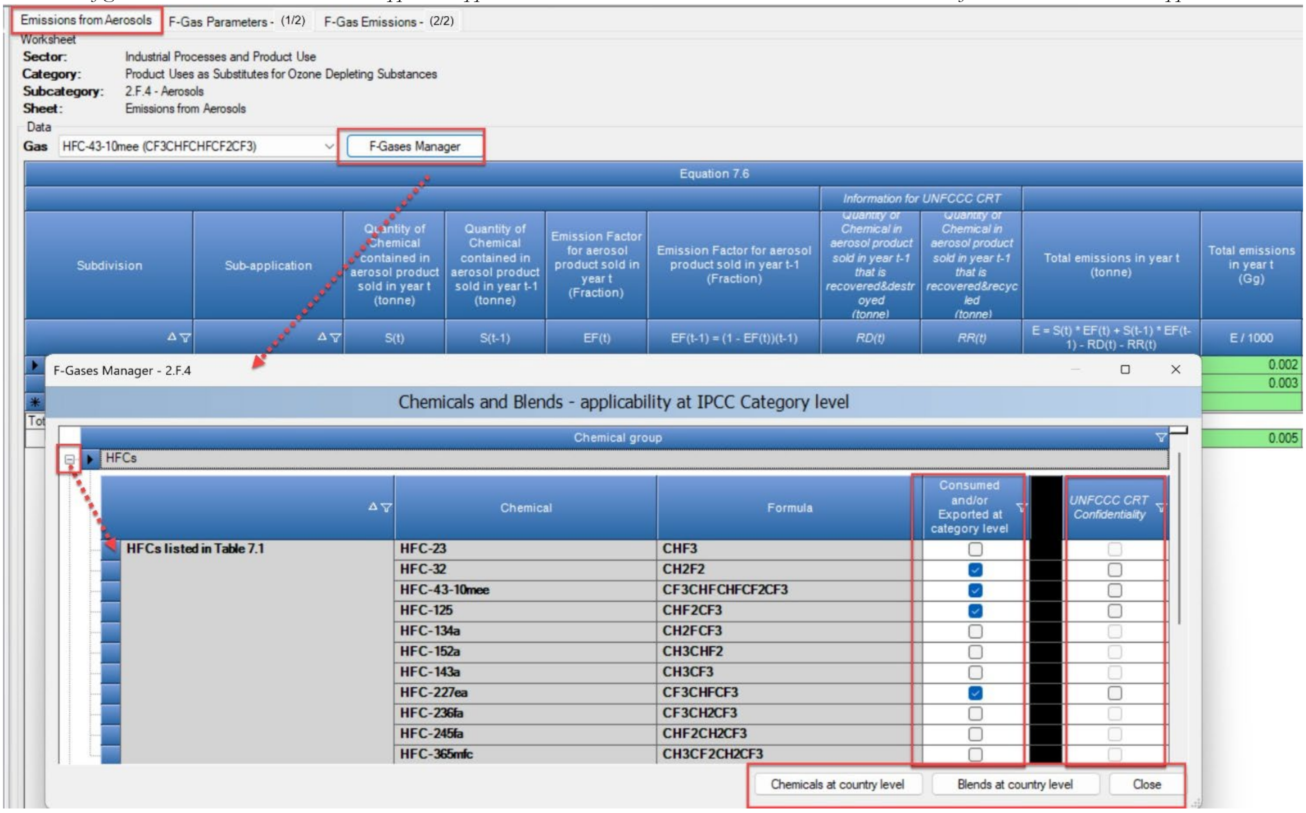


To select the F-gas(es)/blends used in each IPCC category:

1. Select **F-Gases Manager**, accessible in worksheet **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications** or **F-Gas Parameters (2/2)** *(aerosols and solvents only)* (F-gases selected in any worksheet will be applicable for the entire source category)
2. Open the relevant [+] to select the type of F-gas and/or blend
3. Check all F-gas(es)/blends consumed for each respective source category
   Note that: the list of possible blends is also accessible in the drop-down menu, after Other GHGs.
   Note that: if a gas 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.*
4. 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 a particular 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. 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: **Adding F-gas(es)/blends for aerosols**

This figure illustrates Aerosols; the same approach applies to the worksheet F-Gas Parameters – Tier 2 as well as for solvents and emissive applications



Sub-division(s) / Sub-application(s)

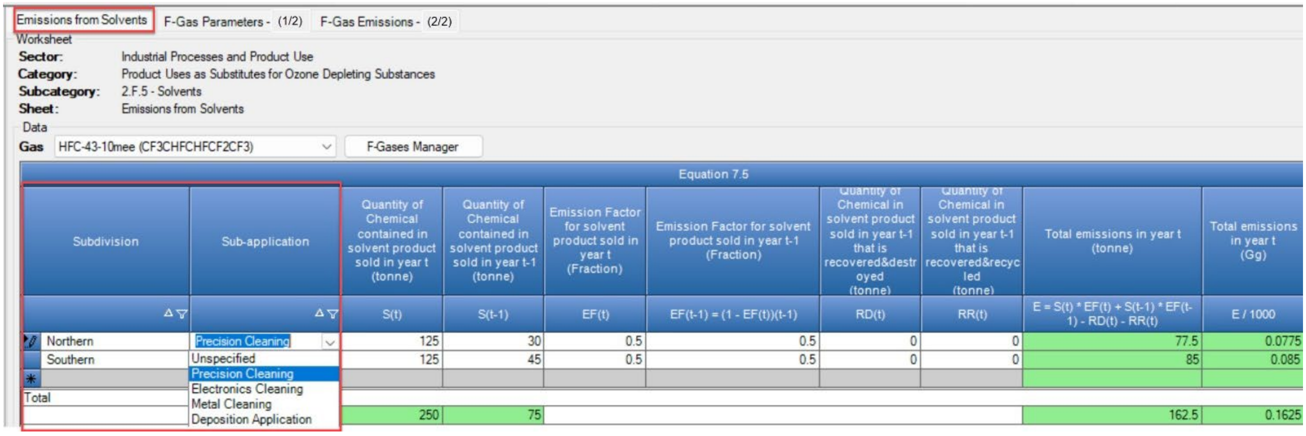
When the default method is applied

In worksheet **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications** input information, row by row, as follows:

1. Column |Subdivision| compile each calculation worksheet 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.
2. Column |Sub-application|: select from the drop-down menu the type of sub-application, if known (e.g. metered dose inhalers, personal care products (aerosols) or e.g. metal cleaning, deposition application (solvents)), or select unspecified (Tier 1 only), or manually overwrite with user-specific infomation.
   *Note that, for users reporting to the UNFCCC ETF Reporting Tool, reporting for **Aerosols** in that tool is disaggregated into two groups: metered dose inhalers and non-metered dose inhalers. Users should not change the category name of metered dose inhalers, as this may impact the import of data into that tool.*

Example: **entering subdivision and sub-applications for emissions from 2.F.5 solvents**

This figure illustrates solvents; the same approach applies to the worksheets ***Emissions from Aerosols (1/1)*** *and* ***Emissive Applications (1/1)***



When the default method with refined assumptions is applied

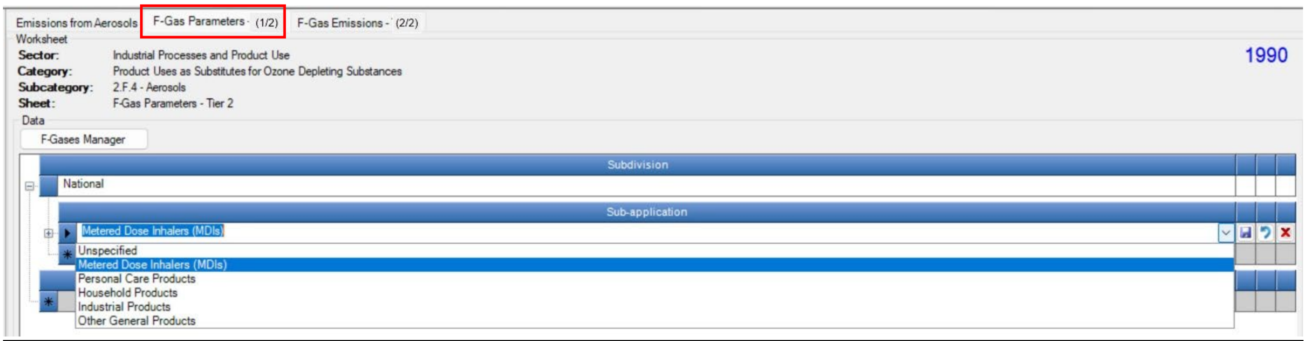
For users estimating GHG emissions using worksheet **F-Gas Emissions (2/2)** *(aerosols and solvents only)***,** subdivision/sub-application information are input in worksheet **F-Gas Parameters (2/2)** row by row, as follows:

1. Select the drop-down menu. To apply a single subdivision (e.g. national) either leave as is (select subdivision =Unspecified) or where subnational aggregations are input, provide the 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 to enable selection of sub-applications (e.g. metered dose inhalers (aerosols) or precision cleaning (solvents) may be selected from the drop-down menu, whereas there are no default options in the drop-down menu for 2.F.6 Other Applications – emissive), or input manually.

   Note that, for users reporting to the UNFCCC ETF Reporting Tool, reporting for ***Aerosols*** *in that tool is disaggregated into two groups: metered dose inhalers and non-metered dose inhalers. Users should not change the category name of metered dose inhalers, as this may impact the import of data into that tool.*

Example: **entering subdivision and sub-applications for F-Gas Parameter (1/2)**

This figure illustrates aerosols; the same approach applies to the same named worksheet for solvents



EF/parameters input

As with other categories under 2.F, the entry of EF and parameters is discussed before entry of AD as the parameter selection is the first step for entry of data in worksheet **F-Gas Emissions (2/2)** *(aerosols and solvents only)* (order does not matter in worksheets **Emissions from Aerosols (1/1), Emissions from Solvents (1/1)** or **Emissive Applications**).

The following sections in Chapter 7, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of EFs:

- ✓ Section 7.3.2.2 contains information on the choice of EF for aerosols.
- ✓ Section 7.2.2.2 contains information on the choice of EF for solvents.
- ✓ Section 7.7.2.2 contains information on the choice of EF for other emissive applications.

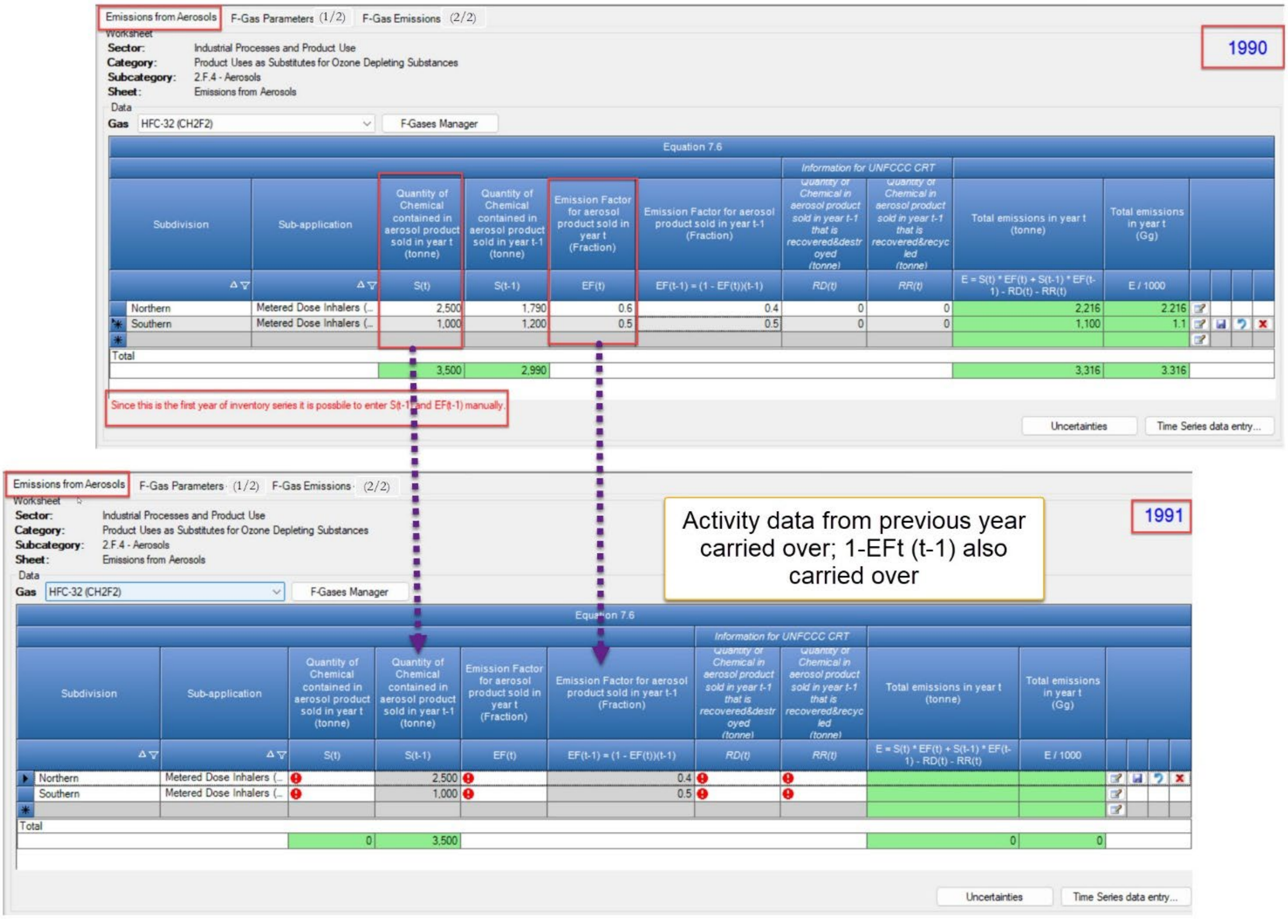
When the default method is applied:

For each combination of subdivision/sub-application (if applicable), data are input in worksheet **Emissions from Aerosols (1/1), Emissions from Solvents (1/1)** or **Emissive Applications** row by row, as follows:

1. Column |$EF_{(t)}$|: input the EF for loss in the current year, fraction.
   Note that it is good practice to use a default EF of 50% of the initial charge per year for the broad spectrum of products when assessed at the application level (Tier 1) (i.e. half the chemical charge is assumed to escape within the first year and the remaining charge escapes during the second year). Inventory compilers should use alternative EFs only when empirical evidence is available for most products at either the application level (Tier 1) or the sub-application level (Tier 2). In any event, the percentage EFs should sum to 100 percent over the time during which it is assumed that the charge will escape.
2. Column |$EF_{(t-1)}$|: input one minus the EF for loss in the previous year, fraction.
   Note that, direct entry is only required in the first year of the inventory time series. When the user creates the next inventory year the fraction equal to the remainder of what was not emitted in year t-1 will be automatically transferred to this column as $EF_{(t-1)}$ *(see image below).*

Example: **AD and EF input (first year and subsequent year) – default method**

Figure illustrates aerosols applications, but the same image applies to solvents and emissive applications



When the default method with refined assumptions is applied ***(aerosols and solvents only)*****:**

EFs and parameters are input in worksheet **F-Gas Parameters (2/2)** for each subdivision and each sub-application, row by row, as follows:

1. Window |Chemical|: select 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).
2. Window |Growth Rate|: input the growth rate in sales of product, usually assumed linear across the period of assessment, in % (no IPCC default).
3. Window |Lifetime|: input the lifetime of product, in years.
   Note that: emissions from aerosols and solvents are considered prompt and typically emitted within two years. This worksheet allows for alternative lifetimes based on country-specific information.
4. Window |EFfyl|: input the fraction of chemical emitted from product in the year of initial use.
   Note that: emissions from aerosols and solvents are considered prompt and in the default method it is assumed that 0.5 is emitted in year 1 and 0.5 in year 2. This worksheet allows for alternative first year loss fractions based on country-specific information.
5. Window |EFal|: input the fraction of chemical emitted annually.
   Note that: emissions from aerosols and solvents are considered prompt and in the default method it is assumed that 0.5 is emitted in year 1 and 0.5 in year 2. This worksheet allows for the scenario where emissions occur over a lifetime longer than 2 years.
6. Window |D|: input the fraction of chemical that is destroyed at disposal (%)
   Note that: the default assumption is that no chemical is destroyed at disposal. The user must ensure that Column |D| plus Column |R| is ≤ 100%. If the sum of these columns is greater than 100%, an alert with an exclamation point will appear in Column |Chemical| (see image below).
7. Window |R|: input the fraction of chemical that is recovered/recycled at disposal (%)
   Note that: the default assumption is that no chemical is destroyed at disposal. The user must ensure that Column |D| plus Column |R| is ≤ 100%. If the sum of these columns is greater than 100%, an alert with an exclamation point will appear in Column |Chemical| (see image below).

Example: **EF input (first year and subsequent year) – F-Gas Parameters (1/2)**

Figure illustrates solvents applications, but the same image applies to aerosols

Activity Data Input

The following sections in Chapter 7, Volume 3 of the *2006 IPCC Guidelines* contain information on the choice of AD:

- ✓ Section 7.3.2.3 contains information on the choice of AD for aerosols.
- ✓ Section 7.2.2.3 contains information on the choice of AD for solvents.
- ✓ Section 7.7.2.3 contains information on the choice of AD for other applications- emissive.

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions.

Input of AD requires the following steps for different Tiers for aerosols, solvents and other applications- emissive:

When the default methods is applied:

For each subdivision in Column |Subdivision and each sub-application in Column |Sub-application|, data are input in worksheet **Emissions from Aerosols (1/1)** or **Emissions from Solvents (1/1)** or **Emissive Applications ,** row by row, as follows:

1. Column |$S_{(t)}$|: input the quantity of the specific F-gas/blend contained in products sold in the current year, in tonnes.
2. Column |$S_{(t-1)}$|: input the quantity of the specific F-gas/blend contained in products sold in the previous year, in tonnes.
   Note that direct entry is only required in the first year of the inventory time series. When the user creates the next inventory year (using the previous year as the basis, which is the recommended approach[51]), the quantity of F-gases/blends will be automatically transferred to this column, in a gray cell.
3. Column |$RD_{(t)}$|: input the quantity of the specific F-gas/blend contained in products sold in the previous year, that are recovered and destroyed, in tonnes.
   Note that the default assumption is that recovery for destruction does not occur.
4. Column |$RR_{(t)}$|: input the quantity of the specific F-gas/blend contained in products sold in the previous year, that are recovered and recycled, in tonnes.
   Note that the default assumption is that recovery for recycling does not occur.

An illustration of the AD input and carry over of the value S(t) to the subsequent year inventory is illustrated above in Figure *Example:* **AD and EF input (first year and subsequent year) – default method**.

[51] Refer to section 3.2.3.2 of the *Software* User Manual, or the accompanying power point manual on the TFI website. The User Manual may also be found in the Help tab of the *Software.*

When the default methods with refined assumptions is applied *(aerosols and solvents only)*:

Parameters input in the tab **F-Gas Parameters (1/2)** will be visible in the worksheet **F-Gas Emissions (2/2).** See section **EF/parameter input** above on how to enter EF/parameter information.

Then, AD are input for each subdivision/sub-application/ F gas/blend, and for each year (based on the year of introduction of the F-gas/blend used) in worksheet **F-Gas Emissions (2/2),** as follows:
Note that, unlike many categories in IPPU, AD entry worksheets for source category 2.F.4 and 2.F.5 are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

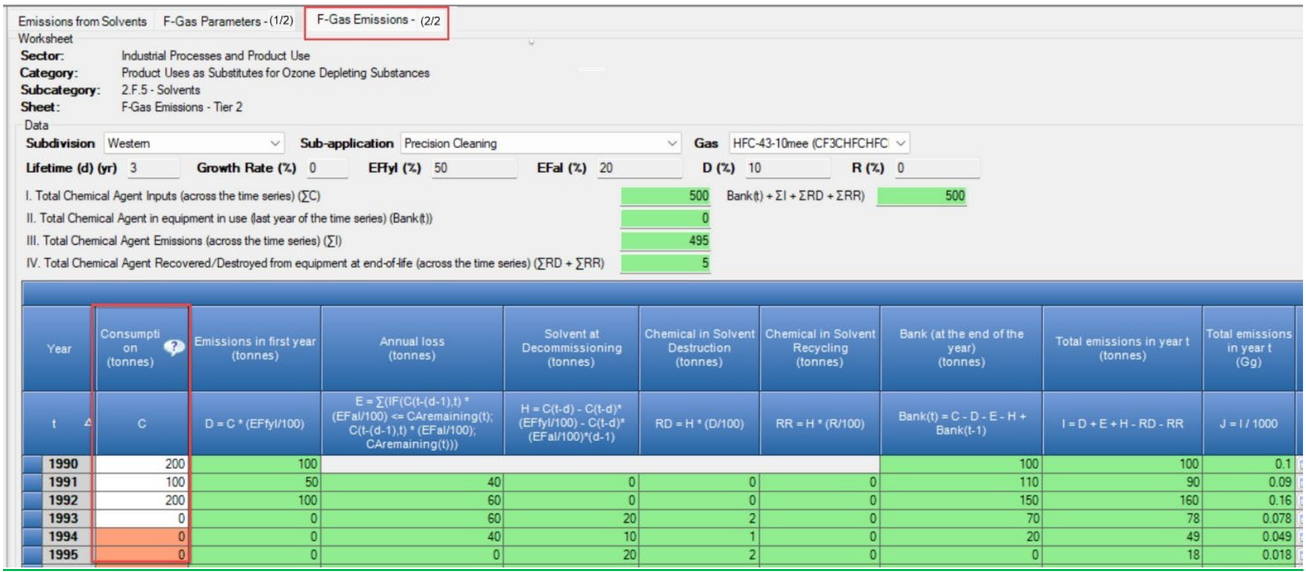
1. Column |C|: input the amount of chemical agent consumed, in tonnes.
   *Note: insert values only for the years known. The Software will interpolate interim years and extrapolate based on the growth rate entered in worksheet **F-Gas Parameters (2/2)**. Insert "0" only if zero is the true value otherwise it impacts the extrapolation.*

Once known AD are input, the *Software* makes several calculations based on the factors added in the F-Gas Parameters (1/2) tab:

2. Column |D|: calculates the amount of chemical agent lost (emitted) in the first year, in tonnes.
   *Note that this cell is calculated by multiplying the amount of chemical used in aerosols/solvents sold in the year by the EF for first year losses (EFfyl) entered in worksheet **F-Gas Parameters (1/2)**.*
3. Column |E|: calculates the amount of chemical agent emitted annually from the bank of chemical in aerosols/solvents, in tonnes.
   *Note that this cell is calculated by multiplying the amount of F-gas in the bank of aerosols/solvents by the EF for annual losses (EFal) entered in worksheet **F-Gas Parameters (1/2)**. This value is constrained to ensure that annual losses are not greater than the amount of chemical remaining in the product, based on the lifetime entered by the user.*
4. Column |H|: calculates the amount of chemical agent remaining in the product at decommissioning, in tonnes.
   *Note that this cell is calculated by subtracting from the total chemical agent in the year of sales, the sum of first year losses (EFfyl) and annual losses (EFal) over the course of the lifetime of the product, parameters entered by the user in worksheet **F-Gas Parameters (1/2)**.*
5. Column |RD|: calculates the amount of chemical agent recovered and destroyed, in tonnes.
   *Note that this cell is calculated by multiplying the amount of chemical agent that reached their end of life (based on the lifetime) and multiplied by the fraction of that chemical that is destroyed (D), as entered in worksheet **F-Gas Parameters (1/2).***
6. Column |RR|: calculates the amount of chemical agent recovered/recycled, in tonnes.
   *Note that this cell is calculated by multiplying the amount of chemical agent that reached their end of life (based on the lifetime) and multiplied by the fraction of that chemical that is recovered/recycled (R) as entered in worksheet **F-Gas Parameters (1/2)**.*
7. Column |$Bank_{(t)}$|: calculates the bank at the end of the year t, in tonnes.
   Note that this cell is calculated as the amount of chemical agent of the bank from the previous year t-1 plus the amount of chemical sold in products in the current year, minus first-year losses and annual losses, and quantity of chemical destroyed, recycled and recovered, in tonnes.
8. Column |I|: calculates total emissions in year t, tonnes.
   Note that this cell is calculated as first year and annual emissions, plus the amount in products at decommissioning, minus any chemical agent recovered and destroyed.
9. Column |J|: calculates total emissions in year t, Gg

Example: **AD input– default method with refined assumptions**

Figure illustrates solvents applications, but the same image applies to aerosols



Emissions from Solvents | F-Gas Parameters - (1/2) | F-Gas Emissions - (2/2

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.5 - Solvents
Sheet: F-Gas Emissions - Tier 2

Data

Subdivision Western **Sub-application** Precision Cleaning **Gas** HFC-43-10mee (CF3CHFCHFC

Lifetime (d) (yr) 3 **Growth Rate (%)** 0 **EFfyl (%)** 50 **EFal (%)** 20 **D (%)** 10 **R (%)** 0

I. Total Chemical Agent Inputs (across the time series) (∑C) 500 Bank(t) + ΣI + ΣRD + ΣRR) 500
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 0
III. Total Chemical Agent Emissions (across the time series) (∑I) 495
IV. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (∑RD + ∑RR) 5

Year	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Solvent at Decommissioning (tonnes)	Chemical in Solvent Destruction (tonnes)	Chemical in Solvent Recycling (tonnes)	Bank (at the end of the year) (tonnes)	Total emissions in year t (tonnes)	Total emissions in year t (Gg)
t	C	D = C * (EFfyl/100)	E = ∑(IF(C(t-(d-1),t) * (EFal/100) <= CAremaining(t); C(t-(d-1),t) * (EFal/100); CAremaining(t)))	H = C(t-d) - C(t-d)* (EFfyl/100) - C(t-d)* (EFal/100)*(d-1)	RD = H * (D/100)	RR = H * (R/100)	Bank(t) = C - D - E - H + Bank(t-1)	I = D + E + H - RD - RR	J = I / 1000
1990	200	100					100	100	0.1
1991	100	50	40	0	0	0	110	90	0.09
1992	200	100	60	0	0	0	150	160	0.16
1993	0	0	60	20	2	0	70	78	0.078
1994	0	0	40	10	1	0	20	49	0.049
1995	0	0	0	20	2	0	0	18	0.018

Ensuring mass conservation of gases in aerosols and solvents

A QA/QC check has been introduced into the worksheets for aerosols and solvents to ensure that the data, EFs and parameters entered by the users are consistent with 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 (∑C)
II. Total chemical agent in equipment in use (last year of the time series) ($Bank_{(t)}$)
III. Total chemical agent emissions, across time (∑I)
IV. Total chemical agent recovered/destroyed/exported (∑RD +∑RR)

In the case of worksheet **F-Gas Emissions (2/2)** conservation of mass means that:

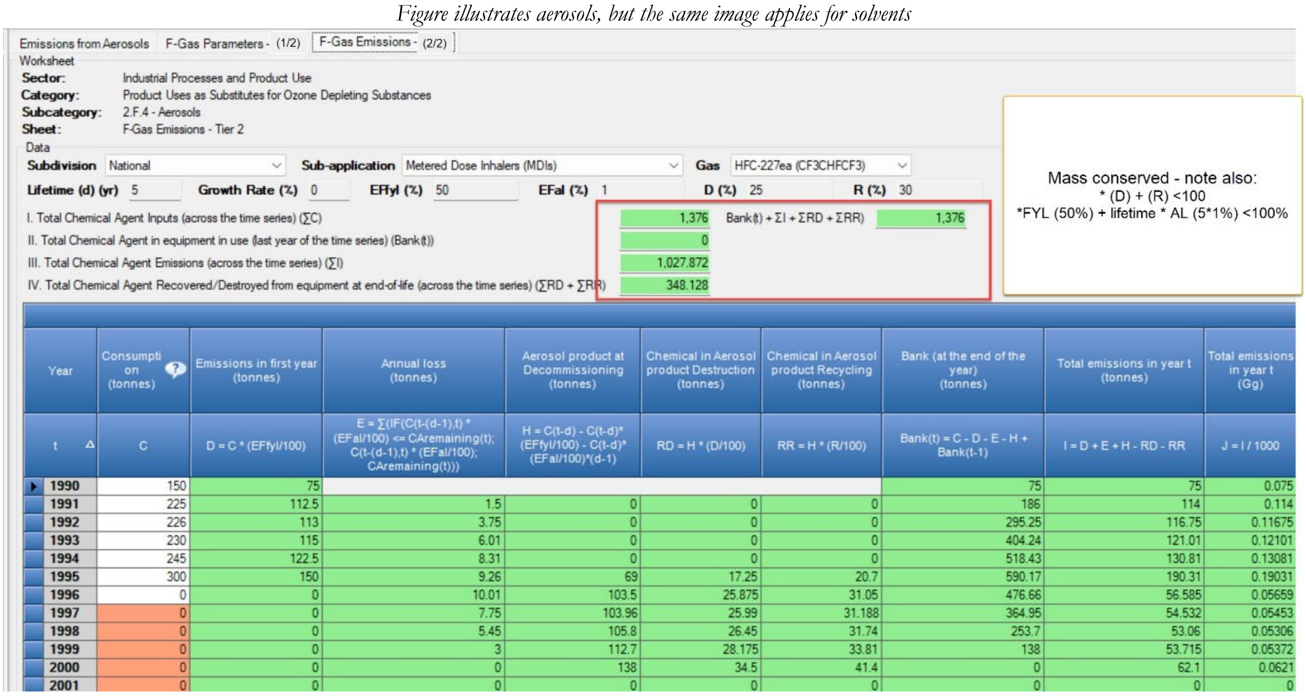
$$\sum C = Bank_{(t)} + \sum I + \sum RD + \sum RR$$

If the total chemical agent in inputs is equal to the sum of chemical in the bank, plus emissions across time, plus the amount recovered and recycled/destroyed then mass has been conserved. This check should be considered a guide and is still a work in progress for aerosols and solvents. It is still possible for the user to insert invalid entries and see a "green" result. The user should check the following:

- ✓ A user could enter in worksheet **F-Gas Parameters (1/2)** an RD +RR that is greater than 100. An alert will appear in that worksheet noting the invalid entry but won't appear in the calculation worksheet **F-Gas Emissions (2/2).** This is because such a change can result in negative emissions owing to the recovery/destruction being greater than the amount available at decommissioning. If a user sees a negative value in Column |J| this is a sign that input should be further checked.
- ✓ It is possible that a user will add a combination of lifetime, first year losses and annual losses that are not coherent (e.g. annual losses over the course of a lifetime could equal to a negative). The calculations in column E correct for this to ensure that annual losses are not greater than the chemical agent input, but the user should review assumptions on first year loss, annual loss and lifetime to ensure coherence.
- ✓ A user currently cannot enter a negative value in Column |C| although it is possible that in a given year exports could be greater than imports, causing negative consumption.

Example: **mass conservation aerosols**

Figure illustrates aerosols, but the same image applies for solvents



Emissions from Aerosols | F-Gas Parameters - (1/2) | F-Gas Emissions - (2/2)

Worksheet

Sector: Industrial Processes and Product Use

Category: Product Uses as Substitutes for Ozone Depleting Substances

Subcategory: 2.F.4 - Aerosols

Sheet: F-Gas Emissions - Tier 2

Data

Subdivision National **Sub-application** Metered Dose Inhalers (MDIs) **Gas** HFC-227ea (CF3CHFCF3)

Lifetime (d) (yr) 5 **Growth Rate (%)** 0 **EFfyl (%)** 50 **EFal (%)** 1 **D (%)** 25 **R (%)** 30

I. Total Chemical Agent Inputs (across the time series) (∑C) 1,376 Bank(t) + ∑I + ∑RD + ∑RR) 1,376

II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 0

III. Total Chemical Agent Emissions (across the time series) (∑I) 1,027.872

IV. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (∑RD + ∑RR) 348.128

Mass conserved - note also:
* (D) + (R) <100
*FYL (50%) + lifetime * AL (5*1%) <100%

Year	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Aerosol product at Decommissioning (tonnes)	Chemical in Aerosol product Destruction (tonnes)	Chemical in Aerosol product Recycling (tonnes)	Bank (at the end of the year) (tonnes)	Total emissions in year t (tonnes)	Total emissions in year t (Gg)
t	C	D = C * (EFfyl/100)	E = ∑(IF(C(t-(d-1),t) * (EFal/100) <= CAremaining(t); C(t-(d-1),t) * (EFal/100); CAremaining(t)))	H = C(t-d) - C(t-d)* (EFfyl/100) - C(t-d)* (EFal/100)*(d-1)	RD = H * (D/100)	RR = H * (R/100)	Bank(t) = C - D - E - H + Bank(t-1)	I = D + E + H - RD - RR	J = I / 1000
1990	150	75					75	75	0.075
1991	225	112.5	1.5	0	0	0	186	114	0.114
1992	226	113	3.75	0	0	0	295.25	116.75	0.11675
1993	230	115	6.01	0	0	0	404.24	121.01	0.12101
1994	245	122.5	8.31	0	0	0	518.43	130.81	0.13081
1995	300	150	9.26	69	17.25	20.7	590.17	190.31	0.19031
1996	0	0	10.01	103.5	25.875	31.05	476.66	56.585	0.05659
1997	0	0	7.75	103.96	25.99	31.188	364.95	54.532	0.05453
1998	0	0	5.45	105.8	26.45	31.74	253.7	53.06	0.05306
1999	0	0	3	112.7	28.175	33.81	138	53.715	0.05372
2000	0	0	0	138	34.5	41.4	0	62.1	0.0621
2001	0	0	0	0	0	0	0	0	0

Results

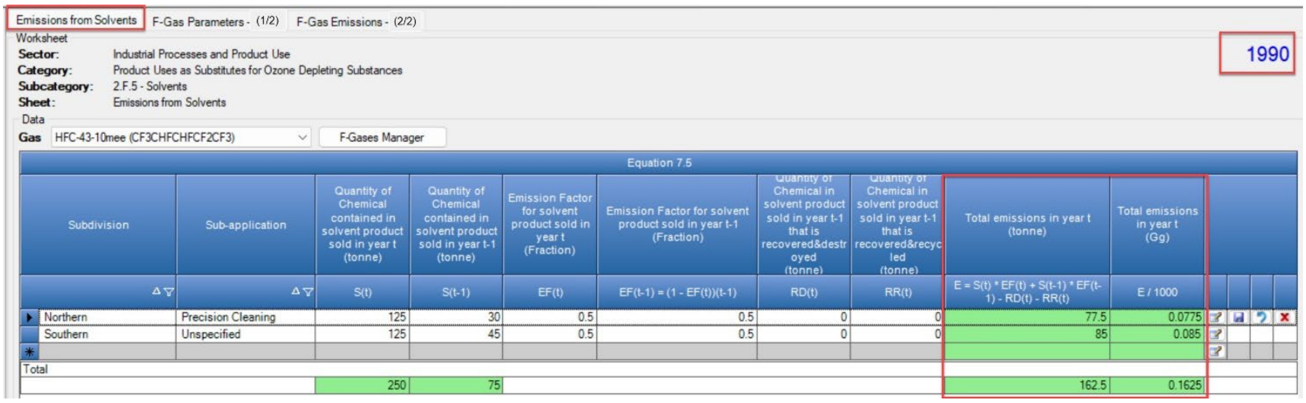
F-gas emissions are estimated in mass units (metric tonnes and Gg) by the *Software* as follows:

- ✓ 2.F.4. Aerosols in worksheets **Emissions from Aerosols (1/1)** and **F-Gas Emissions (2/2)**
- ✓ 2.F.5 Solvents in worksheets **Emissions from Solvents (1/1)** and **F-Gas Emissions (2/2)**
- ✓ 2.F.6 Other applications (emissive) in worksheet **Emissive Applications**

Where the default method is used, each worksheet estimates emissions for a single year. Where the default method with refining assumptions is used, emissions estimates for all years are available in the worksheet for a given inventory year.

The user will note that these categories do 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 – default method**



Emissions from Solvents | F-Gas Parameters - (1/2) | F-Gas Emissions - (2/2)

1990

Worksheet

Sector: Industrial Processes and Product Use

Category: Product Uses as Substitutes for Ozone Depleting Substances

Subcategory: 2.F.5 - Solvents

Sheet: Emissions from Solvents

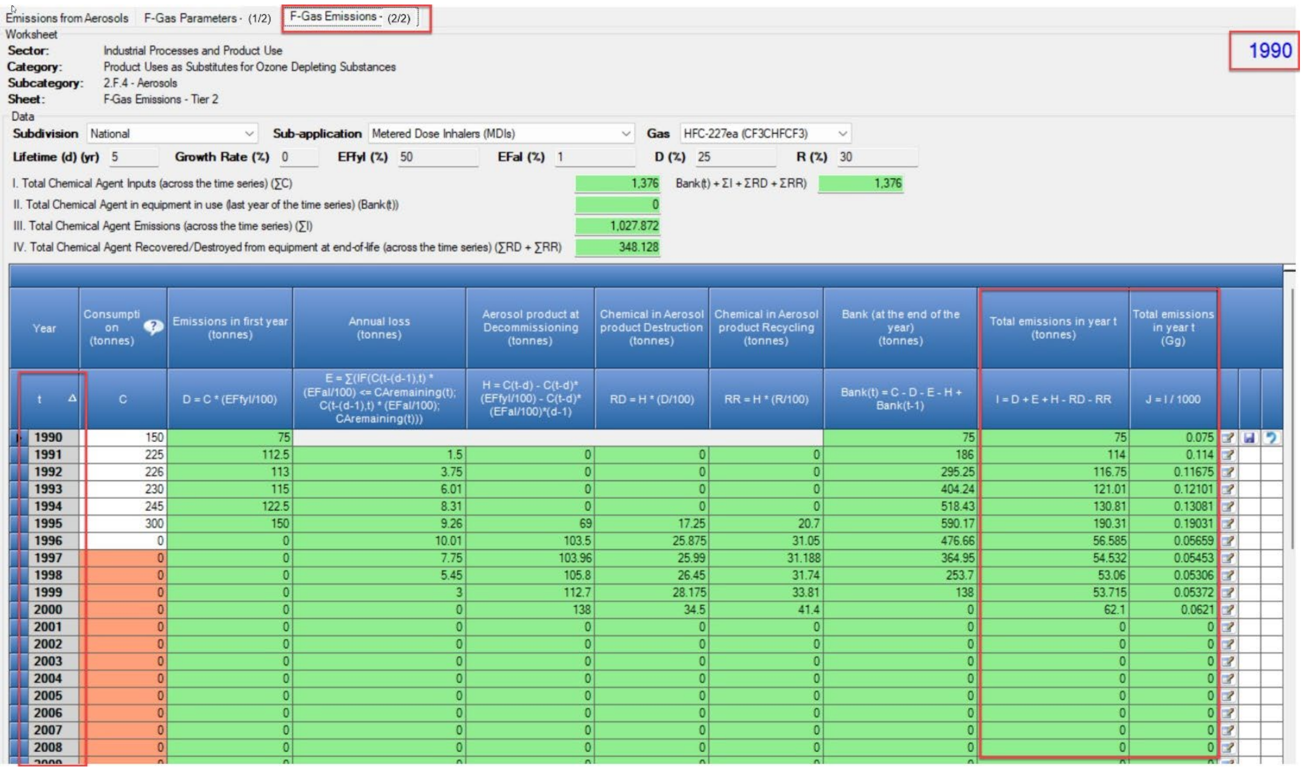
Data

Gas HFC-43-10mee (CF3CHFCHFCF2CF3) F-Gases Manager

Equation 7.5

Subdivision	Sub-application	Quantity of Chemical contained in solvent product sold in year t (tonne)	Quantity of Chemical contained in solvent product sold in year t-1 (tonne)	Emission Factor for solvent product sold in year t (Fraction)	Emission Factor for solvent product sold in year t-1 (Fraction)	Quantity of Chemical in solvent product sold in year t-1 that is recovered&destroyed (tonne)	Quantity of Chemical in solvent product sold in year t-1 that is recovered&recycled (tonne)	Total emissions in year t (tonne)	Total emissions in year t (Gg)
		S(t)	S(t-1)	EF(t)	EF(t-1) = (1 - EF(t))(t-1)	RD(t)	RR(t)	E = S(t) * EF(t) + S(t-1) * EF(t-1) - RD(t) - RR(t)	E / 1000
Northern	Precision Cleaning	125	30	0.5	0.5	0	0	77.5	0.0775
Southern	Unspecified	125	45	0.5	0.5	0	0	85	0.085
Total		250	75					162.5	0.1625

Example: **results: F-Gas emissions – default method with refining assumptions**


Emissions from Aerosols | F-Gas Parameters - (1/2) | F-Gas Emissions - (2/2)

1990

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.4 - Aerosols
Sheet: F-Gas Emissions - Tier 2

Data

Subdivision National **Sub-application** Metered Dose Inhalers (MDIs) **Gas** HFC-227ea (CF3CHFCF3)

Lifetime (d) (yr) 5 **Growth Rate (%)** 0 **EFfyl (%)** 50 **EFal (%)** 1 **D (%)** 25 **R (%)** 30

I. Total Chemical Agent Inputs (across the time series) (∑C) 1,376 Bank(t) + ∑I + ∑RD + ∑RR) 1,376
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 0
III. Total Chemical Agent Emissions (across the time series) (∑I) 1,027.872
IV. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (∑RD + ∑RR) 348.128

Year	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Aerosol product at Decommissioning (tonnes)	Chemical in Aerosol product Destruction (tonnes)	Chemical in Aerosol product Recycling (tonnes)	Bank (at the end of the year) (tonnes)	Total emissions in year t (tonnes)	Total emissions in year t (Gg)
t	C	D = C * (EFfyl/100)	E = ∑(IF(C(t-(d-1),t) * (EFal/100) <= CAremaining(t); C(t-(d-1),t) * (EFal/100); CAremaining(t)))	H = C(t-d) - C(t-d)* (EFfyl/100) - C(t-d)* (EFal/100)*(d-1)	RD = H * (D/100)	RR = H * (R/100)	Bank(t) = C - D - E - H + Bank(t-1)	I = D + E + H - RD - RR	J = I / 1000
1990	150	75					75	75	0.075
1991	225	112.5	1.5	0	0	0	186	114	0.114
1992	226	113	3.75	0	0	0	295.25	116.75	0.11675
1993	230	115	6.01	0	0	0	404.24	121.01	0.12101
1994	245	122.5	8.31	0	0	0	518.43	130.81	0.13081
1995	300	150	9.26	69	17.25	20.7	590.17	190.31	0.19031
1996	0	0	10.01	103.5	25.875	31.05	476.66	56.585	0.05659
1997	0	0	7.75	103.96	25.99	31.188	364.95	54.532	0.05453
1998	0	0	5.45	105.8	26.45	31.74	253.7	53.06	0.05306
1999	0	0	3	112.7	28.175	33.81	138	53.715	0.05372
2000	0	0	0	138	34.5	41.4	0	62.1	0.0621
2001	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0

2.F.5 Solvents

Guidance for the use of the *Software* for source category 2.F.5 Solvents is provided above in the section **2.F.4 (Aerosols), 2.F.5 (Solvents) and 2.F.6: (Other Applications - Emissive)**.

2.F.6 Other Applications

Information

For all other applications in category 2.F, Section 7.7 the *2006 IPCC Guidelines* provide two broad methods: i) the first one is applicable to prompt or emissive applications, like aerosols and solvents, where EFs are expected to be more than 50%, i.e. emissions will happen within two years; and ii) the second method is applicable to contained applications, where annual EFs are smaller and emissions can be divided into production/manufacture, lifetime and disposal emissions. For contained applications, a Tier 2 method can be used when AD and EFs are available at the sub-application level, if not, then the default Tier 1 method at the application level is to be used.

For the Other Applications source category there is a need to be sure that double counting does not occur with other categories (particularly 2.E and other applications in 2.F). For further information, see Section 7.7.1 of the *2006 IPCC Guidelines.*

Guidance for the use of the *Software* for source category 2.F.6 Other Applications- Emissive is provided above in the section **2.F.4 (Aerosols), 2.F.5 (Solvents) and 2.F.6: (Other Applications - Emissive)** owing to the common methods among those categories.

This section describes use of the *Software* for the category 2.F.6 Other Applications – Contained.

GHGs

The *Software* includes the following GHGs for the other applications source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

- ✓ Tier 1 Equation 7.19 (contained applications), at application level
- ✓ Tier 2: Same equation as Tier 1, although at the sub-application level
- ✓ 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 equations.

Software Worksheets

GHG emissions from the Other Applications source category (contained only) are estimated using the following worksheets:

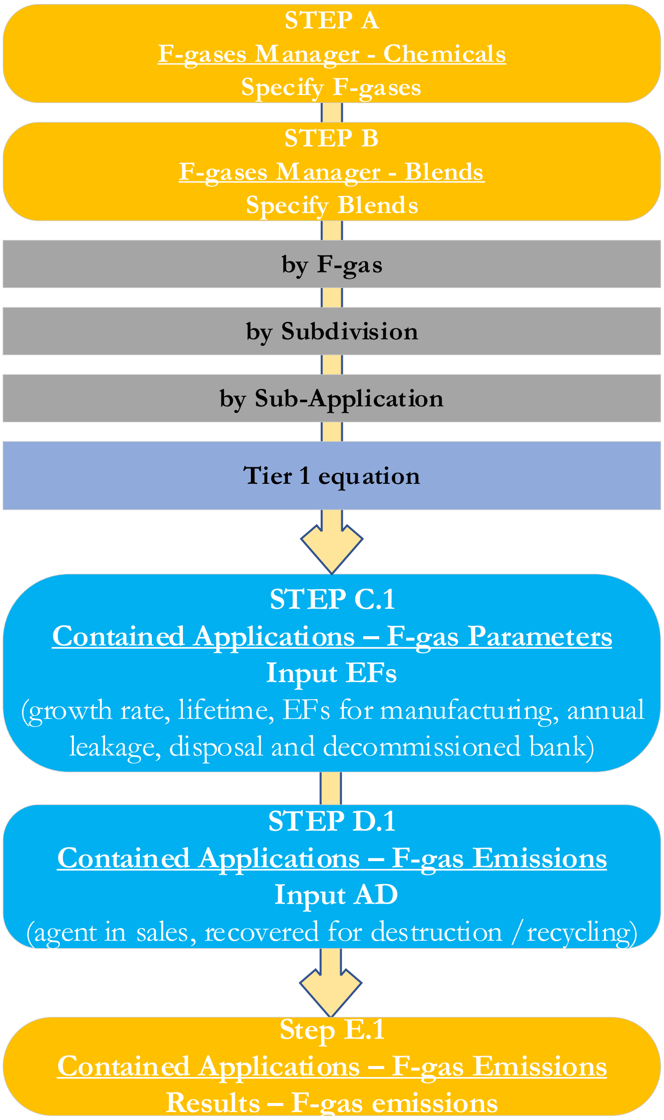
- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ➢ **Contained Applications – F-Gas Parameters** allows for input of necessary information: subdivisions, sub-applications and chemicals (i.e. gases) consumed. For each gas, additional parameters are available for data input; growth rate, product lifetime, and EFs for manufacturing, annual leakage and disposal, as well as the rate of loss from the decommissioned bank. These parameters are automatically transferred into the calculation of emissions in worksheet **Contained Applications – F-Gas Emissions.**
- ✓ **Contained Applications – F-Gas Emissions:** contains for each F-gas / subdivision/sub-application information on chemical contained in annual sales, the bank, chemical recovery for recycling/destruction and from the decommissioned bank, and calculates emissions from manufacturing, the bank, disposal and from the decommissioned bank. The worksheet calculates the associated F-gas emissions for Tier 1 and if AD and EFs are available at sub-application level, for Tier 2.

User’s Work Flowchart

For Other Applications- contained, consistent with the key category analysis and the decision tree in Figure 7.10 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[52] 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 Applications- contained:

Other Applications - contained– flowchart



[52] 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 source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends consumed (including imported for consumption) or produced and exported and related to other applications - contained have been checked off first in the country level F-gases Manager, and then in the IPCC category level F-gases Manager. See the section below on EF/Parameter input to customize the *Software* to fit the users' needs to designate gases at the category level.

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), and sub-applications, if applicable. Tier 2 requires also information on sub-applications.

Then, for each subdivision/sub-application, if any:

Step C.1, in worksheet **Contained Applications – F-Gas Parameters,** users collect and input in the *Software* information on the growth rate, product lifetime, and EFs for manufacturing, annual leakage and disposal, as well as the rate of loss from the decommissioned bank.

Step D.1, in worksheet **Contained Applications – F-Gas Emissions**, users input the amount of annual sales of chemical and the amount recovered for recycling/destruction.

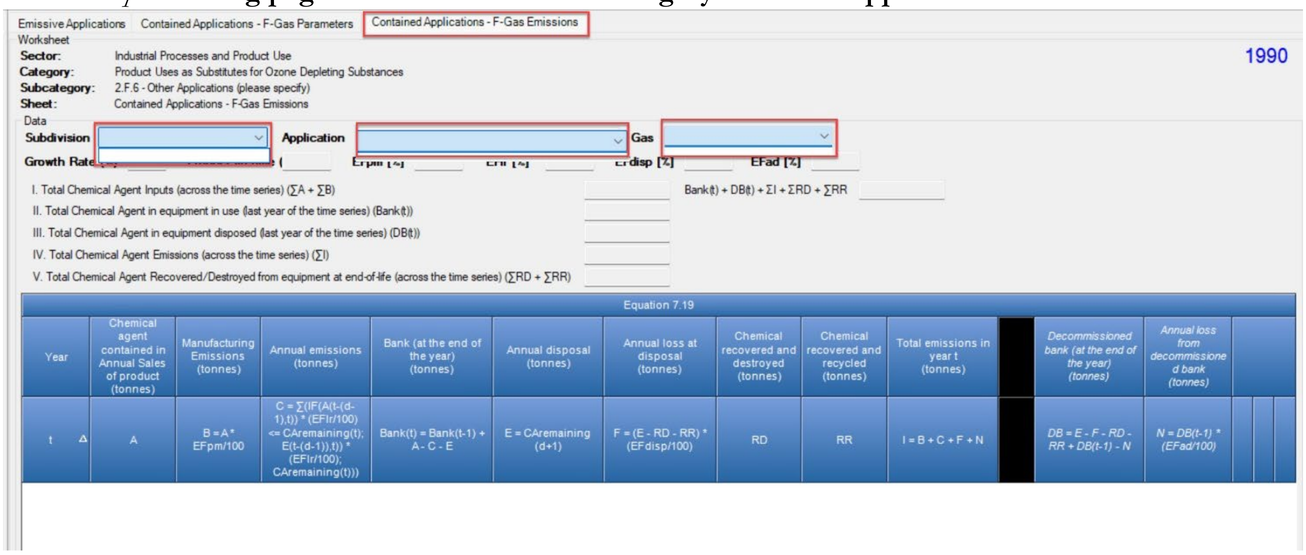
Step E.1, in worksheet **Contained Applications – F-Gas Emissions,** the *Software* calculates the associated F-gas emissions for each subdivision in mass units (metric tonne).

Customizing the *Software* for Other Applications: F-gases/blends

When the user first enters the *Software*, there are no F-gases available for selection for data entry in worksheets **Contained Applications – F-Gas Parameters** and **Contained Applications – F-Gas Emissions** and it is not possible to enter data. The user must customize the *Software* to identify the F-gas(es)/blends consumed at the IPCC category level of Other Applications - contained, before data can be entered in the worksheets.

Important: When the user first enters the *Software* for other applications – contained, there is only a single subdivision (Unspecified) and no F-gases available for selection for data entry. 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 contained applications – F-Gas Emissions**



Entering subdivision(s)

For worksheet **Contained Applications – F-Gas Parameters** 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**. For Tier 2, information on specific applications must be entered; Tier 1 may use a single application (e.g. unspecified or national).

Identifying relevant F-gases /blends at the IPCC category level

For Other Applications- Contained, entering of F-gases /blends takes place in worksheet **Contained Applications – F-Gases Manager** tab following the same procedure as outlined **above** for Tier 2 refrigeration and air conditioning.

EF/Parameter Input

Section 7.7.2.2 in Chapter 7 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EF for contained applications.

Data are entered in worksheet **Contained Applications – F-Gas Parameters,** for each combination of subdivision/sub-application (if applicable), row by row, as follows:

1. Window |Chemical|: select 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).
2. Window |Growth Rate|: input the growth rate in consumption, usually assumed linear across the period of assessment, in % (no IPCC default).
3. Window |Lifetime|: input the lifetime of product, in years.
   Note that: the category of Other applications broadly is divided into emissive and contained applications. Thus, these contained applications are presumed to have lifetimes greater than 2 years, but no IPCC defaults are available.
4. Window |EF_{pm}|: input the EF for manufacturing, based on a percentage of the sales of the chemical in other applications- contained (no IPCC default).
5. Window |EF_{lr}|: input the EF (rate of leakage) of the bank, based on a percentage of the bank of chemicals in other applications- contained (no IPCC default).
6. Window |EF_{disp}|: input the EF for disposal, based on a percentage of the chemical disposed in that year (no IPCC default)
7. Window |EF_{ad}|: input the EF for losses from the decommissioned bank, based on a percentage of the amount of chemical in the decommissioned bank (no IPCC default).
8. Window |UNFCCC confidentiality|: for users reporting to the UNFCCC ETF Reporting Tool, indicate through use of the checkbox if reporting of this gas, in this category, is considered confidential.

Example: **EF/parameter input – contained applications**

Activity Data Input

Section 7.7.2.3 in Chapter 7 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for other contained applications.

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

For each subdivision/application/gas, data are entered in worksheet **Contained Applications – F-Gas Emissions,** row by row, as follows:

1. Column |A|: input the amount of annual sales of F-gas for other contained applications, in tonnes.
   Note that: the user should insert values only for the years known. The Software will interpolate interim years and extrapolate based on the growth rate entered in worksheet ***Contained Applications -F-Gas Parameters****. Insert "0" only if zero is the true value otherwise it impacts the extrapolation.*
2. Column |RD|: input the amount of chemical from other contained applications that is recovered and destroyed at the end of the lifetime, in tonnes (default assumption is zero).
3. Column |RR|: input the amount of chemical from other contained applications that is recovered and recycled at the end of the lifetime, in tonnes (default assumption is zero).

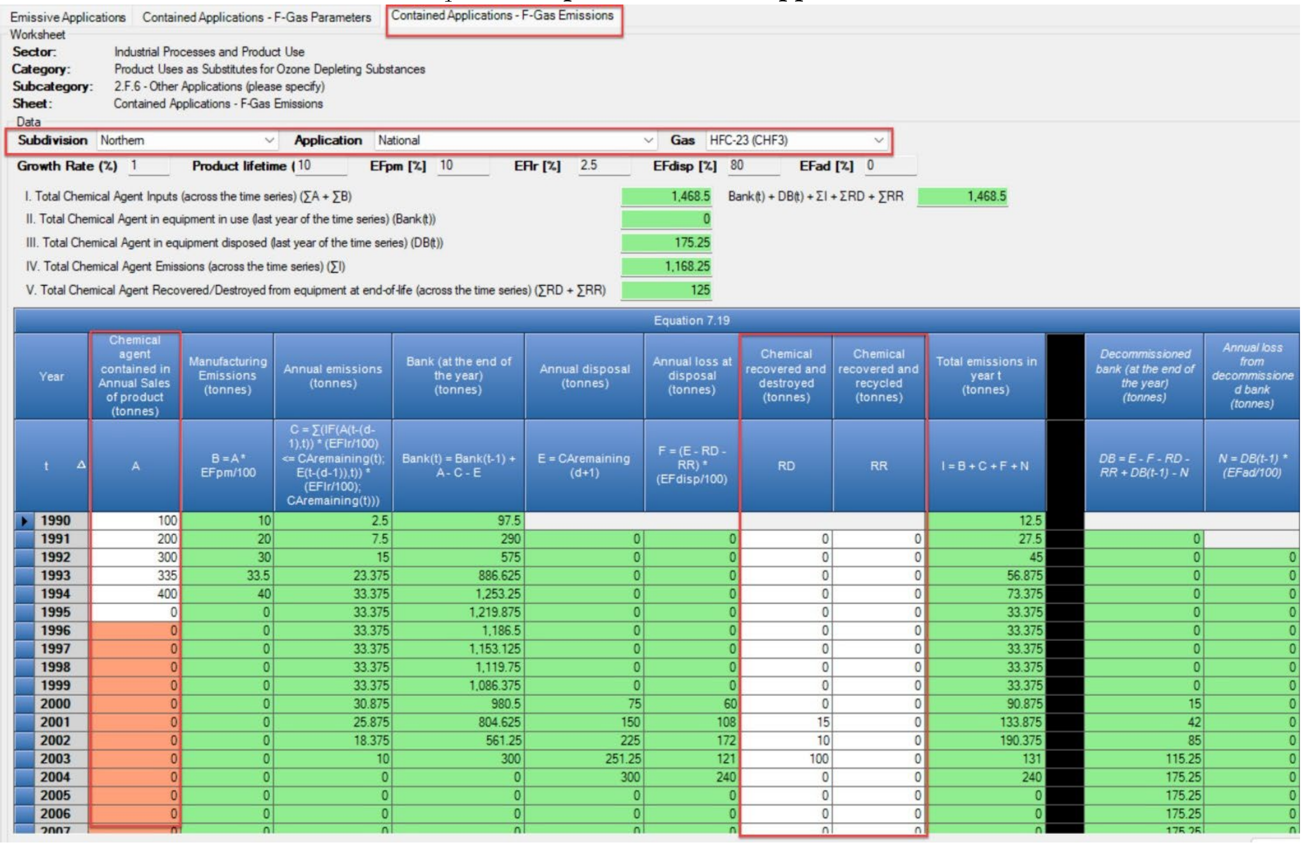
Once known AD are input, the *Software* makes several calculations based on the factors added in the Contained Applications- F-Gas Parameters tab:

4. Column |B|: calculates the amount of chemical agent lost (emitted) during manufacturing, in tonnes.
   Calculated by multiplying the amount of chemical contained in product sold in the year by the manufacturing EF (EFpm) entered in worksheet ***Contained Applications - F-Gas Parameters.***
5. Column |C|: calculates the amount of chemical agent emitted annually from the bank of chemical in contained applications, in tonnes.
   Calculated by multiplying the amount of F-gas in the bank contained applications by the annual leakage rate (EFlr) entered in worksheet ***Contained Applications - F-Gas Parameters.*** *This value is constrained to ensure that annual losses are not greater than the amount of chemical remaining in the product, based on the lifetime entered by the user.*
6. Column |Bank$_{(t)}$|: calculates the bank at the end of the year t, in tonnes.
   Calculated as the amount of chemical agent of the bank from the previous year t-1 plus the amount of chemical sold in products in the current year, minus manufacturing losses and annual losses, and quantity of chemical destroyed, recycled and recovered, in tonnes.
7. Column |E|: calculates the amount of F-gases in contained equipment at the end-of-life, in tonnes.
   Calculated by subtracting from the total chemical agent in the year of sales, the sum of manufacturing losses (EFpm) and annual losses (EFlr) over the course of the lifetime of the product, parameters entered by the user in worksheet ***Contained Applications - F-Gas Parameters****.*
8. Column |F|: calculates the emissions during disposal, in tonnes.
   Calculated as the amount of chemical agent at disposal (less any agent recovered for destruction/recycling) and, multiplied by the EFdisp, as entered by the user. in worksheet ***Contained Applications - F-Gas Parameters****.*
9. Column |DB|: calculates the decommissioned bank as the quantity of F gas/blend that remains in contained applications after decommissioning, and will continue to emit, in tonnes.

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 annual emissions from the decommissioned bank.

10. Column |N|: calculates annual losses 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 **Contained Applications - F-Gas Parameters.***
11. Column |P|: calculates total emissions in year t, in tonnes.
    Calculated as the sum of manufacturing and annual losses, as well as losses during decommissioning and from the decommissioned bank.

Example: **AD input – contained applications**



Emissive Applications | Contained Applications - F-Gas Parameters | Contained Applications - F-Gas Emissions

Worksheet
Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.6 - Other Applications (please specify)
Sheet: Contained Applications - F-Gas Emissions

Data
Subdivision Northern **Application** National **Gas** HFC-23 (CHF3)
Growth Rate (%) 1 **Product lifetime (** 10 **EFpm [%]** 10 **EFlr [%]** 2.5 **EFdisp [%]** 80 **EFad [%]** 0

I. Total Chemical Agent Inputs (across the time series) (∑A + ∑B) 1,468.5 Bank(t) + DB(t) + ∑I + ∑RD + ∑RR 1,468.5
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 0
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t)) 175.25
IV. Total Chemical Agent Emissions (across the time series) (∑I) 1,168.25
V. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (∑RD + ∑RR) 125

Equation 7.19

Year	Chemical agent contained in Annual Sales of product (tonnes)	Manufacturing Emissions (tonnes)	Annual emissions (tonnes)	Bank (at the end of the year) (tonnes)	Annual disposal (tonnes)	Annual loss at disposal (tonnes)	Chemical recovered and destroyed (tonnes)	Chemical recovered and recycled (tonnes)	Total emissions in year t (tonnes)	Decommissioned bank (at the end of the year) (tonnes)	Annual loss from decommissioned bank (tonnes)
t	A	B = A * EFpm/100	C = ∑(IF(A(t-(d-1),t)) * (EFlr/100) <= CAremaining(t); E(t-(d-1)),t)) * (EFlr/100); CAremaining(t)))	Bank(t) = Bank(t-1) + A - C - E	E = CAremaining (d+1)	F = (E - RD - RR) * (EFdisp/100)	RD	RR	I = B + C + F + N	DB = E - F - RD - RR + DB(t-1) - N	N = DB(t-1) * (EFad/100)
1990	100	10	2.5	97.5					12.5		
1991	200	20	7.5	290	0	0	0	0	27.5	0	
1992	300	30	15	575	0	0	0	0	45	0	0
1993	335	33.5	23.375	886.625	0	0	0	0	56.875	0	0
1994	400	40	33.375	1,253.25	0	0	0	0	73.375	0	0
1995	0	0	33.375	1,219.875	0	0	0	0	33.375	0	0
1996	0	0	33.375	1,186.5	0	0	0	0	33.375	0	0
1997	0	0	33.375	1,153.125	0	0	0	0	33.375	0	0
1998	0	0	33.375	1,119.75	0	0	0	0	33.375	0	0
1999	0	0	33.375	1,086.375	0	0	0	0	33.375	0	0
2000	0	0	30.875	980.5	75	60	0	0	90.875	15	0
2001	0	0	25.875	804.625	150	108	15	0	133.875	42	0
2002	0	0	18.375	561.25	225	172	10	0	190.375	85	0
2003	0	0	10	300	251.25	121	100	0	131	115.25	0
2004	0	0	0	0	300	240	0	0	240	175.25	0
2005	0	0	0	0	0	0	0	0	0	175.25	0
2006	0	0	0	0	0	0	0	0	0	175.25	0
2007	0	0	0	0	0	0	0	0	0	175.25	0

<u>Ensuring mass conservation of gases in contained applications</u>

A QA/QC check has been introduced into the worksheets for other applications- contained to ensure that the data, EFs and parameters entered by the users are consistent with 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 ($\sum A + \sum B$)
II. Total chemical agent in equipment in use (last year of the time series) ($Bank_{(t)}$)
III. Total chemical agent in equipment disposed (last year of the time series) ($DB_{(t)}$)
IV. Total chemical agent emissions, across time ($\sum I$)
V. Total chemical agent recovered/destroyed/exported ($\sum RD + \sum RR$)

In the case of worksheet **Contained Applications** - **F-Gas Emissions** conservation of mass means that:

$$\sum A + \sum B = Bank_{(t)} + DB_{(t)} + \sum I + \sum RD + \sum RR$$

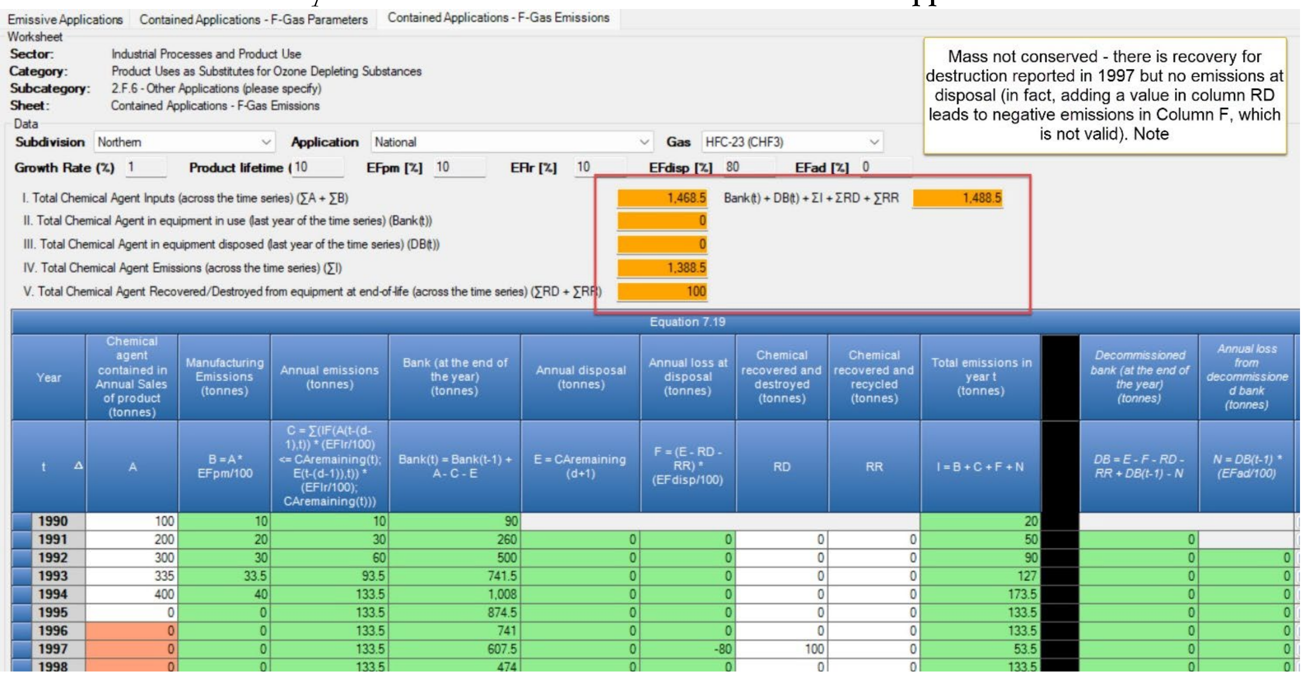
If the total chemical agent in inputs (which includes both the products sold, as well as the manufacturing emissions to fill those products) is equal to the sum of chemical in the current bank and the decommissioned bank, plus emissions across time, plus the amount recovered and recycled/destroyed, then 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.

This check should be considered a guide and is still a work in progress for other applications- contained. It is still possible for the user to insert invalid entries and see a "green" result. The user should check the following:

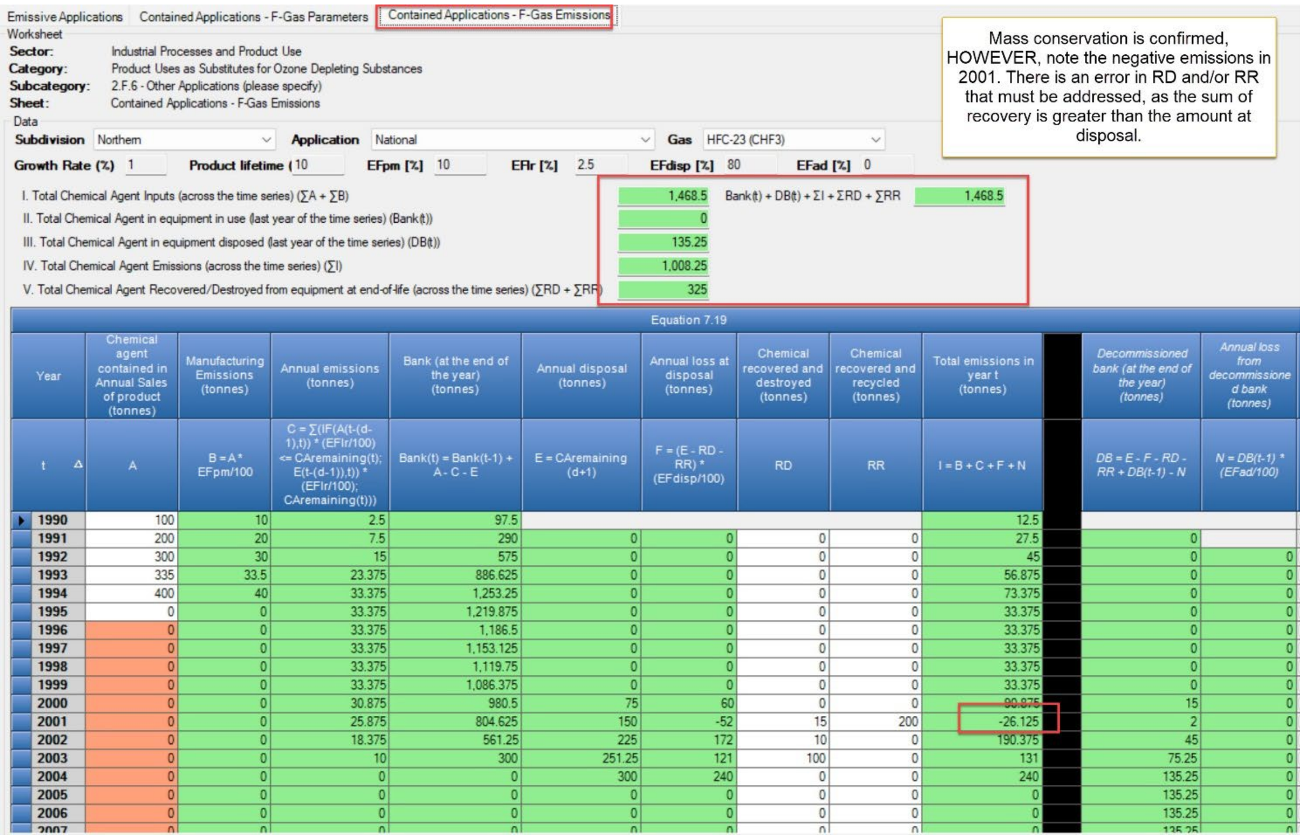
- ✓ Ensure that the sum of RD + RR is less than or equal to chemical agent at disposal (Column E). It is possible to enter data so that the sum of agent destroyed and recycled is greater than the amount disposed, and the system will show as green (mass conserved), but the user will see that there are negative emissions in Column I which his not valid.
- ✓ Ensure that (d * EF_{lr}) is not greater than 100%.
- ✓ A user currently cannot enter a negative value in Column |A| although it is possible that in a given year exports could be greater than imports, causing negative consumption.

Example: **mass conservation not realized – contained applications**



Year	Chemical agent contained in Annual Sales of product (tonnes)	Manufacturing Emissions (tonnes)	Annual emissions (tonnes)	Bank (at the end of the year) (tonnes)	Annual disposal (tonnes)	Annual loss at disposal (tonnes)	Chemical recovered and destroyed (tonnes)	Chemical recovered and recycled (tonnes)	Total emissions in year t (tonnes)	Decommissioned bank (at the end of the year) (tonnes)	Annual loss from decommissioned bank (tonnes)
t	A	B = A * EFpm/100	C = ∑(IF(A(t-(d-1),t)) * (EFlr/100) <= CAremaining(t); E(t-(d-1)),t)) * (EFlr/100); CAremaining(t)))	Bank(t) = Bank(t-1) + A - C - E	E = CAremaining (d+1)	F = (E - RD - RR) * (EFdisp/100)	RD	RR	I = B + C + F + N	DB = E - F - RD - RR + DB(t-1) - N	N = DB(t-1) * (EFad/100)
1990	100	10	10	90					20		
1991	200	20	30	260	0	0	0	0	50	0	
1992	300	30	60	500	0	0	0	0	90	0	0
1993	335	33.5	93.5	741.5	0	0	0	0	127	0	0
1994	400	40	133.5	1,008	0	0	0	0	173.5	0	0
1995	0	0	133.5	874.5	0	0	0	0	133.5	0	0
1996	0	0	133.5	741	0	0	0	0	133.5	0	0
1997	0	0	133.5	607.5	0	-80	100	0	53.5	0	0
1998	0	0	133.5	474	0	0	0	0	133.5	0	0

Example: **mass conservation confirmed – contained applications**



Equation 7.19

Year	Chemical agent contained in Annual Sales of product (tonnes)	Manufacturing Emissions (tonnes)	Annual emissions (tonnes)	Bank (at the end of the year) (tonnes)	Annual disposal (tonnes)	Annual loss at disposal (tonnes)	Chemical recovered and destroyed (tonnes)	Chemical recovered and recycled (tonnes)	Total emissions in year t (tonnes)	Decommissioned bank (at the end of the year) (tonnes)	Annual loss from decommissioned bank (tonnes)
t	A	B = A * EFpm/100	C = ∑(IF(A(t-(d-1),t)) * (EFlr/100) <= CAremaining(t); E(t-(d-1)),t)) * (EFlr/100); CAremaining(t)))	Bank(t) = Bank(t-1) + A - C - E	E = CAremaining (d+1)	F = (E - RD - RR) * (EFdisp/100)	RD	RR	I = B + C + F + N	DB = E - F - RD - RR + DB(t-1) - N	N = DB(t-1) * (EFad/100)
1990	100	10	2.5	97.5					12.5		
1991	200	20	7.5	290	0	0	0	0	27.5	0	
1992	300	30	15	575	0	0	0	0	45	0	0
1993	335	33.5	23.375	886.625	0	0	0	0	56.875	0	0
1994	400	40	33.375	1,253.25	0	0	0	0	73.375	0	0
1995	0	0	33.375	1,219.875	0	0	0	0	33.375	0	0
1996	0	0	33.375	1,186.5	0	0	0	0	33.375	0	0
1997	0	0	33.375	1,153.125	0	0	0	0	33.375	0	0
1998	0	0	33.375	1,119.75	0	0	0	0	33.375	0	0
1999	0	0	33.375	1,086.375	0	0	0	0	33.375	0	0
2000	0	0	30.875	980.5	75	60	0	0	90.875	15	0
2001	0	0	25.875	804.625	150	-52	15	200	-26.125	2	0
2002	0	0	18.375	561.25	225	172	10	0	190.375	45	0
2003	0	0	10	300	251.25	121	100	0	131	75.25	0
2004	0	0	0	0	300	240	0	0	240	135.25	0
2005	0	0	0	0	0	0	0	0	0	135.25	0
2006	0	0	0	0	0	0	0	0	0	135.25	0
2007	0	0	0	0	0	0	0	0	0	135.25	0

Results

Recall that discussion of the results for worksheet **Emissive Applications** is included in section 2.F.4 (Aerosols), 2.F.5 (Solvents) and 2.F.6: (Other Applications - Emissive).

GHG emissions from Other Applications- contained are estimated one row for each year of the time series, in the worksheet **Contained Applications- F-Gas Emissions**. Total F-gas emissions from other applications is the sum of all emissions in the above worksheet, along with any emissions from worksheet **Emissive Applications.**

The user will note that Other Applications 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 – contained applications

Emissive Applications | Contained Applications - F-Gas Parameters | Contained Applications - F-Gas Emissions

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.6 - Other Applications (please specify)
Sheet: Contained Applications - F-Gas Emissions

Data

Subdivision Northern **Application** National **Gas** HFC-23 (CHF3)

Growth Rate (%) 1 **Product lifetime (** 10 **EFpm [%]** 10 **EFlr [%]** 2.5 **EFdisp [%]** 80 **EFad [%]** 0

I. Total Chemical Agent Inputs (across the time series) (∑A + ∑B)	1,468.5	Bank(t) + DB(t) + ΣI + ΣRD + ∑RR	1,468.5
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t))	0		
III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t))	135.25		
IV. Total Chemical Agent Emissions (across the time series) (∑I)	1,008.25		
V. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (∑RD + ∑RR)	325		

Equation 7.19

Year	Chemical agent contained in Annual Sales of product (tonnes)	Manufacturing Emissions (tonnes)	Annual emissions (tonnes)	Bank (at the end of the year) (tonnes)	Annual disposal (tonnes)	Annual loss at disposal (tonnes)	Chemical recovered and destroyed (tonnes)	Chemical recovered and recycled (tonnes)	Total emissions in year t (tonnes)	*Decommissioned bank (at the end of the year) (tonnes)*	*Annual loss from decommissioned bank (tonnes)*
t	A	B = A * EFpm/100	C = ∑(IF(A(t-(d-1),t)) * (EFlr/100) <= CAremaining(t); E(t-(d-1)),t)) * (EFlr/100); CAremaining(t)))	Bank(t) = Bank(t-1) + A - C - E	E = CAremaining (d+1)	F = (E - RD - RR) * (EFdisp/100)	RD	RR	I = B + C + F + N	*DB = E - F - RD - RR + DB(t-1) - N*	*N = DB(t-1) * (EFad/100)*
1990	100	10	2.5	97.5					12.5		
1991	200	20	7.5	290	0	0	0	0	27.5	0	
1992	300	30	15	575	0	0	0	0	45	0	0
1993	335	33.5	23.375	886.625	0	0	0	0	56.875	0	0
1994	400	40	33.375	1,253.25	0	0	0	0	73.375	0	0
1995	0	0	33.375	1,219.875	0	0	0	0	33.375	0	0
1996	0	0	33.375	1,186.5	0	0	0	0	33.375	0	0
1997	0	0	33.375	1,153.125	0	0	0	0	33.375	0	0
1998	0	0	33.375	1,119.75	0	0	0	0	33.375	0	0
1999	0	0	33.375	1,086.375	0	0	0	0	33.375	0	0
2000	0	0	30.875	980.5	75	60	0	0	90.875	15	0
2001	0	0	25.875	804.625	150	-52	15	200	-26.125	2	0
2002	0	0	18.375	561.25	225	172	10	0	190.375	45	0
2003	0	0	10	300	251.25	121	100	0	131	75.25	0
2004	0	0	0	0	300	240	0	0	240	135.25	0
2005	0	0	0	0	0	0	0	0	0	135.25	0
2006	0	0	0	0	0	0	0	0	0	135.25	0
2007	0	0	0	0	0	0	0	0	0	135.25	0

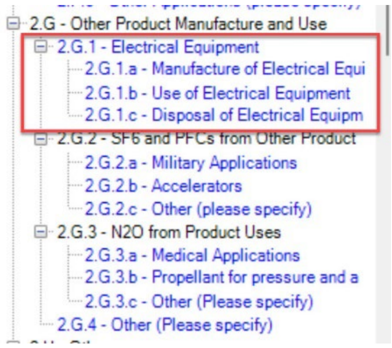
2.G Other Product Manufacture and Use (2.G)

2.G.1 Electrical Equipment

Most of the SF_6 used in electrical equipment is used in gas insulated switchgear and substations and in gas circuit breakers, though some SF_6 is used in high voltage gas-insulated lines, outdoor gas-insulated instrument transformers and other equipment. These applications may be either *Sealed Pressure Systems* (equipment that does not require any refilling/topping up) and which generally contains less than 5 kg of gas per functional unit or *Closed Pressure Systems* (equipment that requires refilling/topping up with gas during its lifetime).

The *Software* divides emissions from Electrical Equipment into three operational steps, and thus sub-categories:

i) **Emissions during manufacturing and installation of electrical equipment (2.G.1.a)**
ii) **Emissions from use of electrical equipment (2.G.1.b)**
iii) **Emissions from disposal (2.G.1.c)**



Guidance for use of the *Software* for each of these subcategories, 2.G.1.a, 2.G.1.b, and 2.G.1.c follows in separate sections below.

In addition, there is one special case of estimating emissions from Electrical Equipment, the Tier 3 utility-level mass-balance approach, which can be entered in the *Software* in category 2.G.1 Electrical Equipment. This approach can be used when there is detailed information at a facility level for the mass balance approach, and in cases where specific criteria are met:

- Emissions during equipment installation, use, and disposal account for 3 percent or more of facility-level gas flows,
- Electrical equipment has been used for 10-20 years or more, and
- Emissions from sealed-pressure equipment are negligible.

Guidance for the **2.G.1 – Tier 3 Utility Level Mass Balance Approach** follows in its own section, after discussion of category 2.G.1.c.

Total Emissions from Electrical Equipment is equal to the sum of estimates in categories 2.G.1, 2.G.1.a, 2.G.1.b and 2.G.1.c.

Section 8.2 in Chapter 8 Volume 3 of the *2006 IPCC* Guidelines provides three tiers for estimating GHG emissions from each life cycle stage of electrical equipment. Tier 1 is based on an EF approach with use of default EFs; Tier 2 applies country-specific EFs to the Tier 1 Equation and Tier 3 is a hybrid approach applied at the facility level and using some combination of a mass balance and/or EF approach for each lifecycle stage.

The pure mass-balance approach is likely to be appropriate for countries where (1) electrical equipment that uses SF_6 has been in use for 10-20 years or more, and (2) emissions from sealed-pressure systems are likely to be negligible. The hybrid approach is likely to be appropriate for other countries.

Important: the ability to use a combination of EF and mass-balance approaches for the various lifecycle stages introduces the possibility of double counting or omission of emissions. Care should be taken by the inventory compiler to ensure accurate accounting. Specific guidance is provided below, where relevant, to assist the user.

2.G.1.a Manufacture of Electrical Equipment

Information

Section 8.2.2.1 of the *2006 IPCC Guidelines* provides three Tiers for estimation of GHG emissions from Manufacture and Installation of Electrical Equipment. The Tier 1 method is based on the use of default EFs, Tier 2 applies the Tier 1 equation but with country-specific EFs, and the Tier 3 method is implemented at the facility level and includes separate equations for each phase of the lifecycle of equipment. The Tier 3 method utilizes either a pure mass-balance approach (Tier 3a) or an EF approach, including a hybrid with the mass balance approach (Tier 3b). According to the *2006 IPCC Guidelines*, the pure mass-balance approach is preferred except where a substantial fraction of a manufacturer's emissions come from processes whose emission rates fall below the precision of the measurements required for the mass-balance approach (e.g., 3 percent of nameplate capacity per year or less). The hybrid method requires that users separate the gas flows associated with equipment for which the mass-balance approach will be used from the gas flows associated with equipment for which the EF approach will be used.

Category 2.G.1.a includes emissions from manufacturing and installation, and recycling, if applicable at these facilities. Emissions from use and disposal of electrical equipment are accounted for in sub-categories 2.G.1.b and 2.G.1.c, respectively.

GHGs

The *Software* includes the following GHGs for the Manufacture of Electrical Equipment source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

GHG emissions from the Manufacture of Electrical Equipment source category are estimated by applying the following IPCC equations (noting that "manufacturing and installation" may only be sub-sets of an equation):

- ✓ Tier 1: Equation 8.1
- ✓ Tier 2: Same equation as Tier 1
  Note that: Equation 8.2 in a Tier 2 Equation, but is calculated under category 2.G.1.c.
- ✓ Tier 3: Equations 8.3, 8.4a (pure mass balance for manufacturing), 8.4b (hybrid mass balance and EF approach for manufacturing), 8.5a (pure mass balance for installation), 8.5b (hybrid mass balance and EF approach for installation) and Equation 8.8 (if recycling is accounted here in 2.G.1.a).

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 F-gases from the **Manufacture of Electrical Equipment** source category, using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Emissions from Electrical Equipment:** contains for each F-gas, subdivision and type of electrical equipment, information on the total consumption of F-gas by equipment manufactures and manufacturing EF as well as on total nameplate capacity of new equipment installed and an installation EF. The worksheet calculates the associated F-gas emissions for Tier 1 (with default EFs) and Tier 2 (with country-specific EFs).
- ✓ **Manufacturing Emissions – Mass Balance Approach – Tier 3 (1/3):** contains for each F-gas, subdivision (i.e. facility) and each type of equipment information on the change in the F-gas inventory, and acquisitions and disbursements of F-gases. The worksheet calculates the associated F-gas emissions for Tier 3 manufacturing.

- ✓ **Installation Emissions – Mass Balance Approach – Tier 3 (2/3):** contains for each F-gas, subdivision (i.e. facility) and each type of equipment, information on the amount of F-gas used to fill the electrical equipment and the total nameplate capacity of new equipment installed. The worksheet calculates the associated F-gas emissions for Tier 3 installation.
- ✓ **Total Emissions – Mass Balance Approach – Tier 3 (3/3):** is a technical table totalling the manufacturing and installation emissions estimated using the mass-balance approach.
- ✓ **Manufacturing Emissions – EF Approach – Tier 3 (1/4):** contains for each F-gas, subdivision (i.e. facility) and type of equipment, information on the total nameplate capacity of new equipment and the manufacturing EF. The worksheet calculates the associated F-gas emissions for Tier 3 manufacturing.
- ✓ **Installation Emissions – EF Approach – Tier 3 (2/4):** contains for each F-gas, subdivision (i.e. facility) and type of equipment, information on total nameplate capacity of new equipment filled onsite and the installation EF. The worksheet calculates the associated F-gas emissions for Tier 3 installation.
- ✓ **Recycling Emissions – EF Approach – Tier 3 (3/4):** contains for each F-gas, subdivision (i.e. facility) and type of equipment, information on the quantity of F-gas fed into the recycling process and a recycling EF. The worksheet calculates the associated F-gas emissions for Tier 3 recycling emissions.
- ✓ **Total Emissions – EF Approach – Tier 3 (4/4):** it is a technical table totalling the manufacturing, installation and recycling emissions using the EF approach.

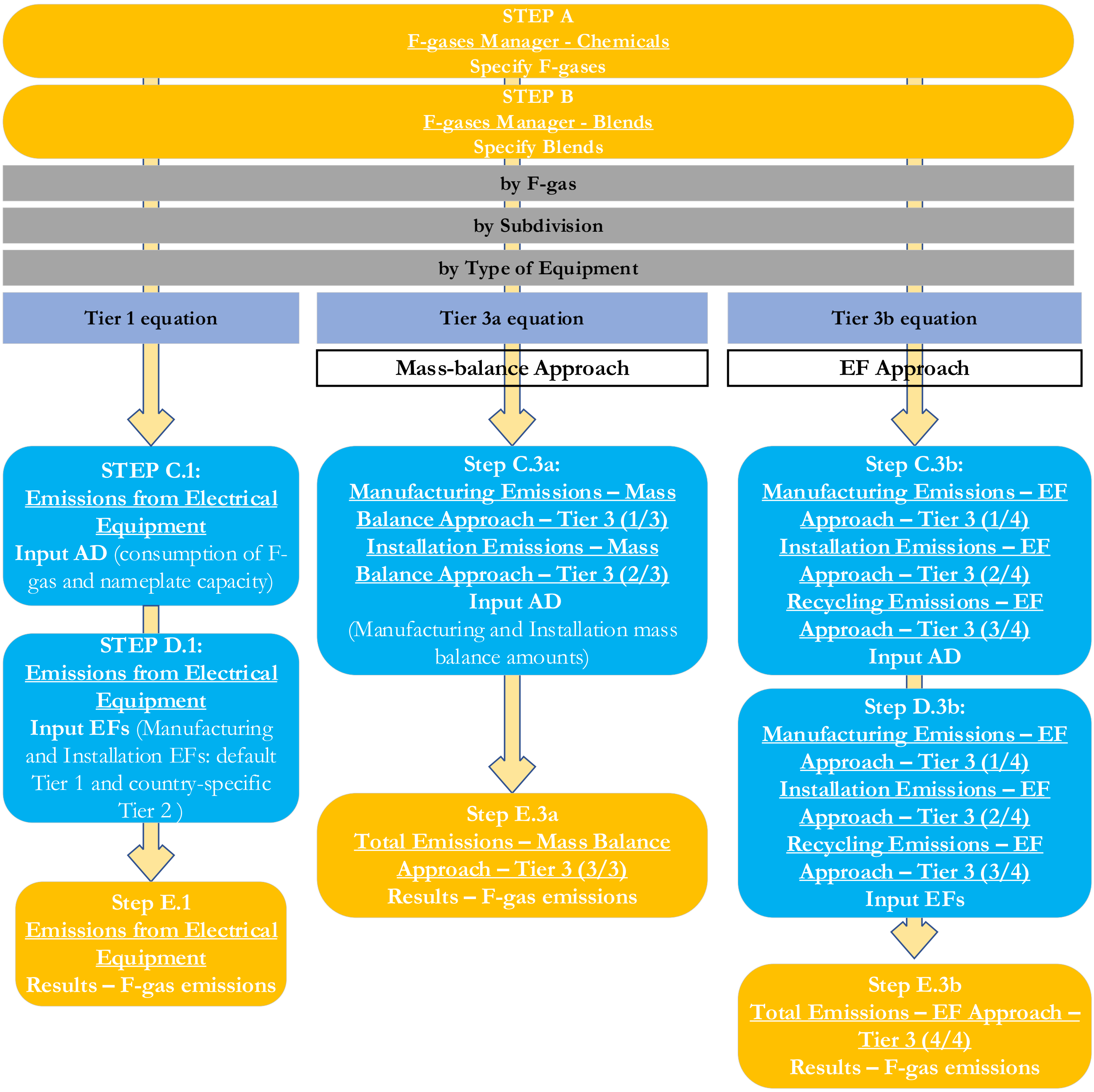
User's Work Flowchart

For Manufacture of Electrical Equipment, consistent with the key category analysis and the decision tree in Figure 8.1 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[53] 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 Manufacture of Electrical Equipment.

[53] 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.

Manufacture of Electrical Equipment- flowchart



Thus, for the source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends 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 C.1, in worksheet **Emissions from Electrical Equipment,** for each F-gas, subdivision and type of electrical equipment users collect and input in the *Software* information on the total consumption of F-gas by equipment manufactures and total nameplate capacity of newly installed equipment onsite (not at the factory).

Step D.1, in worksheet **Emissions from Electrical Equipment**, for each F-gas, subdivision and type of electrical equipment users input respective manufacturing and installation EFs (default EFs for Tier 1, country-specific for Tier 2).

Step E.1, in worksheet **Emissions from Electrical Equipment**, the *Software* calculates the associated emissions in mass units (metric tonne and Gg) for each F-gas.

When the Tier 3 Equations are applied:

Mass Balance Approach

Step C.3a, for each F-gas, subdivision (i.e. facility) and each type of equipment users collect and input in the *Software*, in worksheet **Manufacturing Emissions – Mass Balance Approach – Tier 3 (1/3),** information on the change in the F-gas inventory, and acquisitions and disbursements of F-gases, and in worksheet **Installation Emissions – Mass Balance Approach – Tier 3 (2/3)** information on F-gases used to fill the electrical equipment and total nameplate capacity of newly installed equipment.

Step E.3a, in the worksheet **Total Emissions – Mass Balance Approach – Tier 3 (3/3)**, the *Software* totals the associated manufacturing and installation emissions estimated with a mass-balance approach in mass units (metric tonne and Gg) for each F-gas.

EF Approach

Step C.3b, for each F-gas, subdivision (i.e. facility) and each type of equipment users collect and input in the *Software*, in worksheet **Manufacturing Emissions – EF Approach – Tier 3 (1/4),** the total nameplate capacity of new equipment manufactured, in worksheet **Installation Emissions – EF Approach – Tier 3 (2/4)** total nameplate capacity of new equipment filled onsite, and worksheet **Recycling Emissions – EF Approach – Tier 3 (3/4)**, the quantity of F-gas fed into the recycling process.

Step D.3b, in the worksheets **Manufacturing Emissions – EF Approach – Tier 3 (1/4), Installation Emissions – EF Approach – Tier 3 (2/4)** and **Recycling Emissions – EF Approach – Tier 3 (3/4)**, for each F-gas, subdivision (i.e. facility) and each type of equipment users collect and input in the *Software* the respective manufacturing, installation and recycling EFs (plant-/company-specific).

Step E.3b, in the worksheet **Total Emissions – EF Approach – Tier 3 (4/4)**, the *Software* totals the associated manufacturing, installation and recycling emissions estimated with the EF approach in mass units (metric tonne and Gg) for each F-gas.

Activity Data Input

Section 8.2.2.3 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for the Manufacture of Electrical Equipment. Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

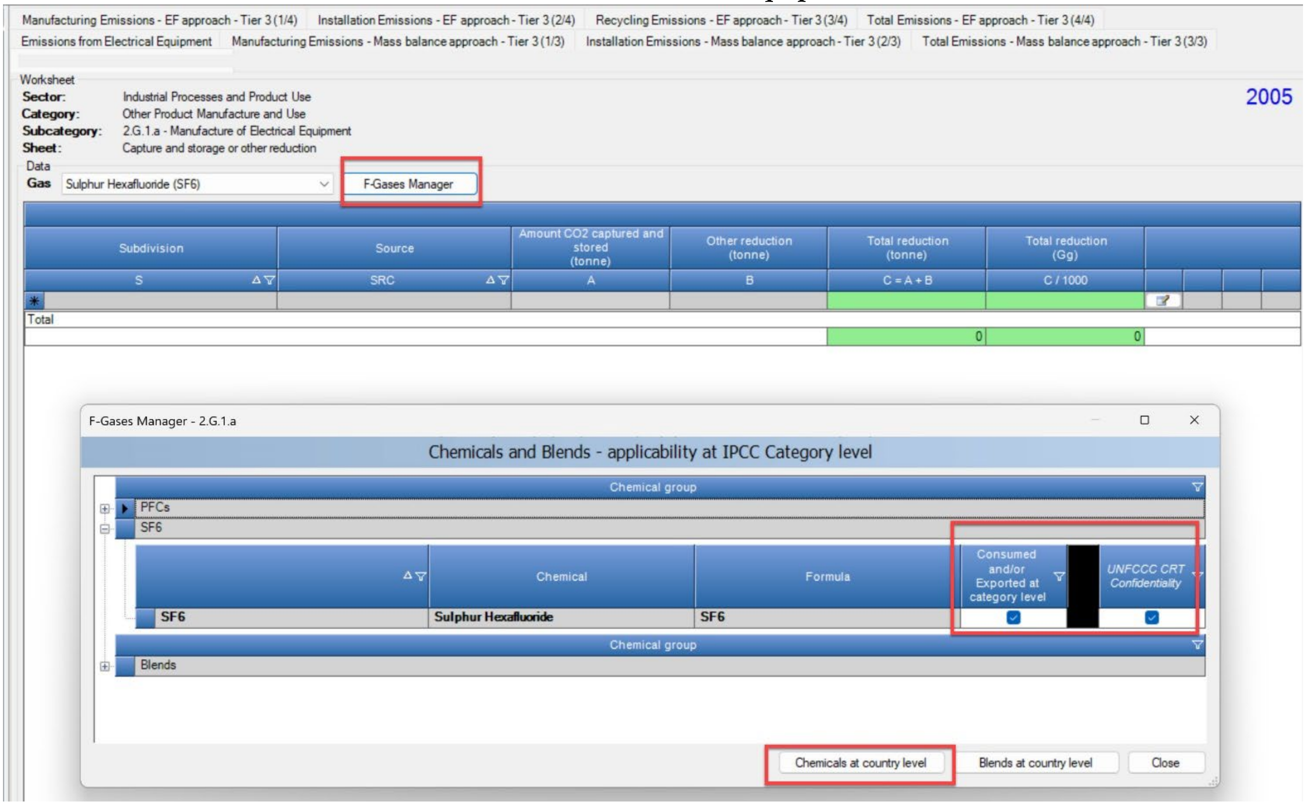
As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category **Manufacture of Electrical Equipment**.

Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the ***F-Gases***

Manager *in any worksheet for this category. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. 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 manufacture and/or installation of electrical equipment. For more information, refer to populating the F-Gases Manager, in the section above.*

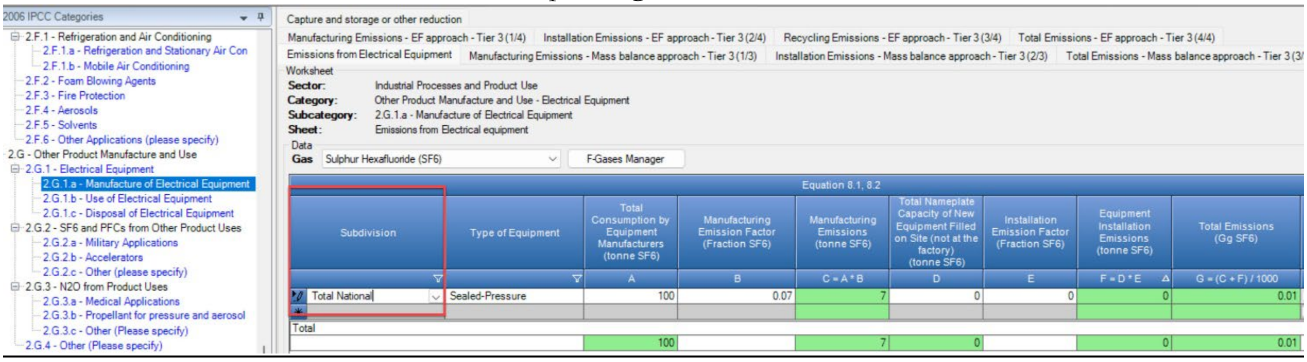
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the 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: manufacture of electrical equipment**

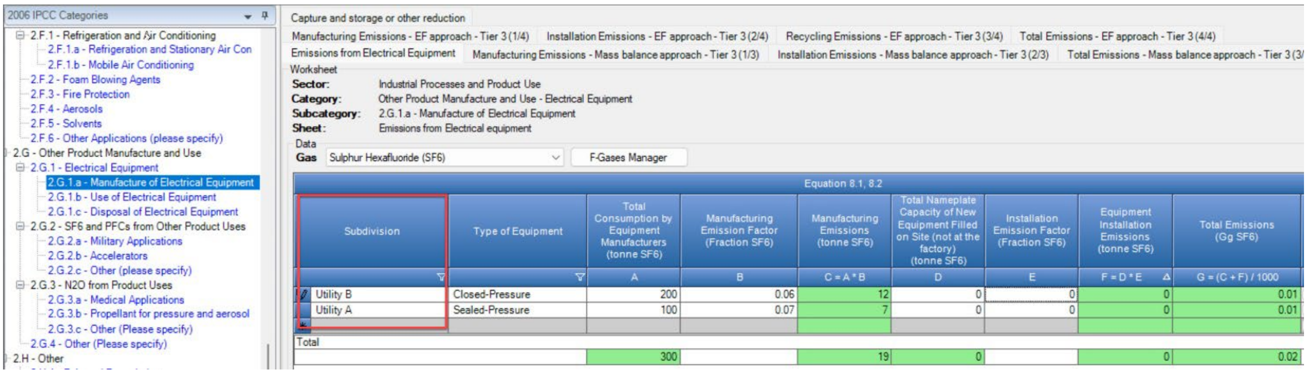


Second, for all Tiers and all worksheets, input of AD for the manufacture and installation of electrical equipment requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Example: **single subdivision**



Example: **multiple subdivisions**

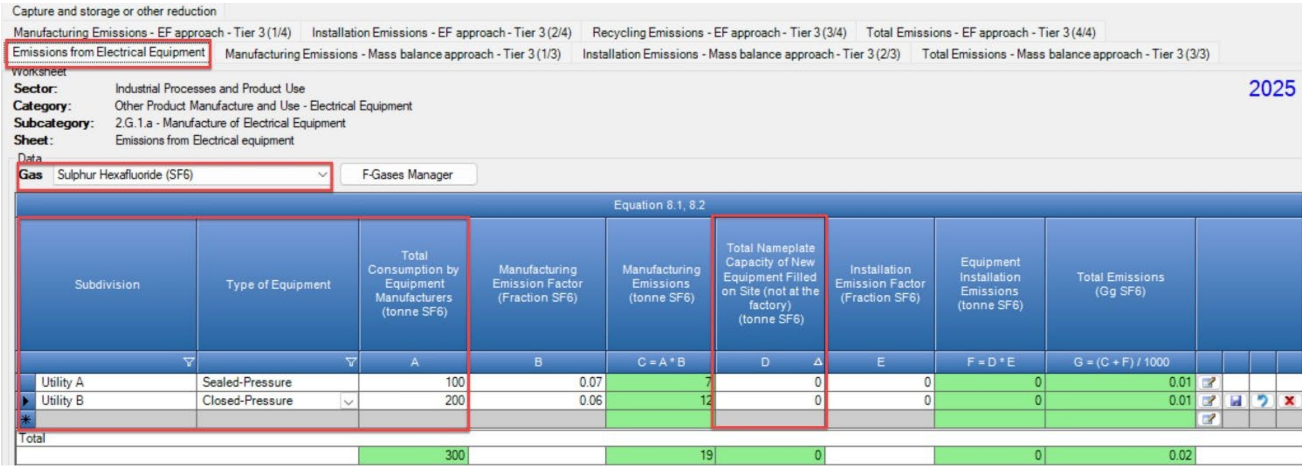


When the Tier 1 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u> and each chemical agent, data are input in worksheet **Emissions from Electrical Equipment,** row by row, as follows:

1. <u>Column |Type of equipment|</u>: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. <u>Column |A|</u>: input the total consumption of F-gas by manufactures of electrical equipment in tonnes of each F-gas.
4. <u>Column |D|</u>: input the total nameplate capacity of newly equipment installed (filled on site and not in the factory), in tonnes of each F-gas.
   <u>Note that:</u> nameplate capacity can be estimated based on information from equipment manufacturers/importers (nameplate capacity of imported equipment should be included, exported equipment excluded), information from utilities on the nameplate capacity of equipment installed each year, or if the first two pieces of information are not available, information from chemical manufactures/importers on their sales of gas to equipment manufacturers.

Example: **AD input for manufacturing emissions – Tier 1 and Tier 2**



Subdivision	Type of Equipment	Total Consumption by Equipment Manufacturers (tonne SF6)	Manufacturing Emission Factor (Fraction SF6)	Manufacturing Emissions (tonne SF6)	Total Nameplate Capacity of New Equipment Filled on Site (not at the factory) (tonne SF6)	Installation Emission Factor (Fraction SF6)	Equipment Installation Emissions (tonne SF6)	Total Emissions (Gg SF6)
		A	B	C = A * B	D	E	F = D * E	G = (C + F) / 1000
Utility A	Sealed-Pressure	100	0.07	7	0	0	0	0.01
Utility B	Closed-Pressure	200	0.06	12	0	0	0	0.01
Total		300		19	0		0	0.02

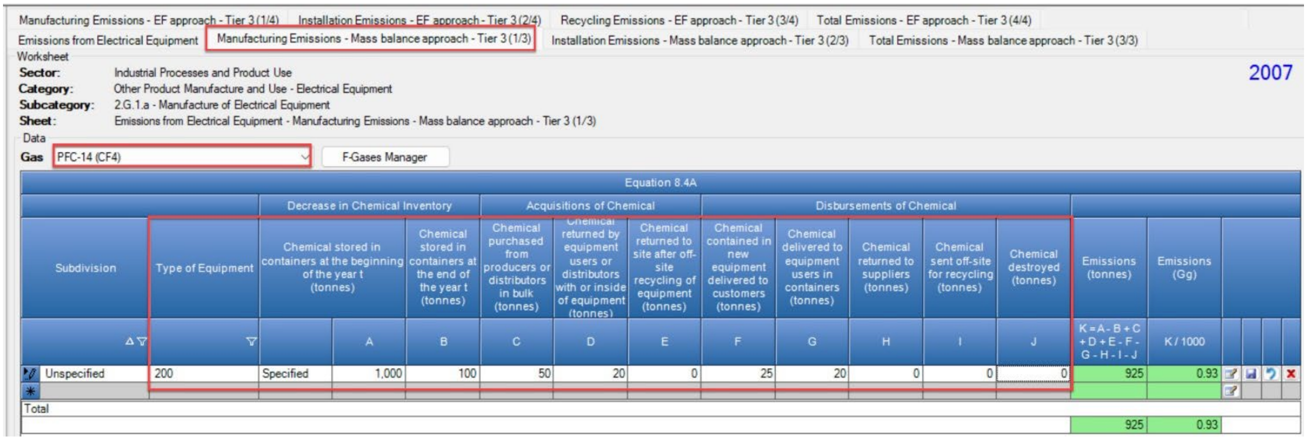
When the Tier 3 Equations are applied:

Tier 3(a) Mass-balance:

To estimate **emissions from manufacturing**, for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent, data are input in worksheet **Manufacturing Emissions – Mass Balance Approach – Tier 3 (1/3)** row by row, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: select whether the amount of F-gas stored in containers at equipment manufacturers at the beginning of the year is "calculated" (automatically taken from the value in Column |B| from the previous year) or "specified" (directly entered), in tonnes.
3. Column |B|: input the amount of F-gas stored in containers at equipment manufacturers?? at the end of the year, in tonnes.
4. Column |C|: input the amount of F-gas purchased by equipment manufacturers from chemical producers or distributors in bulk, in tonnes.
5. Column |D|: input the amount of F-gas returned by equipment users or distributors to equipment manufacturers with or inside of equipment, in tonnes.
6. Column |E|: input the amount of F-gas returned to site of equipment manufacturers after off-site recycling of equipment, in tonnes.
7. Column |F|: input F-gas from the equipment manufacturers that is contained in new equipment delivered to customers, in tonnes.
8. Column |G|: input F-gas from the equipment manufacturers delivered to equipment users in containers, in tonnes.
9. Column |H|: input the amount of F-gas from the equipment manufacturers returned to suppliers, in tonnes.
10. Column |I|: input the amount of F-gas from the equipment manufacturers sent off-site for recycling, in tonnes.
11. Column |J|: input the amount of F-gas destroyed by the equipment manufacturers, in tonnes.

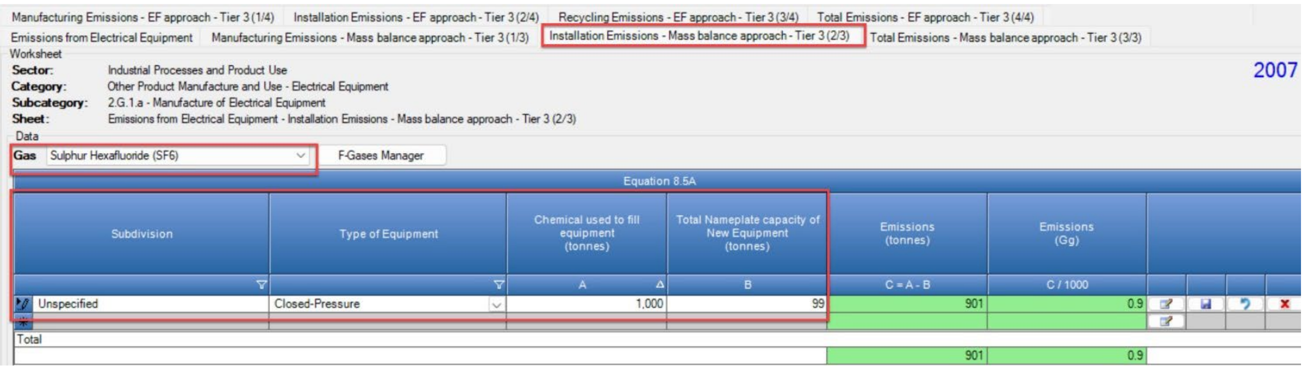
Example: **AD input for manufacturing emissions – Tier 3 mass-balance**



To estimate **emissions from installation**, for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent, data are input in worksheet **Installation Emissions – Mass Balance Approach – Tier 3 (2/3)** row by row, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: input the amount of F-gas used to fill new equipment onsite, in tonnes.
3. Column |B|: input the total nameplate capacity of new equipment that is installed and filled onsite, in tonnes.

Example: **AD input for installation emissions – Tier 3 mass-balance**



Tier 3(b) EF/Hybrid approach:

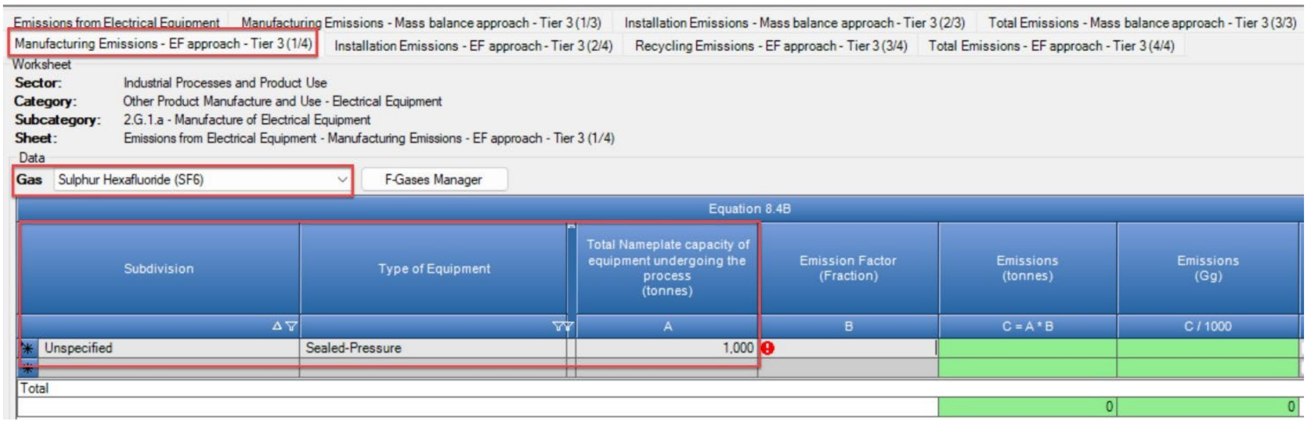
The pure mass-balance approach is preferred except where a substantial fraction of a manufacturer's emissions come from processes whose emission rates fall below the precision of the measurements required for the mass-balance approach (e.g., 3 percent of nameplate capacity per year or less). In these cases, it is good practice to use EFs to estimate emissions from the processes with very low emission rates and to use the mass balance approach to estimate emissions from the other manufacturing processes.

Please note that if a Tier 3b Hybrid approach is used (i.e. mass balance for some processes and EF for other processes) this requires that manufacturers separate the gas flows associated with processes for which the mass-balance approach is used (Tier 3a) from the gas flows associated with processes for which the EF approach is used (Tier 3b).

To estimate **emissions from manufacturing**, for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent, AD are input in worksheet **Manufacturing Emissions – EF Approach – Tier 3 (1/4)** row by row, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: input the total nameplate capacity of newly manufactured equipment, in tonnes.

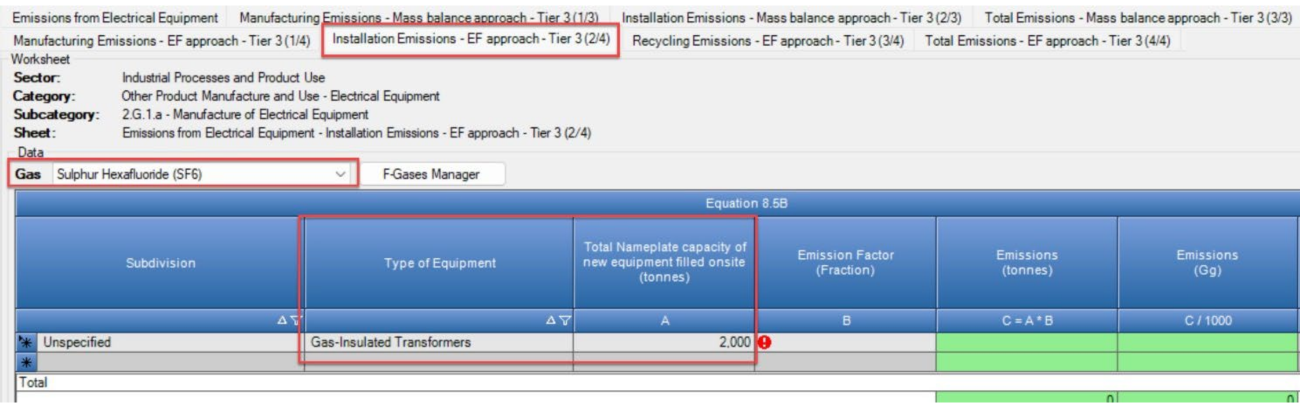
Example: **AD input manufacturing emissions – EF approach – Tier 3b**



Then, if there is newly manufactured equipment filled onsite (not by the manufacturer), **emissions from installation** can be estimated for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent in worksheet **Installation Emissions – EF Approach – Tier 3 (2/4)** row by row, as follows

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: input the total nameplate capacity of newly manufactured equipment that is not filled in the factory, but onsite, in tonnes.
   Note that: installation emissions may not always occur, for example depending on the EF used for manufacturing, these emissions may have already been estimated. The user should be careful to avoid double counting.

Example: **AD input for installation emissions – EF approach – Tier 3**

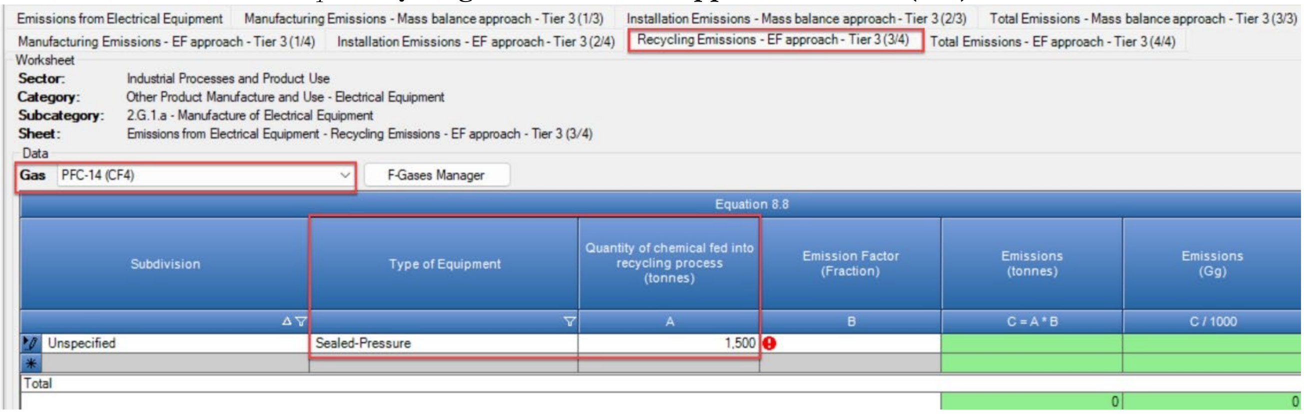


Then, if the manufacturer undertakes **recycling of gas**, these emissions can be estimated for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent in worksheet **Recycling Emissions – EF Approach – Tier 3 (3/4)** row by row, as follows

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).

2. Column |A|: input the quantity of chemical fed into the recycling process by manufacturers, in tonnes.

Example: **recycling emissions – EF approach – Tier 3 (3/4)**



Emission Factor Input

Section 8.2.2.2 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Manufacture of Electrical Equipment. There are three sets of default Tier 1 EFs for Manufacturing Emissions:

i) Sealed-pressure electrical equipment containing SF_6 (Table 8.2)
ii) Closed-pressure electrical equipment (Table 8.3)
iii) Gas-insulated transformers (Table 8.4)

Note that: it is important to review the footnotes to these tables regarding the coverage of EFs. For example, the default values from Japan are intended to be applied to all equipment types, including sealed pressure systems, closed pressure systems, and gas-insulated transformers. Further, installation emissions may be included in the EF for emissions from manufacturing.

The Tier 3(b) Hybrid/EF approach also provides guidance for the inclusion of recycling emissions, if applicable, with the use of a recycling EF. Emissions from recycling are generally expected to be small — on the order of less than one percent of the total quantity fed into the recycling process. However, these emissions may be higher if state-of-the art handling equipment and practices are not used.

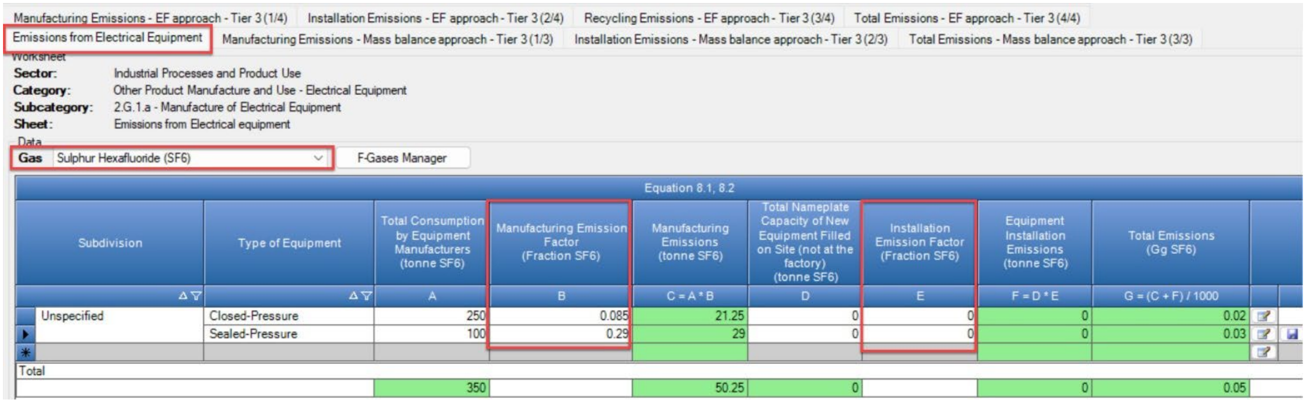
As for reporting category, in most cases recycling is expected to occur on the site of the equipment manufacturer (2.G.1.a) or user (2.G.1.b). In other cases, recycling may take place at a centralised recycling facility that is not associated with a chemical producer (2.G.1.c). Finally, recycling may take place on the premises of a chemical producer (2.B.9). Recycling emissions from chemical producers will be accounted for under chemical production (2.B.9) and should not be included here in source category 2.G.1.

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, and each gas, EF data are input in worksheet **Emissions from Electrical Equipment,** row by row as follows:

1. Column |B|: Input an appropriate default EF for manufacturing as contained in Tables 8.2-8.4, or input manually a country-specific EF (as a fraction of total consumption of the gas by equipment manufacturers).
2. Column |E|: If appropriate, input a country-specific EF for installation of equipment that is not charged in the factory (as a fraction of total consumption of the gas during installation onsite).
   Note that a separate default EF is not available for installation in Tables 8.2-8.4, as installation emissions are assumed to be included in the manufacturing or use EFs.

Example: **EF input for manufacturing and installation emissions**



When Tier 3 Equations are applied:

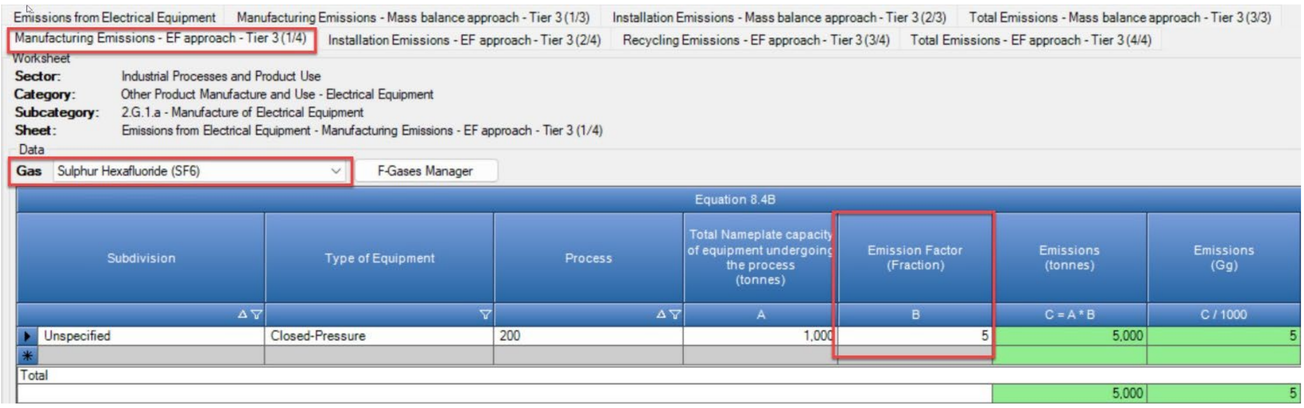
Tier 3(a) Mass balance approach

The Tier 3a mass balance approach does not rely on the use of EFs.

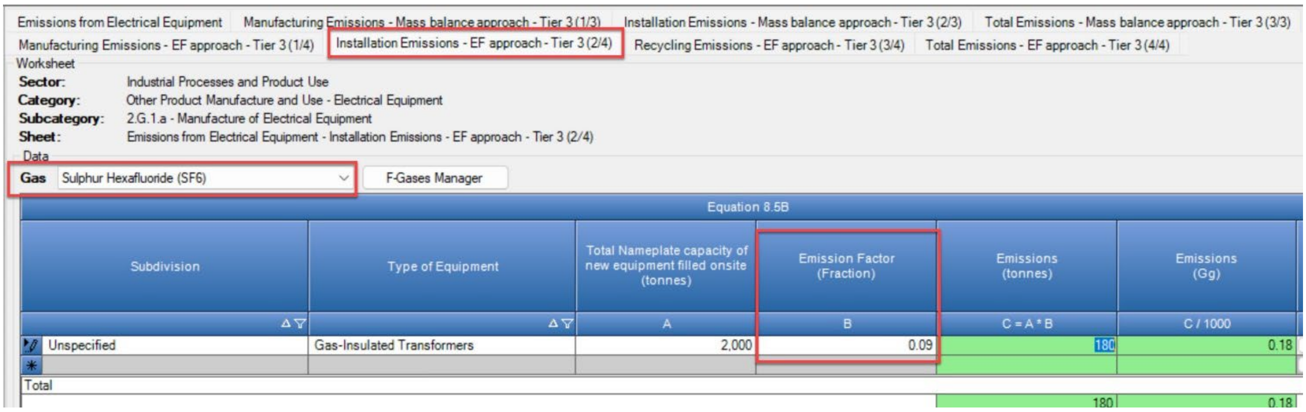
Tier 3(b) EF/Hybrid approach:

The Tier 3b method requires the user to enter facility-specific EFs for manufacturing, installation, and as appropriate recycling, for each subdivision in Column |Subdivision|, and each gas, in Column |B| of worksheets **Manufacturing Emissions – EF Approach – Tier 3 (1/4), Installation Emissions – EF Approach – Tier 3 (2/4)** and **Recycling Emissions – EF Approach – Tier 3 (3/4)**, respectively.

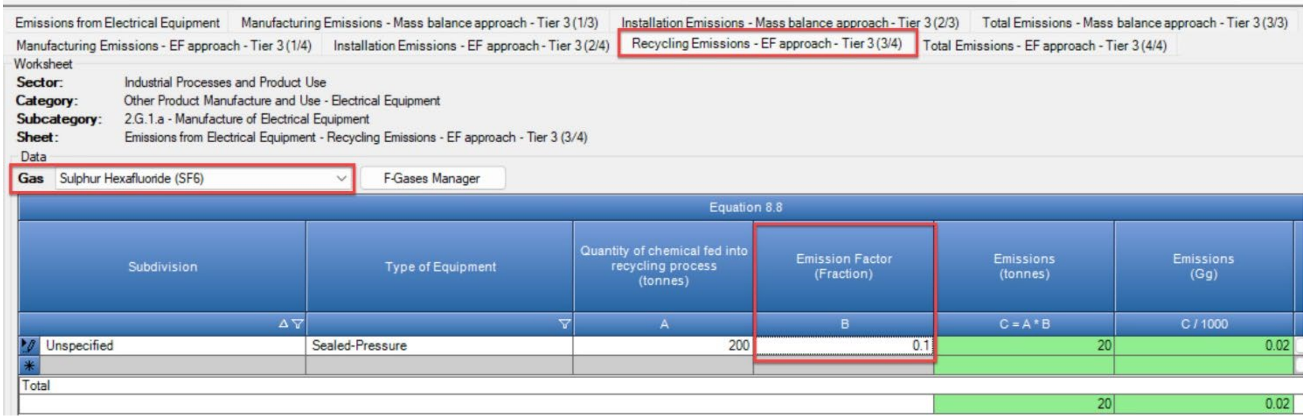
Example: **EF input manufacturing emissions – EF approach – Tier 3 (1/4)**



Example: **EF input for installation emissions – EF approach – Tier 3 (2/4)**



Example: **EF input for recycling emissions – EF approach – Tier 3 (3/4)**



Results

The *Software* follows the *2006 IPCC Guidelines* and allows users to differentiate and report emissions from Manufacture of Electrical Equipment in the following manner:

- use different Tiers (Tier 1, Tier 2, Tier 3 (a) and Tier 3 (b));
- differentiate or split mass-balance estimates and EF estimates by lifecycle stage;
- have flexibility to estimate and report emissions from recycling under manufacturing when the recycling is undertaken by the equipment manufacturers.

F-gas emissions from Manufacture of Electrical Equipment are reported in mass units (metric tonnes and Gg) of each F-gas in the following three worksheets:

✓ **Emissions from Electrical Equipment**
✓ **Total Emissions – Mass Balance Approach – Tier 3 (3/3)**
✓ **Total Emissions – EF Approach – Tier 3 (4/4)**

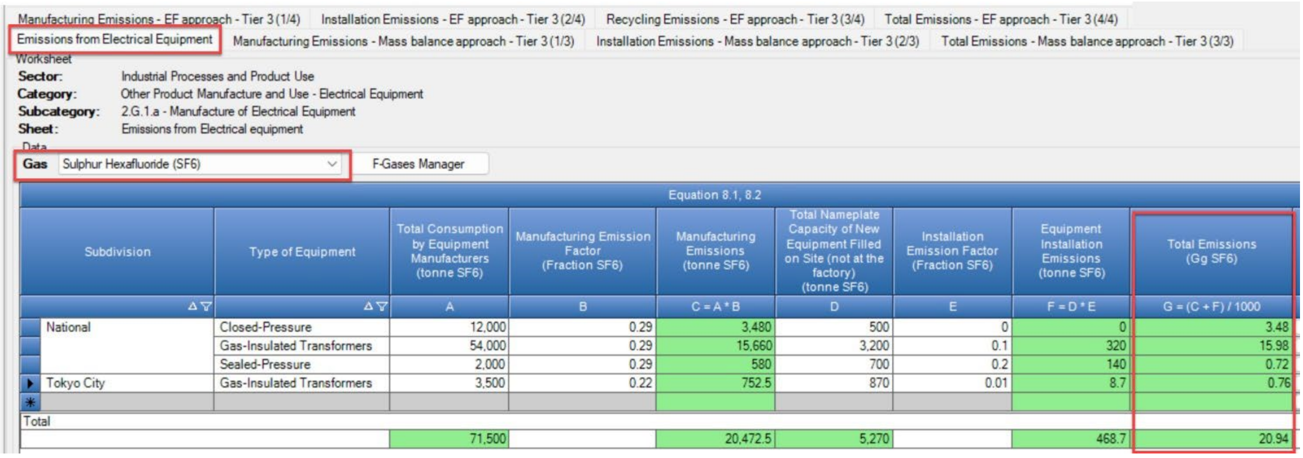
Total F-gas emissions from manufacturing of electrical equipment is the sum of all emissions in the above worksheets. In the example below, the *Software* estimated emissions for the national level and the sub-national level (Tokyo city) and also for two main electrical companies (Company ELEQ and Company EMPEXO), by gas. All four sub-divisions estimate F-gas emissions separately using different methods, as follows:

i) Subdivision national = national emissions with Tier 1 default EFs
ii) Subdivision - Tokyo city with Tier 2 country specific EFs (Tier 2 approach, see Tokyo city, but can be national level as well with country specific EFs)

iii) Company ELEQ - company emissions with Tier 3(a) mass-balance approach (company level – Tier 3(a))

iv) Company EMPEXO - company emissions with Tier 3(b) EF approach (company level – Tier 3(b))

Example: **results of Tier 1/2 emissions**



Manufacturing Emissions - EF approach - Tier 3 (1/4) | Installation Emissions - EF approach - Tier 3 (2/4) | Recycling Emissions - EF approach - Tier 3 (3/4) | Total Emissions - EF approach - Tier 3 (4/4)

Emissions from Electrical Equipment | Manufacturing Emissions - Mass balance approach - Tier 3 (1/3) | Installation Emissions - Mass balance approach - Tier 3 (2/3) | Total Emissions - Mass balance approach - Tier 3 (3/3)

Worksheet

Sector: Industrial Processes and Product Use

Category: Other Product Manufacture and Use - Electrical Equipment

Subcategory: 2.G.1.a - Manufacture of Electrical Equipment

Sheet: Emissions from Electrical equipment

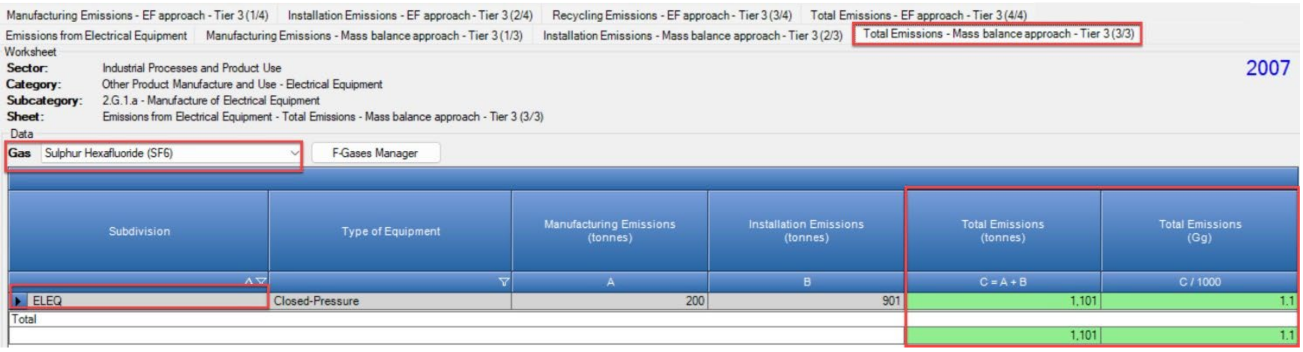
Data

Gas Sulphur Hexafluoride (SF6) | F-Gases Manager

Equation 8.1, 8.2

Subdivision	Type of Equipment	Total Consumption by Equipment Manufacturers (tonne SF6)	Manufacturing Emission Factor (Fraction SF6)	Manufacturing Emissions (tonne SF6)	Total Nameplate Capacity of New Equipment Filled on Site (not at the factory) (tonne SF6)	Installation Emission Factor (Fraction SF6)	Equipment Installation Emissions (tonne SF6)	Total Emissions (Gg SF6)
		A	B	C = A * B	D	E	F = D * E	G = (C + F) / 1000
National	Closed-Pressure	12,000	0.29	3,480	500	0	0	3.48
	Gas-Insulated Transformers	54,000	0.29	15,660	3,200	0.1	320	15.98
	Sealed-Pressure	2,000	0.29	580	700	0.2	140	0.72
Tokyo City	Gas-Insulated Transformers	3,500	0.22	752.5	870	0.01	8.7	0.76
Total		71,500		20,472.5	5,270		468.7	20.94

Example: **results of Tier 3(a) emissions – mass-balance**



Manufacturing Emissions - EF approach - Tier 3 (1/4) | Installation Emissions - EF approach - Tier 3 (2/4) | Recycling Emissions - EF approach - Tier 3 (3/4) | Total Emissions - EF approach - Tier 3 (4/4)

Emissions from Electrical Equipment | Manufacturing Emissions - Mass balance approach - Tier 3 (1/3) | Installation Emissions - Mass balance approach - Tier 3 (2/3) | Total Emissions - Mass balance approach - Tier 3 (3/3)

Worksheet

2007

Sector: Industrial Processes and Product Use

Category: Other Product Manufacture and Use - Electrical Equipment

Subcategory: 2.G.1.a - Manufacture of Electrical Equipment

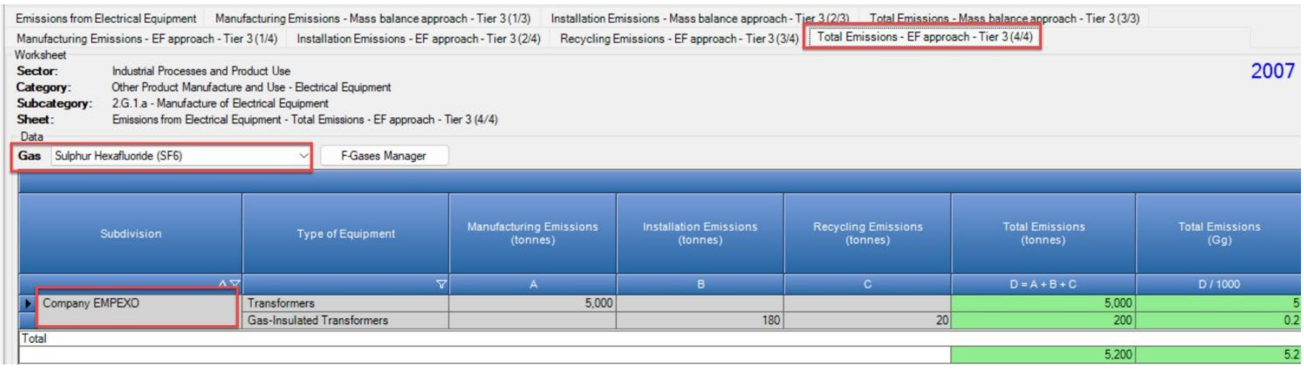
Sheet: Emissions from Electrical Equipment - Total Emissions - Mass balance approach - Tier 3 (3/3)

Data

Gas Sulphur Hexafluoride (SF6) | F-Gases Manager

Subdivision	Type of Equipment	Manufacturing Emissions (tonnes)	Installation Emissions (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)
		A	B	C = A + B	C / 1000
ELEQ	Closed-Pressure	200	901	1,101	1.1
Total				1,101	1.1

Example: **results of Tier 3(b) emissions – EF approach**



Emissions from Electrical Equipment | Manufacturing Emissions - Mass balance approach - Tier 3 (1/3) | Installation Emissions - Mass balance approach - Tier 3 (2/3) | Total Emissions - Mass balance approach - Tier 3 (3/3)

Manufacturing Emissions - EF approach - Tier 3 (1/4) | Installation Emissions - EF approach - Tier 3 (2/4) | Recycling Emissions - EF approach - Tier 3 (3/4) | Total Emissions - EF approach - Tier 3 (4/4)

Worksheet

2007

Sector: Industrial Processes and Product Use

Category: Other Product Manufacture and Use - Electrical Equipment

Subcategory: 2.G.1.a - Manufacture of Electrical Equipment

Sheet: Emissions from Electrical Equipment - Total Emissions - EF approach - Tier 3 (4/4)

Data

Gas Sulphur Hexafluoride (SF6) | F-Gases Manager

Subdivision	Type of Equipment	Manufacturing Emissions (tonnes)	Installation Emissions (tonnes)	Recycling Emissions (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)
		A	B	C	D = A + B + C	D / 1000
Company EMPEXO	Transformers	5,000			5,000	5
	Gas-Insulated Transformers		180	20	200	0.2
Total					5,200	5.2

2.G.1.b Use of Electrical Equipment

Information

Section 8.2.2.1 of the *2006 IPCC Guidelines* provide three Tiers for estimation of GHG emissions from Use of Electrical Equipment: The Tier 1 method is based on the use of default EFs, Tier 2 applies the Tier 1 equation but with country-specific EFs, and the Tier 3 method is implemented at the facility level and includes separate equations for each phase of the lifecycle of equipment, including use of the electrical equipment. The Tier 3 method utilizes either a pure mass-balance approach (Tier 3a) or an EF approach, including a hybrid with the mass balance approach (Tier 3b). The pure mass-balance approach is likely to be appropriate for countries where (1) electrical equipment that uses SF_6 has been in use for 10-20 years or more, and (2) emissions from sealed-pressure systems are likely to be negligible. The hybrid approach is likely to be appropriate for other countries. The hybrid method requires that users separate the gas flows associated with equipment for which the mass-balance approach will be used from the gas flows associated with equipment for which the EF approach will be used.

Category 2.G.1.b includes emissions from use of electrical equipment. Emissions from manufacturing and installation, and disposal of electrical equipment are accounted for in sub-categories 2.G.1.a and 2.G.1.c, respectively.

GHGs

The *Software* includes the following GHGs for the Use of Electrical Equipment source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

GHG emissions from the Use of Electrical Equipment source category are estimated by applying the following IPCC equations (noting that the "use" may only be a sub-set of an equation):

- ✓ Tier 1: Equation 8.1
- ✓ Tier 2: Same equation as Tier 1
  Note that: Equation 8.2 in a Tier 2 Equation, but is calculated under category 2.G.1.c.
- ✓ Tier 3: Equations 8.3, 8.6a (pure mass balance), 8.6b (hybrid mass balance and EF approach) and 8.11 (equation to estimate retiring nameplate capacity)

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 F-gases from the **Use of Electrical Equipment** source category, using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Emissions from Electrical Equipment:** contains for each F-gas, subdivision and each type of equipment information on the total nameplate capacity of installed equipment and the EF from use. The worksheet calculates the associated F-gas emissions for Tier 1 (with default EF) and Tier 2 (with country-specific EFs) and Tier 2 (with country-specific EFs).
- ✓ **Mass Balance Approach – Tier 3:** contains for each F-gas, subdivision (a facility level) and each type of equipment information on the amount of F-gas used to recharge closed pressure equipment at servicing and the amount of F-gas recovered from closed pressure equipment at servicing. The worksheet calculates the associated F-gas emissions for Tier 3a.

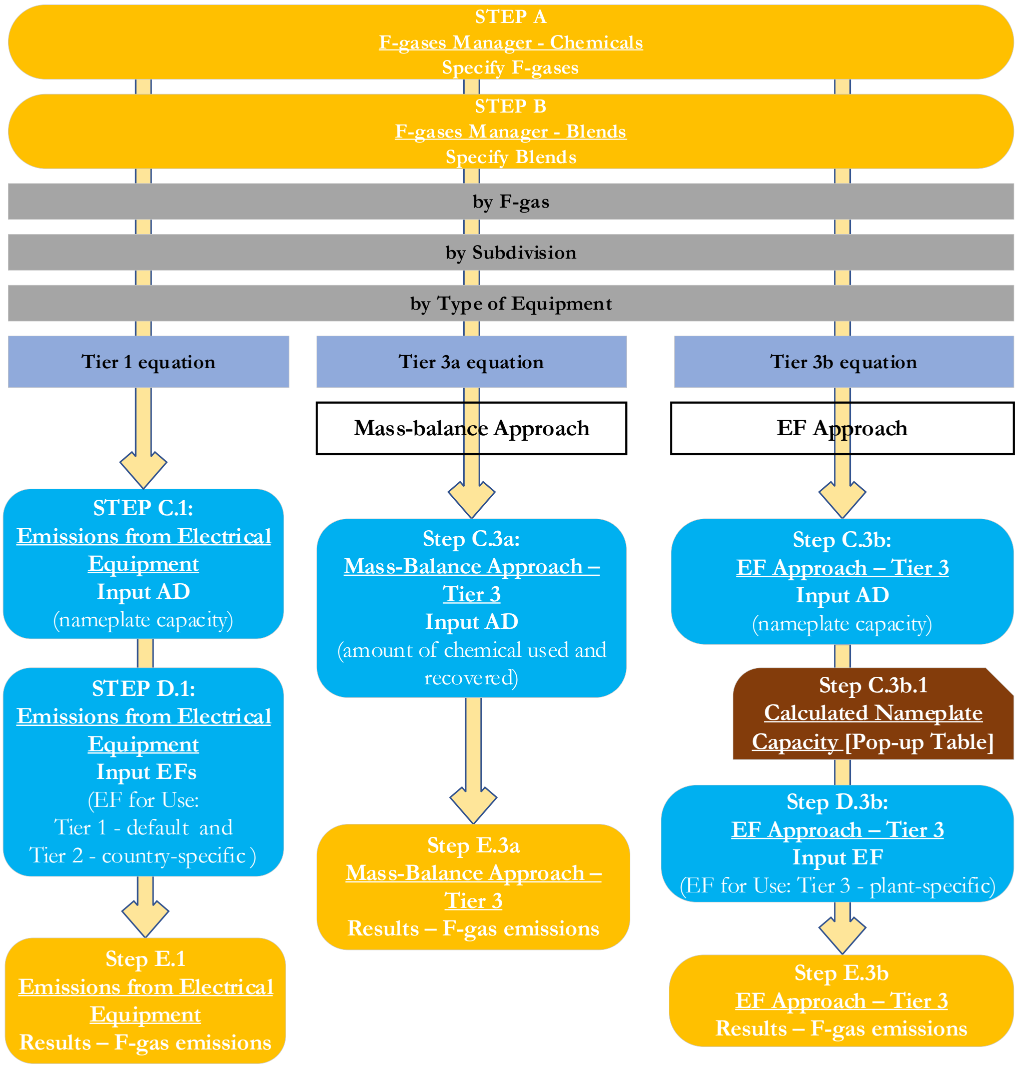
- ✓ **EF Approach – Tier 3:** contains for each F-gas, subdivision (a facility level) and type of equipment information on the total nameplate capacity of installed equipment and an EF from use. The worksheet calculates the associated F-gas emissions for Tier 3b.

User's Work Flowchart

For Use of Electrical Equipment, consistent with the key category analysis and the decision tree in Figure 8.1 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[54] 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 Use of Electrical Equipment.

Use of Electrical Equipment- flowchart



54 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 source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends 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 C.1, in worksheet **Emissions from Electrical Equipment,** for each F-gas, subdivision and type of electrical equipment users collect and input in the *Software* information on the total nameplate capacity of all installed equipment.

Step D.1, in worksheet **Emissions from Electrical Equipment**, for each F-gas, subdivision and type of electrical equipment users input a use EF (default EFs for Tier 1, country-specific for Tier 2).

Step E.1, in worksheet **Emissions from Electrical Equipment**, the *Software* calculates the associated emissions in mass units (metric tonne and Gg) for each F-gas.

When the Tier 3 Equations are applied:

Mass Balance Approach

Step C.3a, for each F-gas, subdivision (i.e. facility) and each type of equipment users collect and input in the *Software*, in worksheet **Mass Balance Approach – Tier 3**, information on the amount of F-gas used to recharge closed pressure equipment at servicing and the amount of F-gas recovered from closed pressure equipment at servicing, in metric tonnes of F-gas.

Step E.3a, in worksheet **Mass Balance Approach – Tier 3**, the *Software* calculates the associated emissions for each facility in mass units (metric tonne and Gg) for each F-gas.

EF Approach

Step C.3b, in worksheet **EF Approach – Tier 3**, for each F-gas, subdivision (i.e. facility) and type of equipment users collect and input in the *Software* information on the total nameplate capacity of installed equipment (either specified or calculated using the pop-up table **(Step C.3b.1)**), in metric tonnes of F-gas.

Step D.3b, in worksheet **EF Approach – Tier 3**, for each F-gas, subdivision (i.e. facility) and type of equipment users collect and input in the *Software* the respective EF from use as fraction of the total nameplate capacity of installed equipment.

Step E.3b, in worksheet **EF Approach – Tier 3**, for the flows using the EF approach the *Software* calculates the associated emissions in mass units (metric tonne and Gg) for each F-gas.

Activity Data Input

Section 8.2.2.3 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for the Use of Electrical Equipment. Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category **Use of Electrical Equipment**.

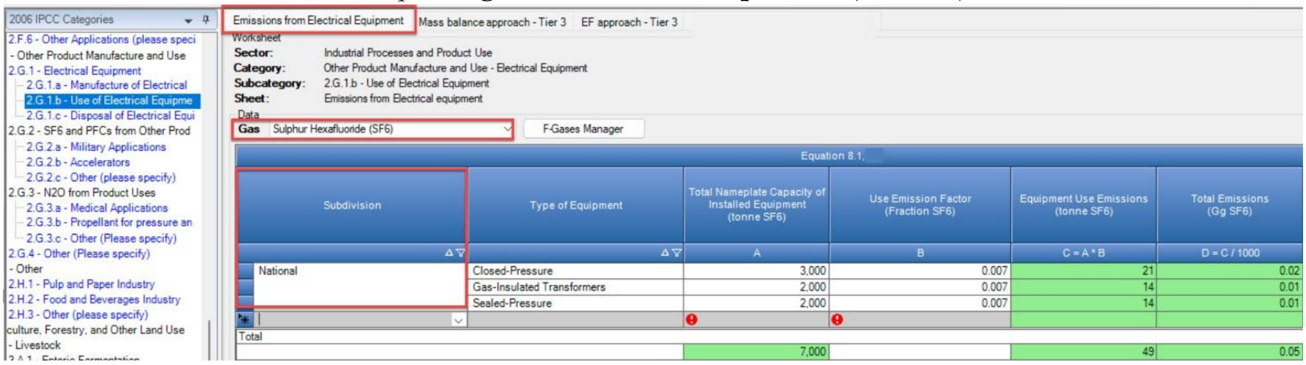
Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the ***F-Gases Manager*** *in any worksheet for this category. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source* *category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. 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 manufacture and/or installation of electrical equipment. For more information, refer to populating the F-Gases Manager, in the section above.*

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.

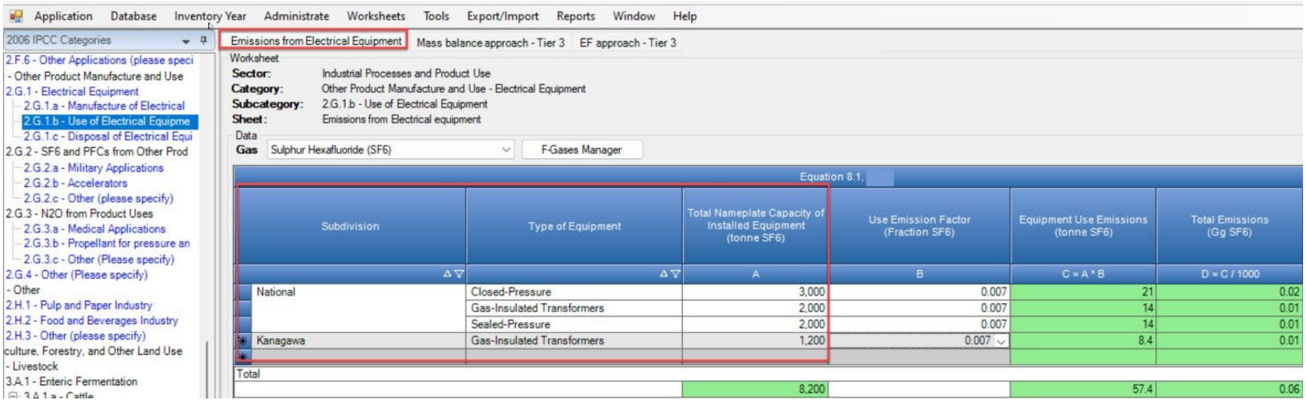
The procedure for populating the F-gases Manager is the same as for category 2.G.1.a Manufacture of Electrical Equipment (refer to Populating the F-gases manager and designating confidentiality for category: Manufacture of Electrical Equipment).

Second, for all Tiers and all worksheets, input of AD for the use of electrical equipment 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

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



Example: **multiple subdivisions: emissions from use of electrical equipment - Tier 1/2 AD input**



When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision| and each chemical agent, data are input in worksheet **Emissions from Electrical Equipment,** row by row, to estimate GHG emissions from use of electrical equipment, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: input the total nameplate capacity of all currently installed equipment in operation, in tonnes of each F-gas.

   Note that: nameplate capacity can be estimated based on information from equipment manufacturers/importers (nameplate capacity of imported equipment *should be included, exported equipment excluded), information from utilities on the nameplate capacity of equipment installed each year, or if the first two pieces of information are not available, information from chemical manufactures/importers on their sales of gas to equipment manufacturers. If data from equipment manufacturers is used, it should include data on sales over the full lifetime of the equipment (30 to 40 years).*

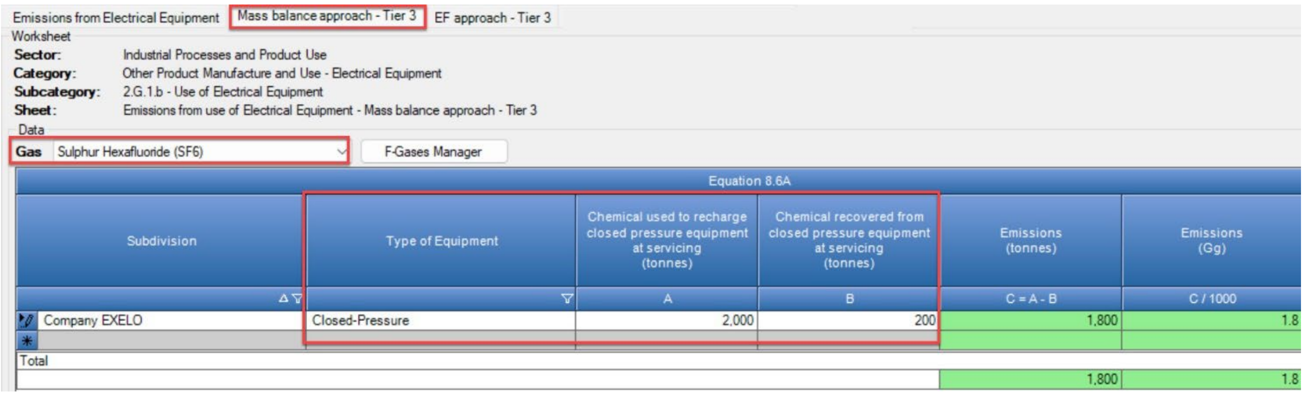
When Tier 3 equations are applied:

Tier 3(a) Mass-balance:

To estimate emissions from use of electrical equipment, for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent, data are input in worksheet **Mass Balance Approach – Tier 3** row by row, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: input the amount of F-gas used to recharge closed pressure equipment at servicing, in tonnes.
3. Column |B|: input the amount of F-gas recovered from closed pressure equipment at servicing, in tonnes.

Example: **AD input for emissions from use of electrical equipment – mass-balance – Tier 3**



Tier 3 (b) EF/Hybrid approach:

Recall that the pure mass-balance approach is likely to be appropriate for countries where (1) electrical equipment that uses SF_6 has been in use for 10-20 years or more, and (2) emissions from sealed-pressure systems are likely to be negligible. The hybrid approach is likely to be appropriate for other countries.

Again, the Hybrid approach requires that users separate the gas flows associated with equipment for which the mass-balance approach will be used from the gas flows associated with equipment for which the EF approach will be used, see the worksheets presented below.

To estimate emissions from use of electrical equipment, for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent, AD are input in worksheet **EF Approach – Tier 3** row by row, as follows:

1. Column |A|: input the total nameplate capacity of installed equipment, in tonnes. In Column |A| there is a drop-down menu for two options:
   a. *Specified:* input country-specific AD on the total nameplate capacity of installed equipment manually, in tonnes.
   Note that the total installed capacity reflects the total equipment in operation, considering the lifetime of that equipment.
   b. *Calculated:* the *Software* estimates the total nameplate capacity of installed electrical equipment for the given subdivision/type of equipment, based on information entered in the pop-up table.

i. Column |Intro Year|: input the year of introduction of that type of equipment in that subdivision.
Note that the year of introduction should be set to the first year of the inventory time series minus the lifetime, or the actual year of introduction, whichever is later. The year of introduction will impact the accumulated amount of chemical agent in the installed bank, so it is important to set an appropriate year.

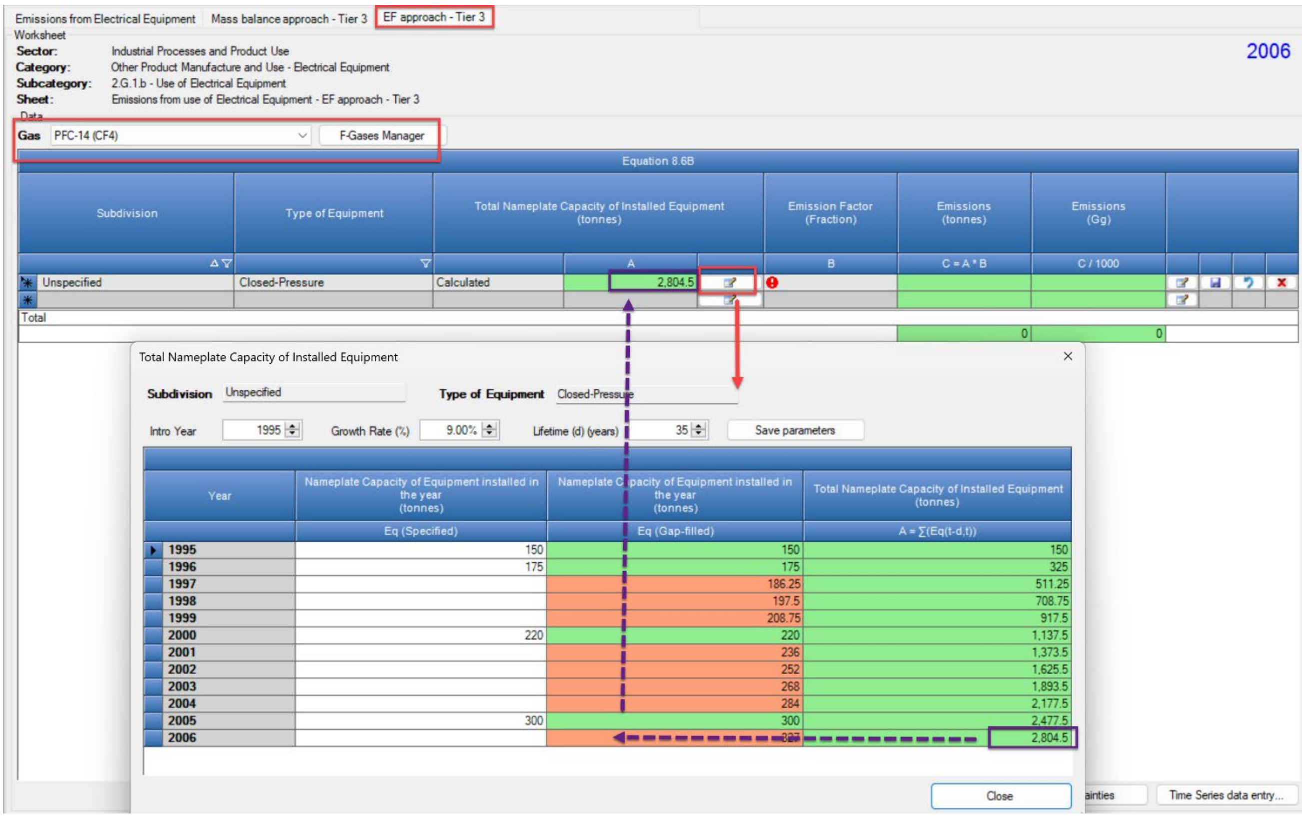
ii. Column |Growth Rate|: input the growth rate of installed equipment, in per cent. Growth rate of equipment is entered to calculate the bank of installed equipment in the case country-specific data are not available and extrapolation to complete the time series is needed.
Note that: in the absence of country-specific information, an IPCC default factor of 9% may be used.

iii. Column |Lifetime (d)|: input the lifetime of installed equipment in that subdivision, in years.
Note that: the 2006 IPCC Guidelines do not provide a "default" but note a range of more than 30 to 40 years.

iv. Column |Eq (specified)|: input the nameplate capacity of equipment installed for each known year back either to the year of introduction of that equipment in that subdivision, or the current inventory year minus the lifetime (d), whichever is more recent.
Note that: enter only data for known years in Column |Eq (specified)|. The Software will interpolate / extrapolate (based on growth rate) unknown years. Do not enter 0 for unknown years, as the Software will include the 0 as a real number in the calculation for the interpolation/extrapolation. Enter 0 when that is the appropriate value to ensure that the bank of installed equipment does not extrapolate backwards or forwards into perpetuity; it is important to ensure that correct year of introduction, and use of "0" when in fact installation is zero, to ensure proper development of the bank.

Based on the parameters entered, and user-specific data entered in Column |Eq (specified)|, the *Software* will gap-fill interim years and calculate the total nameplate capacity of installed equipment for the inventory year. This value will be populated in Column |A|.

Example: **AD input from use of electrical equipment – EF approach – Tier 3**



Emission Factor Input

Section 8.2.2.2 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Use of Electrical Equipment. There are three sets of default Tier 1 EFs for Use Emissions:

i) Sealed-pressure electrical equipment containing SF_6 (Table 8.2)
ii) Closed-pressure electrical equipment (Table 8.3)
iii) Gas-insulated transformers (Table 8.4)

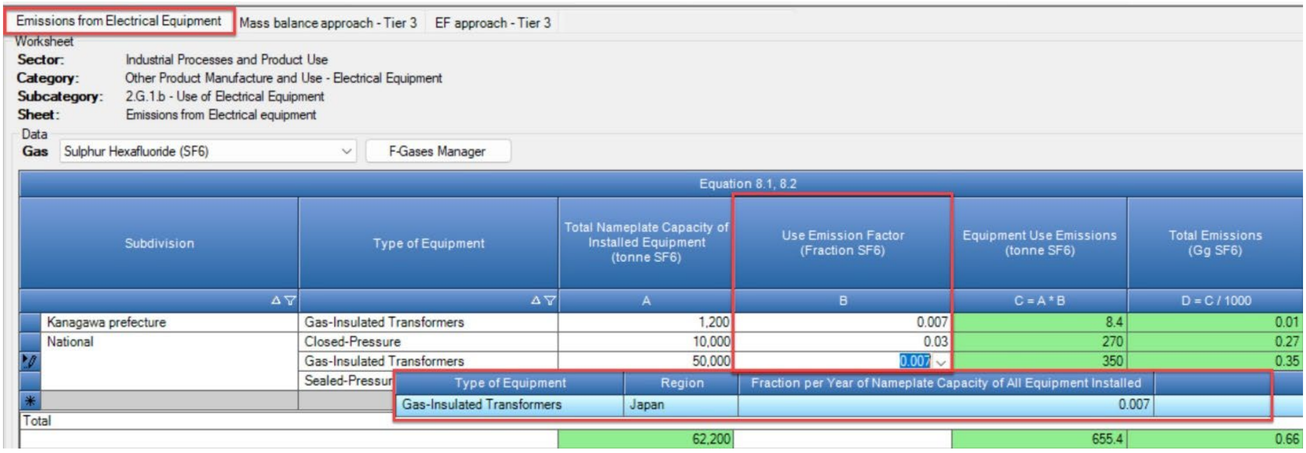
Note that: it is important to review the footnotes to these tables regarding the coverage of EFs. For example, the default values from Japan are intended to be applied to all equipment types, including sealed pressure systems, closed pressure systems, and gas-insulated transformers. Further, installation emissions may be included in the EF for emissions from use.

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, and each gas, EF data are input in worksheet **Emissions from Electrical Equipment,** row by row as follows:

1. Column |B|: Select the appropriate EF from the drop-down menu or from Tables 8.2-8.4, or input manually a country-specific EF (as a fraction of total nameplate capacity of installed equipment).

Example: **EF input for emissions from use of electrical equipment**



When Tier 3 Equations are applied:

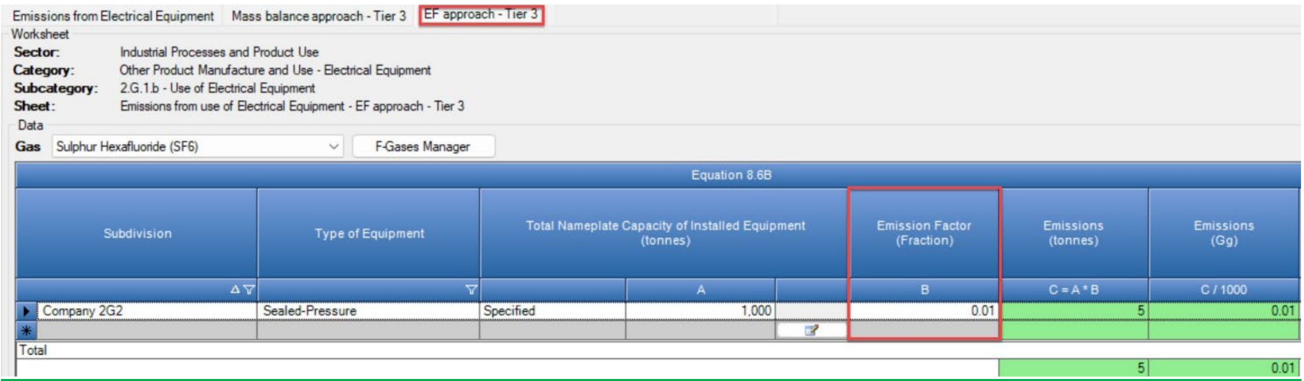
Tier 3(a) Mass balance approach

The Tier 3a mass balance approach does not rely on the use of EFs.

Tier 3(b) EF/Hybrid approach:

The Tier 3b method requires to input facility-specific EFs for use for each gas and each subdivision in Column |Subdivision|, in Column |B| of worksheet **EF Approach – Tier 3.** The EF is entered as a fraction of total nameplate capacity of installed equipment.

Example: **EF input emissions from use of electrical equipment – EF approach – Tier 3b**



Results

The *Software* follows the *2006 IPCC Guidelines* and allows users to differentiate and report emissions from Use of Electrical Equipment in the following manner:

- use different Tiers (Tier 1, Tier 2, Tier 3 (a) and Tier 3 (b))
- differentiate or split mass-balance estimates and EF estimates by lifecycle stage
- have flexibility to estimate and report emissions from recycling under use when the recycling is undertaken by the equipment users.

F-gas emissions from Use of Electrical Equipment are reported in mass units (metric tonnes and Gg) of each F-gas in the following three worksheets:

- ✓ **Emissions from Electrical Equipment**
- ✓ **Mass Balance Approach – Tier 3**
- ✓ **EF Approach – Tier 3**

2.G.1.c Disposal of Electrical Equipment

Information

Section 8.2.2.1 of the *2006 IPCC Guidelines* provides three Tiers for estimation of GHG emissions from Disposal of Electrical Equipment: The Tier 1 method is based on the use of default EFs, Tier 2 applies the Tier 1 equation but with country-specific EFs and an additional factor to take into account recovery and/or destruction, and the Tier 3 method is implemented at the facility level and includes separate equations for each phase of the life cycle of equipment, including disposal the electrical equipment. The Tier 3 method utilizes either a pure mass-balance approach (Tier 3a) or an EF approach, including a hybrid with the mass balance approach (Tier 3b). The pure mass-balance approach is likely to be appropriate for countries where the gas-collection infrastructure (including recovery equipment, technician training, and economic or legal incentives to recover) is not very well-developed or widely applied. In countries where the disposal of equipment is well controlled and understood (i.e., where an efficient gas collection infrastructure is in place) and where emissions from use of sealed-pressure equipment are accounted for under 2.G.1.c Use of Electrical Equipment, the EF/hybrid approach may be used (this correction is discussed further below under entry of AD for the mass balance approach in category 2.G.1.c.)

Category 2.G.1.c includes emissions from disposal of electrical equipment. Emissions from manufacturing and installation, and use of electrical equipment are accounted for in sub-categories 2.G.1.a and 2.G.1.b, respectively

GHGs

The *Software* includes the following GHGs for the Disposal of Electrical Equipment source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	X	X	X	X

IPCC Equations

GHG emissions from the Disposal of Electrical Equipment source category are estimated by applying the following IPCC equations (noting that "disposal" may only be a sub-set of an equation):

- ✓ Tier 1: Equation 8.1
- ✓ Tier 2: Equation 8.2
- ✓ Tier 3: Equations 8.3, 8.7a (pure mass balance) 8.7b (hybrid mass balance and EF approach), 8.8 (emissions from recycling), 8.9 (emissions from destruction) and 8.11 (equation to estimate retiring nameplate capacity)

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 F-gases from the **Disposal of Electrical Equipment** source category, using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Emissions from Electrical Equipment:** contains for each F-gas, subdivision and each type of equipment information on the total nameplate capacity of retiring electrical equipment and the fraction of gas remaining at retirement. The worksheet calculates the associated F-gas emissions for Tier 1 (with default EF).
  Note that unlike the case for categories 2.G.1.a and 2.G.1.b, this worksheet is not used to estimate disposal emission with the Tier 2 method, worksheets under tabs for EF Approach - Tier 2/3 are used.
- ✓ **Mass Balance Approach – Tier 3 (1/3),** for closed-pressure systems contains for each F-gas, subdivision and type of equipment information on the total nameplate capacity of retired closed-pressure equipment and the amount of F-gas recovered from that equipment.

- ✓ **Mass Balance Approach – Tier 3 (2/3),** for sealed-pressure systems contains for each F-gas, subdivision and type of equipment information on the total nameplate capacity of retired sealed-pressure equipment and the amount of F-gas recovered from that equipment.
- ✓ **Total Emissions – Mass Balance Approach – Tier 3 (3/3),** is a technical table totalling the closed-pressure and sealed-pressure disposal emissions estimated using the mass-balance approach.
- ✓ **EF Approach – Tier 2/3 (1/3),** contains for each F-gas, subdivision and type of equipment, information on the total nameplate capacity of retired sealed-pressure equipment, use EF, lifetime of equipment, the fraction of retiring equipment whose F-gas is recovered and the recovery efficiency.
- ✓ **EF Approach – Tier 2/3 (2/3),** contains for each F-gas, subdivision and type of equipment, the quantity of chemical fed into the destruction and recycling processes and the respective EFs for each process.
- ✓ **Total Emissions – EF Approach – Tier 2/3 (3/3),** is a technical table totalling the closed-pressure and sealed-pressure disposal emissions estimated using the EF approach.

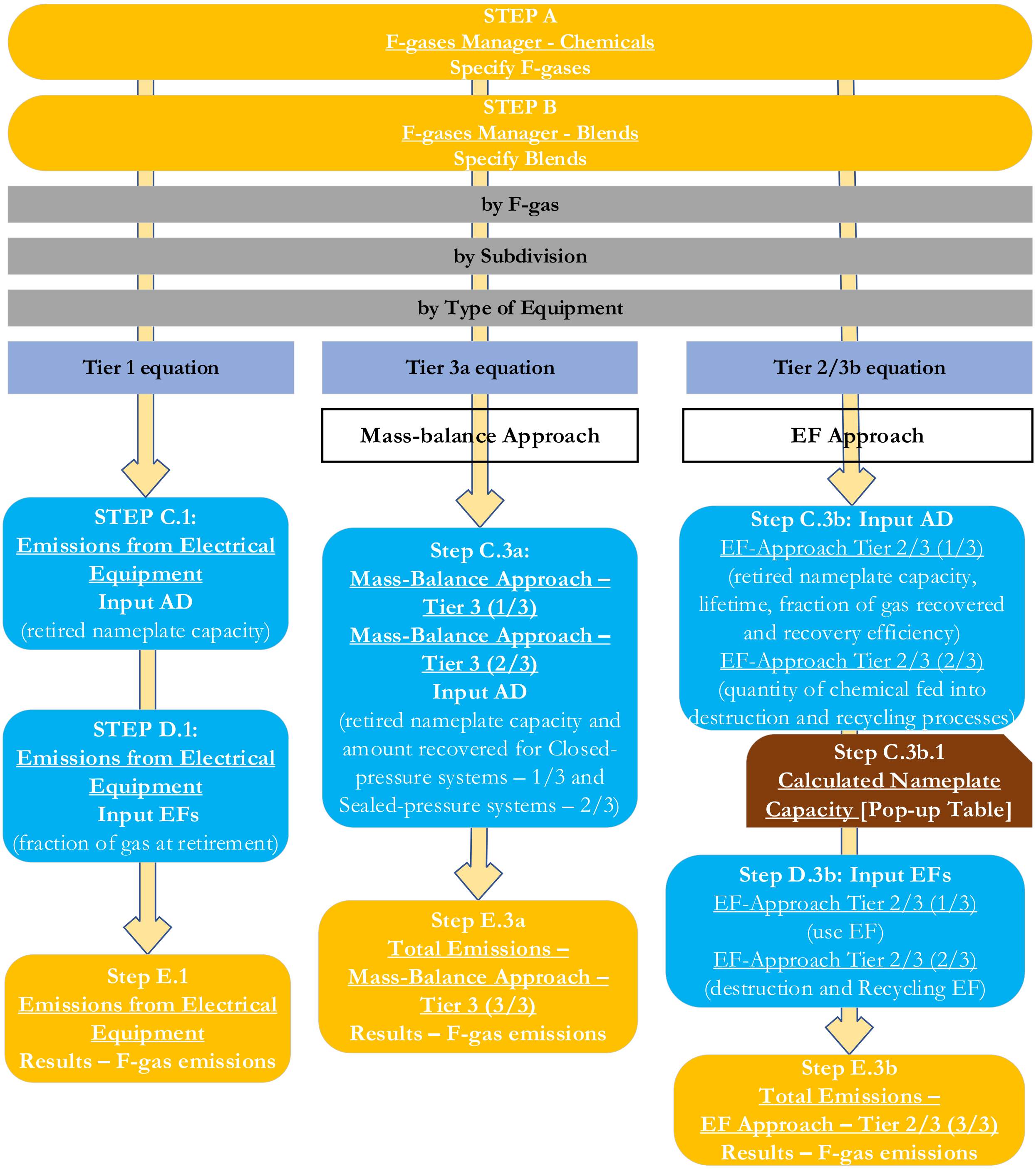
User's Work Flowchart

For Disposal of Electrical Equipment, consistent with the key category analysis and the decision tree in Figure 8.1 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[55] 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 Disposal of Electrical Equipment.

[55] 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.

Disposal of Electrical Equipment- flowchart



Thus, for the source-category:

Steps A and B, **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 C.1, in worksheet **Emissions from Electrical Equipment,** for each F-gas, subdivision and type of electrical equipment users collect and input in the *Software* information on the total nameplate capacity of all retired equipment.

Step D.1, in worksheet **Emissions from Electrical Equipment**, for each F-gas, subdivision and type of electrical equipment users input the fraction of gas remaining at disposal.

Step E.1, in worksheet **Emissions from Electrical Equipment**, the *Software* calculates the associated emissions in mass units (metric tonne and Gg) for each F-gas.

When Tier 2/3 Equations are applied:

Mass Balance Approach (Tier 3 only)

Step C.3a, for each F-gas, subdivision (i.e. facility) and each type of equipment, users collect and input in the *Software*, in worksheet **Mass Balance Approach – Tier 3 (1/3)**, information on the total nameplate capacity of retired closed-pressure equipment and the amount of F-gas recovered from that equipment and in worksheet **Mass Balance Approach – Tier 3 (2/3)**, information on the total nameplate capacity of retired sealed-pressure equipment and the amount of F-gas recovered from that equipment.

Step E.3a, in worksheet **Total Emissions – Mass Balance Approach – Tier 3 (3/3)**, the *Software* calculates, for each facility, the associated emissions from closed- and sealed-pressure equipment in mass units (metric tonnes and Gg) for each F-gas.

EF Approach (Tier 2 and Tier 3)

Step C.3b, in the worksheet **EF Approach – Tier 2/3 (1/3)**, for each F-gas, subdivision (i.e. facility) and type of sealed-pressure equipment, users collect and input in the *Software* information on the total nameplate capacity of retired equipment (either specified or calculated using the pop-up table **(Step C.3b.1)**), in metric tonnes of F-gas, the fraction of gas that is recovered from that equipment and the recovery efficiency, as well as the lifetime of that equipment. In worksheet **EF Approach – Tier 2/3 (2/3)**, for each F-gas, subdivision (i.e. facility) and type of equipment (closed- or sealed pressure) users collect and input in the *Software* the quantity of chemical fed into the destruction and recycling processes.

Step D.3b, in the worksheet **EF Approach – Tier 2/3 (1/3),** for each F-gas, subdivision (i.e. facility) and type of equipment, users collect and input in the *Software* the EF for use and in worksheet **EF Approach – Tier 2/3 (2/3)**, the destruction and recycling EFs.

Step E.3b, in the worksheet **EF Approach – Tier 2/3 (3/3)**, for the flows using the EF approach the *Software* calculates the associated emissions in mass units (metric tonne and Gg) for each F-gas.

Activity Data Input

Section 8.2.2.3 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Disposal of Electrical Equipment. Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category **Disposal of Electrical Equipment**.

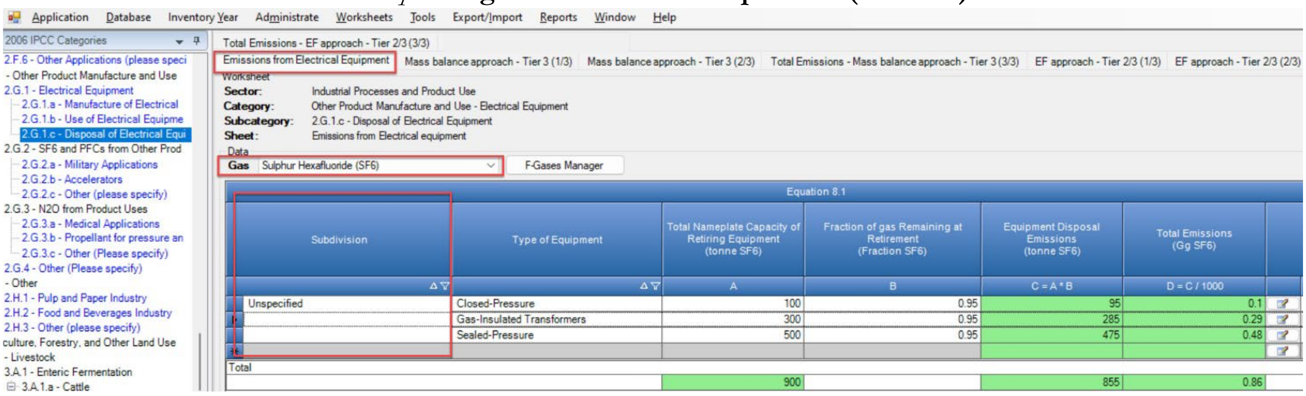
Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the ***F-Gases Manager*** *in any worksheet for this category. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. 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 manufacture and/or installation of electrical equipment. For more information, refer to populating the F-Gases Manager, in the section above.*

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.

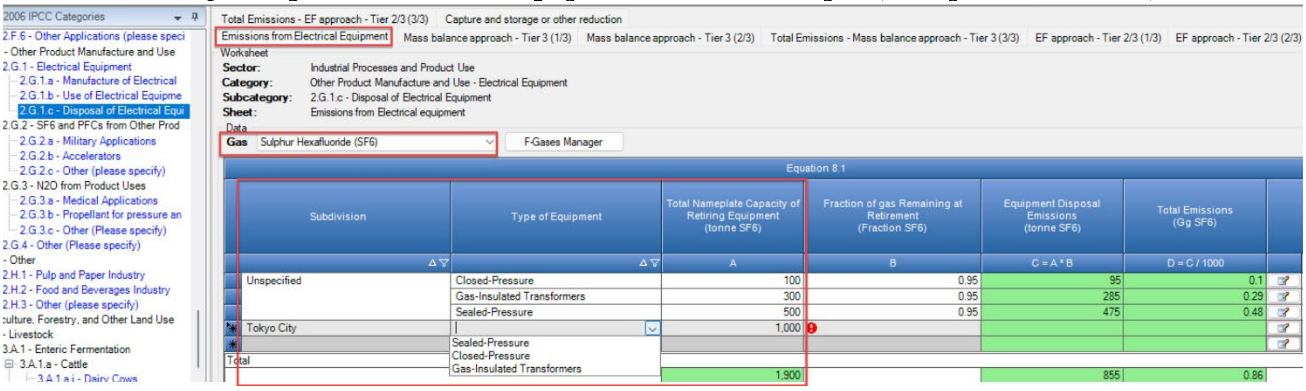
The procedure for populating the F-gases Manager is the same as for category 2.G.1.a Manufacture of Electrical Equipment (refer to Populating the F-gases manager and designating confidentiality for category: Manufacture of Electrical Equipment).

Second, for all Tiers and all worksheets, input of AD for disposal of electrical equipment 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

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



Example: **disposal of electrical equipment - Tier 1 AD input (multiple subdivisions)**



When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision| and each chemical agent, data are input in worksheet **Emissions from Electrical Equipment,** row by row, to estimate GHG emissions from disposal of electrical equipment, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of equipment (e.g. sealed-pressure, closed-pressure, gas-insulated transformers) or input manually a specific type of equipment (e.g. gas circuit breakers).
2. Column |A|: input total nameplate capacity of retiring equipment in tonnes of each F-gas.

When Tier 2/3 Equations are applied:

Mass-balance (Tier 3 only)

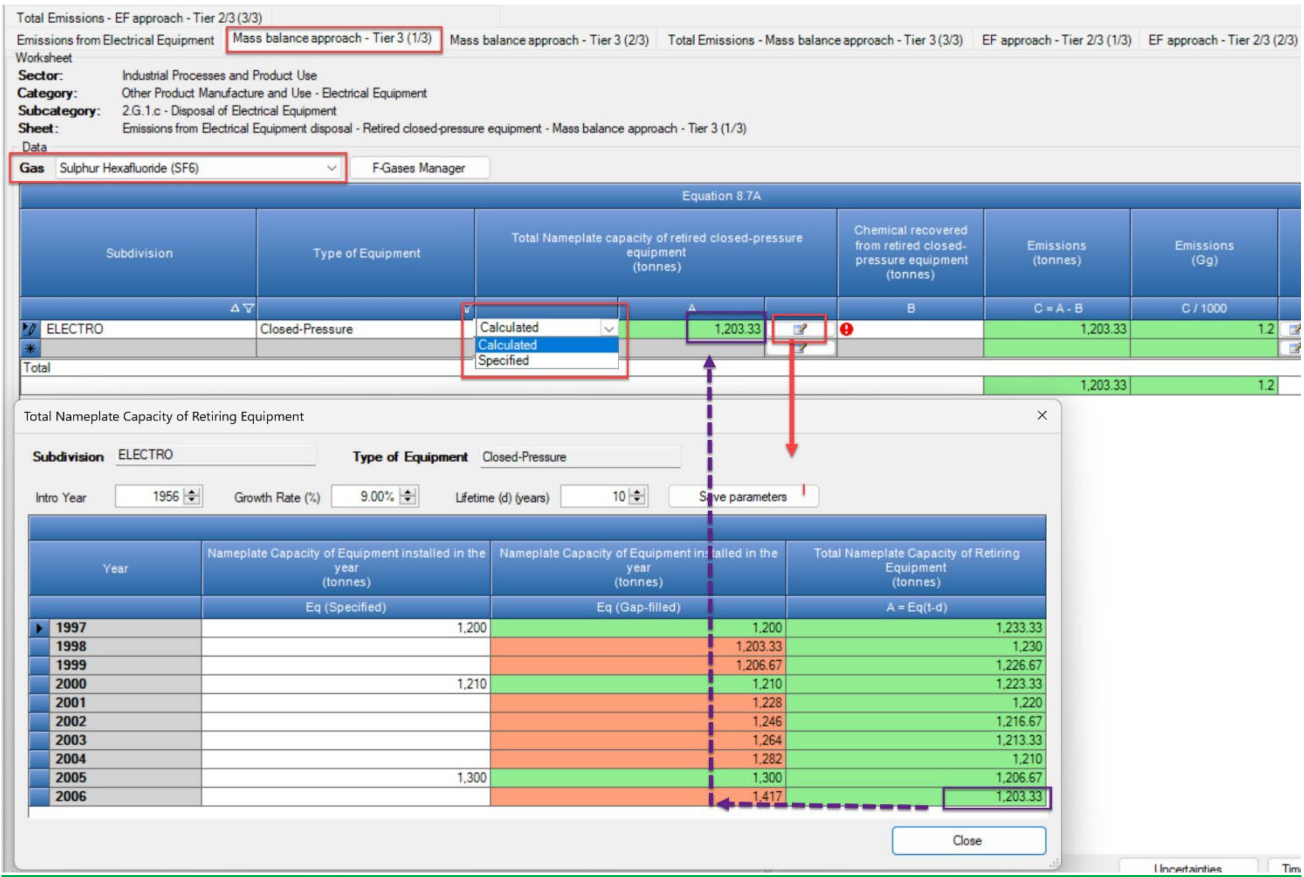
To estimate emissions from disposal of closed-pressure electrical equipment, for each subdivision in Column |Subdivision| (for Tier 3 this should be a specific facility/manufacturer) and each chemical agent, data are input in worksheet **Mass Balance Approach – Tier 3** (1/3), row by row, as follows:

1. Column |Type of equipment|: this worksheet is for closed-pressure equipment only, thus select Closed-Pressure from the drop-down menu.
2. Column |A|: input the total nameplate capacity of retired closed-pressure equipment, in tonnes. In Column |A| select from one of two options in the drop-down menu:
   a. *Specified:* input country-specific AD on the total nameplate capacity of retired equipment manually, in tonnes.
      Note that the total nameplate capacity of retired equipment must take into account the lifetime of that equipment.
   b. *Calculated:* the *Software* estimates the total nameplate capacity of retiring closed-pressure electrical equipment for the given subdivision, based on information entered by the user in the pop-up table.
      i. Column |Intro Year|: input the year of introduction of that type of equipment in that subdivision.
         Note that the year of introduction should be set to the first year of the inventory time series minus the lifetime, or the actual year of introduction, whichever is later. The year of introduction will impact the accumulated amount of chemical agent in the retiring equipment, so it is important to set an appropriate year.
      ii. Column |Growth Rate|: input the growth rate of installed equipment, in per cent. Growth rate of equipment is entered to calculate the bank of installed equipment in the case country-specific data are not available and extrapolation to complete the time series is needed.
         Note that: in the absence of country-specific information, an IPCC default factor of 9% may be used.
      iii. Column |Lifetime (d)|: input the lifetime of installed equipment, in years.
         Note that: the 2006 IPCC Guidelines do not provide a "default" but note a range of more than 30 to 40 years.
      iv. Column |Eq (specified)|: input the nameplate capacity of equipment installed for each known year back either to the year of introduction of that equipment in that subdivision, or the current inventory year minus the lifetime (d), whichever is more recent.
         Note that: enter only data for known years in Column |Eq (specified)|. The Software will interpolate / extrapolate (based on growth rate) unknown years. Users should not enter 0 for unknown years, as the software will include the 0 as a real number in the calculation for the interpolation/extrapolation.
         Do not enter 0 for unknown years, as the Software will include the 0 as a real number in the calculation for the interpolation/extrapolation. Enter 0 when that is the appropriate value to ensure that the bank of installed equipment does not extrapolate backwards or forwards into perpetuity; it is important to ensure that correct year of introduction, and use of "0" when in fact installation is zero, to ensure proper development of the bank.

   Based on the parameters entered, and user-specific data entered in Column |Eq (specified)|, the *Software* will gap-fill interim years and calculate the total nameplate capacity of retiring equipment for the inventory year. This value will be populated in Column |A|.
3. Column |B|: input the amount of F-gas recovered from closed pressure equipment at retirement, in tonnes.

Example: **AD input for emissions from disposal of electrical equipment – mass-balance – Tier 3**

Note that image is for closed pressure equipment in worksheet 1/3, but the same approach applies for sealed-pressure equipment in worksheet 2/3, as well as for worksheet ***EF approach Tier 2/3 (1/3)***



To estimate emissions from disposal of sealed-pressure electrical equipment, for each subdivision in Column |Subdivision| and each chemical agent, data are input in worksheet **Mass Balance Approach – Tier 3 (2/3),** row by row, as follows:

1. Column |Type of equipment|: select from the drop-down menu one of the listed types of sealed pressure equipment (e.g. sealed-pressure, gas-insulated transformers) or input manually a specific type of sealed-pressure equipment.
2. Column |A|: input the total nameplate capacity of retired sealed-pressure equipment, in tonnes. In Column |A| select from one of two options in the drop-down menu:
   a. *Specified:* input country-specific AD on the total nameplate capacity of retired equipment manually, in tonnes.
      Note that the total nameplate capacity of retired equipment must take into account the lifetime of that equipment.
   b. *Calculated (see image above):* the *Software* estimates the total nameplate capacity of retiring sealed-pressure electrical equipment for the given subdivision, based on information entered by the user in the pop-up table.
      i. Column |Intro Year|: input the year of introduction of that type of equipment in that subdivision.
         Note that the year of introduction should be set to the first year of the inventory time series minus the lifetime, or the actual year of introduction, whichever is later. The year of introduction will impact the accumulated amount of chemical agent in the retiring equipment, so it is important to set an appropriate year.
      ii. Column |Growth Rate|: input the growth rate of installed equipment, in per cent. Growth rate of equipment is entered to calculate the bank of installed equipment in the case country-specific data are not available and extrapolation to complete the time series is needed.
         Note that: in the absence of country-specific information, an IPCC default factor of 9% may be used.

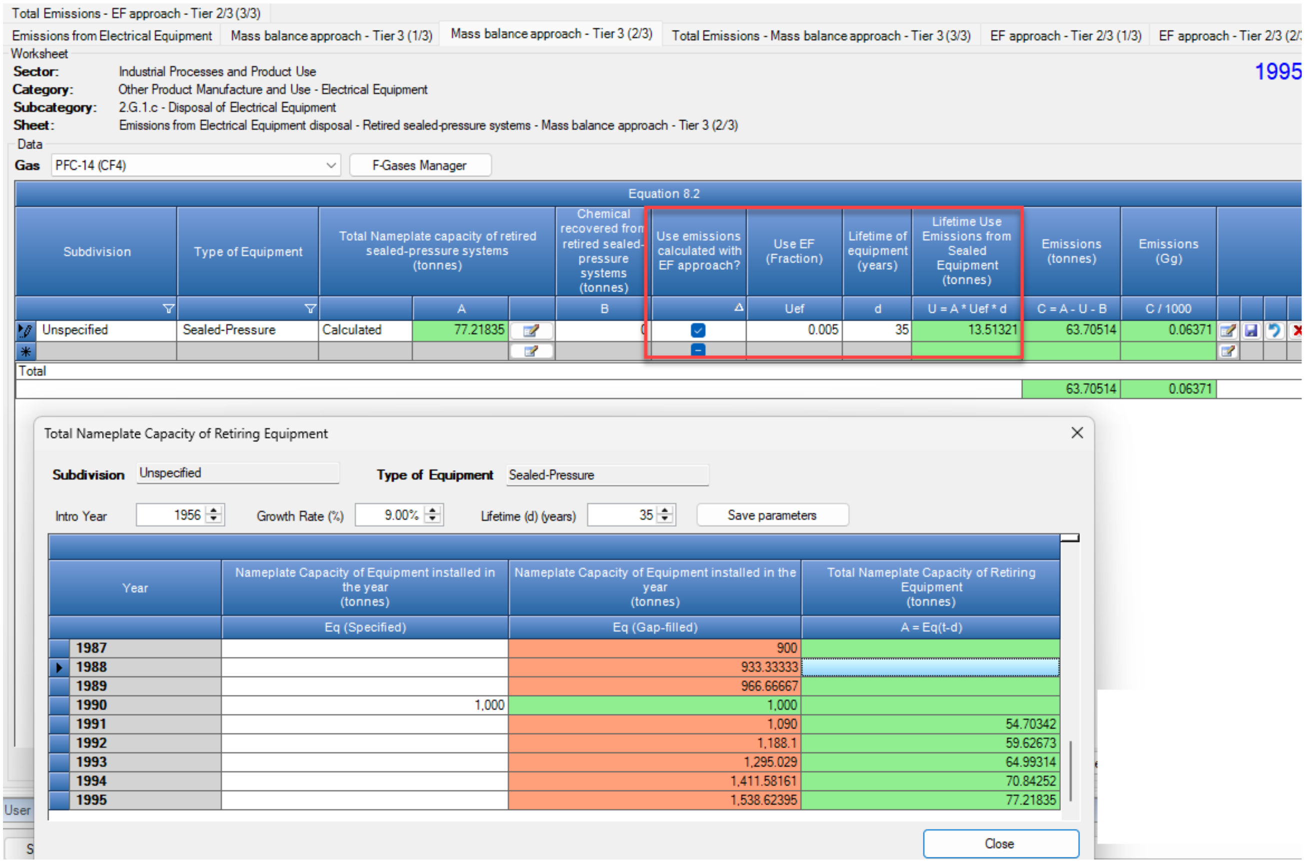
iii. Column |Lifetime (d)|: input the lifetime of the equipment being retired in that subdivision, in years.
Note that: the 2006 IPCC Guidelines do not provide a "default" but note a range of more than 30 to 40 years.

iv. Column |Eq (specified)|: input the nameplate capacity of equipment installed for each known year back either to the year of introduction of that equipment in that subdivision, or the current inventory year minus the lifetime (d), whichever is more recent.
Note that: enter only data for known years in Column |Eq (specified)|. The Software will interpolate / extrapolate (based on growth rate) unknown years. Users should not enter 0 for unknown years, as the software will include the 0 as a real number in the calculation for the interpolation/extrapolation.
Do not enter 0 for unknown years, as the Software will include the 0 as a real number in the calculation for the interpolation/extrapolation. Enter 0 when that is the appropriate value to ensure that the bank of installed equipment does not extrapolate backwards or forwards into perpetuity; it is important to ensure that correct year of introduction, and use of "0" when in fact installation is zero, to ensure proper development of the bank.

Based on the parameters entered, and user-specific data entered in Column |Eq (specified)|, the *Software* will gap-fill interim years and calculate the total nameplate capacity of sealed-pressure retiring equipment for the inventory year. This value will be populated in Column |A|.

3. Column |B|: input amount of F-gas recovered from sealed pressure equipment at retirement, in tonnes.
4. Column |Use emissions calculated w/EF approach|: a checkbox is provided for the user to indicate if the emissions from the use of the electrical equipment in this subdivision (estimated in category 2.G.1.b) were estimated using the EF approach. If the mass balance approach was used to estimate emissions from the use of this equipment, leave the box unchecked.
Note that: an adjustment is needed to avoid double counting of emissions from use of sealed-pressure equipment, in the case where emissions from the use of the electrical equipment was estimated with an EF approach, but disposal emissions are estimated using the mass balance approach. If the EF approach was used to estimate emissions for this equipment in category 2.G.1.b, these lifetime emissions from use must be subtracted in this worksheet for disposal.
   a. Column |U_{EF}|: input the annual EF for use of this equipment, fraction of the total nameplate capacity of the retired equipment.
   Note that the EF for use should be consistent with the Use EF in Column |B| for that subdivision/type of equipment in worksheet ***EF approach – Tier 3*** *of category 2.G.1.b.*
   b. Column |d|: input the lifetime of the equipment being retired in that subdivision, in years. Note that: if the user calculated the total nameplate capacity of retired sealed-pressure equipment in Column |A| the same lifetime shall be input here.
   c. Column |U|: Lifetime use emissions are calculated based on the use EF and lifetime, and for subtraction from final emissions from disposal.

Example: **Correction for sealed-pressure equipment where EF approach is used to estimate use emissions, and the mass balance approach for emissions from disposal**



EF/Hybrid Approach (Tier 2 and Tier 3b)

The EF approach may be used for all equipment (closed – and sealed-pressure systems) when implementing a Tier 2 approach. **For the Tier 3b approach, this approach is only applicable for sealed-pressure systems.** The Tier 3b approach is not appropriate for closed-pressure systems.

To estimate emissions from disposal of electrical equipment for each subdivision in Column |Subdivision| and each chemical agent, data are input in worksheet **EF Approach – Tier 2/3 (1/3)**, row by row, as follows:

1. Column |Type of equipment|: select from the drop-down menu the appropriate type of electrical equipment or manually enter in facility-specific information, recalling that at the Tier 2 level this worksheet may be used for closed- and/or sealed pressure systems, while for the Tier 3b approach it is only appropriate for sealed-pressure.
2. Column |A|: input the total nameplate capacity of retired equipment, in tonnes. In Column |A| there is a drop-down menu for two options:
   a. *Specified:* users enter country-specific AD on the total nameplate capacity of retired equipment manually, in tonnes.
   Note that the total nameplate capacity of retired equipment must take into account the lifetime of that equipment.
   b. *Calculated:* the *Software* estimates the total nameplate capacity of retiring electrical equipment for the given subdivision, based on information entered by the user in the pop-up table.
      i. Column |Intro Year|: input the year of introduction of that type of equipment in that subdivision.
      ii. Column |Growth Rate|: input the growth rate of installed equipment, in per cent. Growth rate of equipment is entered to calculate the bank of installed equipment in the case country-specific data are not available and extrapolation to complete the time series is

needed.

Note that: in the absence of country-specific information, an IPCC default factor of 9% may be used.

iii. Column |Lifetime (d)|: input the lifetime of installed equipment in that subdivision, in years.

Note that: the 2006 IPCC Guidelines do not provide a "default" but a range of more than 30 to 40 years.

iv. Column |Eq (specified)|: input the nameplate capacity of equipment installed for each known year back either to the year of introduction of that equipment in that subdivision, or the current inventory year minus the lifetime (d), whichever is more recent.

Note that: enter only data for known years in Column |Eq (specified)|. The Software will interpolate / extrapolate (based on growth rate) unknown years. Do not enter 0 for unknown years, as the software will include the 0 as a real number in the calculation for the interpolation/extrapolation.

Based on the parameters entered, and user-specific data entered in Column |Eq (specified)|, the *Software* will gap-fill interim years and calculate the total nameplate capacity of retiring equipment for the inventory year. This value will be populated in Column |A| (see figure above for worksheet **Mass balance approach- Tier 3 (1/3)**.

3. Column |C|: input the lifetime of installed equipment in that subdivision, in years. If the user selects *Calculated* in Column |A| the lifetime is automatically populated based on the information entered in the pop-up table of Column |A|, otherwise, manually input the lifetime, in years.

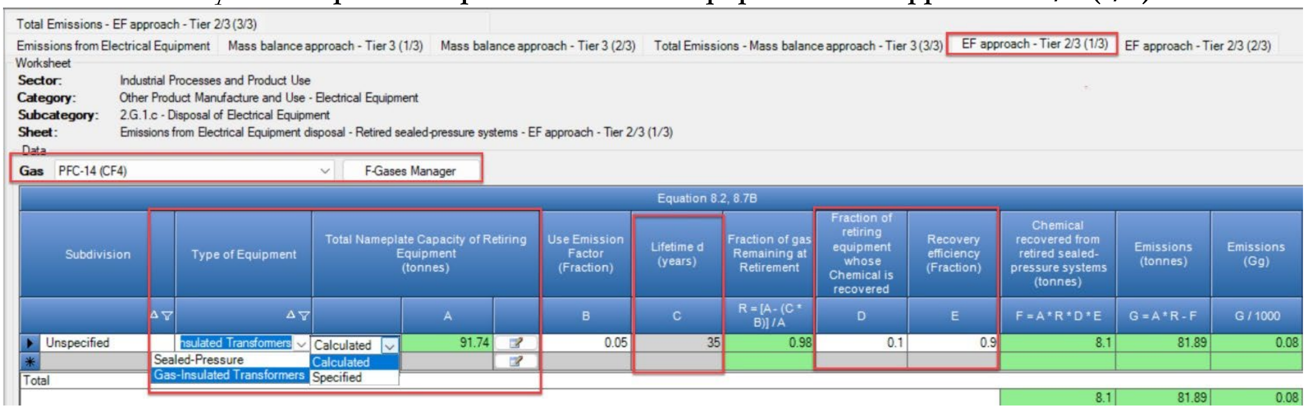
   Note that: the 2006 IPCC Guidelines do not provide a "default" but note a range of more than 30 to 40 years.
4. Column |D|: input the fraction of retiring equipment whose chemical is recovered.
5. Column |E|: input the recovery efficiency of the chemical recovered, fraction.

Then, in worksheet, **EF Approach – Tier 2/3 (2/3),** for each subdivision in Column |Subdivision| and each chemical agent, data are input on destruction and recycling row by row, as follows:

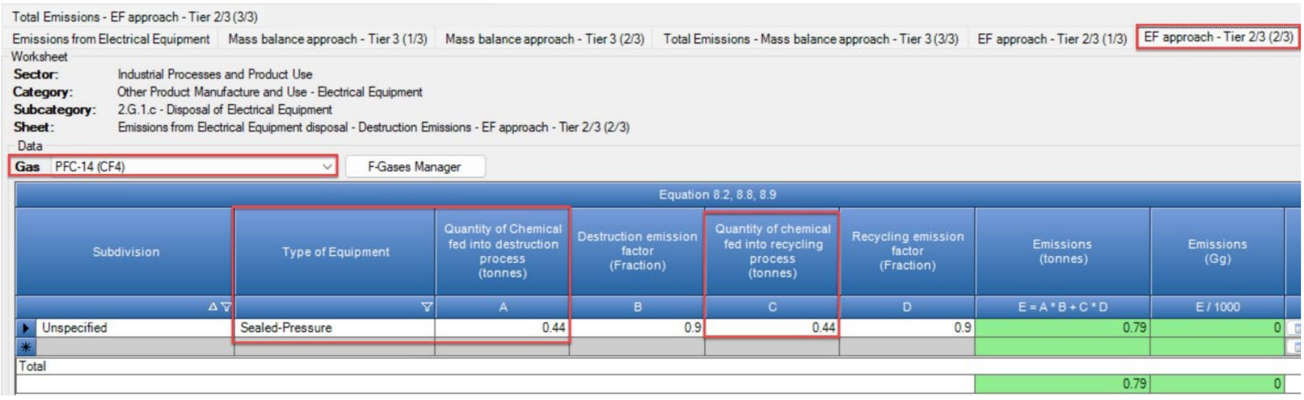
1. Column |A|: input the quantity of chemical fed into the destruction process, in tonnes.
2. Column |C|: input the quantity of chemical fed into the recycling process, in tonnes.

Note that *the total quantity of chemical entered in Columns A and C, for a given subdivision should be equal to the chemical recovered for that subdivision, estimated in Column |F| of worksheet* ***EF approach – Tier 2/3 (1/3)****.*

Example: **AD input for disposal of electrical equipment – EF approach – 2/3 (1/3)**



Example: **AD input for disposal of electrical equipment – EF approach- Tier 2/3 (2/3)**



Emission Factor Input

Section 8.2.2.2 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of EFs for Disposal of Electrical Equipment. There are three sets of default Tier 1 EFs for Disposal Emissions:

i) Sealed-pressure electrical equipment containing SF_6 (Table 8.2)
ii) Closed-pressure electrical equipment (Table 8.3)
iii) Gas-insulated transformers (Table 8.4)

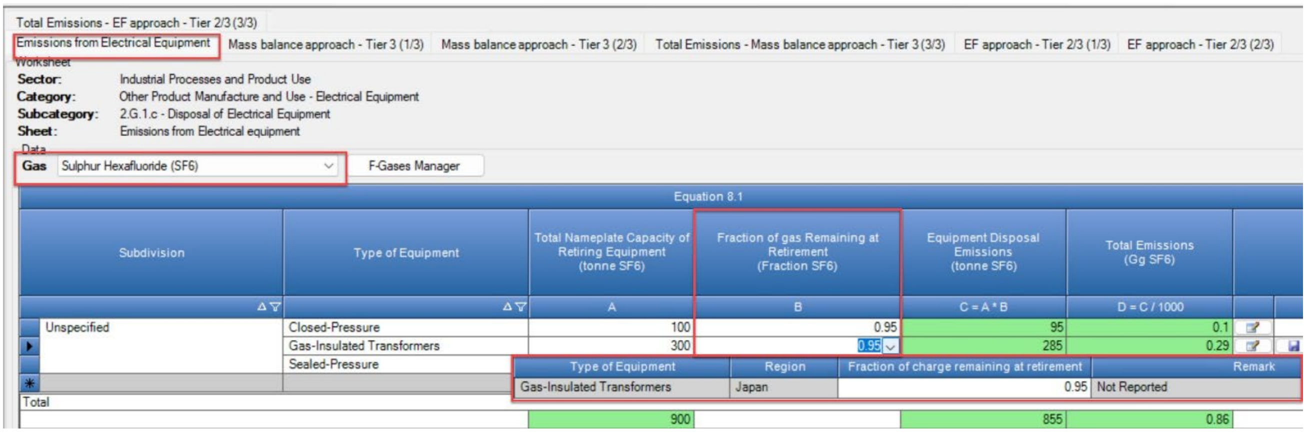
Note that: it is important to review the footnotes to these tables regarding the coverage of EFs. For example, the default values from Japan are intended to be applied to all equipment types, including sealed pressure systems, closed pressure systems, and gas-insulated transformers.

When the Tier 1 Equation is applied:

For each subdivision in Column |Subdivision|, and each gas, EF data are input in worksheet **Emissions from Electrical Equipment,** row by row as follows:

1. Column |B|: Select the appropriate EF from the drop-down menu or from Tables 8.2-8.4, or input manually a country-specific EF (as a fraction of gas remaining at retirement).

Example: **EF input for disposal of electrical equipment – Tier 1**



When Tier 2 /Tier 3 Equations are applied

Mass balance approach (Tier 3 only)

The Tier 3a mass balance approach does not rely on the use of EFs, except in the limited exception where use of emissions from sealed-pressure equipment was estimated through an EF approach and disposal emission are estimated with the mass balance approach. In this case, an adjustment to the emissions estimated using the mass balance equation must be made to avoid double counting of emissions from use during the lifetime. Please refer to the important note regarding sealed pressure systems under Activity Data Input.

EF/Hybrid approach (Tier 2 and Tier 3)

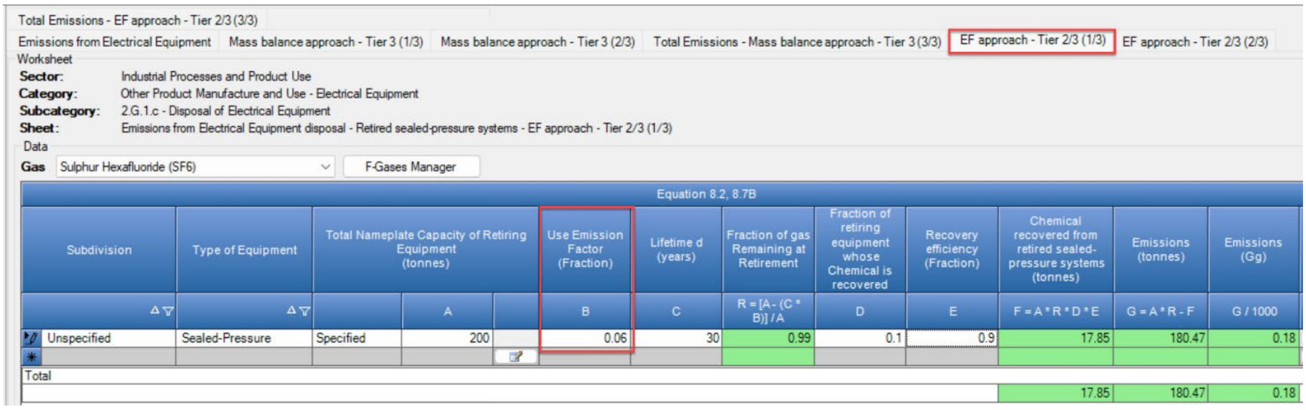
The Tier 2 and Tier 3 methods require the user to input facility-specific EFs for disposal for each gas and each subdivision in Column |Subdivision| in worksheet **EF Approach – Tier 2/3 (1/3),** row by row, as follows:

1. Column |B|: input the annual use EF, as a fraction. The fraction entered should be consistent with any use EF entered for that subdivision/type of equipment in category 2.G.1.b Use of Electrical Equipment (where the EF approach is used) and is applied to ensure there is no double counting of use emissions, at disposal.

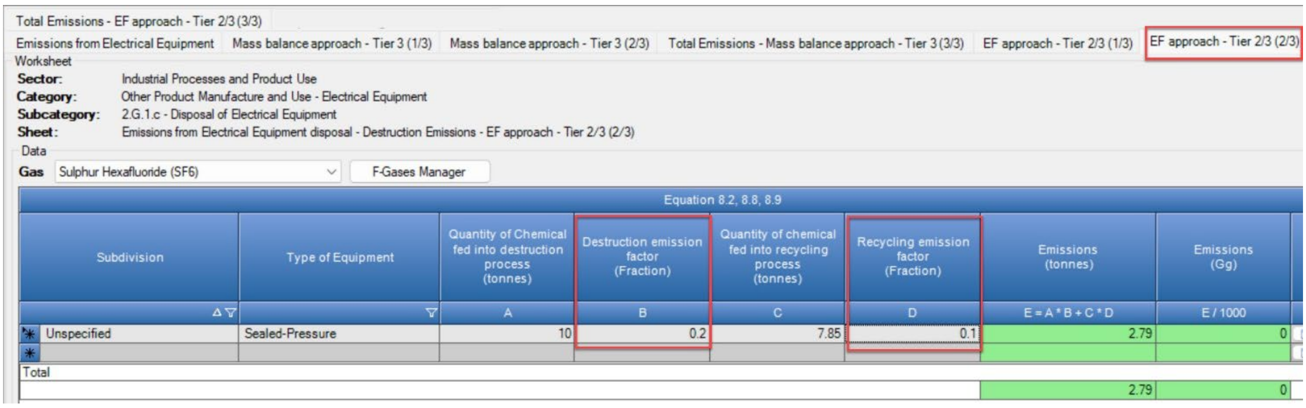
Then, in worksheet **EF approach – Tier 2/3 (2/3)** for each gas and each subdivision in Column |Subdivision| input information, row by row, as follows:

1. Column |B|: input the destruction EF, as a fraction.
2. Column |D|: input the recycling EF, as a fraction.

Example: **EF input for disposal of electrical equipment – EF approach Tier 2/3 (1/3)**



Example: **EF destruction and recycling – EF approach Tier 2/3 (2/3)**



Results

The *Software* follows the *2006 IPCC Guidelines* and allows users to differentiate and report emissions from Disposal of Electrical Equipment in the following manner:

- use different Tiers (Tier 1, Tier 2, Tier 3 (a) and Tier 3 (b))
- differentiate or split mass-balance estimates and EF estimates by lifecycle stage, being careful not to double count or omit emissions based on the method selected

F-gas emissions from Disposal of Electrical Equipment are reported in mass units (metric tonnes and Gg) of each F-gas in the following three worksheets:

- ✓ **Emissions from Electrical Equipment**
- ✓ **Total Emissions – Mass Balance Approach – Tier 3 (3/3)**
- ✓ **Total Emissions – EF Approach – Tier 3 (3/3)**

Special Case: 2.G.1 – Tier 3 Utility Level Mass Balance Approach

Information

Section 8.2.2.1 of the *2006 IPCC Guidelines* refers to the use of a special case of the Tier 3 method: the utility-level, pure mass-balance approach Users that satisfy the good practice criteria for using the pure mass-balance approach beyond equipment manufacturing (i.e., for countries where emissions during equipment installation, use, and disposal account for 3 percent or more of facility-level gas flows, where electrical equipment has been used for 10-20 years or more, and where emissions from sealed-pressure equipment are negligible), may, with little or no loss of accuracy, use a simplified version of the Tier 3 method to estimate emissions during equipment use.

This section describes the simplified Tier 3 approach that may be used to capture total emissions from electrical equipment.

IPCC Equation

- ✓ Tier 3: Equation 8.10

Software Worksheets

The *Software* calculates total emissions from Electrical Equipment (manufacturing, use and disposal) source category, using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ **Emissions from Electrical Equipment- Tier 3:** contains for each F-gas, information to estimate the decrease in chemical inventory, acquisitions of chemical, disbursements of chemical and net increases in nameplate capacity.

Activity Data Input

Section 8.2.2.3 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for Electrical Equipment.

As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category **Electrical Equipment**.

Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the ***F-Gases Manager*** *in any worksheet for this category. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. 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 manufacture and/or installation of electrical equipment. For more information, refer to populating the F-Gases Manager, in the section above.*

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.

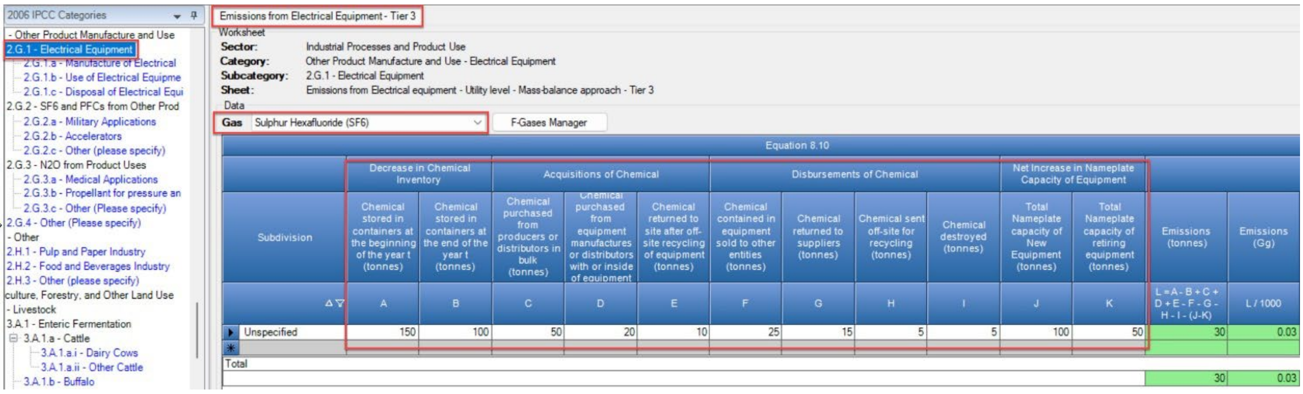
The procedure for populating the F-gases Manager is the same as for category 2.G.1.a Manufacture of Electrical Equipment (refer to Populating the F-gases manager and designating confidentiality for category: Manufacture of Electrical Equipment).

Second, input of AD for Electrical Equipment requires the user to input 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

Then, for each subdivision in Column |Subdivision| and each chemical agent, data are input in worksheet **Emissions from Electrical Equipment – Tier 3,** row by row, as follows:

1. Column |A|: amount of F-gas (e.g., SF_6) stored in containers at the beginning of the year, in tonnes.
2. Column |B|: amount of F-gas stored in containers at the end of the year, in tonnes.
3. Column |C|: amount of F-gas purchased from chemical producers or distributors in bulk, in tonnes.
4. Column |D|: amount of F-gas purchased from equipment manufacturers or distributors with or inside of equipment, in tonnes.
5. Column |E|: amount of F-gas returned to site after off-site recycling, in tonnes.
6. Column |F|: amount of F-gas contained in equipment that is sold to other entities, in tonnes.
7. Column |G|: amount of F-gas returned to suppliers, in tonnes.
8. Column |H|: amount of F-gas sent off-site for recycling, in tonnes.
9. Column |I|: amount of F-gas destroyed, in tonnes.
10. Column |H|: total nameplate capacity of new equipment, in tonnes.
11. Column |K|: total nameplate capacity of retiring equipment in tonnes.

Example: **Special case – simplified Tier 3 utility-level mass-balance approach**



Emission Factor Input

The simplified tier 3 mass balance approach does not rely on the use of EFs.

Results

F-gas emissions from Electrical Equipment are reported in mass units (metric tonnes and Gg) of each F-gas in worksheet **Emissions from Electrical Equipment – Tier 3.**

2.G.2 SF_6 and PFCs from Other Product Uses

This category includes use of SF_6 and PFCs in all products, except those already includes elsewhere. The *2006 IPCC Guidelines* include the following activities under source category 2.G.2:

- ✓ 2.G.2.a Military applications
- ✓ 2.G.2 b Accelerators
- ✓ 2.G.2.c Other (please specify), including adiabatic applications (e.g. tires, sport shoes soles), sound-proof windows and PFCs used in other applications.

Excluded from this category are use of PFCs and SF_6 in electrical equipment (covered in category 2.G.1) and aluminium production (covered in category 2.C.3) and semiconductors (covered in category 2.E).

2.G.2.a Military Applications

Information

Section 8.3.2.1 in the *2006 IPCC Guidelines* provides two Tiers for estimation of GHG emissions from airborne warning and control systems (AWACS). The Tier 1 method is based on the use of EFs, while Tier 2 is a mass-balance approach.

Additional possible uses of F-gases for military operations have been identified in the *2006 IPCC Guidelines*. Depending on the profile of the use, e.g. if the gas is used in equipment like electrical equipment and information on manufacture, use and disposal are available, methods such as in 2.G.1 Electrical Equipment may be used. Alternatively, emissions from these other uses in military applications could be estimated in category 2.G.3.c Other (please specify).

GHGs

The *Software* includes the following GHG for the Military Applications source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	--	X (Tier 1 only)	X	--

IPCC Equations

- ✓ Tier 1: Equation 8.12
- ✓ Tier 2: Equation 8.13
- ✓ Tier 3: No Tier 3 Equations provided

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 Military Applications source category are estimated using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ➢ **Emissions from Military Applications (AWACS):** contains for each gas information on the number of AWACS and an EF. The worksheet calculates the associated SF_6 and PFCs emissions for Tier 1.
- ➢ **SF_6 Emissions from Military Applications (AWACS) – Tier 2:** contains mass-balance information on the amount of SF_6: decrease in inventory, acquisitions, disbursements and net increase in AWACS charge. The worksheet calculates the associated SF_6 emissions for Tier 2.
- ➢ **Capture and storage or other reduction** contains information on reduction of F-gases, not accounted previously in the worksheets for different Tiers.

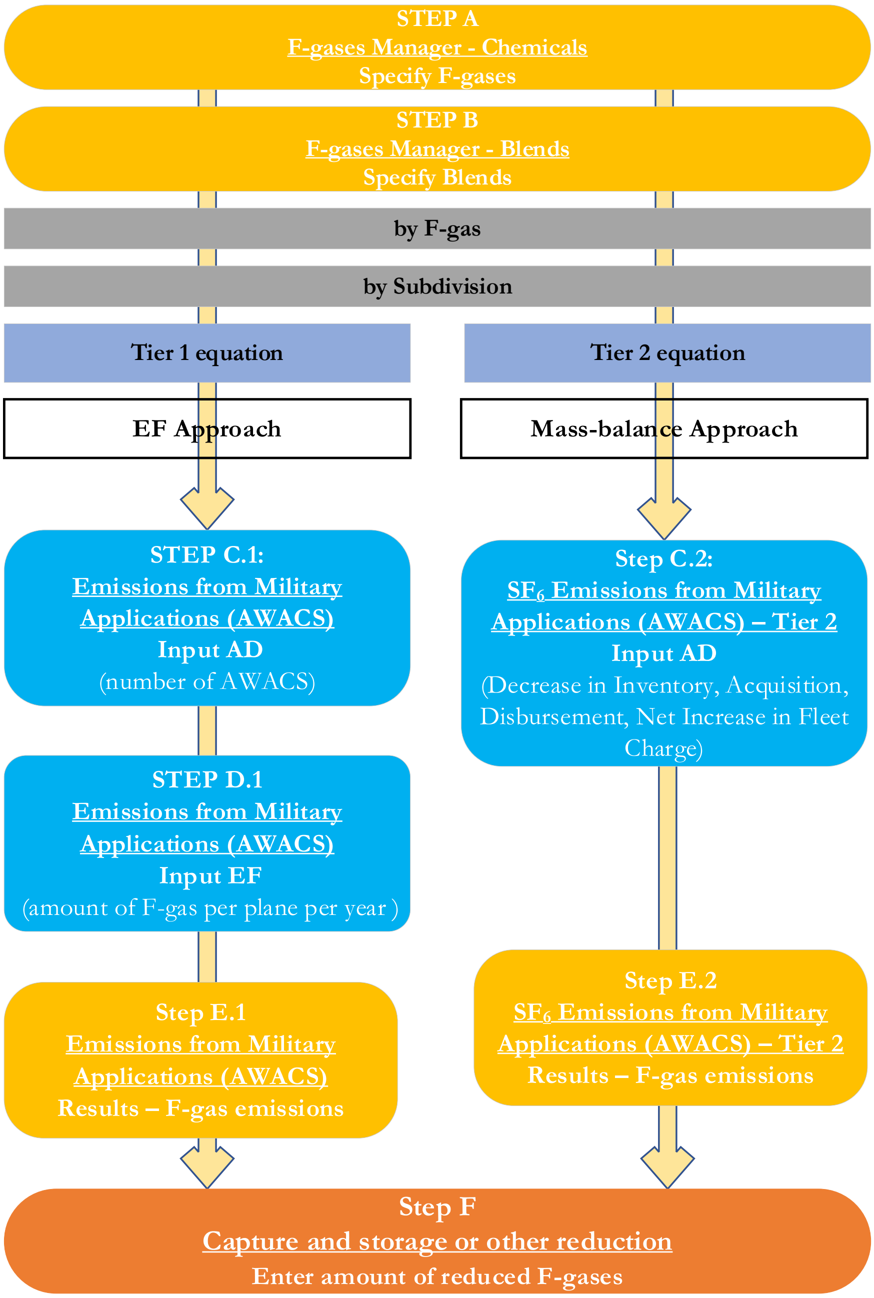
User's Work Flowchart

Consistent with the key category analysis and the decision tree in Figure 8.2 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[56] EFs or direct measurements.

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

[56] 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.

Military Applications - flowchart



Thus, for the source-category:

Steps A and B, F-gases Manager, users ensure that all F-gases/blends 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 C.1, in worksheet **Emissions from Military Applications (AWACS)**, users collect and input in the *Software* information on the number of AWACS.

Step D.1, in worksheet **Emissions from Military Applications (AWACS)**, for each F-gas, users input EFs in kg F-gas per plane. Users may overwrite default EFs manually with country-specific EFs.

Step E.1, in worksheet **Emissions from Military Applications (AWACS),** the *Software* calculates the associated emissions for AWACS in kg and Gg of F-gas.

When the Tier 2 Equation is applied:

Step C.2, in worksheet **SF_6 Emissions from Military Applications (AWACS) – Tier 2**, users collect and input in the *Software* information on the net decrease in the SF_6: inventory in the year, acquisitions of SF_6, disbursements of SF_6 and the net increase in the AWACS fleet charge.

Step E.2, in worksheet **SF_6 Emissions from Military Applications (AWACS) – Tier 2,** the *Software* calculates the associated emissions for AWACS in tonnes and Gg of F-gas.

Then, for each tier, and each gas, as appropriate:

Step F, in the worksheet **Capture and storage or other reduction**, users collect and input information on the amount of GHG captured or otherwise reduced and not otherwise captured in the worksheets above. Capture/destruction is typically only applicable when higher-tiered methods are used. It is noted that in category 2.G.2 the higher tier method is only applicable to SF_6, thus if higher tiers are used for other gases, the results may need to be entered in the worksheet for the Tier 1 equation.

Activity Data Input

Section 8.3.2.1 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* provides 2005 data on national AWACS fleets but recognizes that these data may be quickly outdated. Section 8.3.2.3 provides generic information on the choice of AD for all Use of SF_6 and PFCs in Other Products.

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

When using Tier 1, as a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category Military Applications.

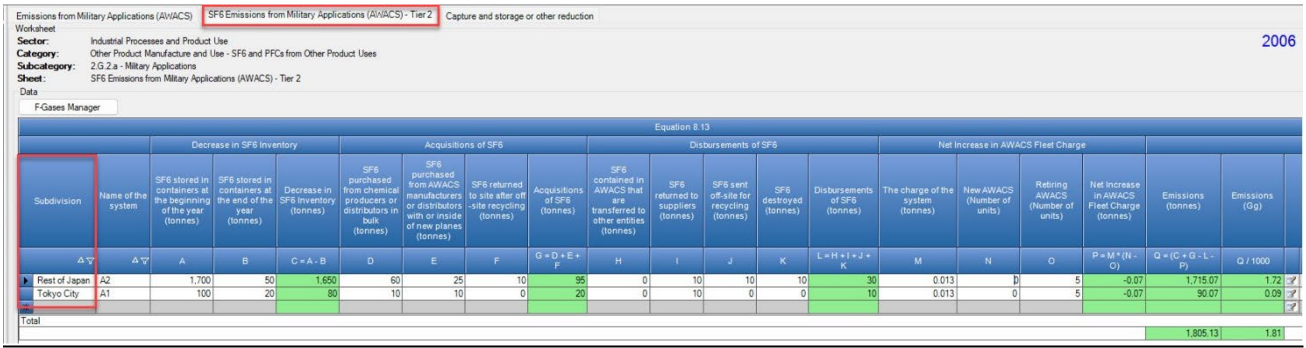
Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the ***F-Gases Manager*** *in worksheet* ***Emissions from Military Applications (AWACS)****. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager. For more information, refer to populating the F-Gases Manager, in the section above.*

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.

For a Figure illustrating Populating the F-gases manager and designating confidentiality for Military Applications, the user may refer to the illustration in category 2.F.1 Refrigeration and Air Conditioning.

Second, input of AD for **Military Applications** requires the user to input 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 where subnational aggregations are input, provide the univocal name/code into Column |S| for each subdivision.

Example: **multiple subdivisions**

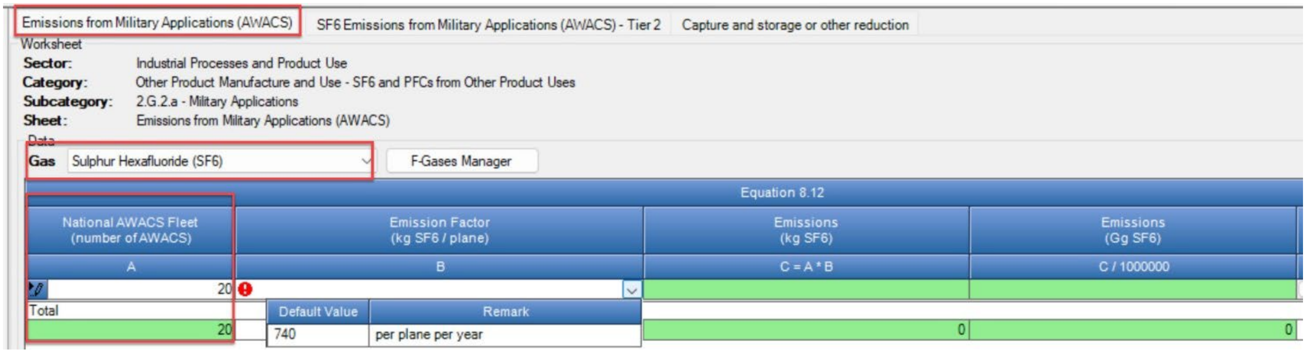


When the Tier 1 Equation is applied

For each subdivision in Column |Subdivision|, and each gas, data are input in worksheet **Emissions from Military Applications (AWACS)** row by row, as follows:

1. Column |A|: enter the number of AWACS in the fleet

Example: **military applications – AD for Tier 1**



When the Tier 2 Equation is applied

For each subdivision in Column |Subdivision|, SF_6 data are input in worksheet **SF_6 Emissions from Military Applications (AWACS)- Tier 2,** row by row, as follows:

1. Column |Name of the System|: input name of the military system where SF_6 is used.

Decrease in SF_6 Inventory

2. Column |A|: input amount of SF_6 stored in containers at the beginning of the year, tonnes.
3. Column |B|: input amount of SF_6 stored in containers at the end of the year, tonnes.

Acquisitions of SF_6

4. Column |D|: input amount of SF_6 purchased from chemical producers or distributors in bulk, tonnes.
5. Column |E|: input amount of SF_6 purchased from AWACS manufacturers or distributors with or inside of new planes, tonnes.
6. Column |F|: input amount of SF_6 returned to site after off-site recycling, tonnes.

Disbursements of SF_6

7. Column |H|: input SF_6 contained in AWACS that are transferred to other entities, tonnes.
8. Column |I|: input amount of SF_6 returned to suppliers, tonnes.
9. Column |J|: input amount of SF_6 sent off-site for recycling, tonnes.
10. Column |K|: input amount of SF_6 destroyed, tonnes.

Net increase in AWACS Fleet Charge

11. Column |M|: input amount of SF_6 charged into each AWACS system, in tonnes (default charge is 0.013t)
12. Column |N|: input number of new AWACS units.
13. Column |O|: input number of retiring AWACS units.

Example: **military applications – AD for Tier 2**

Emissions from Military Applications (AWACS) | SF6 Emissions from Military Applications (AWACS) - Tier 2 | Capture and storage or other reduction

Worksheet

Sector: Industrial Processes and Product Use
Category: Other Product Manufacture and Use - SF6 and PFCs from Other Product Uses
Subcategory: 2.G.2.a - Military Applications
Sheet: SF6 Emissions from Military Applications (AWACS) - Tier 2

Data

F-Gases Manager

		Decrease in SF6 Inventory			Acquisitions of SF6			
Subdivision	Name of the system	SF6 stored in containers at the beginning of the year (tonnes)	SF6 stored in containers at the end of the year (tonnes)	Decrease in SF6 Inventory (tonnes)	SF6 purchased from chemical producers or distributors in bulk (tonnes)	SF6 purchased from AWACS manufacturers or distributors with or inside of new planes (tonnes)	SF6 returned to site after off -site recycling (tonnes)	Acquisitions of SF6 (tonnes)
		A	B	C = A - B	D	E	F	G = D + E + F
Rest of Japan	A2	1,700	50	1,650	60	25	10	95
Tokyo City	A1	100	20	80	10	10	0	20

Equation 8.13

Disbursements of SF6					Net Increase in AWACS Fleet Charge					
SF6 contained in AWACS that are transferred to other entities (tonnes)	SF6 returned to suppliers (tonnes)	SF6 sent off-site for recycling (tonnes)	SF6 destroyed (tonnes)	Disbursements of SF6 (tonnes)	The charge of the system (tonnes)	New AWACS (Number of units)	Retiring AWACS (Number of units)	Net Increase in AWACS Fleet Charge (tonnes)	Emissions (tonnes)	Emissions (Gg)
H	I	J	K	L = H + I + J + K	M	N	O	P = M * (N - O)	Q = (C + G - L - P)	Q / 1000
0	10	10	10	30	0.013	0	5	-0.07	1,715.07	1.72
0	10	0	0	10	0.013	0	5	-0.07	90.07	0.09
									1,805.13	1.81

Emission Factor Input

Section 8.3.2.2 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* provides generic information on the choice of EF for all Use of SF_6 and PFCs in Other Products. For Military Applications, a Tier 1 default EF for use of SF_6 in AWACS is provided in Table 8.7.

When the Tier 1 Equation is applied

For each subdivision in Column |Subdivision|, and each gas, data are input in worksheet **Emissions from Military Applications (AWACS),** row by row, as follows:

1. Column |B|: select from the drop-down menu the default Tier 1 SF_6 EF of 740 kg/plane or enter manually a country-specific EF the F-gas.
   Note that the user shall the relevant gas in the "Gas" bar at the top, to enter data for each F-gas one by one

For an illustration of entering the Tier 1 EF for military applications, refer to *Example:* **military applications – AD for Tier 1** above.

When the Tier 2 Equation is applied

The Tier 2 method applies a mass balance approach, and thus entry of EF information is not required.

Results

SF_6 and PFC emissions from Military Applications are estimated in mass units (tonnes/kg and Gg) by the *Software* in the following worksheets:

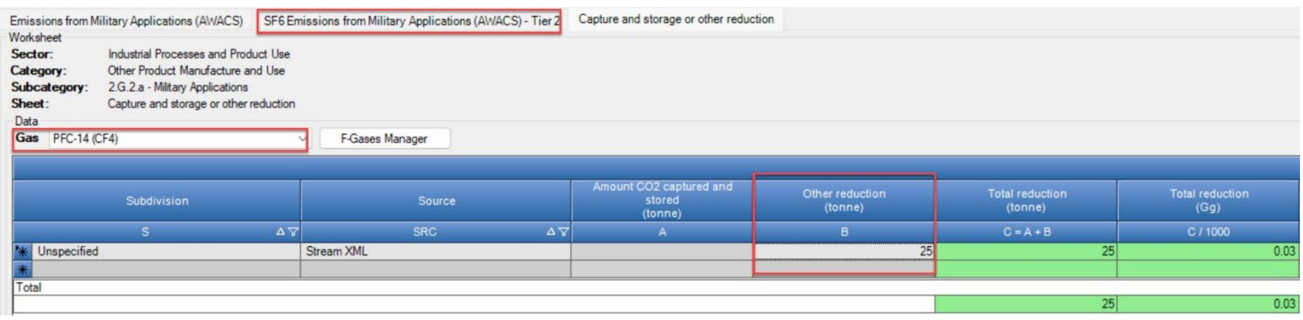
- ✓ **Emissions from Military Applications (AWACS) (SF_6 and PFCs)**
- ✓ **Emissions from Military Applications (AWACS) – Tier 2 (SF_6 only)**

Total SF_6 and PFC emissions from military applications 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 worksheet **Capture and storage or other reduction** for each subdivision and each gas:

4. Column |SRC|: 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).
5. Column |A|: not applicable for this category.
6. Column |B|: collect and input information on any other long-term reduction of F-gas emissions, in tonnes.
   Note that: any destruction estimated in the Tier 2 worksheet should not be included in Column |B|. This worksheet is not expected to be used for this category since the Tier 2 method includes a destruction factor already, and it is generally not good practice to include capture in Tier 1. However, it has been retained noting that the Tier 2 worksheet only includes emissions from SF_6 and it is possible that alternative, higher tier methods will need to be inserted in the worksheet Emissions from Military Applications (AWACS).

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



2.G.2.b Accelerators

Information

Section 8.3.2.1 of the *2006 IPCC Guidelines* provides three Tiers for estimation of GHG emissions from category 2.G.2.b Accelerators. The Tier 1 method requires information on the number of university and research particle accelerators and default assumptions, Tier 2 is based on the use of country-specific EFs for accelerator charge, while the Tier 3 method is a mass-balance approach at user/accelerator level.

The *Software* distinguishes between i) university and research accelerators and ii) medical and industrial accelerators.

GHGs

The *Software* includes the following GHG for the Accelerators source category:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	--	X (Tier 1 only)	X	--

IPCC Equations

- ✓ Tier 1: Equation 8.14 (university and research) and Equation 8.18 (industrial and medical particle accelerators)
- ✓ Tier 2: Equation 8.15 (all accelerators)
- ✓ Tier 3: Equation 8.16 and Equation 8.17 (all accelerators)

As explained in section **1.A.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 Accelerators source category are estimated using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ➢ **SF_6 and PFCs Emissions from Particle Accelerators:** contains for each subdivision, each F- gas and type of accelerator, information on the number of accelerators and default EFs (use factor, charge factor and EF). The worksheet calculates the associated F-gas emissions for Tier 1.
- ➢ **SF_6 Emissions from Particle Accelerators – Tier 2:** contains for each subdivision, each F- gas and type of accelerator, information on individual user accelerator charges and country-specific EFs. The worksheet calculates the associated SF_6 emissions for Tier 2.
- ➢ **SF_6 Emissions from Particle Accelerators – Tier 3:** contains mass-balance information on the amount of SF_6: decrease in inventory, acquisitions, disbursements and net increase in accelerator charge. The worksheet calculates the associated SF_6 emissions for Tier 3.
- ➢ **Capture and storage or other reduction** contains information on reduction of F-gases, not accounted previously in the worksheets for different Tiers.

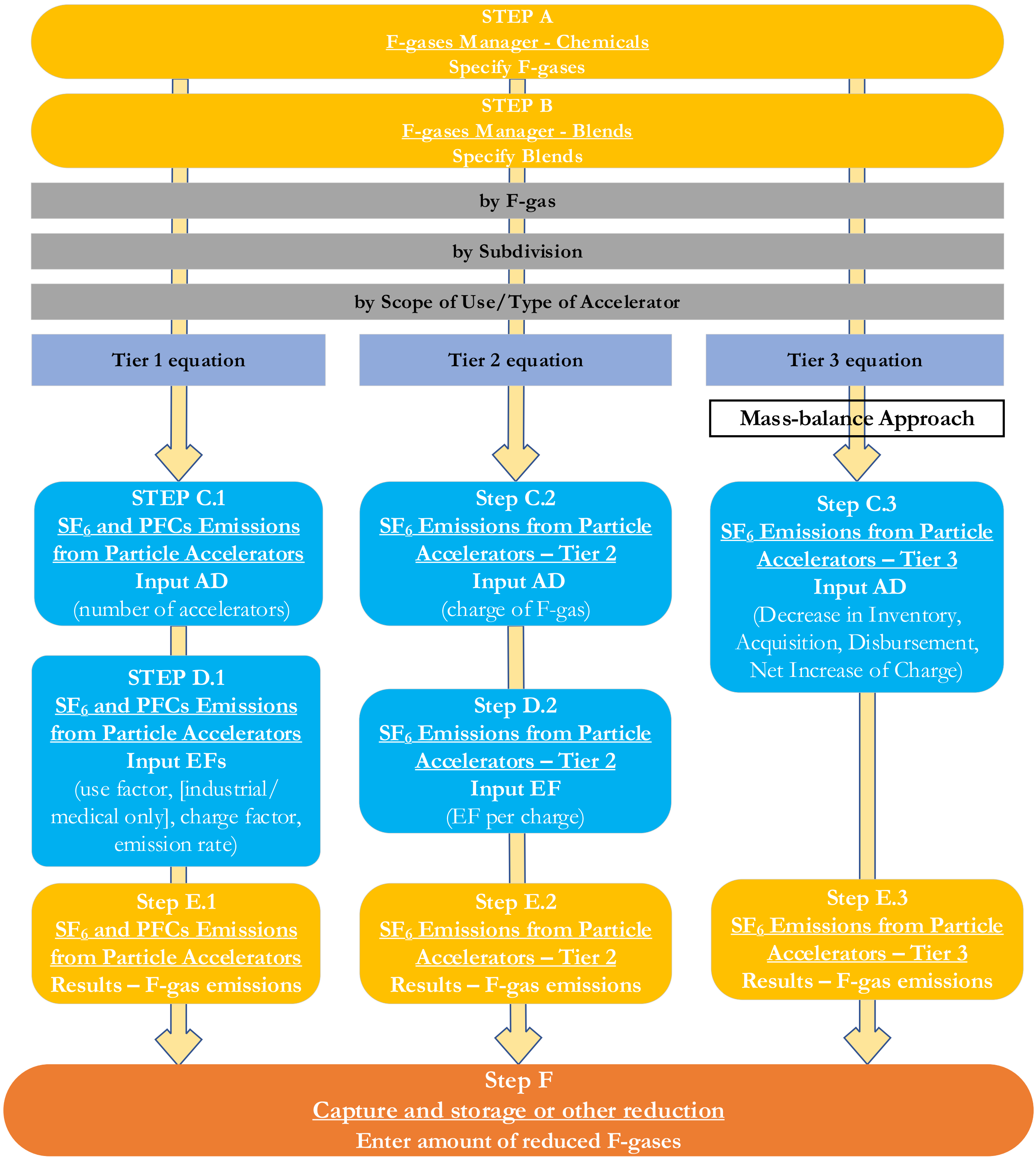
User's Work Flowchart

Consistent with the key category analysis and the decision trees in Figure 8.3 (research accelerators) and Figure 8.4 (industrial and medical particle accelerators) 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[57] EFs or direct measurements.

[57] 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

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

Accelerators- flowchart



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 source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends 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 Tier 1 Equations are applied:

Step C.1, in worksheet **SF_6 and PFC Emissions from Particle Accelerators**, for each F-gas, users collect and input in the *Software* information on the number of accelerators, by scope of use (industrial/medical or research) and process description.

Step D.1, in worksheet **SF_6 and PFC Emissions from Particle Accelerators**, for each F-gas, users collect and input in the *Software* information on the fraction of accelerators using that gas (research accelerators only), the F-gas charge and EF.

Step E.1, in worksheet **SF_6 and PFC Emissions from Particle Accelerators,** the *Software* calculates the associated emissions for accelerators in kg and Gg of F-gas.

When the Tier 2 Equation is applied:

Step C.2, in worksheet **SF_6 Emissions from Particle Accelerators – Tier 2**, for each type of accelerator and process type, users collect and input in the *Software* information on individual accelerator charges.

Step D.2, in worksheet **SF_6 Emissions from Particle Accelerators – Tier 2**, for each type of accelerator, users input EFs in kg SF_6 per kg of charge or fraction.

Step E.2, in worksheet **SF_6 Emissions from Particle Accelerators – Tier 2,** the *Software* calculates the associated emissions for accelerators in kg and Gg of F-gas.

When Tier 3 Equations are applied:

Step C.3, in worksheet **SF_6 Emissions from Particle Accelerators – Tier 3** , users collect and input in the *Software* information on the net decrease in the SF_6: inventory in the year, acquisitions of SF_6, disbursements of SF_6 and the net increase in accelerator charge.

Step E.3, in worksheet **SF_6 Emissions from Particle Accelerators – Tier 3,** the *Software* calculates the associated emissions for accelerators in kg and Gg of F-gas.

Then, for each tier, and each gas, as appropriate:

Step F in the worksheet **Capture and storage or other reduction**, users collect and input information on the amount of GHG captured or otherwise reduced and not otherwise captured in the worksheets above. Capture/destruction is typically only applicable when higher-tiered methods are used. It is noted that in category 2.G.2 the higher tier method is only applicable to SF_6, thus if higher tiers are used for other gases, the results may need to be entered in the worksheet for the Tier 1 equation.

Activity Data Input

Section 8.3.2.1 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* provides a link indicating if a country is known to have research particle accelerators (note that the list excludes particle accelerators used for medical/industrial uses only and may not be complete for all users). Section 8.3.2.3 provides generic information on the choice of AD for all Use of SF_6 and PFCs in Other Products.

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

When using Tier 1, as a **starting step**, users must ensure that the **F-gases Manager** has been populated for all F-gases to be reported for the source category Accelerators.

*Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the **F-Gases Manager** in worksheet **SF_6 and PFC Emissions from Particle Accelerators**. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager. For more information, refer to populating the F-Gases Manager, in the section above.*

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.

For a Figure illustrating Populating the F-gases manager and designating confidentiality for Accelerators, the user may refer to the illustration in category 2.F.1 Refrigeration and Air Conditioning.

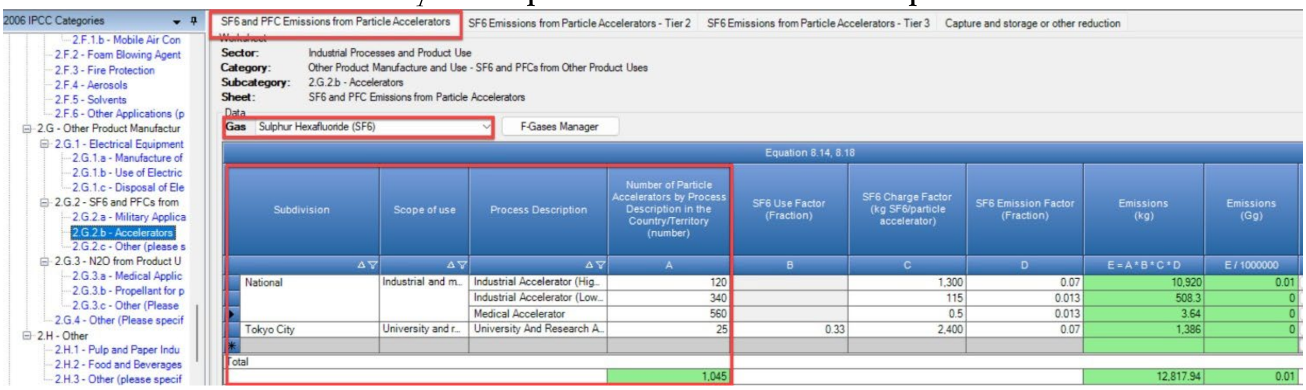
Second, input of AD for **Accelerators** requires the user to input information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

When Tier 1 Equations are applied

For each subdivision in Column |Subdivision| and each gas, data are input in worksheet **SF_6 and PFCs Emissions from Particle Accelerators** row by row, as follows:

1. Column |Scope of Use|: select from the drop-down menu: *university and research* or *industrial and medical.*
2. Column |Process Description|: select from the drop-down menu the applicable process description (e.g. high or low voltage industrial accelerators) or manually enter in a user-specific process description.
3. Column |A|: input the number of accelerators, by scope and use.

Example: **multiple subdivisions – Tier 1 AD input**



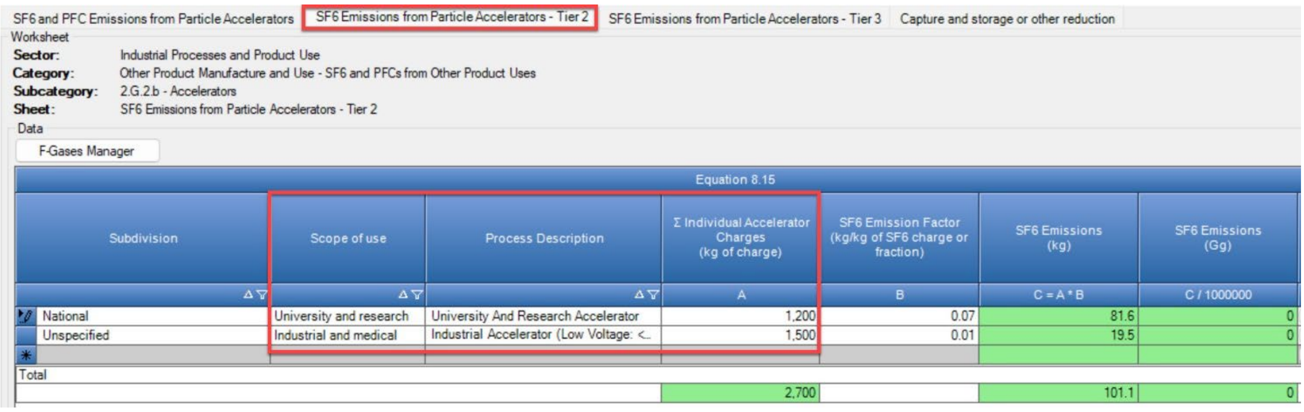
When the Tier 2 Equation is applied

For each subdivision in Column |Subdivision|, data are input in worksheet **SF_6 Emissions from Particle Accelerators – Tier 2** row by row, as follows:

1. Column |Scope of Use|: select from the drop-down menu: *university and research* or *industrial and medical.*
2. Column |Process Description|: select from the drop-down menu the applicable process description (e.g. high or low voltage industrial accelerators) or manually enter in a user-specific process description.

3. Column |A|: input the sum of the individual accelerator charge for the accelerators in that subdivision/scope of use/process description, in kg charge.

Example: **accelerators – Tier 2 AD input**


SF6 and PFC Emissions from Particle Accelerators | SF6 Emissions from Particle Accelerators - Tier 2 | SF6 Emissions from Particle Accelerators - Tier 3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Other Product Manufacture and Use - SF6 and PFCs from Other Product Uses
Subcategory: 2.G.2.b - Accelerators
Sheet: SF6 Emissions from Particle Accelerators - Tier 2
Data
F-Gases Manager

Equation 8.15

Subdivision	Scope of use	Process Description	Σ Individual Accelerator Charges (kg of charge)	SF6 Emission Factor (kg/kg of SF6 charge or fraction)	SF6 Emissions (kg)	SF6 Emissions (Gg)
			A	B	C = A * B	C / 1000000
National	University and research	University And Research Accelerator	1,200	0.07	81.6	0
Unspecified	Industrial and medical	Industrial Accelerator (Low Voltage: <...	1,500	0.01	19.5	0
Total			2,700		101.1	0

When Tier 3 Equations are applied

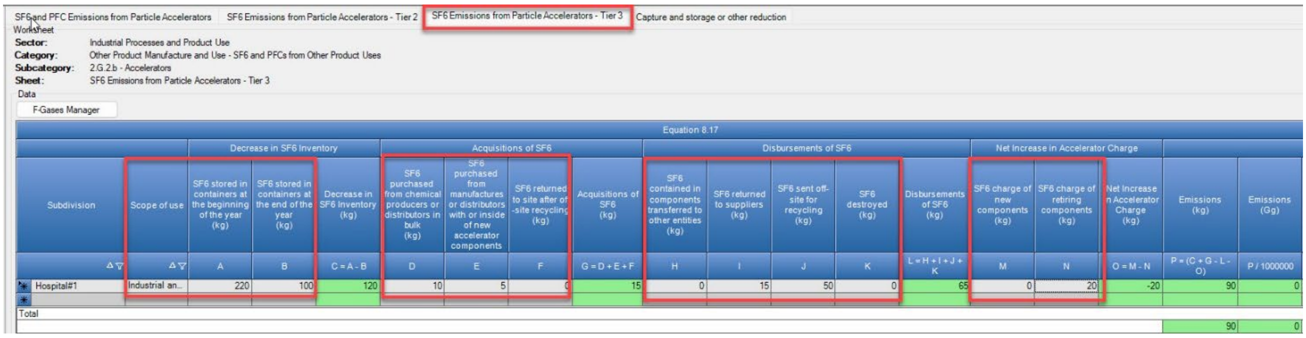
For each subdivision in Column |Subdivision| data are input in worksheet **SF_6 Emissions from Particle Accelerators – Tier 2** row by row

1. Column |Scope of Use|: select from the drop-down menu: *university and research* or *industrial and medical.*
2. Columns |A|-|K|: the **Decrease in SF_6 inventory, Acquisitions of SF_6, and Disbursements of SF_6** are filled in with user-specific information, in kg, in the same manner as for Tier 2 military applications.

Net increase in Accelerator Charge

3. Column |M|: input the amount of SF_6 which is charged to new accelerator components, kg.
4. Column |N|: input amount of SF_6 which is charged to retiring accelerator components, kg.

Example: **Accelerators – Tier 3 AD input**


SF6 and PFC Emissions from Particle Accelerators | SF6 Emissions from Particle Accelerators - Tier 2 | SF6 Emissions from Particle Accelerators - Tier 3 | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Other Product Manufacture and Use - SF6 and PFCs from Other Product Uses
Subcategory: 2.G.2.b - Accelerators
Sheet: SF6 Emissions from Particle Accelerators - Tier 3
Data
F-Gases Manager

Equation 8.17

Subdivision	Scope of use	Decrease in SF6 Inventory: SF6 stored in containers at the beginning of the year (kg)	Decrease in SF6 Inventory: SF6 stored in containers at the end of the year (kg)	Decrease in SF6 Inventory: Decrease in SF6 Inventory (kg)	Acquisitions of SF6: SF6 purchased from chemical producers or distributors in bulk (kg)	Acquisitions of SF6: SF6 purchased from manufactures or distributors with or inside of new accelerator components	Acquisitions of SF6: SF6 returned to site after off-site recycling (kg)	Acquisitions of SF6: Acquisitions of SF6 (kg)
		A	B	C = A - B	D	E	F	G = D + E + F
Hospital#1	Industrial an...	220	100	120	10	5	0	15
Total								

Subdivision	Disbursements of SF6: SF6 contained in components transferred to other entities (kg)	Disbursements of SF6: SF6 returned to suppliers (kg)	Disbursements of SF6: SF6 sent off-site for recycling (kg)	Disbursements of SF6: SF6 destroyed (kg)	Disbursements of SF6: Disbursements of SF6 (kg)	Net Increase in Accelerator Charge: SF6 charge of new components (kg)	Net Increase in Accelerator Charge: SF6 charge of retiring components (kg)	Net Increase in Accelerator Charge: Net Increase in Accelerator Charge (kg)	Emissions (kg)	Emissions (Gg)
	H	I	J	K	L = H + I + J + K	M	N	O = M - N	P = (C + G - L - O)	P / 1000000
Hospital#1	0	15	50	0	65	0	20	-20	90	0
Total									90	0

Emission Factor Input

Section 8.3.2.1 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* provides some default EFs in the explanation to equations, while section 8.3.2.2 provides generic information on the choice of EF for all Use of SF_6 and PFCs in Other Products.

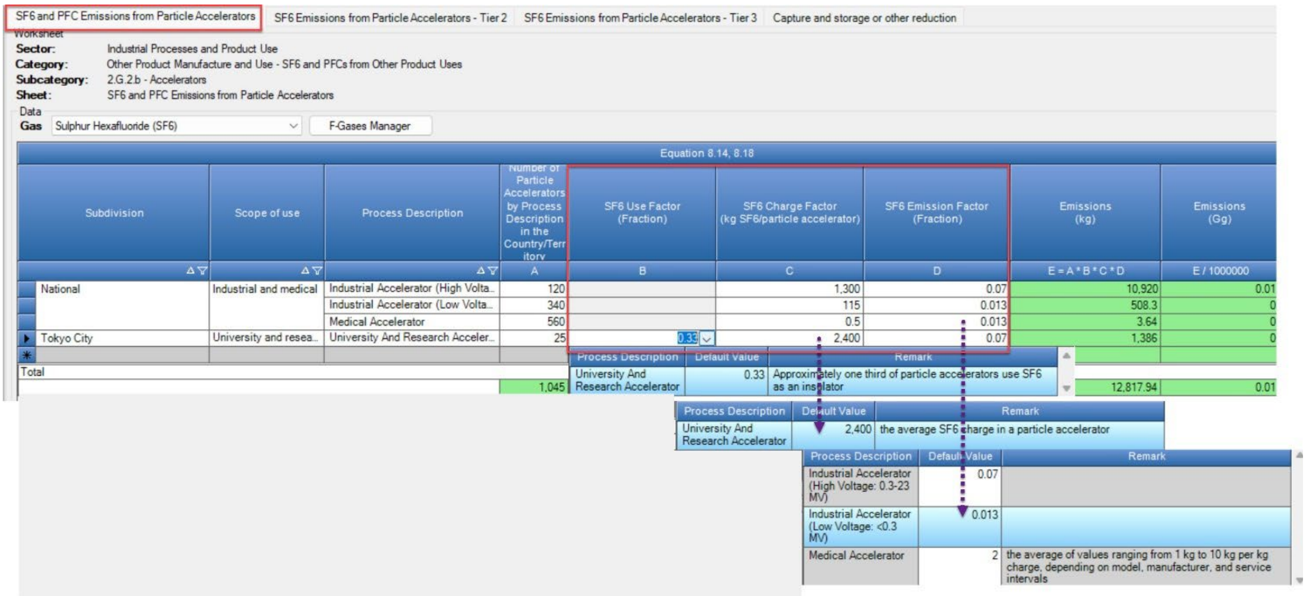
In addition, specific default factors are provided in Table 8.9 (average SF_6 charge in particle accelerators, by process description, for Tier 1) and Table 8.10 (Tier 2 EFs for industrial and medical accelerators).

When Tier 1 Equations are applied

For each subdivision in Column |Subdivision|, gas, scope of use, and process description, data are input in worksheet **SF_6 and PFCs Emissions from Particle Accelerators,** row by row, as follows:

1. Column |B|: (university and research accelerators only) users select from the drop-down menu the default fraction of accelerators using the gas (a default fraction of 0.33 is available for SF_6 only) or manually input a user-specific fraction.
   Note that the user shall the relevant gas in the "Gas" bar at the top, to enter data for each F-gas one by one
2. Column |C| select from the drop-down menu the default average F-gas charge in a particle accelerator by process description in kg of F-gas, or manually enter in user-specific information.
   Note that the IPCC default SF_6 charge for university and research accelerators is 2400 kg SF_6 per accelerator, while default values for industrial/medical accelerators may be found in Table 8.9.
3. Column |D| select from the drop-down menu the default F-gas EF as fraction of charge by scope and process description, or manually enter in user-specific information.
   Note that the IPCC default SF_6 EF for university and research accelerators is 0.7, while default values for industrial/medical accelerators may be found in Table 8.10.

Example: **accelerators – Tier 1 EFs**

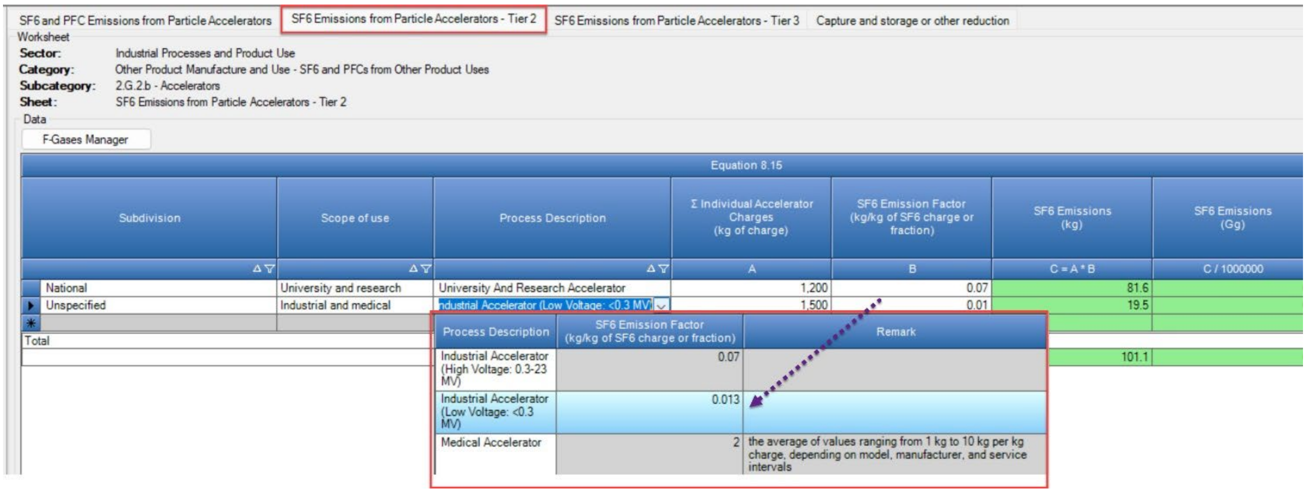


When the Tier 2 Equation is applied

For each subdivision in Column |Subdivision|, scope of use, and process description, data are input in worksheet **SF_6 Emissions from Particle Accelerators – Tier 2,** row by row, as follows:

1. Column |B|: the default SF_6 EF will be automatically populated in this column based on the process-description selected. The user many enter manually a country-specific SF_6 EF.

Example: **accelerators – Tier 2 EFs**



When Tier 3 Equations are applied

The Tier 3 method applies a mass balance approach, and thus entry of EF information is not required.

Results

GHG emissions from 2.G.2.b Accelerators are estimated by the *Software* in the following worksheets:

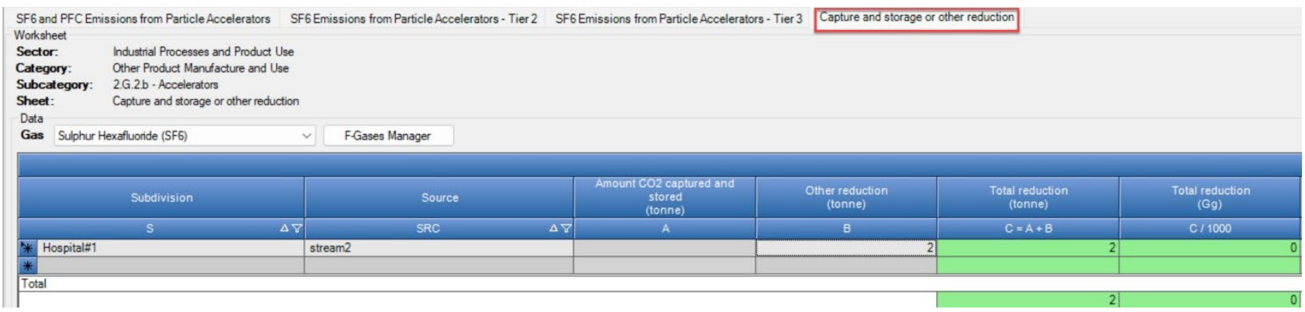
- Tier 1: **SF_6 and PFCs Emissions from Particle Accelerators**
- Tier 2: **SF_6 Emissions from Particle Accelerators – Tier 2**
- Tier 3: **SF_6 Emissions from Particle Accelerators – Tier 3**

Total SF_6 and PFC emissions from accelerators 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:

4. Column |SRC|: 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).
5. Column |A|: not applicable for this category.
6. Column |B|: collect and input information on any other long-term reduction of F-gas emissions, in tonnes.
   Note that: any destruction estimated in the Tier 3 worksheet should not be included in Column |B|.

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



2.G.2.c Other (please specify)

Information

Section 8.3.2.1in the *2006 IPCC Guidelines* provide guidance with specific equations for:

- ✓ Adiabatic uses,
- ✓ Sound-proof glazing,
- ✓ Other uses of SF_6 and PFCs (prompt emissions).

In addition, the *Software* includes a worksheet to estimate F-gas emissions from waterproofing of electronic circuits, a category added from the *2019 Refinement* owing to its inclusion in the CRT for reporting under the Paris Agreement.

Steps for use of the *Software* for each activity is included below in the relevant section.

GHGs

The *Software* includes the following GHGs for Other (SF_6 and PFCs from Other Product Uses)

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	--	**X** (waterproofing only)	**X** (all, except sound-proof glazing)	**X** (all)	--

IPCC Equations

- ✓ Tier 1: Equation 8.19 (Adiabatic uses), Equations 8.20, 8.21 and 8.22 (Sound-proof glazing), Equation 8.22a (New) (waterproofing electronic circuits) and Equation 8.23 (other prompt uses)
- ✓ Tier 2: No Tier 2 Equations provided
- ✓ Tier 3: No Tier 3 Equations provided

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

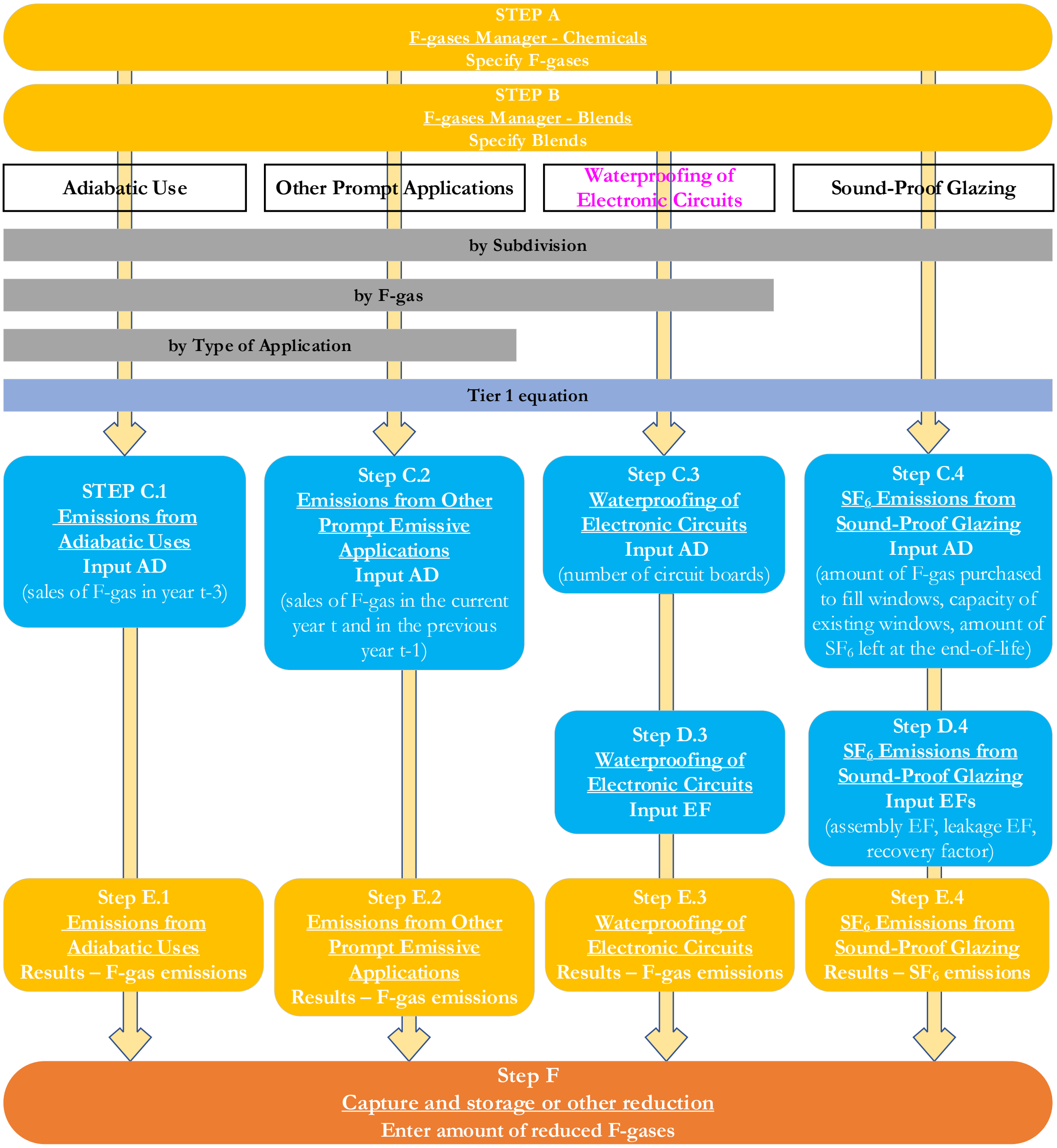
GHG emissions from source category 2.G.2.c Other are estimated using the following worksheets:

- ✓ **F-gases Manager**: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ✓ **Emissions from Adiabatic Uses:** contains for each subdivision, each type of application and each F-gas information on sales of F-gas in the year t-3 (three years prior to the inventory year). The worksheet calculates the associated F-gas emissions.
- ✓ **SF_6 Emissions from Sound-Proof Glazing:** contains for each subdivision, information on the amount of SF_6 emissions from assembly, use and disposal. The worksheet calculates the associated SF_6 emissions.
- ✓ **Waterproofing of Electronic Circuits:** contains for each subdivision, information on the number of circuit boards manufactured and an appropriate EF. The worksheet calculates the associated F-gas emissions.
- ✓ **Emissions from Other Prompt Emissive Applications:** contains for each subdivision and each F-gas, information on the amount of F-gas sold in the current and previous year. The worksheet calculates the associated F-gas emissions.
- ✓ **Capture and storage or other reduction** contains information on reduction of F-gases, not accounted in the previous worksheets.

User's Work Flowchart

To estimate emissions from source category 2.G.2.c Other, users utilize the worksheets of the *Software* referred to above. No decision tree for methodological choice is provided for this source category, and only a single approach is provided for each activity. To ease the use of the *Software* as well as to avoid its misuse, for the source category 2.G.2.c Other, users follow the following flowchart.

Other Applications (SF_6 and PFCs from Other Product Use) - flowchart



Thus, for the source-category:

Steps A and B, **F-gases Manager**, users ensure that all F-gases/blends 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:

Adiabatic Uses

Step C.1, in worksheet **Emissions from Adiabatic Uses**, for each subdivision, F-gas and type of application, users collect and input in the *Software* information on sales of F-gas in the year t-3 (three years prior to the inventory year).

Step E.1, in worksheet **Emissions from Adiabatic Uses,** the *Software* calculates the associated emissions in tonne and Gg of each F-gas.

Emissions from Other Prompt Emissive Applications

Step C.2, in worksheet **Emissions from Other Prompt Emissive Applications**, for each subdivision, F-gas and application, users collect and input in the *Software* information on the amount of F-gas sold in the current and previous year.

Step E.2, in worksheet **Emissions from Other Prompt Emissive Applications,** the *Software* calculates the associated emissions of each F-gas in tonnes and Gg.

Waterproofing of Electronic Circuits

Step C.3, in worksheet **Waterproofing of Electronic Circuits**, for each subdivision and each gas, users collect information on the number of circuit boards manufactured.

Step D.3, in worksheet **Waterproofing of Electronic Circuits**, for each subdivision and each gas, users input the respective EF.

Step E.3, in worksheet **Waterproofing of Electronic Circuits**, the *Software* calculates the associated emissions in grams and Gg.

Sound-proof Glazing

Step C.4, in worksheet **SF_6 Emissions from Sound-proof Glazing**, for each subdivision, users collect information on the amount of F-gas purchased to fill windows, capacity of existing windows and amount left in window at end of lifetime.

Step D.4, in worksheet **SF_6 Emissions from Sound-proof Glazing,** for each subdivision, users input EFs for assembly and use/leakage, and a factor for the fraction of gas recovered at disposal.

Step E.4, in worksheet **SF_6 Emissions from Sound-proof Glazing,** the *Software* calculates the associated emissions in tonnes and Gg.

Then, for each tier, as appropriate:

Step F, in worksheet **Capture and storage or other reduction**, users collect and input information on the amount of GHG captured or otherwise reduced and not otherwise captured in the worksheets above.

Activity Data Input

Section 8.3.2.3 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains general information on the choice of AD. AD for these categories includes sales information and capacity (windows).

Refer to the introduction in section 2.F of this Guidebook to review important notes to avoid double counting of F-gas consumption when estimating GHG emissions for fluorinated gases.

As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the different activities (except SF_6 Emissions from Sound-Proof Glazing, which is only SF_6 and thus the F-gases Manager is pre-populated). Adding an F-gas in one worksheet (e.g. adiabatic uses) automatically adds it to the other worksheets. The exception being if a user reports on waterproofing of electronic circuits. HFC-23 is, exceptionally, reported in that activity, consistent with the *2019 Refinement*, and thus must be added in that worksheet.

*Note that if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the **F-Gases Manager** in any worksheet. This will open the F-gases Manager – applicability at IPCC Category Level. Check the relevant F-gases for this source category. If no gases are available for selection, or a desired gas is not available, 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 at the national level. Save and close the dialogue box for the country level F-gases Manager and the user returns to the Category level F-gases Manager. For more information, refer to populating the F-Gases Manager, in the section above.*

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.

For a Figure illustrating **Populating the F-gases manager and designating confidentiality for Other (SF_6 and PFCs from Other Products Uses),** the user may refer to the illustration in category 2.F.1 Refrigeration and Air Conditioning.

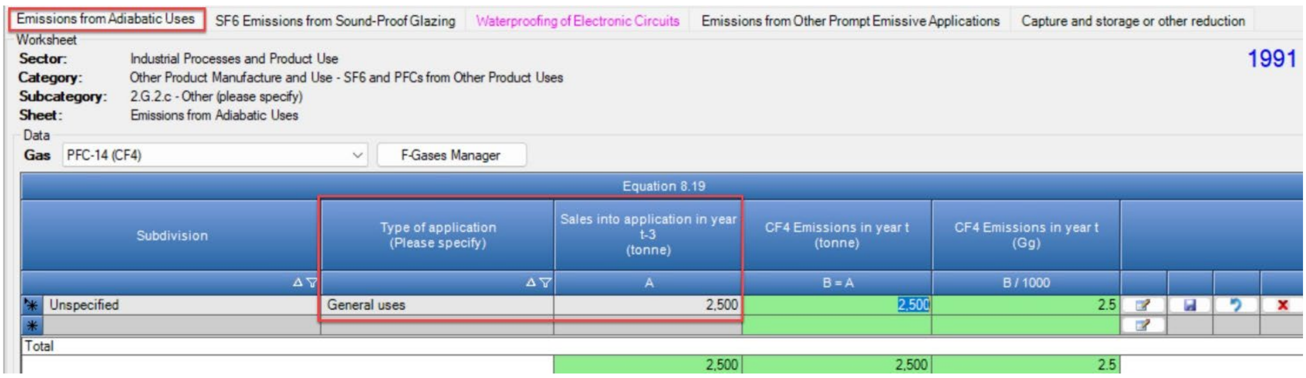
Second, input of AD for **SF_6 and PFCs from Other Products Uses r**equires the user to input information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in Column |Subdivision| [e.g. "country name" or "Unspecified" as selected from the drop-down menu] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision.

When Tier 1 Equations are applied

For each subdivision in Column |Subdivision| and each gas, data are input in worksheet **Emissions from Adiabatic Uses** row by row, as follows:

1. Column |Type of Application|: manually specify the type of adiabatic use.
2. Column |A|: input the sales of that gas into that application from three years ago (year t -3), in tonnes.

Example: **emissions from adiabatic uses – AD input and calculation of emissions**

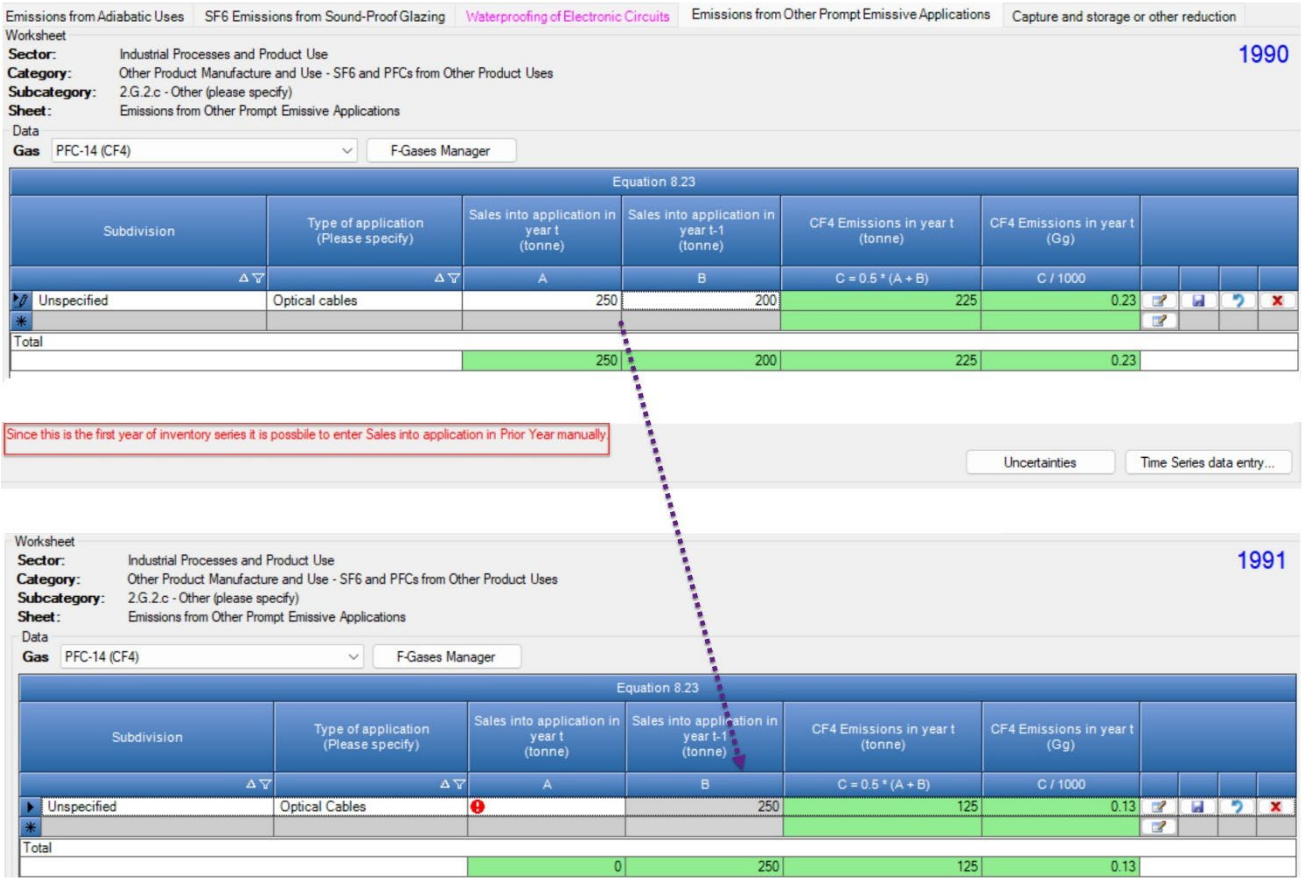


Then, for each subdivision in Column |Subdivision|, and each gas, data are input in worksheet **Emissions from Other Prompt Emissive Applications** row by row, as follows:

1. Column |Type of Application|: input any other type of application of SF_6 and/or PFCs in the country (e.g. user of tracers in leak detection, in optical cables).
2. Column |A|: input the tonnes of sales of the chemical for this type of application in current year, in tonnes.
   Note that: as always it is important to save after entering the data. This ensures that the value is available for automatic population of Column |B| for the next year. Data should be entered from the first inventory year in the time series, forward, to ensure proper calculations.
3. Column |B|: The sales of sales of the chemical for this type of application in the previous year, in tonnes. In the first year of the inventory time series, directly input a value in Column |B|. For all other years, this

value is automatically populated using the value entered in Column |A| in year t-1. The value will not appear until the user enters in the matching subdivision name/ type of application entered in year t-1.

Example: **emissions from other prompt emissive applications – AD input and calculation of emissions**



Then, for each subdivision in Column |Subdivision|, and each gas (note that for this category ALL gases must be entered, HFC-23, CF_4 and C_2F_6), data are input in worksheet **Waterproofing of Electronic Circuits** row by row, as follows:

1. Column |n|: input the number of circuit boards manufactured *(see image under EF input).*

Then, for each subdivision in Column |Subdivision| data are input in worksheet **SF_6 Emissions from Sound-Proof Glazing** row by row, as follows:

1. Column |A|: input the amount of SF_6 purchased to fill windows assembled in year t, in tonnes.
2. Column |D|: input the capacity (amount of SF_6) of existing windows in year t, in tonnes.
   Note that the total installed capacity reflects the total amount of SF_6 in existing windows, including domestically manufactured and imported, and excluding exports, and considering the lifetime of windows.
   In a future release, in Column |D| an option will be made available to calculate this value based on the introduction year, growth rate, lifetime and the nameplate capacity of equipment installed in each year, similar to the worksheets for nameplate capacity of installed equipment in source categories 2.G.1.b and 2.G.1.c.
3. Column |G|: input amount of SF_6 remaining in windows at the end-of-lifetime in year t, in tonnes.
   Note that: consistent with the 2006 IPCC Guidelines, for the stock of gas remaining inside the windows (capacity), an annual leakage rate of 1 percent is assumed (including glass breakage). Thus, about 75 percent of initial stock remains at the end of its 25-year lifetime.
   In a future release, in Column |G| an option will be made available to calculate this value based on the introduction year, growth rate, lifetime and nameplate capacity of existing windows.

Emission Factor Input

Input of EFs is only relevant for Sound-proof Glazing and Waterproofing of Electronic Circuits. Emissions from Adiabatic Uses rely only on the sale of chemicals into these uses, while Emissions from Other Prompt Emissive Applications automatically assume an EF of 0.5 (cannot be changed by the user). Default EFs for SF_6 EFs from Sound-proof Glazing are found in Equations 8.20 and 8.21. Section 8.3.2.2 provides generic information on the choice of EF for all Use of SF_6 and PFCs in Other Products.

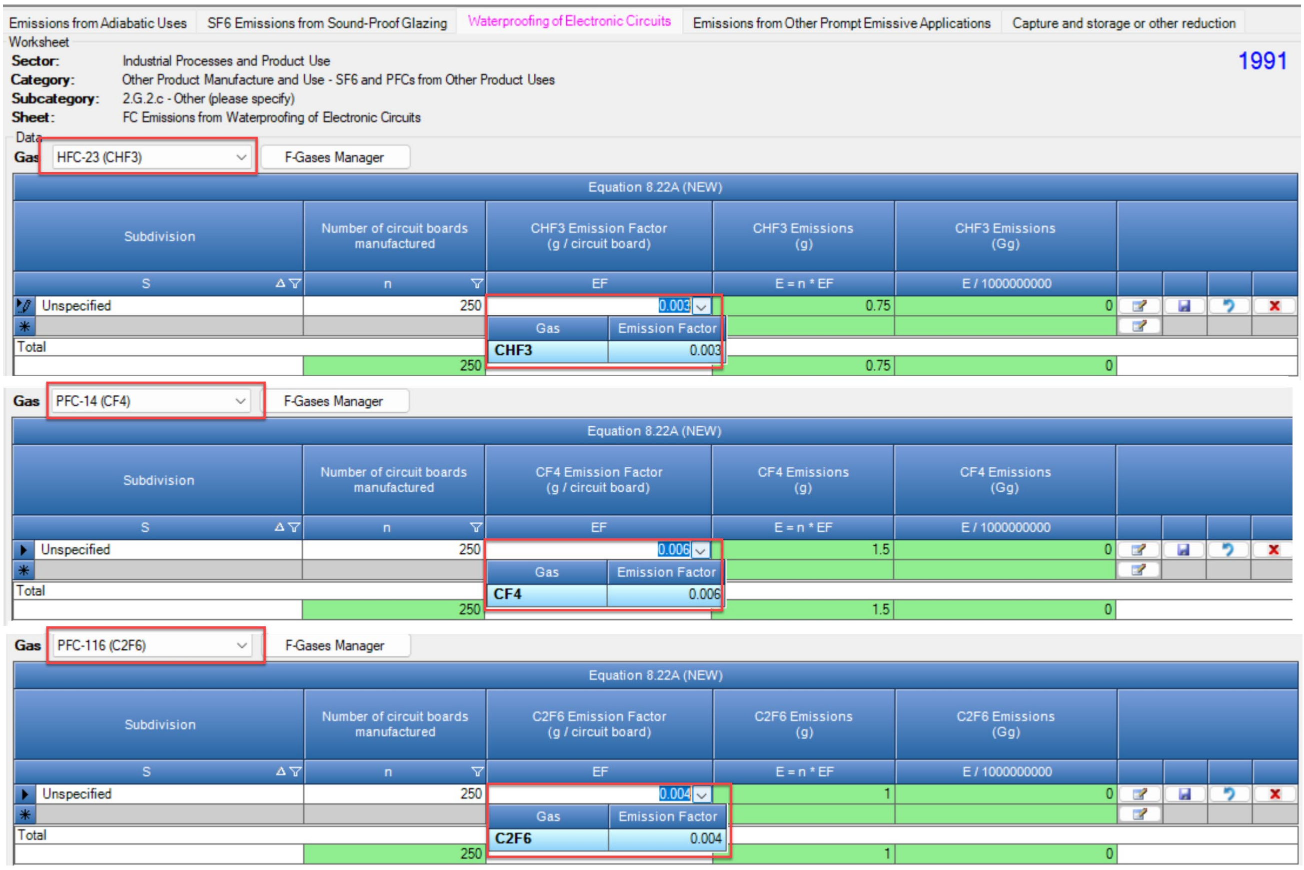
EFs for **Waterproofing of Electronic Circuits** may be found in Table 8.11 (New) of the *2019 Refinement.*

When Tier 1 Equations are applied

For each subdivision in Column |Subdivision|, and each gas (note that for this category ALL gases must be entered, HFC-23, CF_4 and C_2F_6), data are input in worksheet **Waterproofing of Electronic Circuits** row by row, as follows:

1. Column |EF|: select from the drop-down menu the EF for the relevant gas or manually input a user-specific value, in grams/circuit board.
   Important: Consistent with guidance in the 2019 Refinement, inventory compilers should apply all three EFs to the number of circuit boards waterproofed to obtain a complete estimate of emissions from this source category. Each gas can be selected from the drop-down menu under Gas.

Example: **emissions from Waterproofing of Electronic Circuits – EF input**

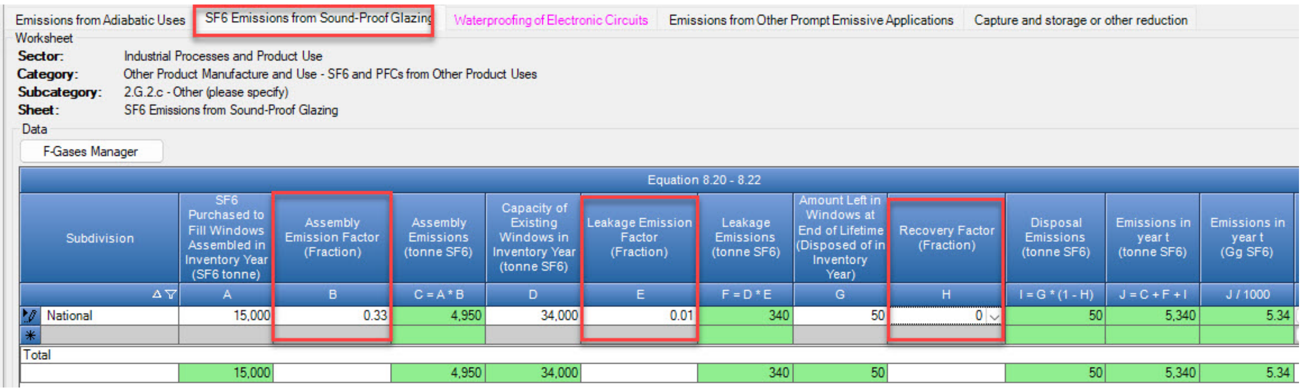


Then, for each subdivision in Column |Subdivision|, data are input in worksheet **Emissions from Sound-proof Glazing,** row by row, as follows:

1. Column |B|: select from the drop-down menu or manually input a user-specific EF for assembly, fraction.
   Note that: the IPCC default EF is 0.33.
2. Column |E|: select from the drop-down menu or manually input a user-specific EF for leakage, fraction.
   Note that: the IPCC default EF is 0.01.

3. Column |H|: select from the drop-down menu or manually input a user-specific recovery factor, fraction. *Note that: the IPCC default EF is 0.*

Example: **emissions from sound-proof glazing – EF input**



Results

GHG emissions from source category 2.G.2.c Other are estimated by the *Software* in the following worksheets:

- ✓ **Emissions from Adiabatic Uses**
- ✓ **Emissions from Other Prompt Emissive Applications**
- ✓ **Waterproofing of Electronic Circuits**
- ✓ **SF_6 Emissions from Sound-proof Glazing**

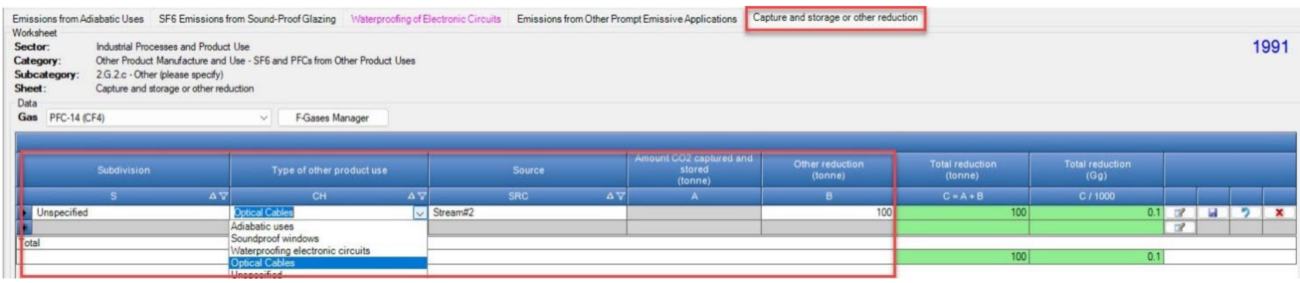
The *Software* calculates the associated emissions for F-gases in the metric units: tonnes/grams and Gg of F-gas.

Total SF_6 and PFC emissions, and in the case of waterproofing of Electronic Circuits, HFC emissions, 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. *Note that, for users reporting to the UNFCCC ETF GHG Reporting Tool, HFC-23 emissions from waterproofing circuits will map to 2.G.4 Other (Other Product Manufacture and Use), since it is not logical to map them to an activity in the category 2.G.2, which specifically covers SF_6 and PFC emissions.*

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

1. Column |CH|: select from the drop-down menu, or input information in which activity the capture or other reduction occurs (e.g. adiabatic uses, sound-proof glazing). The drop-down menu will include any country specific categories entered under emissions from other prompt emissive applications. *Note that, for users reporting to the UNFCCC ETF GHG Reporting Tool, users must select one of the selections in the drop-down menu to ensure that the capture maps to the correct category.*
2. Column |SRC|: 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).
3. Column |A|: not applicable for this category.
4. Column |B|: collect and input information on any other long-term reduction of F-gas emissions, in tonnes.

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



2.G.3 N_2O from Product Uses

The 2006 IPCC Guidelines provide single methodological guidance for various sources of N_2O emissions from product use. This section provides guidance for the following source categories:

- ✓ *2.G.3.a Medical Applications*
- ✓ *2.G.3.b Propellant for Pressure and Aerosol Products*
- ✓ *2.G.3.c Other*

In general, medical applications and use as a propellant in aerosol products are likely to be larger sources than others. Inventory compilers are encouraged to estimate and report N_2O emissions from the other sources as well, if data are available.

GHGs

The *Software* includes the following GHGs for source categories 2.G.3.a (medical applications), 2.G.3.b (Propellant for pressure and aerosol products) and 2.G.3.c (Other N_2O from product uses):

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
--	--	X	--	--	--	--

IPCC Equations

- ✓ Tier 1: Equation 8.24
- ✓ Tier 2: No Tier 2 Equations provided
- ✓ Tier 3: No Tier 3 Equations provided

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

N_2O emissions from categories 2.G.3.a (medical applications), 2.G.3.b (Propellant for pressure and aerosol products) and 2.G.3.c (Other N_2O from product uses) are estimated using the following worksheets:

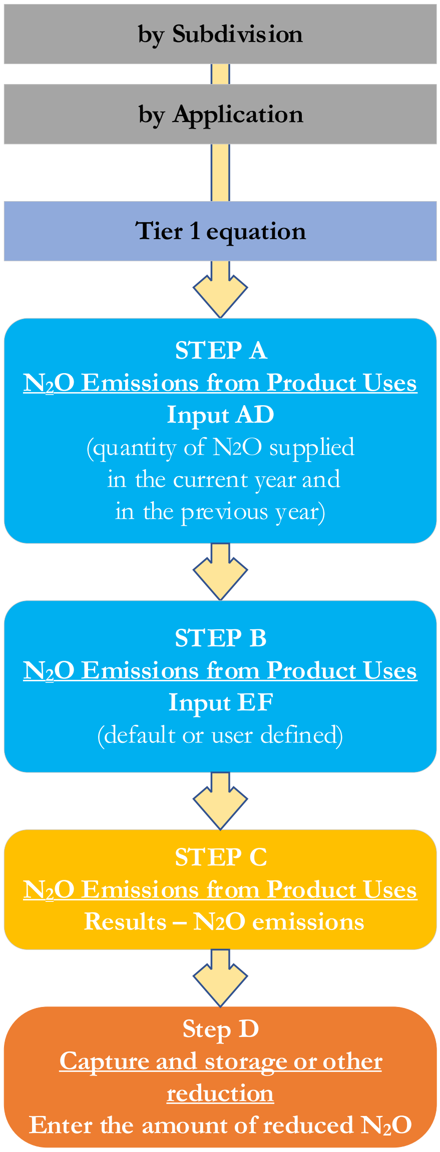
- ➢ **N_2O Emissions from Product Use:** contains for each subdivision and each type of application information on quantity of N_2O supplied in the current and the previous year and N_2O EF. The worksheet calculates the associated N_2O emissions.
- ➢ **Capture and storage or other reduction** contains information on reduction of N_2O, if any (this source category is unlikely to be a source with reduction technologies).

User's Work Flowchart

To estimate emissions from source category 2.G.3.a (medical applications), 2.G.3.b (Propellant for pressure and aerosol products) and 2.G.3.c (Other N_2O from product uses), users utilize the worksheets of the *Software* referred to above. No decision tree for methodological choice is provided for this source category, and only a single approach is provided for each source category.

To ease the use of the *Software* as well as to avoid its misuse, for source categories 2.G.3.a (medical applications), 2.G.3.b (Propellant for pressure and aerosol products) and 2.G.3.c (Other N_2O from product uses), users follow the following flowchart:

N$_2$O from Product Use - 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 worksheet **N$_2$O Emissions from Product Use** for each source category**,** users collect and input in the *Software* information on the amount of on quantity of N$_2$O supplied in the current year and the previous year.

Step B, in worksheet **N$_2$O Emissions from Product Use**, for each source category, users input the relevant N$_2$O EF.

Step C, in worksheet **N$_2$O Emissions from Product Use** for each source category**,** the *Software* calculates the associated N$_2$O emissions for each subdivision in mass units (tonnes and Gg).

Step D, in worksheet **Capture and storage or other reduction**, users collect and input in the *Software* information on the amount of N_2O reduced, if any.

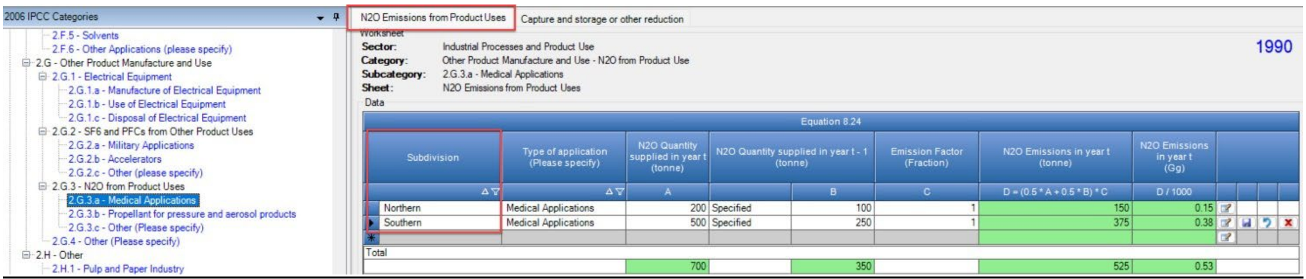
Activity Data Input

Section 8.4.2.3 in Chapter 8 Volume 3 of the *2006 IPCC Guidelines* contains information on the choice of AD for the N_2O from Product Uses source category.

Input of AD for N_2O from Product Uses requires the user to input 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] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision

Example: **multiple subdivisions**

Note that figure below is applicable to source categories 2.G.3.a, 2.G.3.b and 2.G.3.c



For each subdivision in Column |Subdivision|, data are input in worksheet **N_2O Emissions from Product Use,** row by row, as follows:

1. Column |Type of Application|: input the type of application (e.g., medical, propellant, other specific).
2. Column |A|: input the quantity of N_2O supplied in the current year, in tonnes.
3. Column |B|: input the quantity of N_2O supplied in the previous year in tonnes. The user may either specify or calculate this value (see figure below).
    a. *Specified:* In the first year of the inventory time series, the user must select specify and directly enter a value in Column |B|. For all other years of the time series, the user may choose to directly specify the value, or calculate the value as described below.
    b. *Calculated:* The value is automatically populated using the value entered in Column |A| in year t-1. The value will not appear until the user enters in the matching subdivision name/ type of application entered in year t-1.

Emission Factor Input

Section 8.4.2.2 provides information on the choice of EF for N_2O for use in medical applications, use as propellants in aerosol products and others uses.

For each subdivision in Column |Subdivision|, data are input in worksheet **N_2O Emissions from Product Use,** row by row, as follows:

1. Column |C|: select from the drop-down menu or manually input a user-specific EF for medical applications, propellants, or other, fraction
   Note that: the IPCC default EF for medical applications and N_2O used as a propellant in aerosol products is 1.0. For the other types of product use, according to the 2006 IPCC Guidelines it may not be appropriate to assume an EF of 1.0. and inventory compilers are encouraged to derive reasonable EFs for those sources from literature. Recognizing that equation 8.24 assumes a two year lifetime, if use of an alternative EF is associated with a longer lifetime, the user may wish to consider if the generic equation in category 2.G may be more appropriate for estimation and reporting of the emissions.

Example: **emissions from N_2O from Product Uses – AD and EF input**

N2O Emissions from Product Uses | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Other Product Manufacture and Use - N2O from Product Use
Subcategory: 2.G.3.a - Medical Applications
Sheet: N2O Emissions from Product Uses
Data

1990

Equation 8.24

Subdivision	Type of application (Please specify)	N2O Quantity supplied in year t (tonne)	N2O Quantity supplied in year t - 1 (tonne)		Emission Factor (Fraction)	N2O Emissions in year t (tonne)	N2O Emissions in year t (Gg)
		A		B	C	D = (0.5 * A + 0.5 * B) * C	D / 1000
Northern	Medical Applications	200	Specified	100	1	150	0.15
Southern	Medical Applications	500	Specified	250	1	375	0.38
Total		700		350		525	0.53

Worksheet
Sector: Industrial Processes and Product Use
Category: Other Product Manufacture and Use - N2O from Product Use
Subcategory: 2.G.3.a - Medical Applications
Sheet: N2O Emissions from Product Uses
Data

1991

Equation 8.24

Subdivision	Type of application (Please specify)	N2O Quantity supplied in year t (tonne)	N2O Quantity supplied in year t - 1 (tonne)		Emission Factor (Fraction)	N2O Emissions in year t (tonne)	N2O Emissions in year t (Gg)
		A		B	C	D = (0.5 * A + 0.5 * B) * C	D / 1000
Northern	Medical Applications	225	Calculated	200	1	212.5	0.21
Southern	Medical Applications	525	Calculated	500	1	512.5	0.51
Total		750		700		725	0.73

Results

N_2O emissions from Product Use are estimated in mass units (tonnes and Gg) by the *Software* in the worksheet **N_2O Emissions from Product Use** in each of the three source categories: 2.G.3.a (medical applications), 2.G.3.b (Propellant for pressure and aerosol products) and 2.G.3.c (Other N_2O from product uses). Total emissions for the source category is the sum of N_2O emissions in each worksheet, 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|: 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|: not applicable for this category.
3. Column |B|: collect and input information on any other long-term reduction of N_2O emissions, in tonnes.

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

N2O Emissions from Product Uses | Capture and storage or other reduction

Worksheet
Sector: Industrial Processes and Product Use
Category: Other Product Manufacture and Use
Subcategory: 2.G.3.c - Other (Please specify)
Sheet: Capture and storage or other reduction
Data
Gas NITROUS OXIDE (N2O)

1991

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
ManufacturerA	Stream3		100	100	0.1
Total				100	0.1

2.G.4 Other

Information

This section describes calculation of emissions from other product manufacture and use not included in source categories 2.G.1, 2.G.2, 2.G.3 or 2.G.4.

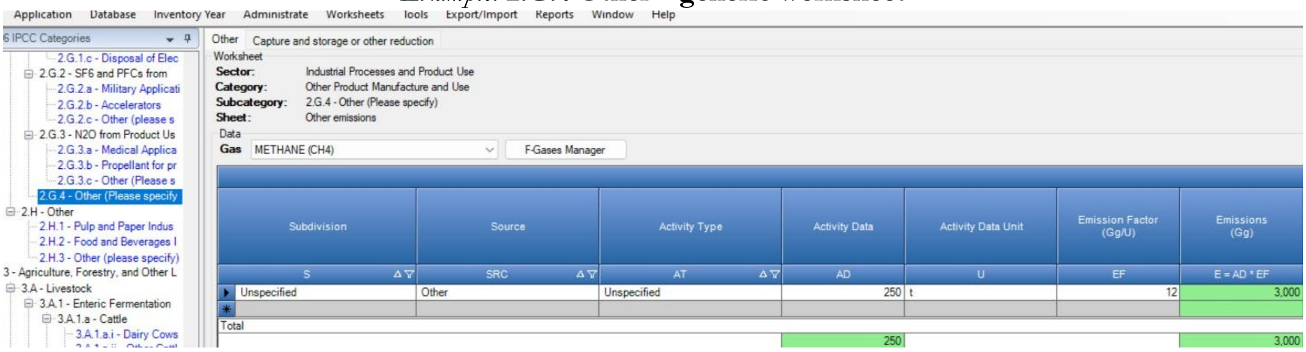
GHGs

Emissions from the Other (Other Product Manufacture and Use) 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 iIput, 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.G.4 Other (Other Product Manufacture and Use).

Example: **2.G.4 Other – generic worksheet**



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 (or worksheets). Below 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

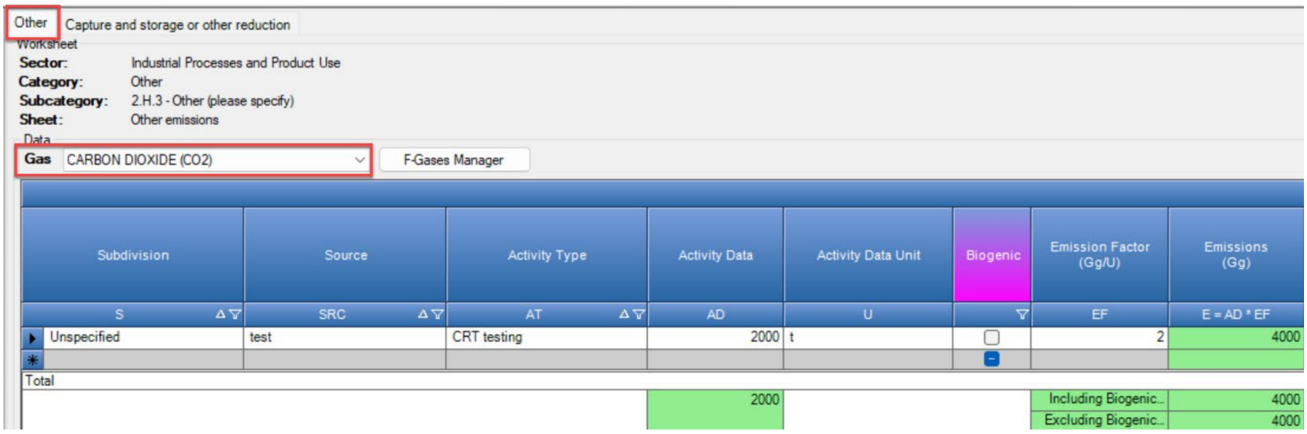
Emissions from the Other (IPPU) source category include the following GHGs:

CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
X	X	X	X	X	X	X
			2.H.3 only			

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.

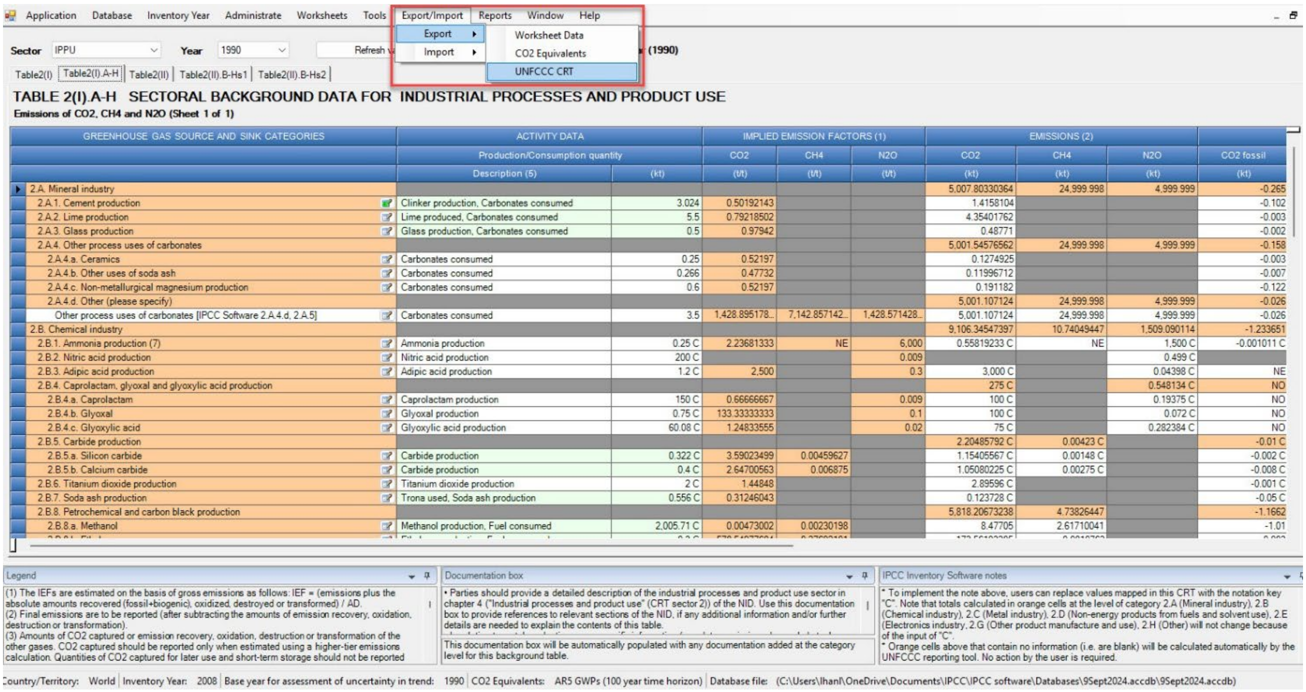
This annex contains detailed information to illustrate the mapping of categories and gases between the *Software* and the CRT for reporting of emissions from the IPPU sector and is supplemental to the general information provided in the UNFCCC Interoperability – CRT Export Quick Start Guide.

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 must formally submit the information through the UNFCCC ETF Reporting Tool, and 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*.

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:

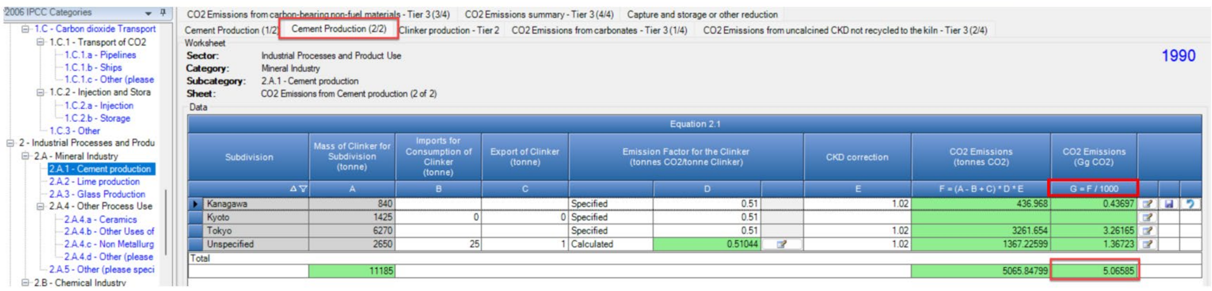
- ✓ The sign **"SUM"** indicates a summatory of information (numerical or alphabetical) contained across the column/row to which applies.
- ✓ The sign **"-SUM"** indicates that the result of the summatory is to be reported as a negative value.
- ✓ The sign **"AND"** indicates an additional element for 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

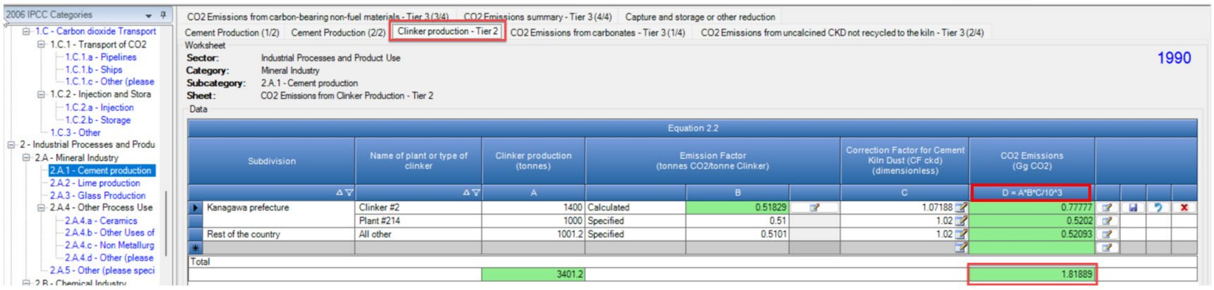
UNFCCC CRT

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.

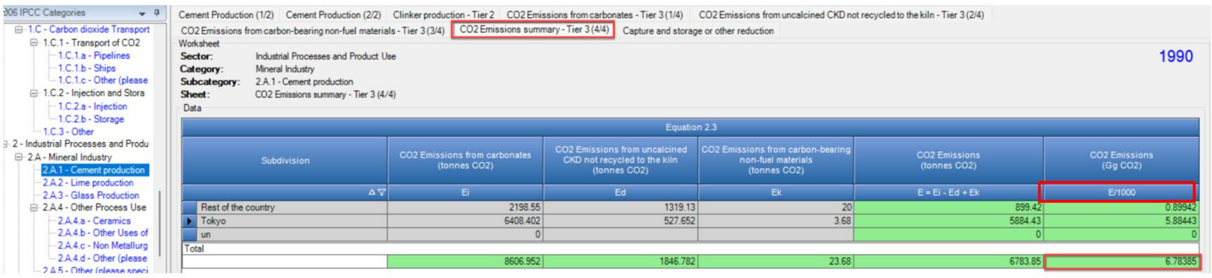
IPCC Inventory Software



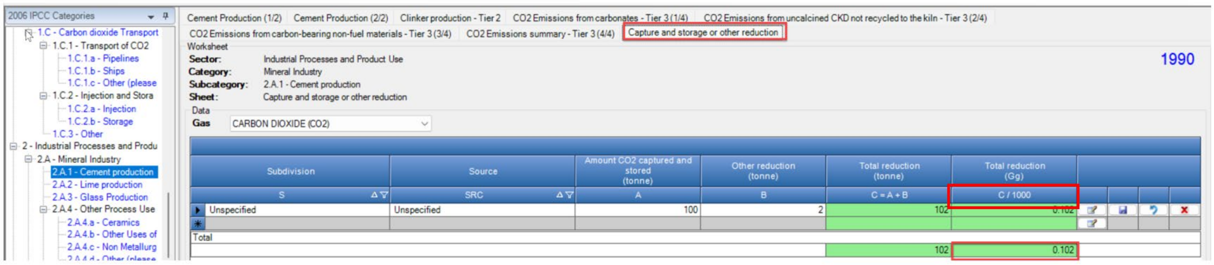
PLUS



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):

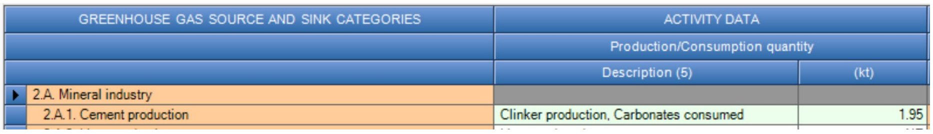
   ✓ If all the same type of AD is used for the user's selected Tiers, these AD values are combined and appear in the visualized CRT (scenario #1 below). In the cement example, if a user applies all Tier 1 and/or Tier 2 methods, the total amount of clinker production is aggregated and the visualized CRT 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.

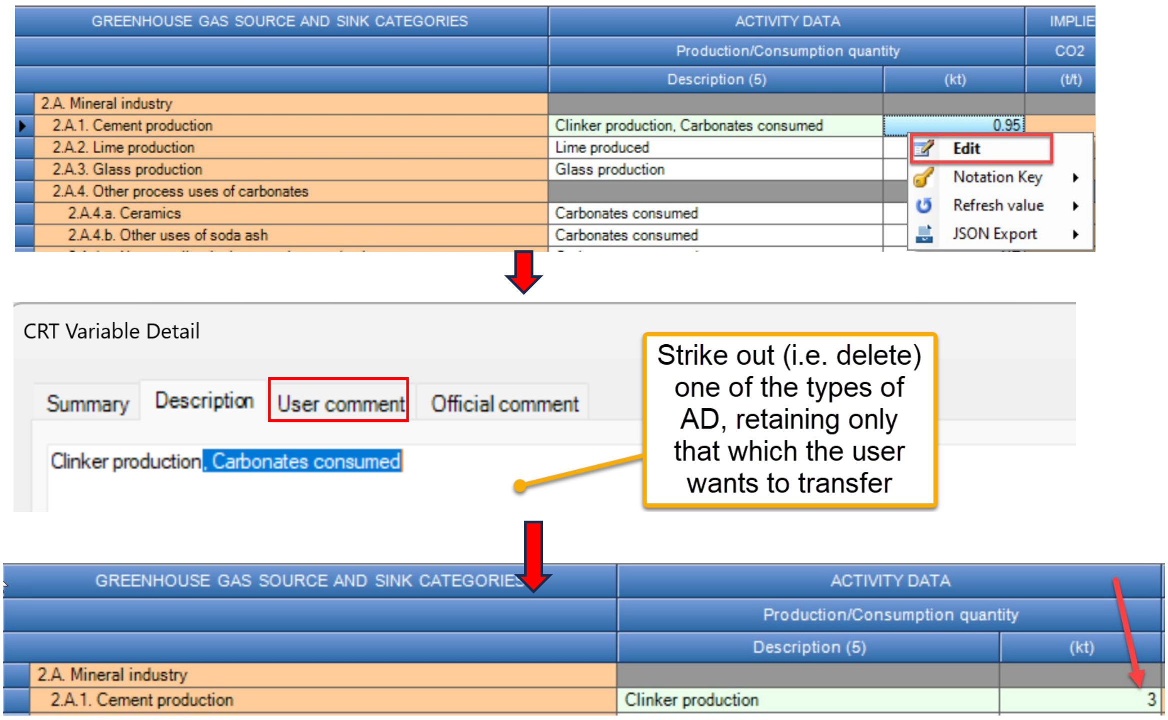
Example: **Aggregating AD: cement production example**

Scenario	How AD are aggregated in visualized CRT
#1: User applies all Tier 1 and/or Tier 2 methods	GREENHOUSE GAS SOURCE AND SINK CATEGORIES | ACTIVITY DATA Production/Consumption quantity Description (5) | (kt) 2.A. Mineral industry 2.A.1. Cement production | Clinker production | 1.95
#2: User applies all Tier 3 methods	GREENHOUSE GAS SOURCE AND SINK CATEGORIES | ACTIVITY DATA Production/Consumption quantity Description (5) | (kt) 2.A. Mineral industry 2.A.1. Cement production | Carbonates consumed | 1

#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.**
  3. With the description change to Clinker production, now **manually edit the value in <u>Column |kt|</u>**: to equal total national amount of clinker produced (0.95 was updated to 3 in the example below).

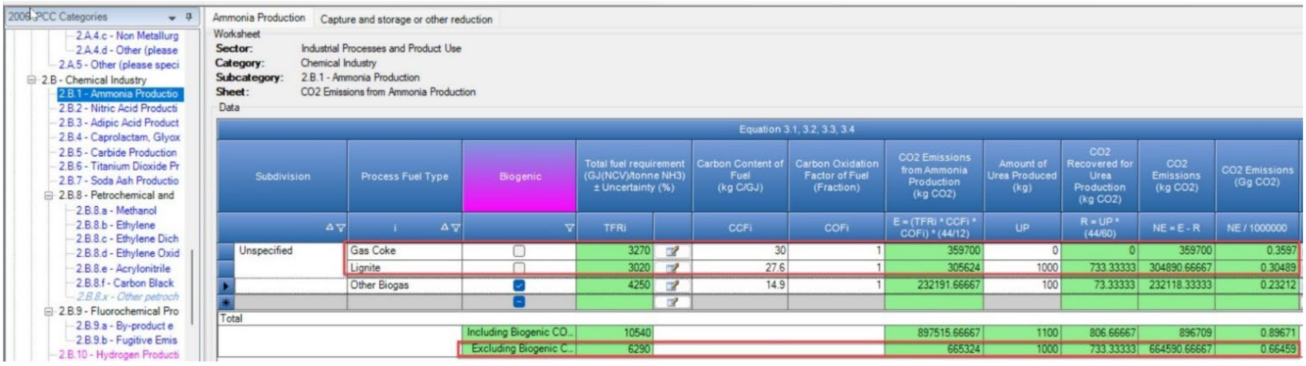
Example: **updating AD when multiple Tiers are used**



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.

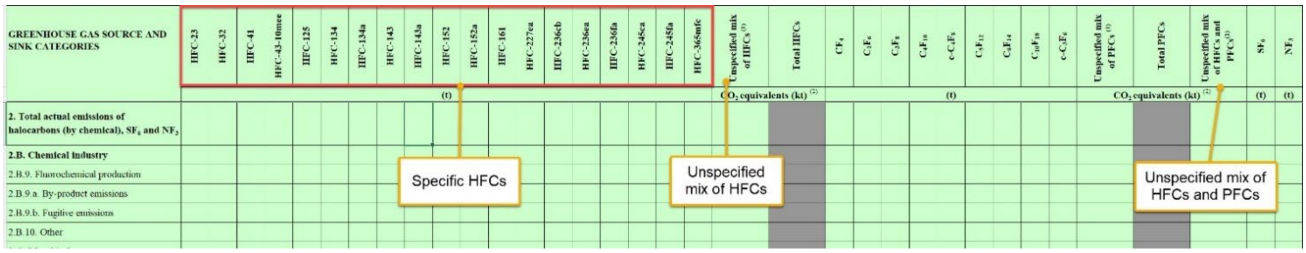
   Example: CO_2 emissions mapped to the CRT is the total, excluding biogenic CO_2. Any capture of biogenic CO_2 would be included as a reduction from CO_2 emissions from ammonia production



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.**

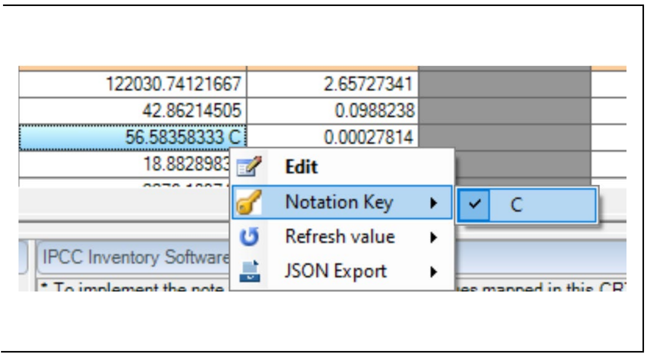
The UNFCCC ETF Reporting Tool allows Parties to claim information as "C", noting that some level of aggregation may be needed to mask confidential information. Confidential emissions must still be included in totals for a complete GHG inventory. If necessary, users of the *Software* may claim AD or emissions 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.



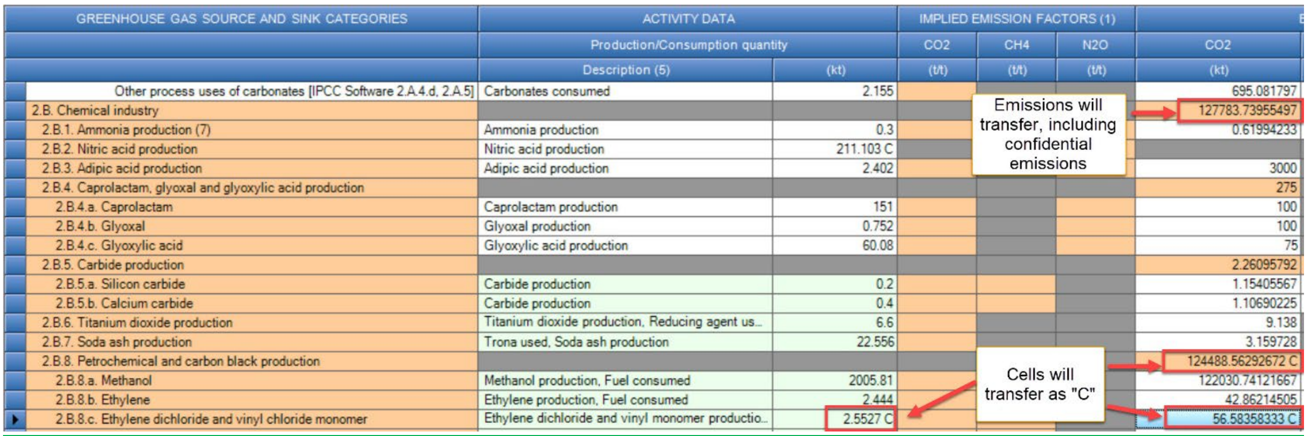
For this CRT, the steps above ensure that the AD are "C", and since there are no aggregations of data in CRT 2(I)A-H, the confidential AD cannot be back-calculated. Typically, emissions are not considered confidential. However, efforts have been made to allow a user to designate emissions as confidential, 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)			E
	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

<u>Designating AD and emissions confidential in 2(II)B-Hs1 and 2(II)B-Hs2</u>

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 (for some Tier 1 worksheets, the F-Gases Manager is accessible through the **Chemical’s Data** tab.
- ✓ check the box(es) for the gas(es) or blends that are confidential

Refer to the relevant source category in the Guidebook to learn how to identify specific category/gas combination Confidential. 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 Update mode **Current year (1990)**

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)			RECO
	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	IE	22	IE	IE	842.24090909	IE	IE	185.293	IE	
2.G.2.b. Accelerators										
Unspecified mix of PFCs	IE	0.14428	IE	IE	2,320,721.29886..	IE	IE	3,348.33669	IE	
SF6	IE	198.9332	IE	IE	16.7569732	IE	IE	33.335183	IE	
2.G.2.c. Soundproof windows										
SF6	2	NE	NE	33	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	NO	NE	NO	
SF6	IE	1	IE	IE	200	IE	IE	2	IE	
2.G.2.e. Other										
2.G.2.e.i. Waterproofing electronic circuits										
CF4	NE	NE	NE	NE	NE	NE	NE	NE	NE	
C2F6	NE	NE	NE	NE	NE	NE	NE	NE	NE	
Unspecified mix of PFCs	NE	NE	NE	NO	NE	NO	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	4	NA	IE	663,000	NA	IE	26,520	NA	
SF6	NO	NE	NA	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	40,945,000,000	IE	IE	51,181,250,000	IE	
SF6	NO	NE	NO	NO	NE	NO	NO	NE	NO	
NF3	NO	NE	NO	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	2,000	IE	IE	56,928,688,277.5	IE	IE	1,138,573,765,550	IE	-
SF6	IE	2,000	IE	IE	299,600	IE	IE	5,992,000	IE	
NF3	IE	2,000	IE	IE	999,500	IE	IE	19,990,000	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, 2.G.2.e, 2.G.4, 2.H.3	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.
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.