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IPPU SECTOR USERS' GUIDEBOOK

IPCC Inventory Software, version 2.98

Compiled by:

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This Guidebook is prepared by IPCC TFI TSU. It has not been subject to the formal IPCC review process. Please submit your feedback to ipcc-software@iges.or.jp

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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
GI	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
LKD m ²	
	square meters cubic meter
m ³	
MPGs	Modalities, procedures and guidelines for the transparency framework for action and support
Nd	referred to in Article 13 of the Paris Agreement
NGHGI	neodymium
	national GHG inventory
NF ₃	nitrogen trifluoride
N ₂ O	nitrous oxide
NGHGI ODS	national GHG inventory
	ozone depleting substances
OHF	open hearth furnace
PFC	perfluorocarbons
PV	photovoltaic
RAC	refrigeration and air conditioning
RE	rare earth
S C	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.

<u>Scope</u>

This Guidebook covers all methodological tiers and approaches provided in the 2006 IPCC Guidelines. Elements of the 2019 Refinement¹ 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-specific³ 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.

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.

<u>Tips</u>

Stratification¹ of variables² 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 out³ while all remaining are reported within a single aggregation⁴, 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 \boxplus on the left-hand side of worksheet. Once clicked the element \boxplus changes to \boxminus 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<u>UNFCCC CRT Export Guide</u>, 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.

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 CO₂, CH₄, N₂O, HFCs, PFCs, SF₆, and NF₃. 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 (SF₆) and N₂O are used in products used in industry (e.g., SF₆ used in electrical equipment, N₂O used as a propellant in aerosol products primarily in the food industry) or by end-consumers (e.g., SF₆ used in running-shoes, N₂O 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, SF₆, NF₃, 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.

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)
<u>2.A.4.c Non-Metallurgical</u> <u>Magnesia Production</u>	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.

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.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).
<u>2.A.5 Other</u>	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 ₂ O.
<u>2.B.3 Adipic Acid</u> <u>Production</u>	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 ₂ O.
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	Most of the annual production of caprolactam (NH(CH ₂) ₅ CO) 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 ₂ O.
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).
<u>2.B.6 Titanium Dioxide</u> <u>Production</u>	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	Solda 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 <i>Software</i> information on the use of biogenic feedstocks. Consistent with the 2006 IPCC Guidelines, the <i>Software</i> 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 <i>Software</i> 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 <i>Software</i> (without a specific IPCC category code) to allow users to implement section 3.9.1 of chapter 3, volume 3 of the <i>2006 IPCC Guidelines</i> , 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 ₂ O 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 ₂ F 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.
<u>2.C.4 Magnesium</u> <u>Production</u>	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 ₃ F ₇ C(O)C ₂ F 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.
<u>2.C.7 Rare Earths</u> <u>Production</u>	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 ₂ F 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 2.D.2 Paraffin Wax Use	Lubricating oils, heat transfer oils, cutting oils and greases. 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	
<u>2.E.1 Integrated Circuit or</u> <u>Semiconductor</u>	Emissions of CF4, C ₂ F ₆ , C ₃ F ₈ , c-C ₄ F ₈ , C ₄ F ₆ , C ₄ F ₈ O, C ₅ F ₈ , CHF ₃ , CH ₂ F 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.
<u>2.E.2 TFT Flat Panel</u> <u>Display</u>	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 CF4 and C2F6 among others.
<u>2.E.4 Heat Transfer Fluid</u>	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	The application domains are mobile air-conditioning systems used in passenger cars, truck cabins, buses, and trains.
Conditioning 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.

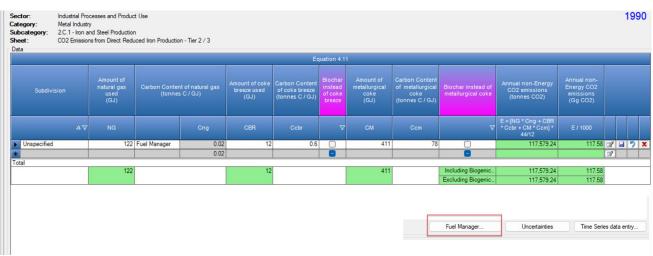
Categories	Definitions
2.F.5 Solvents	HFCs and, to a much lesser extent PFCs, are being used as substitutes for ODS (most notably CFC- 113). Typical HFCs used are HFC-365mfc and HFC-43-10mee. Use of these fluorinated replacements is much less widespread than the ODS they replace. Re-capture and re-use 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.
<u>2.G.2.c Other (please</u> <u>specify)</u>	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 ₂ O 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 ₂ O) 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 ₂ O 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).

Application Database Inventory Year	Administrate	Work	sheets Tools	Export/Im	nport Report	s Window	Help									- 8
06 IPCC Categories	Users			ers - Tier	2 F-Gas Emis	sions - Tier 2a	F-Gas Emission	is - Tier 2b								
- 2.D.1 - Lubricant Use - 2.D.2 - Paraffin Wax Use - 2.D.3 - Solvent Use		/Territon uivalents			roduct Use	lating Substance										1994
2.D.3 - Solvent Use 2.D.4 - Other (please specify)	Energy				el Manager	ining										
2.E - Electronics Industry	IPPU			Emission	8											
- 2.E.1 - Integrated Circuit or Semiconducto - 2.E.2 - TFT Flat Panel Display	AFOLU			. ~	Gas hop (ho	p1hop 2)	~	Chemical's Data								
2.E.3 - Photovoltaics 2.E.4 - Heat Transfer Fluid		nventory		th Rate	(%) 0	Lifetime (d)	(years) 15	EF (%) 15	Destr	oyed (%) 0						
2.E.5 - Other (please specify)	Deleter	iventory					Equation 7.2	3					Inform	ation for UNFCC	CORT	-
- 2.F - Product Uses as Substitutes for Ozone D						Total new			Release of				in a start	Agent in new		^
2.F.1 - Refrigeration and Air Conditioning 2.F.1a - Refrigeration and Stationary A 2.F.1a - Nobile Air Conditioning 2.F.2 - Foam Blowing Agents			Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Agent for servicing (tonnes)	equipment installed in year t (tonnes)	Agent in all equipment installed (tonnes)	
2.F.3 - Fire Protection 2.F.4 - Aerosols 2.F.5 - Solvents 2.F.6 - Other Applications (please specify) □ 2.G - Other Product Manufacture and Use	t	۵Ţ	P				R = [L(t-(d-1)) - (L(t-(d-1)) * EF/100)] - [S_needed(t- d)) - S_done(t- d)]	F = R * (destroyed/100)		H = H(t-1) + D - R - I	I = M * EF/100	E = G + I	K = IF(D>I(t- 1), I(t-1), D)		$M = \sum_{\substack{(L, t) \\ (d-1)}} (L(t, t))$	
2.G.1 - Electrical Equipment		1990	10000	0	0	10000		0	0	8500	1500	1500	0	10000	10000	1
-2.G.1.a - Manufacture of Electrical Equ																

- 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.

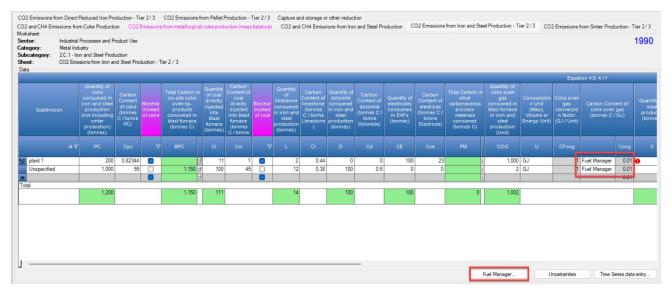
uid Fuels			(TJ / Gg)	(kg C / GJ)
uid ruels	Aviation Gasoline		44.3	19.1
	Bitumen		40.2	22
	Crude Oil		42.3	20
	Ethane		46.4	16.8
	Gas/Diesel Oil		43	20.2
	Jet Gasoline		44.3	19.1
	Jet Kerosene		44.1	19.5
	Liquefied Petroleum Gases	0	47.3	17.2
	Lubricants		40.2	20
	Motor Gasoline	0	44.3	18.9
	Naphtha		44.5	20
	Natural Gas Liquids		44.2	17.5
	Orimulsion		27.5	21
	Other Kerosene		43.8	19.6
	Other Petroleum Products	0	40.2	20
	Paraffin Waxes		40.2	20
	Petroleum Coke		32,5	26.6
	Refinery Feedstocks		43	20
	Refinery Gas		49.5	15.7
	Residual Fuel Oil		40.4	21.1
	Shale Oil	0	38.1	20
	White Spirit and SBP	0	40.2	20
id Fuels	Anthracite		26.7	26.8
	Blast Furnace Gas		2.47	70.8
	Brown Coal Briquettes		20.7	26.6
	Coal Tar	0	28	22

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*.

Fuel Type	✓ Fuel Name	Primary Fuel V	Gross Calorific Value (TJ / Gg)	Carbon content (GCV) (kg C / GJ)
Liquid Fuels	Aviation Gasoline			19.1
	Bitumen	0		22
	Crude Oil			20
	Ethane			16.8
	Gas/Diesel Oil			20.2
	Jet Gasoline			19.1
	Jet Kerosene			19.5
	Liquefied Petroleum Gases			17.2
	Lubricants			20
	Motor Gasoline	0		18.9
	Naphtha			20
	Natural Gas Liquids		-	17.5
	Orimulsion			21
	Other Kerosene		2	19.6
	Other Petroleum Products	0		20
	Paraffin Waxes			20
	Petroleum Coke	0		26.6
	Refinery Feedstocks	0		20
	Refinery Gas	0		15.7
	Residual Fuel Oil			21.1
	Shale Oil	0		20
	White Spirit and SBP			20
Solid Fuels	Anthracite			26.8
	Blast Furnace Gas Brown Coal Briguettes			70.8
	Coal Tar			20.6
	I, e.g. dung, not covered in the definitions in table 1.1 (Vol.2, Cha ed in the definitions in table 1.1 (Vol.2, Chapter 1 of the 2006 IPC0			
serspecific biomass-derived fue ser-specific fossil fuel not cover Manager				considered "waste derived" Save Undo Oor
serspecific biomass-derived fue ser-specific fossil fuel not cover Manager	ed in the definitions in table 1.1 (Vol.2, Chapter 1 of the 2006 IPCC		r fossil fuels" ; these fuels are all	considered "waste derived" Save Undo Oor
serspecific biomass derived fue serspecific fossil fuel not cover Manager wersion Factor Type	ed in the definitions in table 1.1 (Vol.2, Chapter 1 of the 2006 IPCC	Cuidelines) shall be classified as "Othe	r fossil fuels" ; these fuels are all e	Considered "waste derived" Save Undo Qot Carbon content (NCV)
serspecific biomass derived fue serspecific fossil fuel not cover Manager Iversion Factor Type Fuel Type	A finite definitions in table 1.1 (Vol.2, Chapter 1 of the 2006 IPCC O NCV O GCV Show user-defined fuels only Fuel Name Diesel for off-road Diesel for trains	Cudelines) shall be classified as "Othe	r fossil fuels" ; these fuels are all Net Calorific Value (TJ / Gg)	Considered "waste derived" Save Undo Got Got Garbon content (NCV) (kg C / GJ) 38 1 40 1
serspecific biomass derived fue serspecific fossil fuel not cover Manager Iversion Factor Type Fuel Type	ed in the definitions in table 1.1 (Vol.2, Chapter 1 of the 2006 IPCC NCV GCV GCV Fuel Name Diesel for off-road Diesel for rolins Lignite Power Plants	Couldelines) shall be classified as "Othe Primary Fuel T	r fossil fuels" : these fuels are all Net Catomic Value (TJ / Gg)	Carbon content (NCV) (kg C / GJ) (kg C / G
serspecific biomass derived fue serspecific fossil fuel not cover Manager Iversion Factor Type Fuel Type	ed in the definitions in table 1.1 (Vol 2, Chapter 1 of the 2006 IPCC C OCV C Show user-defined fuels only Fuel Name Diesel for off-road Diesel for trains Lignite Power Plants Natural Gas Power Plants	Cudelines) shall be classified as "Othe Primary Fuel	r fossi fuels" ; these fuels are all v (TJ / Gg)	Carbon content (NCV) (kg C / GJ) 38 11 40 12 345
serspecific biomass derived fue serspecific fossil fuel not cover Manager Iversion Factor Type Fuel Type	ed in the definitions in table 1.1 (Vol.2, Chapter 1 of the 2006 IPCC NCV GCV GCV Fuel Name Diesel for off-road Diesel for rolins Lignite Power Plants	Cudelines) shall be classified as "Othe	r fossi fuels" ; these fuels are all v (TJ / Gg)	Carbon content (NCV) (kg C / GJ) 12 33 12 33 35 36 37 37 37 37 38 38 38 38 38 37 38 38 38 38 38 38 38 38 38 38
Manager Wersion Factor Type Fuel Type Other Fossil Fuels	ed in the definitions in table 1.1 (Vol 2, Chapter 1 of the 2006 IPCC C OCV C Show user-defined fuels only Fuel Name Diesel for off-road Diesel for trains Lignite Power Plants Natural Gas Power Plants	Caudelines) shall be classified as "Othe Primary Fuel C C C C C C C C C	r fossi fuels" ; these fuels are all v (TJ / Gg)	Carbon content (NCV) (kg C / GJ) 38 11 40 12 345
Manager Wersion Factor Type Fuel Type Other Fossil Fuels	ed in the definitions in table 1.1 (Vol 2, Chapter 1 of the 2006 IPCC C OCV C Show user-defined fuels only Fuel Name Diesel for off-road Diesel for trains Lignite Power Plants Natural Gas Power Plants	Caudelines) shall be classified as "Othe Primary Fuel C C C C C C C C C	r fossi fuels" ; these fuels are all v (TJ / Gg)	Carbon content (NCV) (kg C / GJ) 38 11 40 12 345

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, SF₆ and NF₃ 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 <u>5th Assessment Report</u>, and allows for the addition of country-specific F-gases.
- ii) F-Gases Manager-Blends provides a list of the blends contained in <u>table 7.8</u> 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, <u>the user selects from the national list</u>, 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.

💀 Application Database Inven	tory Year	Administrate Worksheets Tools	Export/Import Reports Window Help		- 8
2006 IPCC Categories 🚽 🤻	F-Gas En		Emissions - Tier 2a F-Gas Emissions - Tier 2b		
2.E - Electronics Industry	Workshee	Country/Territory			
	Sector:		,		1990
- 2.E.2 - TFT Flat Panel Displa	Categor		ve Depleting Substances		
2.E.3 - Photovoltaics	Subcate	Energy +	Air Conditioning		
- 2.E.4 - Heat Transfer Fluid	Sheet:	IPPU 🕨	F-Gases Manager - Chemicals		
2.E.5 - Other (please specify	Data	AFOLU •	F-Gases Manager - Blends		
E 2.F - Product Uses as Substitute	Subdivi	Waste	al's Data	IY 1990 GR (%) 3 d (years) 15 EF (%) 15 X (%) 0	
2.F.1 - Refrigeration and Air	I. Total C		D)	2.368.322312 Bankt) + ΣE + ΣF 2.368.322312	
2.F.1.a - Refrigeration an		Delete Inventory	57		
- 2.F.1.b - Mobile Air Cond	II. Total	сполнов и устя и серирински и вас увас усв	w the time series) (Bank(t))	0	
	III. Total	Chemical Agent Emissions (across the time se	nies) (∑E)	2,368,322312	
2.F.3 - Fire Protection	IV. Total	Chemical Agent Recovered/Destroyed/Expo	ted from equipment at end-of-life (across the time series) (ΣF)	0	

Then a new window will appear.

F-Gase	is Manager - Chemicals			×
	Chemicals - definition and applicability at country level			
	Chemical group			V
	HFCs PFCs			
÷-	SF6			
.	NF3			
±	Ethers and Halogenated Ethers Other GHGs			
				_
	Save	Jndo	Clos	se

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.

	Ch	iemical group		
G	✓ Chemical	Formula	AR5 GWP	nsumed and 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	0
	HFC-134	CHF2CHF2	1120	
	HFC-143	CH2FCHF2	328	0
	HFC-227ca	CF3CF2CHF2	2640	0
	HFC-245ca	CH2FCF2CHF2	716	0
	HFC-245cb	CF3CF2CH3	4620	0
	HFC-245ea	CHF2CHFCHF2	235	
	HFC-245eb	CH2FCHFCF3	290	0
	HFC-152	CH2FCH2F	16	0
	HFC-161	CH3CH2F	4	
	HFC-236cb	CH2FCF2CF3	1210	
	HFC-236ea	CHF2CHFCF3	1330	0
	HFC-263fb	CH3CH2CF3	76	0
	HFC-272ca	CH3CF2CH3	144	0

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.

-		(Z)-HFC-1336	CF3CH=CHCF3(Z)	2	
		HFC-1243zf	CF3CH=CH2	1	
		HFC-1345zfc	C2F5CH=CH2	1	
		3,3,4,4,5,5,6,6,6-Nonafluorohex-1-ene	C4F9CH=CH2	1	
		3, 3, 4, 4, 5, 5, 6, 6, 7, 7, 8, 8, 8-Tridecafluorooct-1-e	C6F13CH=CH2	1	
		3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10- Heptade	C8F17CH=CH2	1	
🐂 User-define	ed HFCs	User defined	User defined	1200	X
*					 ×
		Chemical gro	up		7
PFCs					
SF6					
NF3					
Ethers and Hal	ogenated Ethers				

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.

		Chemical group		
PFCs				
SF6				
NF3				
Ethers and Halogenated Ethers				
Other GHGs				
			1	Consumed and/or
				Exported at country
Other GHGs with AR5 GWP	Methylene bromide	CH2Br2	1	level
	Chloroform	CHCI3	16	0
-	1.2-Dichloroethane	CH2CICH2CI	10	
	Methyl chloride	CH3CI	12	0
-	Methylene chloride	CH2CI2	9	0
-	2,2,2-Trifluoroethanol	(CF3)CH2OH	20	
-	2.2.3.3.3-Pentafluoropropan-1-ol	CF3CF2CH2OH	19	
· 📕	1.1.1.3.3.3-Hexafluoropropan-2-ol	(CF3)2CHOH	15	
	2.2,3,3,4,4,5,5-Octafluorocyclopentanol	-(CF2)4CH(OH)-	13	
	Halon-1201	CHBrF2		0
	Halon-1201	CBr2F2	376	0
	Halon-1202 Halon-1211	CBr2F2 CBrCIF2	231	0
			1750	0
	Halon-1301	CBrF3	6290	0
	Halon-2301	CH2BrCF3	173	
	Halon-2311 / Halothane	CHBrCICF3	41	
	Halon-2401	CHFBrCF3	41	0
· 📕	Halon 2402	CBrF2CBrF2	1470	
	Sulphuryl fluoride	SO2F2	4090	
	Carbon tetrachloride	CCI4	1730	0
	Methyl bromide	CH3Br	2	
	Methyl chloroform	CH3CCI3	160	
Other GHGs without AR5 GWP	Fluor	F2		0
	Carbonyl fluoride	COF2		
	C4F8O	C4F80		0
	Perfluorotripropylamine	C9F21N		
	Perfluorotributylamine	C12F27N		0
	PerfluoroisopropyImorpholine	C7F15NO	i i i i i i i i i i i i i i i i i i i	
	Perfluoromethylmorpholine	C5F11ND		
	Trifluoroiodomethane	CF3I		0
	HFE-7300	1 1 1 2 2 3 4 5 5 5-decafluoro-3-methoxy-4-trifluoromethyl-pentane		
	HFE-7500	3-ethoxy-1,1,1,2,3,4,4,5,5,6,6,6-dodecafluoro-2-trifluoromethyl-hexane		
	Novec ^{TI} 612	C3F7C(0)C2F5		0
Vser-defined Other GHGs	Add user-defined gas	Add formula		

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.

2006 IPCC Categories 🚽 🕈	F-Gas En	Users		Emissions - Tier 2a F-Gas Emissions -	Tier 2b					
2.E - Electronics Industry 2.E.1 - Integrated Circuit or S 2.E.2 - TFT Flat Panel Displa 2.E.3 - Photovoltaics	Worksher Sector: Categor Subcate	Country/Territory CO2 Equivalents Energy		e Depleting Substances Ar Conditioning						1990
2.E.4 - Heat Transfer Fluid	Sheet:	IPPU		F-Gases Manager - Chemicals						
2.E.5 - Other (please specify 2.F - Product Uses as Substitute	Data Subdivi	AFOLU Waste	•	F-Gases Manager - Blends	al's Data	IY 1990	GR (%) 3	d (years) 15	EF (%) 15 X (%) 0	
 2.F.1 - Refrigeration and Air 2.F.1.a - Refrigeration an 2.F.1.b - Mobile Air Cond 	I. Total C	Delete Inventory		D) the time series) (Bank(t))		2,368.322312	Bank‡) + ΣE + Σ	F 2.368.322312		
	III. Total C	Chemical Agent Emissions (across th	he time ser		no option) (FE)	2,368.322312				

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). <u>Note that:</u> By default, the F-gases listed in <u>section</u> 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 <u>Table 7.8</u>.

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.

	Blends - definition a	and applicability at country level			
	∆∀ Blend name	Composi	ion	Consumed and/or Exported at country ⊽ level	
Blends referenced in section 7.5.1 of the 2006 GL	R-410A	HFC-32/HFC-125 (50.0/50.0)			
Constituent		AR5 GWP	Composi (%)	tion	
HFC-32		677		50	
HFC-125		3170		50	
	∆ ⊽ Biend name	Composi		Consumed and/or Exported at country V level	
Blends referenced in section 7.5.1 of the 2006 GL	R-404A	HFC-125/HFC-143a/HFC-134a (44.0/	52.0/4.0)		
	R-407C	HFC-32/HFC-125/HFC-134a (23.0/25.	0/52.0)		
	R-507A	HFC-125/HFC-143a (50.0/50.0)			
Other blends	R-401A	HCFC-22/HFC-152a/HCFC-124 (53.0/13.	0/34.0)		
	R-401B	HCFC-22/HFC-152a/HCFC-124 (61.0/11.	0/28.0)	0	
	R-401C	HCFC-22/HFC-152a/HCFC-124 (33.0/15.	0/52.0)		
	R-402A	2A HFC-125/HC-290/HCFC-22 (60.0/2.0/38.0)			
	R-402B	0			
	R-403A	HC-290/HCFC-22/PFC-218 (5.0/75.0/20.0))		
	R-403B	HC-290/HCFC-22/PFC-218 (5.0/56.0/39.0))	0	
	R-405A	HCFC-22/ HFC-152a/ HCFC-142b/PFC-3	18 (45.0/7.0/5.5/42.5)	0	
	R-407A	HFC-32/HFC-125/HFC-134a (20.0/40.0/4	0.0)	0	
	R-407B	HFC-32/HFC-125/HFC-134a (10.0/70.0/2	0.0)		
	R-407D	HFC-32/HFC-125/HFC-134a (15.0/15.0/7	0.0)	0	
	R-407E	HFC-32/HFC-125/HFC-134a (25.0/15.0/6	0.0)	0	
	R-408A	HFC-125/HFC-143a/HCFC-22 (7.0/46.0/4	7.0)		
	R-410B	HFC-32/HFC-125 (45.0/55.0)		0	
	R-411A	HC-1270/HCFC-22/HFC-152a (1.5/87.5/1	1.0)		
	R-411B	HC-1270/HCFC-22/HFC-152a (3.0/94.0/3	.0)		
	R-411C	HC-1270/HCFC-22/HFC-152a (3.0/95.5/1	.5)	0	
	R-4124	HCEC-22/PEC-218/HCEC-142b (70.0/5.0	(25.0)	1 1	

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, SF₆ and NF₃ 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

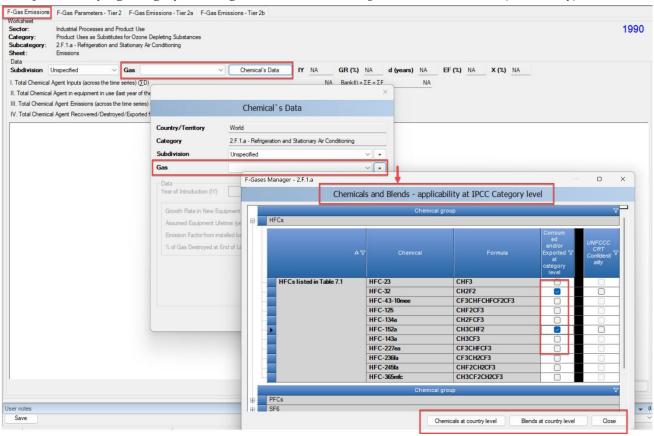
	siends - definition a	and applicability at country level				
ΔΥ	Biend name	Composition		onsumed and/or ported at country level	7	
	R-515A	HCFC-22/HFC-152a (82.0/18.0)			T	
	R-515B	HCFC-22/HFC-152a (25.0/75.0)			T	
	R-416A	HFC-134a/HCFC-124/HC-600 (59.0/39.5/1.5)			T	
	R-417A	HFC-125/HFC-134a/HC-600 (46.6/50.0/3.4)			T	
	R-418A	HC-290/HCFC-22/HFC-152a (1.5/96.0/2.5)			T	
	R-419A	HFC-125/HFC-134a/HE-E170 (77.0/19.0/4.0)				
	R-420A	HFC-134a/HCFC-142b (88.0/12.0)			T	
	R-421A	HFC-125/HFC-134a (58.0/42.0)			1	
	R-421B	HFC-125/HFC-134a (85.0/15.0)	1		1	
	R-422A	HFC-125/HFC-134a/HC-600a (85.1/11.5/3.4)			1	
	R-422B	HFC-125/HFC-134a/HC-600a (55.0/42.0/3.0)			+	
	R-422C	HFC-125/HFC-134a/HC-600a (82.0/15.0/3.0)			+	
	R-500	CFC-12/HFC-152a (73.8/26.2)			+	
	R-503	HFC-23/CFC-13 (40.1/59.9)			1	
	R-504	HFC-32/CFC-115 (48.2/51.8)			+	
	R-508A	HFC-23/PFC-116 (39.0/61.0)			+	
	R-508B	HFC-23/PFC-116 (46.0/54.0)			1	
	R-509A	HCFC-22/PFC-218 (44.0/56.0)			1	
User-defined blends	hop	hop1 hop 2		\checkmark		
Constituent		AR5 GWP	Composition (%)			
		1		5	50	
2,2,3,3,4,4,5,5-Octafluorocyclopentanol		13		5	50	
*						
Δ٧	Blend name	Composition		onsumed and/or ported at country ה level	7	
*						

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



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 Chemical's Data

- 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

2006 IPCC Categories + 7 F-Gas Emissions	F-Gas Parameters - Tier 2 F-Gas Emissions - Tier 2	a F-Gas Emissions - Tier 2b			
2.D.3-Solvent Use Worksheet 2.D.4-Other (Jacks specify) 2.D.4-Other (Jacks specify) - Bectronics Industry 2.E.2-TFF Flat Planel Display 2.E.3-Photoversites Display 2.E.3-Photoversites Display 2.B.3-Photoversites Display	Industrial Processes and Product Use Product Uses as Substitutes for Ozone Depleting Substar 2.F.1.a Refrigeration and Stationary Air Conditioning F-Gas Parameters - Tier 2	ices			1990
2.E.4 - Heat Transfer Fluid F-Gases Mana	sger 2				
2.E.5 - Other (please specify)		Conductoria			
Product Uses as Substitutes for Ozone Depleting F-Gases Manage F-Gases Manage	251-	Susanda	14	- 0 X	
2.F.1.a - Refrigeration and Stationary Air Conditioni	3	nicals and Blends - applicability at	IDCC Category lavel		₩ 🤊 🗙
Z.F.1.b - Mobile Air Conditioning	Che	fileais and blends - applicability at	IFCC Category level		
2.F.2 - Foam Blowing Agents		Chemical group		(4) v	
2.F.3 - Fire Protection					
2.F.4 - Aerosols 2.F.5 - Solvents	•				
2.F.5 - Solvents 2.F.6 - Other Applications (please specify)				Consumed and/or	
Other Product Manufacture and Use				Exported at	
				category level	
2.G.1.a - Manufacture of Electrical Equipment	FCs listed in Table 7.1	HFC-23	CHF3		
- 2.G.1.b - Use of Electrical Equipment		HFC-32	CH2F2		
-2.G.1.c - Disposal of Electrical Equipment		HFC-43-10mee	CF3CHFCHFCF2CF3		
2.G.2 - SF6 and PFCs from Other Product Uses		HFC-125	CHF2CF3		
-2.G.2.a - Military Applications		HFC-134a	CH2FCF3		
- 2.G.2.b - Accelerators		HFC-152a	CH3CHF2		
-2.G.2.c - Other (please specify)					
2.G.3 - N2O from Product Uses		HFC-143a	CH3CF3		
-2.G.3.a - Medical Applications		HFC-227ea	CF3CHFCF3		
-2.G.3.b - Propellant for pressure and aerosol produ		HFC-236fa	CF3CH2CF3		
2.G.3.c - Other (Please specify)		HFC-245fa	CHF2CH2CF3		
2.G.4 - Other (Please specify)		HFC-365mfc	CH3CF2CH2CF3		
- Other		HFC-360mic	CH3CF2CH2CF3	0	
2.H.1 - Pulp and Paper Industry		Chemical group		7	
2 H.2 - Food and Beverages Industry					
	N				
with use Expertise and Other Land Uses					
- Livestock					
3 A 1 - Enteric Fermentation	s and Halogenated Ethers				
3A1a-Cattle	GHGs				
- 3.A.1.a.i - Dairy Cows	s				
3A1aii - Other Cattle					
3.A.1.b - Buffalo					
- 3.A.1.c - Sheep					
- 3.A.1.d - Goats					
Worksheet notes 👻 🕈			•		
			5		
Us			-		* 4
Worksheet notes 2006 IPCC Guidelines			Chemicals at country level Blends at cour	ntry level Close	~
Country/Territory: World Inventory Year: 1990 Base year				×292.	accdb)

To identify the list of F-gases blends for all other categories through the F-Gases Manager

- 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 approach¹, 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 generally² 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.

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

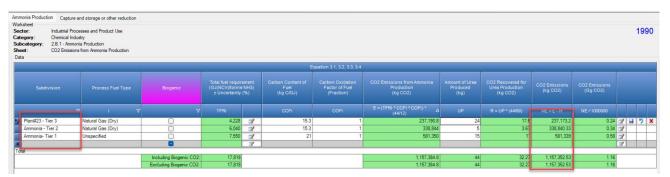
² In some cases, IPCC also provides a Tier 3 methodology, as for instance for HFC-23 emissions from HCFC-22 production.

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 userspecific 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 tiers¹

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 <u>Column</u> <u>|Subdivision|</u> 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 <u>Column |Subdivision|</u>. 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 worksheet² 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

tegory: Che bcategory: 2.8.	strial Processes a mical Industry 2 - Nitric Acid Pro) Emissions from I		L.								19)9
					Equatio	n 3.5, 3.6						
Subdivis	ion	Production proces	ss / technology	Nitric acid production from technology i (tonnes)	N2O emission factor for technology type i (kg N2O/tonne nitric acid produced)	Destruction factor for abatement technology type j (Fraction)	Abatement system utilisation factor for abatement technology type j (Fraction)	N2O Emissions (kg)	N2O Emissions (Gg)			
	۵Ţ		ΔŢ	NAPi				E=NAPi*EFi(1- DFj*ASUFj)	E/1000000			
Kanagawa		High pressure plan	its	10,000	9	0.8	0.9	25,200	0.03	2		T
		Medium pressure		1,000	7	0.8	0.9	1,960	0	2		T
Tokyo		Plants with proces	s-integrated o	100	2.5	0.9	0.9	47.5	0		-	I
Unspecified		Unspecified		200,000	9	0.8	0.9	504,000	0.5		2	1
	1									2		1
otal				011 100				504 007 C	0.52		 	_
				211,100				531,207.5	0.53			

Example: viewing filtered results

egory: Chemical Industry ccategory: 2.B.2 - Nitric Acid F	s and Product Use roduction n Nitric Acid Production								199
			Equatio	n 3.5, 3.6					
Subdivision	Production process / technolog	Nitric acid production from technology i (tonnes)	N2O emission factor for technology type i (kg N2O/tonne nitric acid produced)		Abatement system utilisation factor for abatement technology type j (Fraction)	N2O Emissions (kg)	N2O Emissions (Gg)		
Δ.	⊽ ij ∆*	7 NAPI				E=NAPi*EFi(1- DFj*ASUFj)	E/1000000		
Kanagawa	High pressure plants	10,000	9	0.8	0.9	25,200	0.03	3	
	Medium pressure combustion pl	1,000	7	0.8	0.9	1,960	0	3	
	incoroni procedie combaction pr							2	

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

Application Database Inventory Year Worksheets 006 IPCC Categories 🗢 🗸	Glass Production - Tier 1/2 Class Pr	Administrate Window roduction - Tier 3 Capture and		tion			
⊇ 2 - Industrial Processes and Product Use ⇒ 2.4 - Mineral Industry −2.4.1 - Cement production −2.4.2 - Lime production <mark>2.4.3 - Gisss Production ⊕ 2.4.4 - Other Process Uses of Carbonates </mark>	Worksheet Sector: Industrial nocesset Category: Mineral Industry Subcategory: 2.A.3 - Glass Produ Sheet: CO2 Emissions from Data						
-2.A.4.a - Ceramics -2.A.4.b - Other Uses of Soda Ash				Equation 2.10, 2.11			
−2.A.4.c - Non Metallurgical Magnesia Productio −2.A.4.c) - Other (please specify) −2.A.5 - Other (please specify) ⊖ 2.B - Chemical Industry	Subdivision	Melted glass of type	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)
 2.B.1 - Ammonia Production 2.B.2 - Nitric Acid Production 			Mi	EFi	CRI	Ei = Mi*EFi*(1-CRi)	Ei/1000
- 2.B.3 - Adipic Acid Production	Unspecified (National level)	All glass production	1,400 🧹	0.224	0.56	137.984	0.13798
 2.8.4 - Caprolactam, Glyoxal and Glyoxylic Acid Pr 2.8.5 - Carbide Production 	*		1				
2 B.6 - Titanium Dioxide Production	Total		1,400			137.984	0.13

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

06 IPCC Categories 👻 🗸		-bearing non-fuel materials - Tier 3 CO2 Emissions s								
1.B.2.b.iii.6 - Other 1.B.3 - Other emissions from Energy Production	Cement Production - Tier 1 (1/2) Cement Production - Tier 1 (2/2) Clinker production - Tier 2 CO2 Emissions from carbonates - Tier 3 CO2 Emissions from uncalcined CKD not recycled toth									
1.C - Carbon dioxide Transport and Storage 1.C - 1 - Transport of CO2 1.C.1.a - Pipelines 1.C.1.b - Ships 1.C.1.c - Other (please specify)	Category: Mineral I Subcategory: 2.A.1 - C	ategory: Mineral foodutry abcategory: 2.A.1 - Cement production eet: CO2 Emissions from Cement production - Ter 1 (1 of 2)								
- 1.C.2 - Injection and Storage - 1.C.2.a - Injection				Equation 2.1						
- 1.C.2.b - Storage - 1.C.3 - Other 2 - Industrial Processes and Product Use	Subd	vision Individual Type of Cemer	nt Produced	Mass of Individual Type of Cement Produced (tonne)	Clinker Fraction in Cement (Fraction)	Mass of Clinker in the Individu Type of Cement Produced (tonne)				
- Industrial Processes and Product Use - 2.A - Mineral Industry										
2.A.1 - Cement production			ΔV			C=A*B				
- 2.A.2 - Lime production	🚺 Kanagawa	masonry cement		100,000 🥑	0.8	80,0				
2 A 3 - Glass Production		portland cement		150,000 🥑	0.9	135,0				
2.A.4 - Other Process Uses of Carbonates	Tokyo	Plant 213		1,000 🥑	0.352	3				
- 2.A.4.a - Ceramics	Unspecified	Plant 211		56,410 🥑	0.351	19,799.1				
2.A.4.b - Other Uses of Soda Ash		Plant 212		23,541 🧭	0.655	15,419.3				
	*		0	3						
2.A.4.d - Other (please specify)	Total	h.								
2.A.5 - Other (please specify)				330.951		250.571.2				

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 CO₂. Note that emissions of CO₂ from biogenic origin in the IPPU sector will not be included in any JSON file generated for UNFCCC reporting.

Ammonia Production Worksheet Capture and storage or other reduction 1990 Sector Industrial Processes and Product Use Category Subcategory Sheet: Chemical Industry 2.8.1 - Ammonia Production CO2 Emissions from Ammonia Production Data otal fuel requirements V(NCV)/tonne NH CO2 Emissions from Ammonia 02 Emissio (Gg CO2) of Fuel (kg C/GJ) E = (TFRi * CCFi * COEi) * (44/12) R = UP nmonia - Tier 2 Natural Gas (Dry) 15.3 0.34 412,470.67 7,550 412,481.6 0.41 📝 🛃 mmonia- Tier 1 Landfill Gas 14.9 Plant#23 - Tier 3 Natural Gas (Dry) 4,228 1 15.3 237,190.0 24 17.6 237,173.2 0.24 2 17.81 988.516.4 44 988,484 0.9 10 268 21.27 0.58 Excluding Bioge 576.034.8 29 576.013.53

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.

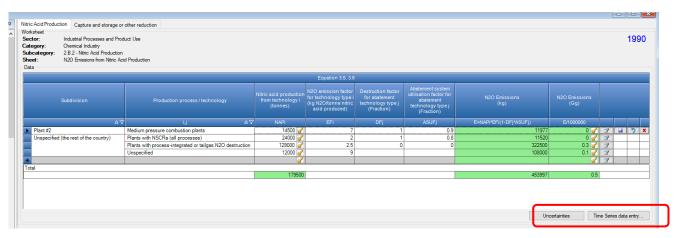
Example: Capture of biogenic CO₂

ector:	Industrial Processes and	Product Use									19	90
tegory:	Chemical Industry										10	~
bcategory:	2.B.1 - Ammonia Produc	tion										
eet:	Capture and storage or	other reduction										
sta												
as CARE	BON DIOXIDE (CO2)											
										_		
	Subdivision		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	Biogenic			
	Subdivision	24	SRC	۵ . ۲	and stored				Biogenic ⊽			
Unspecifier	Subdivision	쇼 文 Unspecified	SRC	ΔV	and stored (tonne)	(tonne)	(tonne)	(Gg)		3	2	,
	Subdivision		SRC	^⊽	and stored (tonne)	(tonne)	(tonne)	(Gg)			2	

For more information on the reporting of emissions and removals of CO₂ 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

ector: ategory: ubcategory: heet: Data	Industrial Processes and Produc Chemical Industry 2.B.2 - Ntric Acid Production N2O Emissions from Ntric Acid																						199
									Equation 3	3.5, 3.6													
						Nitric acid p from tech (tonr	nology i	on forte (kg N	emission f chnology I2O/tonne id produce	type i nitric	Destructio for abat technolo (Fract	ement gytypej	utilisat al techr	ment sys ion facto batement iology typ Fraction)			N2O Emi (kg				I2O Emissions (Gg)		
	ΔV	ij			ΔŢ	NA			EFi		DF	ij		ASUFj		E=N	APi*EFi(1	-DFj*ASU			E/1000000		
 Plant #2 Unspecifi 		Medium pressure combustion pla	ants				14500	/		7			1		0.9				119		0 🧹	3 4	2
	Time Series Data Entry																	- 1		×	0.3	3	-
	2.B.2 - Nitric Acid Production																				0.1 🥑		
	Category Chemical Indu Category code 2.B.2 - Nitric /	Acid Production Is from Nitric Acid Production																		~	0.5		
	Subdivision	Production process /	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2007	2008	2009	2010	2020			e Series dat	
	Plant#2	technology Medium pressure combus	14500	14700	15000	14500	15700	16000	17800	18200	18600	19050	20000	19500	20500	21000	21500	25000	12000	ta	inties Tim	e Senes da) entry
r notes	Unspecified (the rest of th		24000		26000		26000	28100		29500	31500	31700	33600	33500	34000	35000	36500	39000	19000				_
		Plants with process-integ	129000	132000	135000			140500	142300	143300	144000	138500	135650	138000	139000	135000	138000	145000	70000				
		Unspecified	12000	12500	12900	13200	13400	13300	13100	13350	13600	13500	13100	13000	13500	14000	15000	16000	3000				

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.

			1	Applica	tion p	referer	nces				
General	Database	Worksheets	Reports	Inventor	y Year	Grid					
	Base year fo	or assessment o		ntory year	2025						
							(ОК	0	Cancel	Apply

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

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3	3/4) C	02 Emissi	ons sumn	nary - Tier	3 (4/4)	Capture	and storag	ge or othe	r reductio	n			
Cement Production (1/2) Compart Production (2/2) Clinker or	aduation	Tion?	CO2 Emir	ninna fra	manchan	tan Tin	2/1/4)	C025-	inninne fr	amunanl	nined CKE	ant rease	ladta thak
Time Series Data Entry											-		×
2.A.1 - Cement production													
Sector Industrial Processes and Product Use													
Category Mineral Industry													
Category code 2.A.1 - Cement production													
Sheet CO2 Emissions from Cement production (1 of 2)													
Sileer CO2 Emissions nom Cement production (1 or 2)													
Parameter Mass of Individual Type of Cement Produced (tonne)												~
Individual Type of Cement													
Subdivision Produced	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
▶ Unspecified Portland		2,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
						I							

												-		>
2.B.2 - Nitric Acid Production														
Category Chemical Ind Category code 2.B.2 - Nitric														
Parameter Nitric acid product	ion from technology i (tonnes)													
Subdivision	Production process / technology	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
🕨 Kanagawa	High pressure plants		10,000											
	Medium pressure combus		1,000											
Tokyo	Plants with process-integ		100											
Unspecified	Unspecified		200,0	200,0	200,0	200,0	200,0	200,0	200,0	200,0	200,0	200,0	200,0	200,0.
is worksheet allows Qtrl+C/Qtrl+		le cells can	be overw	vritten wh	en pasting	1.			_					

- 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

Nitric Acid Pro Worksheet Sector: Category:	Industrial Processes an Chemical Industry													19	90
Subcategor Sheet: Data	y: 2.B.2 - Nitric Acid Proc N2O Emissions from N														
						Equation 3.5, 3.6									
	Subdivision	Production process / technology		acid production technology i (tonnes)	N2O emission factor for technology type i (kg N2O/tonne nitric acid produced)	Destruction factor for abatement technology type j (Fraction)	Abatement system utilisation factor for abatement technology type j (Fraction)	N	I2O Emissions (kg)		N2O Emissions (Gg)				
	ΔΥ	i,j ∆⊽		NAPi	EFi	DFj	ASUFj	E=NAF	Pi*EFi(1-DFj*ASUFj)		E/1000000				
Plant #2		Medium pressure combustion pl		14000	7	1	0.0			11977	0 🥑	3		う	X
Unspec	fied (the rest of the coun	Plants with NSCRa (all processe	1	1				×		11520	0 🥑	2			
		Plants with process-integrated or		-						322500	0.3 🥑				
		Unspecified		-	U	Incertainties				108000	0.1 🥑	3		_	_
Total				-							6	<u> 3</u>			_
Total				Category	2.B.2 - Nitric Acid Proc	luction				453997	0.5				
				1 .											
				Sheet	N2O Emissions from N	itric Acid Production									
				Activitiy Dat	a Uncertainties										
				Lower	-2.00 % 🜩	Upper	+2.00 % 🖨								
				201101	2.00 10 1	oppor	12.00 10 1			U	Incertainties T	me Ser	ies dai	ta entr	y
				Emission Ex	ctors Uncertainties										
User notes				Gas		~									– 1
				Gas	NITROUS OXIDE (N2	0)	~	UTDOUGOX	IDE (N2O) Emissions (Ga	0005-00					_
				Lower	0.00 % 🗢	Upper	+0.00 % 🖨	ITROUGUX	IDE (N2O) Emissions (dq	CO2 Equiv	alents)				
								_							
				ОК	1		Cancel								
				UK			Cancel								
			 \ 			100									
								/							

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 CO₂ between the IPPU and Energy sectors. Any methodology including CO₂ capture should consider that CO₂ 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 CO₂ are not double counted.

Example: capture and storage or other reduction

		-tuel mate	rials - Lier 3 (3/4) CO2 Emi	ssions summa	ary - Tier 3 (4/4) Capture and	storage or other reduction						
rksheet					-7							
ctor.	Industrial Processes an	nd Product	Use									19
egory:	Mineral Industry											10
category:	2.A.1 - Cement product	tion										
et:	Capture and storage or		uction									
	Captore and storage of	- outor room										
	ON DIOXIDE (CO2)		~									
	ON DIOXIDE (CO2)		~									
	ON DIOXIDE (CO2)		~						-			
					Amount CO2 captured and	Other reduction	Total reduction	Total reduction	Ĩ			
	ON DIOXIDE (CO2) Subdivision		Source		stored	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)				
				<u>م</u> ۲	stored (tonne)							Ť
S CARBO	Subdivision S		Source SRC	۵V	stored (tonne) A	(tonne)	(tonne) C = A + B	(Gg)	01	,		2
	Subdivision S		Source	۵Ţ	stored (tonne)	(tonne)	(tonne)	(Gg)	0.1	3	a	2

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 CO₂ 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 ₂ O	HFCs	PFCs	SF ₆	NF ₃
X						

IPCC Equations

- \checkmark Tier 1: <u>Equations 2.1</u> and <u>2.4</u>
- $\checkmark \quad \text{Tier 2: } \underline{\text{Equations 2.2}} \text{ and } \underline{2.5}$
- ✓ 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

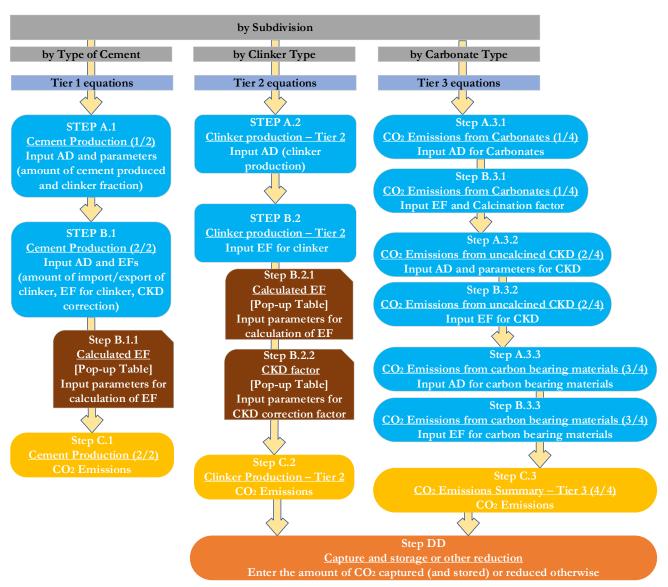
The *Software* calculates emissions of CO₂ from Cement Production using worksheets:

- ✓ 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 CO₂ EF. The worksheet calculates the associated CO₂ emissions.
- ✓ Clinker Production Tier 2: contains for each subdivision information on the amount of clinker production, the clinker CO₂ 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 CO₂ emissions.
- ✓ CO₂ Emissions from Carbonates Tier 3 (1/4): contains for each subdivision information on types of carbonates used: amount, CO₂ EF and fraction of calcination. The worksheet calculates the associated CO₂ emissions
- ✓ CO₂ 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 CO₂ EF. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ EF. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ capture (with subsequent storage) and other reduction of CO₂, not accounted previously in the worksheets for different Tiers.

User's Work Flowchart

Consistent with the key category analysis and the decision tree in <u>Figure 2.1</u> 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-specific¹ 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),** CO₂ emissions are calculated in mass units (tonnes and Gg). In addition, total CO₂ 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 CO₂ 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, CO₂ emissions are calculated in mass units (Gg). In addition, total CO₂ 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 <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)

06 IPCC Categories - 7		uel materials - Tier 3 (3/4) CO2 Emissions summary - Tier 3						
1.B.3 - Other emissions from Energy Productio		tion (2/2) Clinker production - Tier 2 CO2 Emissions from	carbonates - Tier 3 (1/4) CO2 Em	hissions from uncalcined CKD not recycle	ed to the kiln - Tier 3 (2/4)			
Carbon dioxide Transport and Storage	Worksheet Sector Industrial Processes and	Desident Unit						199
1.C.1 - Transport of CO2	Category: Mineral Industry	I Product Use						199
1.C.1.a - Pipelines								
-1.C.1.b - Ships	Subcategory: 2.A.1 - Cement production Sheet: CO2 Emissions from Cem							
-1.C.1.c - Other (please specify)		tent production (1 of 2)						
.C.2 - Injection and Storage	Data							
			Equation 2.1					
					Mass of Clinker in the			
C 3 - Other			Mass of Individual Type of	Clinker Fraction in Cement	Individual Type of Cement			
trial Processes and Product Use	Subdivision		Cement Produced (tonne)	(Fraction)				
Mineral Industry			A	8	C=A*B		2 P	
A.1 - Cement production	Unspecified	Masonry	1,000	0.75	750	3	-	6
A.2 - Lime production	Chispechieu	Portland	2,000	0.95	1,900			2 ×
A3 - Glass Production	59	Portland	2,000	0.95	1,900		- 10	7 .
A.4 - Other Process Uses of Carbonates	*					2		
-2.A.4.a - Ceramics	Total							
-2.A.4.b - Other Uses of Soda Ash -2.A.4.c - Non Metallurgical Magnesia Produ			3,000		2,650			
		Example: multiple	subdivisions	3				
1.B.2.b.iii.6 - Other 1.B.3 - Other emissions from Energy Productio Carbon dioxide Transport and Storage	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a	Example: multiple n-fuel materials - Tier 3 (34) CO2 Emissions summary - Tie function (212) Clinker production - Tier 2 CO2 Emissions fro and Product Use	r 3 (4/4) Capture and storage or o	ther reduction	voled to the kiln - Tier 3 (2/4)			19
1.8.2.b.ii.6 - Other 1.8.3.c.bit.6 - Other 1.8.3.c.bit.6 - Other 1.8.3.c.bhar emissions from Energy Productio C- Carbon dioxide Transport and Storage 1.C.1 - Transport dC02 1.C.1 = Pipelines 1.C.1.5.bit.9 1.C.1.5.bit.9 1.C.1.5.bit.9 1.C.1.5.bit.9 1.C.1.5.bit.9	Cement Production (1/2) Cement Production (1/2) Cement Production (1/2) Cement Production Sector: Industrial Processes a Category: Mineral Industry Subcategory: 2.A.1 - Cement production	n-fuel materials - Tier 3 (3/4) CO2 Emissions summary - Tie Juction (2/2) Clinker production - Tier 2 CO2 Emissions fro and Product Use	r 3 (4/4) Capture and storage or o	ther reduction	voled to the kiln - Tier 3 (2/4)			19
1.8.2.biii.6 - Other 1.8.2.biii.6 - Other 1.8.3 - Other emissions from Energy Productio C - Carbon dioxide Transport and Storage 1.C.1 - Transport of CO2 1.C.1.a - Pipelines 1.C.1.b - Ships 1.C.1.b - Ships 1.C.2 - Injection and Storage	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Mneral Industry Subcategory: 2, A1 - Cement produ Sheet: CO2 Emissions from C	n-fuel materials - Tier 3 (34) CO2Emissions summary - Tie duction (22) Clinker production - Tier 2 CO2Emissions fro and Product Use ction	r 3 (4/4) Capture and storage or o	ther reduction	voled to the kiln - Tier 3 (2/4)			19
18.2 bit 6 - Other 18.3 - Other emissions from Energy Productio C - Carbon dixold's Transport and Storage 1.C.1 - Transport of CO2 1.C.1 - Transport of CO2 1.C.1 - Definise 1.C.1.5 - Ships 1.C.1.6 - Definise 1.C.1.6 - Other (please specify) 1.C.2 - Injection and Storage 1.C.2.8 - Injection	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Mneral Industry Subcategory: 2, A1 - Cement produ Sheet: CO2 Emissions from C	n-fuel materials - Tier 3 (34) CO2Emissions summary - Tie duction (22) Clinker production - Tier 2 CO2Emissions fro and Product Use ction	3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO2/ Equation 2.1	ther reduction				19
18.2 bill 6 - Other 18.2 bill 6 - Other 18.3 - Other emissions from Energy Productio C - Carbon dioxide Transport and Storage 11.C.1.7 Transport of CO2 11.C.1.8 - Pipelines 11.C.1.8 - Pipelines 11.C.1.8 - Pipelines 11.C.1.8 - Pipelines 11.C.2.8 - Injection 11.C.2.8 - Injection 11.C.2.8 - Storage	Center Production (1/2) Center Production Worksheet Sector: Industrial Processes a Category: Mineral Industry Subcategory: 2A1 - Center produ Sheet : CO2 Emissions from C Data	n-fuel materials - Tier 3 (34) CO2 Emissions summary - Tie Juction (22) Clinker production - Tier 2 CO2 Emissions fro and Product Use ction Zement production (1 of 2)	3 (44) Capture and storage or or m carbonates - Tier 3 (1/4) CO21 Equation 2.1 Mass of Individual Type of	ther reduction Emissions from uncalcined CKD not recy	Mass of Clinker in the			19
18.2 - Other	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Mneral Industry Subcategory: 2, A1 - Cement produ Sheet: CO2 Emissions from C	n-fuel materials - Tier 3 (34) CO2Emissions summary - Tie duction (22) Clinker production - Tier 2 CO2Emissions fro and Product Use ction	3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO2 Equation 2.1 Mass of Individual Type of Cement Produced	ther reduction				19
	Center Production (1/2) Center Production Worksheet Sector: Industrial Processes a Category: Mineral Industry Subcategory: 2A1 - Center produ Sheet : CO2 Emissions from C Data	n-fuel materials - Tier 3 (34) CO2 Emissions summary - Tie Juction (22) Clinker production - Tier 2 CO2 Emissions fro and Product Use ction Zement production (1 of 2)	3 (44) Capture and storage or or m carbonates - Tier 3 (1/4) CO21 Equation 2.1 Mass of Individual Type of	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement	Mass of Clinker in the Individual Type of Cement			19
18.3 - Other emissions from Energy Productio C - Carbon dixols' Transport and Storage 11.C.1.7 Transport of CO2 - T.C.1.a. Pipelines - T.C.1.b. Ships - T.C.1.b. Ships - T.C.1.b. Chefer (Jesse specify) 11.C.2 Other (Jesse specify) 11.C.2.b. Storage - T.C.2.b. Storage -	Center Production (1/2) Center Production Worksheet Sector: Industrial Processes a Category: Mineral Industry Subcategory: 2A1 - Center produ Sheet : CO2 Emissions from C Data	n-fuel materials - Tier 3 (34) CO2Emissions summary - Tie fuction (22) Clinker production - Tier 2 CO2Emissions for and Product Use ction ement production (1 of 2) Individual Type of Cement Produced	-3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO2 -Equation 2.1 Mass of individual Type of Cement Produced (tonne)	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction)	Mass of Clinker in the Individual Type of Cement Produced (tonne)			19
18.3 - Other emissions from Energy Productio C - Sachon dioxids Transport and Storage 11.C.1.7 Transport of CO2 - 1.C.1.8 - Pipelines - 1.C.1.6 - Ships - 1.C.2.6 - Shorage - 2.A.1.e.Genera ground-class	Cenent Production (1/2) Cenent Prod Worksheet Industrial Processes a Category: Minami Industry Sabcategory: 2A 1 - Cenert produ Sheet: C02 Ensers from C Data Subdivision	n-fuel materials - Tier 3 (14) CO2 Emissions summary - Tie suction (22) Clinker production - Tier 2 CO2 Emissions for and Product Use ction Dement production (1 of 2) Individual Type of Cement Produced	13 (44) Capture and storage or o m carbonates - Tier 3 (14) CO2 Equation 2.1 Mass of Individual Type of Cement Produced (tonne) 7 A	ther reduction Emissions from uncalclined CKD not recy Clinker Fraction in Cement (Fraction) B	Mass of Clinker in the Individual Type of Cement Victores C=>45			19
18.2 - Dite - Other 18.3 - Other emissions from Energy Productio C - Carbon dixolo: Transport and Storage 1 - C.1 a - Pipelines - 1.C.1 b - Ships - 1.C.1 c - Unection and Storage - 1.C.2 b - Storage - 1.C.2 b - Storage - 1.C.3 - Other (General Production A- Mineral Industry 2.A.3 - Energe Production 2.A.2 - Ling production	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Manal Industry Subcategory: 2A.1 - Cement prod Sheet: CO2 Emissions from C Data Subdivision	Individual Type of Cement Produced Individual Type of Cement Produced Masony	3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO21 Equation 2.1 Mass of Individual Type of Cement Produced (tonne) 7 A 1.500	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction) B 07	Mass of Clinker in the Individual Type of Cement Produced (tonna) C-AYS 5 1.12	5 7		19
18.3 - Other emissions from Energy Productio C - Carbon dixold: Transport and Storage 11.0.1.7 Transport of CO2 11.0.1.7 Transport of CO2 11.0.1.7 Transport of CO2 11.0.1.7 Transport of CO2 11.0.2.7 Unperiment 11.	Cenent Production (1/2) Cenent Prod Worksheet Industrial Processes a Category: Minami Industry Sabcategory: 2A 1 - Cenert produ Sheet: C02 Ensers from C Data Subdivision	n-fuel materials - Tier 3 (14) CO2 Emissions summary - Tie suction (22) Clinker production - Tier 2 CO2 Emissions for and Product Use ction Dement production (1 of 2) Individual Type of Cement Produced Masonry Masonry	3 (44) Capture and storage or o m carbonates - Tier 3 (14) CO2 Equation 2.1 Mass of Individual Type of Cement Produced (tonne) 7 A 1.500 1.500	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction) B 07 0.7	Mass of Clinker in the Individual Type of Cement Produced (onne) 5 C=A*B 5 75	0 3		19
18.2 - Dite - Other 18.3 - Other emissions from Energy Productio C - Carbon dixolo: Transport and Storage 1.1 - Transport of CO2 1.1 - Torasport of CO2	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Menai Industry Subcategory: 2.A.1-Cement produ Sheet: CO2 Emissions from C Data Subdivision Kanagewa Urspecified	n-fuel materials - Tier 3 (34) CO2 Emissions summary - Tie fuction (22) Clinker production - Tier 2 CO2 Emissions for and Product Use ction Lement production (1 of 2) Individual Type of Cement Produced Arr Masonry Portand	3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO2 Equation 2.1 Mass of Individual Type of Cement Produced (conne) 7 A 1.500 1.000 2.000	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction) B 0.7 0.7 0.7 0.7 0.7 0.7 0.7	Mass of Clinker in the Individual Type of Cement Produced (tonna) 5	0 3		
18.3 - Other emissions from Energy Productio 18.3 - Other emissions from Energy Productio 18.3 - Other emissions from Energy Productio 19.1 - Transport of CO2 10.1 - Transport of CO2 10.1 - Totaport of CO2 10	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Manal Industry Subcategory: 2A.1 - Cement prod Sheet: CO2 Emissions from C Data Subdivision	n-fuel materials - Tier 3 (14) CO2 Emissions summary - Tie suction (22) Clinker production - Tier 2 CO2 Emissions for and Product Use ction Dement production (1 of 2) Individual Type of Cement Produced Masonry Masonry	3 (44) Capture and storage or o m carbonates - Tier 3 (14) CO2 Equation 2.1 Mass of Individual Type of Cement Produced (tonne) 7 A 1.500 1.500	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction) B 07 0.7	Mass of Clinker in the Individual Type of Cement Produced (tonna) 5	0 3		
	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Menai Industry Subcategory: 2.A.1 - Cement produ Sheet : CO2 Emissions from C Data Subdivision Kanagaoa Unspecified Todyo	n-fuel materials - Tier 3 (34) CO2 Emissions summary - Tie fuction (22) Clinker production - Tier 2 CO2 Emissions for and Product Use ction Lement production (1 of 2) Individual Type of Cement Produced Arr Masonry Portand	3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO2 Equation 2.1 Mass of Individual Type of Cement Produced (conne) 7 A 1.500 1.000 2.000	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction) B 0.7 0.7 0.7 0.7 0.7 0.7 0.7	Mass of Clinker in the Individual Type of Cement Produced (tonna) 5	0 3		
	Cement Production (1/2) Cement Prod Worksheet Sector: Industrial Processes a Category: Menai Industry Subcategory: 2.A.1-Cement produ Sheet: CO2 Emissions from C Data Subdivision Kanagewa Urspecified	n-fuel materials - Tier 3 (34) CO2 Emissions summary - Tie fuction (22) Clinker production - Tier 2 CO2 Emissions for and Product Use ction Lement production (1 of 2) Individual Type of Cement Produced Arr Masonry Portand	3 (44) Capture and storage or o m carbonates - Tier 3 (1/4) CO2 Equation 2.1 Mass of Individual Type of Cement Produced (conne) 7 A 1.500 1.000 2.000	ther reduction Emissions from uncalcined CKD not recy Clinker Fraction in Cement (Fraction) B 0.7 0.5 0.5 0.5	Mass of Clinker in the Individual Type of Cement Produced (tonna) 5			

When Tier 1 Equations are applied:

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

- 1. <u>Column |Individual type of Cement Produced</u>]: 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. <u>Column |A|</u>: input the mass of individual type of cement produced, in tonnes.
- 3. <u>Column |B|</u>: 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. <u>Column |A|</u>: automatically calculates the total clinker content for each subdivision.

Example: automatic calculation of clinker content for each subdivision

ector: Industrial Processes ategory: Mineral Industry abcategory: 2.A.1 - Cement prod heet: CO2 Emissions from lata		2)							199
				E.	Equation 2.1				
		Imports for							
Subdivision	Mass of Clinker for Subdivision (tonne)	Consumption of Clinker (tonne)	Export of Clinker (tonne)		ion Factor for the Clinker nes CO2/tonne Clinker)		CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)	
Subdivision	Subdivision (tonne)	Consumption of Clinker				CKD correction			

- 2. <u>Column |B|</u>: input the amount of imported clinker, in tonnes.
- 3. <u>Column |C|:</u> 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. <u>Column | Name of plant or type of clinker |</u>: Enter a name for plant/facility and/or type of clinker produced.
- 2. <u>Column |A|</u>: enter the amount of clinker production, in tonnes.

Example: AD for Tier 2 clinker production for each subdivision

ement Production (1/2) Cement Produ /orksheet iector: Industrial Processes an category: Mineral Industry /iubcategory: 2.A.1 - Cement product /heet: CO2 Emissions from Clii Data	d Product Use	CO2Emission	ns from carbonates - 1 ier	3(1/4) CO2 Emissions	rrom uncaicir	led UND not recycled to the kiin	- Tier 3 (2/4)
			Equa	ation 2.2			
Subdivision	Name of plant or type of clinker	Clinker production (tonnes)		mission Factor ; CO2/tonne Clinker)		Correction Factor for Cement Kiln Dust (CF ckd) (dimensionless)	CO2 Emissions (Gg CO2)
	A A	A		В		C	D = A*B*C/10^3
Kanagawa prefecture	Plant #214	1,000	Specified	0.52		1.02 📝	0
>	Clinker #2	1400	Specified	0.53		1.02 📝	0
Rest of the country	All other	1,001.2	Specified	5.19		1.02 📝	
*						2	
Total							
		3.401.2					· · · · · · · · · · · · · · · · · · ·

When Tier 3 Equations are applied:

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

In worksheet CO₂ Emissions from Carbonates – Tier 3 (1/4), data are entered row by row, as follows:

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

CO2 Emissions from carbon-bearing non-fuel n	naterials - Tier 3 (3/4) CO2 Emis	sions sum	many - Tier 3 (4/4) Capture an	d storage or other reduction	1	
ement Production (1/2) Cement Production /orksheet	(2/2) Clinker production - Tier 2	CO2 Emi	ssions from carbonates - Tier 3	(1/4) CO2 Emissions fro	om uncalcined CKD not recycl	led to the kiln - Tier 3 (2/4)
iector: Industrial Processes and Proc Category: Mineral Industry Subcategory: 2.A.1 - Cement production Sheet: CO2 Emissions from carbonal Data						
			Equation	n 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)
7	i 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
otal						

\mathbf{r} 1

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. <u>Column |Md|</u>: input weight or mass of CKD not recycled to the kiln, in tonnes.
- 2. <u>Column |Cd|:</u> input the weight fraction of original carbonate in the CKD (i.e., before calcination) not recycled to the kiln, fraction.

<u>Note that</u> 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. <u>Column | Fd |:</u> input fraction of calcination achieved for CKD.

<u>Note that</u> 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

	(1/2) Cement Production (2	2/2) Clinker production - Tie	2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)				
Category: Subcategory:	Industrial Processes and Prode Mineral Industry 2.A.1 - Cement production CO2 Emissions from uncalcine	uct Use d CKD not recycled to the kiln	- Tier 3 (2/4)				
				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 no recycled to the kiln (tonnes CO2)	
	۵V	Md		Fd	EFd	Ed = Md*Cd*(1-Fd)*EFd	
Rest of the co	untry	5,000	1	0.4	0.44	1,319.	
Tokyo		2,000	1	0.4	0.44	527	
*							
Total							
		7,000				1,846	

CO₂ 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. <u>Column |k|</u>: input the type of carbon-bearing non-fuel materials.
- 2. <u>Column |Mk|</u>: input the weight or mass of organic or other carbon-bearing non-fuel raw materials, in tonnes.
- <u>Column | Xk |</u>: input the fraction of total organic or other carbon in specific non-fuel raw material, fraction. <u>Note that</u> the CO₂ 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 • X_k • 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

Vorksheet	Ĩ	s - Tier 3 (3/	of CO2 Emissions a	Junning	- Tier 3 (4/4) Capture and store	ige of other reduction			
Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Product Use Mineral Industry 2.A.1 - Cement production CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4)								
					E	Equation 2.3 (3)			
	Subdivision		Raw material type		Weight or mass of organic or other carbon-bearing non-fuel raw material (tonnes)		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)	
				-					
	Δγ			$\Delta \nabla$	Mk		EFk	Ek = Mk*Xk*EFk	
Rest of the c		caco3	k	ΔV	Mk 100	Xk 0.99	EFk 0.5	Ek = Mk*Xk*EFk	
Rest of the c		caco3 other	k	∆ 7		0.99			

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 CO₂ EF:

- ✓ CO₂ EF for clinker in tonnes of CO₂ per tonne of clinker (<u>Section 2.2.1.2</u> and <u>Equation 2.4</u> in Chapter 2 Volume 3 of the 2006 IPCC Guidelines) and
- ✓ Carbon content or CO₂ content of carbonates used, tonnes of CO₂ per tonne carbonate (<u>Table 2.1</u> 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)
- \checkmark CO₂ Emissions from Carbonates Tier 3 (1/4)
- \checkmark CO₂ Emissions from uncalcined CKD not recycled to the kiln Tier 3 (2/4)
- \checkmark CO₂ 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. <u>Column |D|</u>: Select either *Specified* or *Calculated* for the CO₂EF.
 - a. If specified, directly enter the default CO₂ EF for clinker of 0.51 tonne CO₂ per tonne of clinker (uncorrected for CKD), or instead enter a user-specific CO₂ EF.
 <u>Note that</u> the Tier 1 default CO₂ EF assumes a default CaO content for clinker of 65 percent and 100 percent of the CaO comes from calcium carbonate material.

ategory: Min ubcategory: 2.A	eral Indus 1 - Ceme	cesses and Product Us stry nt production ns from Cement product									19
						Equation 2.1					
Subdivision		Mass of Clinker for Subdivision (tonne)	Imports for Consumption of Clinker (tonne)	Export of Clinker (tonne)		sion Factor for the Clinker nes CO2/tonne Clinker)	CKD correction	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)		
	۵V	A	В	с	-	D	E	F = (A - B + C) * D * E	G = F / 1000		
Kanagawa	∆ 7	A 840		с	Specified	D 0.51	E 1.02	F = (A - B + C) * D * E 436.968	G = F / 1000 0.43697	3	
Kanagawa Kyoto	^⊽				Specified Specified				0.43697	3	6
	∆ ⊽	840				0.51			0.43697	3	G.

Example: Tier 1 EF for clinker

 b. If calculated, the user may calculate the CO₂ 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. <u>Note that</u> for the default CaO composition: 1 tonne of clinker contains 0.65 tonnes CaO from CaCO₃. This carbonate is 56.03 percent

<u>Note that</u> for the default CaO composition: 1 tonne of clinker contains 0.65 tonnes CaO from CaCO₃. This carbonate is 56.03 percent CaO and 43.97 percent CO₂ by weight. The amount of CaCO₃ needed to yield 0.65 tonnes CaO is 0.65/0.5603 = 1.1601 tonnes CaCO₃ (unrounded). The amount of CO₂ released by calcining this CaCO₃ = 1.1601 \bullet 0.4397 = 0.5101 tonnes CO₂ (unrounded). The Tier 1 is not corrected for MgO content. Assuming no correction for CKD, the rounded default EF for clinker is 0.51 tonnes CO₂ / tonne clinker.

2. <u>Column |E|</u>: 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

egory: category:	Mineral Indus 2.A.1 - Cemer												19
						Equation	2.1						
Subdivis	sion	Mass of Clinker for Subdivision (tonne)	Imports for Consumption of Clinker (tonne)	Export of Clinker (tonne)		Emission Factor for t (tonnes CO2/tonne		CKD correction	CO2 Emissi (tonnes CC		CO2 Emissions (Gg CO2)		
	۵V	A	В			i i	D C	E	F = (A - B + C)		G = F / 1000		
Kanagawa		840			Specified		0.51	1.	02	436.968	0.43697	"and the second	
Kyoto		1425	0	0	Specified		0.51						
Tokyo Unspecified		6270 2650	25		Specified Calculated		0.51		02	3261.654 1367.22599	3.26165		
Unspecified		2650	25		Calculated		0.51044	d L	02	1367.22533	1.36/23		M.
-		11185								5065.84799	5.06585		
	Emission Fa	ctor					+		×)			
					E	uation 2.4							
		age CaO Content of linker (CaO) (%)	Percentage Non-ca sources of Ca (%)	lO from ca sou	of clinker rbonate	CaO percentage of CaCO3 (%)	Total CaCO3 needed for tonne CaO (tonne)	CO2 from calcining 1 tonne CaCO3 (tonne)	Emission Factor (uncorrected for MgO) (tonnes CO2 / tonne Clinker)				
	-	A	B	C = .					G = E * F				
		65		0	65	56.03	1.16009	0.44	0.51044				

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 CO₂ EF.
 - a. If specified, directly enter the default CO₂ EF for clinker of **0.51 tonne CO₂ per tonne of clinker**, uncorrected for CKD, or input a user-specific CO₂ EF.
 - b. If calculated, the CO₂ 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.

gory: Mine category: 2.A.	strial Processes an eral Industry 1 - Cement product Emissions from Clir	ion										1	99
						Equation 2.2							
Subdivis	iion		plant or type of linker	Clinker production (tonnes)	(1	Emission Fac tonnes CO2/tonne		Cement	ection Factor for Kiln Dust (CF ckd) mensionless)	CO2 Emissions (Gg CO2)			
	۵V		۵V	A			в		с	D = A*B*C/10^3		1	
Kanagawa prefect	ure	Clinker #2			Calculated			3	1.02 📝			2	
		Plant #214			Specified		0.51		1.02 📝		0.52		
Rest of the country	/	All other		1,001.2	Specified		0.51		1.02 🛃	<u></u>	0.52	-	+
ł				3.401.2							1.04		
	Emission Facto	or								×		 	
					Ē	Equation 2.4							
	Percenta Content o (Ca (%	f Clinker O)	Percentage Non- carbonate sources CaO (%)		CaO percentage of CaCO3 (%)	Total CaCO3 needed for tonne CaO (tonne)	CO2 from calcining 1 tonne CaCO3 (tonne)	Emission Factor (uncorrected for MgO) (tonnes CO2) tonne Clinker	derived from carbonate (optional	Emission Factor (tonnes CO2 / tonne Clinker)			
	A		в	C = A - B	D	E=C/D	F	G = E * F	н	I = G + (H * 0.011)			
					56.03	Contractory of the owner	0.44			0			

Example: calculating a Tier 2 EF for clinker

- 2. <u>Column |C|</u>: 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. <u>Note that</u> 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 <u>Note that</u> it is acceptable to assume that the original carbonate is all CaCO₃ 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 <u>Column |B|</u>.

Example: pop-up table for CKD estimation (Tier 2 cement production)

ment Produc orksheet actor: ategory: ubcategory neet: ata	Industrial I Mineral In 2.A.1 - Ce	Processes and dustry ment productio	Product Use	CO2 Emissions from	n carbonates - Tier 3 (1/4)	CO2 Emissions from	uncalo	cined CKD not recycled to the kiln	Tier 3 (2/4)			19	90
					Equation 2.2								
	Subdivision		Name of plant or type of clinker	Clinker production (tonnes)	Emission (tonnes CO2/to			Correction Factor for Cement Kiln Dust (CF ckd) (dimensionless)	CO2 Emissions (Gg CO2)				
		IPCC Invent	ory Software				×	С	D = A*B*C/10^3				
	ne country		Correct	ion Factor for Cement	Kiln Dust, CF ckd			1.07 2 1.02 2 1.02 2	0.	78 52 52		2	X
otal				Weight of CKD not recycled	d to the kiln (tonnes), Md	200,000.00000	?	2		2			
		-		Weight of clinker	r produced (tonnes), Mcl	1,000,000.00000		-	1.	82			_
			Fraction of original ca	arbonate in the CKD (i.e., before o	calcination) (fraction), Cd	0.85000	?						
			Fraction cal	cination of the original carbonate	in the CKD (fraction), Fd	0.50000	?						
			Emission factor	or for the carbonate (tonnes CO2	/ tonne carbonate), EFc	0.43971 🗸							
			Emission factor for clink	er uncorrected for CKD (tonnes (CO2/tonne clinker), EFcl	0.52000	?						
					CF ckd	1.07188]						
		Copy las	t		Apply to works	heet cell Cancel							
									Uncertainties	T C	eries da	to onte	

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. <u>Column |EFi|</u>: the CO₂ EF is automatically populated, based on the carbonate selected from the dropdown menu in column i. If a user-specific carbonate is entered in column i, enter the stoichiometric EF for the carbonate in <u>Column |EFi|</u>, in tonne of CO₂ per tonne of carbonate.

Then, in worksheet CO₂ Emissions from uncalcined CKD not recycled to the kiln – Tier 3 (2/4):

2. <u>Column |EFd|:</u> input the EF for the uncalcined carbonate in CKD, in tonnes CO₂/tonne carbonate. <u>Note that</u> 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 CO₂ Emissions from carbon-bearing non-fuel materials – Tier 3 (3/4):

3. <u>Column |EFk|:</u> input the EF for kerogen or other non-bearing non-fuel raw material, in tonnes CO₂/tonne carbonate.

<u>Note that</u> the CO₂ emissions from non-carbonate carbon (e.g., carbon in kerogen, carbon in fly ash) in the non-fuel raw materials can be ignored (set $Mk \cdot Xk \cdot EFk = 0$) if the heat contribution from kerogen or other carbon is < 5 percent of total heat (from fuels).

Results

CO₂ 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
- \checkmark CO₂ 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. <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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO₂ (e.g., re-conversion to carbonates), in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.

ement Production (1/2) Cement Productio O2 Emissions from carbon-bearing non-fuel						
rksheet			(4)4) copies of and			
ector: Industrial Processes and Proceses and Processes and Processes and Processes and Processes and						
ata						
as CARBON DIOXIDE (CO2)	~					
Subdivision	Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
Subdivision		ΔV	stored			
Subdivision	Source		stored (tonne)	(tonne)	(tonne)	(Gg)
Subdivision S	Source SRC		stored (tonne) A	(tonne)	(tonne) C = A + B	(Gg)
Subdivision	Source SRC		stored (tonne) A	(tonne)	(tonne) C = A + B	(Gg)

Example: capture and storage or other reduction

2.A.2 Lime Production

Information

Section 2.3 of the 2006 IPCC Guidelines provides three basic methodologies to estimate CO₂ 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.

<u>GHGs</u>

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

- $\checkmark \quad \underline{\text{Tier 1:} Equation 2.8}$
- \checkmark <u>Tier 2: Equations 2.6</u> and <u>2.9</u>
- ✓ <u>Tier 3:Equation 2.7</u>

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 CO2 from Lime Production using worksheets:

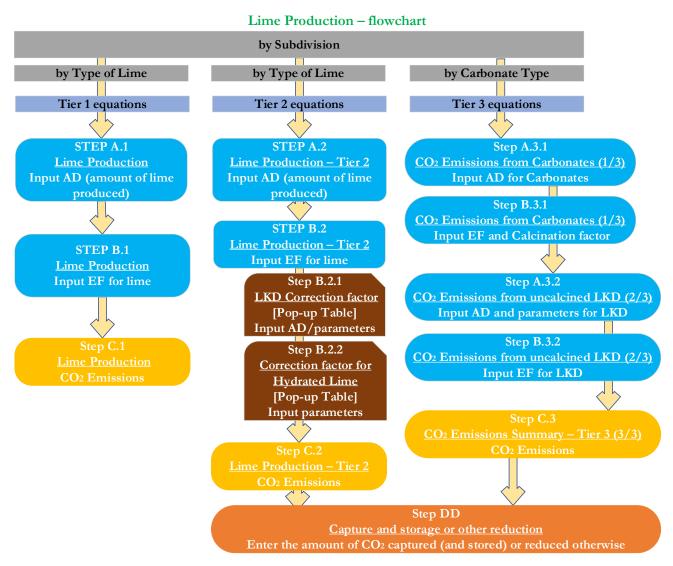
- ✓ Lime Production: contains for each subdivision and type of lime produced: information on the amount of lime produced and the lime EF. The worksheet calculates the associated CO₂ emissions.
- ✓ Lime Production Tier 2: contains for each subdivision, name of plant and type of lime produced information on the amount of lime produced, the stoichiometric ratio of CO₂ 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 CO₂ emissions.
- ✓ CO₂ Emissions from carbonates Tier 3 (1/3): contains for each subdivision information on types and amounts of carbonates used, the CO₂ EF and fraction of calcination achieved. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ EF. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ capture (with subsequent storage) and other reduction of CO₂, not accounted previously in the worksheets for different Tiers.

User's Work Flowchart

Consistent with the key category analysis and the decision tree in <u>Figure 2.2</u> 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-specific¹ 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.



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 CO₂ 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.

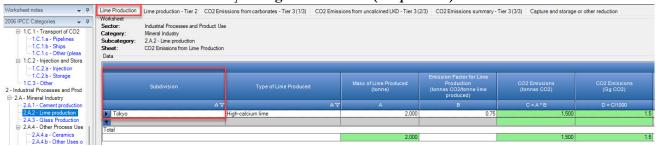
Then, for each tier, as appropriate:

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., reconversion 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 <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

Worksheet notes 👻 🔻		Lime production - Tier 2 CO2 Emi	issions from carbonates - Tier 3 (1/3) CO2 E	missi	ons from uncalcined LKD - Tier 3 (2/3) CO2 Emissions summary - 1	Tier 3 (3/3) Capture and storage	or other reduction
2006 IPCC Categories	Worksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Product Use Mineral Industry 2.A.2 - Lime production CO2 Emissions from Lime Production						
IC22 - Injection IC2a - Injection IC2a - Storage IC3 - Other IC3 - Other IC3 - Other IC3 - Mineral Industry			Type of Lime Produced	1	Mass of Lime Produced (torne)	Emission Factor for Lime Production (tonnes CO2/tonne lime produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
- 2.A.1 - Cement production		Δ 🖓		$\Delta \nabla$	A	в	C = A * B	D = C/1000
2.A.2 - Lime production 2.A.3 - Glass Production 2.A.4 - Other Process Use	Rest of Japa Tokyo	in	High-calcium lime High-calcium lime		1,400 2,000	0.75 0.75	1,050 1,500	1.05 1.5
2.A.4.a - Ceramics 2.A.4.b - Other Uses o 2.A.4.c - Non Metallur	Total				3,400		2,550	2.55

When the Tier 1 Equation is applied:

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

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

When Tier 2 Equations are applied:

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

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

/orksheet iector: Industrial Pi Category: Mineral Ind Subcategory: 2.A.2 - Lime	rocesses and Product Use	2 Emissions from carbonat	es - mer 3 (1/3)	CO2 Emissions from	uncalcined LKD - Tier :	(2/3) CO2 Emissio	ons summary - Tier 3 (3/	capture and st	torage or other n
				Equati					
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 Emission (Gg CO2)
ΔΥ	Δγ	× ۵						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	1.4
Tokyo	All plants	High-calcium lime	1,000	0.79	0.95	1 📝	0.97 📝	724.87	0.1
Unspecified	Unspecified	Dolomitic lime	3,500	0.79	0.95	1.01 📝	0.97 📝	2,562.41	2.5
		High-calcium lime	1,300	0.79	0.95	1 📝	0.97 📝	942.33	0.
*						2	0.97 📝		
Total									
			7,800					5,679.35	5.

Example: AD for Tier 2 lime production for each subdivision

When the Tier 3 Equation is applied:

For Tier 3, for each subdivision in <u>Column | Subdivision |</u>, 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. <u>Column | Mi |:</u> for each subdivision/ carbonate type, input the mass of carbonate consumed, in tonnes.

ime Production	Lime production - Tier	2 CO2Er	missions from carbon	ates - Tier 3 (1/	3) CO2 Emissions from	n uncalcined LKD - Tier 3 (2/3)	CO2 Emissions summar	y - Tier 3 (3/3)	Capture and storag
Category: Subcategory:	Industrial Processes and Produ Mineral Industry 2.A.2 - Lime production CO2 Emissions from carbonate		3)						
					Equati	on 2.7 (1)			
s	ubdivision		Carbonate type		Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)	Fraction calcination achieved for carbonate (Fraction)		ns from carbonates nes CO2)
	ΔV	_	1	۵V	Mi	EFi	Fi	Ei = 1	EFi * Mi * Fi
Plant #1		CaCO3			250	0.44	1	Ĩ.	109.9
		MgCO3			200	0.52	1		104.3
Plant#2		CaCO3		1.1	100	0.44	1		43.97
		MgCO3			120	0.52	1		62.64
Tokyo * Total									

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. <u>Column | Md |</u>: input weight or mass of LKD not recycled to the kiln, in tonnes
- 2. <u>Column |Cd|</u>: 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.

ime Production Vorksheet	Lime production - Tier	2 CO2 Emissions from car	rbonates - Tier 3 (1/3)	CO2	Emissions from uncalcined L	KD - Tier 3 (2/3)	CO2 Emiss	ions summary - Tier 3 (3/3)	Capture and storag
Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Produ Mineral Industry 2.A.2 - Lime production CO2 Emissions from uncalcine								
					Equation 2.7 (2)				
	Subdivision	Weight or mass of LKD (tonnes)	Weight fraction of orig carbonate in the LKI (Fraction)		Fraction calcination achieved for LKD (Fraction)	Emission facti uncalcined car LKD (tonnes CO2 carbona	bonate in 2/tonne	CO2 Emissions from (tonnes C	
	$\Delta \nabla$	Md			Fd	EFd		Ed = Md*Cd*(1	-Fd)*EFd
Plant #1		1,000		1	0.95		0.44		21.
Plant#2		200		0.9	0.97		0.44		2.
Tokyo		200		0.9	1		p.43971		
*									
Total									
		1,400							24.

Example: AD for Tier 3 - amount of uncalcined LKD not recycled to the kiln

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. <u>Column |B|</u>: the default CO₂ EF is automatically populated, in tonnes CO₂/tonne lime produced, depending on the type of lime produced in <u>Column |Type of Lime Produced|</u>. The user may overwrite this value with user-specific information.

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

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

	production - Tier 2 CO2	Emissions from car	bonates - Tier 3 (1	1/3) CO2 Emissions from the second	m uncalcined LKD - T	ier 3 (2/3)	CO2 Emissions summary - Tier 3	(3/3) Capture and storag
Category: Mineral Indus Subcategory: 2.A.2 - Lime p		er 1						
Subdivision		Type of Lime Pro	duced	Mass of Lime Produce (tonne)	Emission Fact d Produc (tonnes CO2/ produc	tion tonne lime	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	V		V		В	Δ	C = A * B	D = C/1000
rest of Japan	All lime	production		2.	000	0.75	1,500	1.5
Tokyo	High-ca	lcium lime		1,	000	0.75	750	0.75
Unspecified	Dolomiti	ic lime			100	0.77	77	0.0
Tokyo	Dolomiti	ic lime		2.	000	0.86	1,720	1.7.
😽 Kanagawa				θ	θ			
* Total		Lime Type		ission Factor /tonne lime produced)	Remark			
	All lime	production		0.75			4,047	4.05
	High-ca	alcium lime		0.75				
	Dolomi	tic lime		0.86	Developed countries			
				0.77	Developing countrie	s		
	Hydrau	lic lime		0.59				

When Tier 2 Equations are applied:

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

- 1. <u>Column |C|</u>: select from the drop-down menu the relevant stoichiometric ratio for the type of lime produced, tonnes CO₂/tonne CaO or tonnes CO₂/tonne CaO·MgO.
- 2. <u>Column |D</u>|: select from the drop-down menu the relevant CaO Content or CaO·MgO content, tonnes CaO/tonne lime or tonnes CaO·MgO/tonne lime.
- 3. <u>Column |E|</u>: Additional information is needed to estimate the correction factor for LKD not recycled into the kiln. The factor can be entered manually (the default is 1.02 (dimensionless)) or can be estimated based on several input data and parameters (a pop-up table). To estimate the LKD factor for each subdivision and plant and type of lime produced, select the edit box and enter the following information:
 - 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. <u>Note that</u> it is acceptable to assume that the original carbonate is all CaCO₃ 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. <u>Column |F|</u>: Additional information is needed to estimate the correction factor for hydrated lime (see discussion under <u>Section 2.3.1.3</u>. 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

ategory: Mineral In ubcategory: 2.A.2 - U	Processes and Product Use ndustry me production ssions from Lime Production -										19
				Equat	ion 2.6					_	
			Mass of Lime Produced (tonnes)	EF1 Stolchiometric 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)		
۵		7 47	8	C	D	۰		G = B*C*D*E*F	H = G/1000		
Kanagawa	Plant#1	High-calcium lime	2,000		0.95	1 🜌		1,449.74	1.45		+-
Tokyo Unspecified	All plants Unspecified	High-calcium lime Dolomitic lime	1,000	0.79	0.95	1.01	0.97	724.87 2.562.41	0.72		+
onspecified	Unspecified	High-calcium lime	1,300	0.79	0.95	1	interaction of the second s	942.33	0.94		+
Ø Yokusko	-	High-calcium lime	2.000			1.02		1,478.73		3 6	1 2
					/	2	0.97			1	
fotal			9,800					7,158.08	7,16		_
			3,000	-	/			7,100.00	7,10		_
rrection Factor for Lime	e Kiln Dust (CF lkd)			×	Correction Facto	or for Hydrated	Lime (C h)			×	
Co	prrection Factor for	Lime Kiln Dust (C	F Ikd)		Co	rrection Fac	tor for Hydrat	ed Lime (Ch)		
			High-ca	Icium lime							
	Weight of LKD no	t recylcled to the kiln (tonne	s), Md	1,000,000.000				High-c	alcium lin	e	
	w	eight of lime produced (tonn	es), M	900,000.000		Pr	oportion of hydrated	lime, X	0.1	00	
Fraction of origi	inal carbonate in the LKD ().	e. before calcination) (fractio	n). Cd	0.800			Water con	tent Y	0.2	80	
Fractio	n calcination of the original	carbonate in the LKD (fractio	m) Fd	.700							
								Ch	0.9	72	
		c	Fikd	1.622				Ch	0.9	72	

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. <u>Column |EFi|</u>: 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 CO₂ per tonne of carbonate.
- 2. <u>Column |Fi|:</u> input fraction of calcination achieved for carbonate. <u>Note that</u> in the absence of actual data, it is consistent with good practice to assume that the degree of calcination achieved is 100 percent (i.e., Fi = 1.00) or very close to it.

ime Production · Lime prod	duction - Tier	2 CO2Emi	ssions from carbon	ates - Tier 3	(1/3) CO2 Emissions from	m uncalcined LKD - Tier 3 (2/3)	CO2 Emissions summary	- Tier 3 (3/3)	Capture and storag
Vorksheet Sector: Industrial Process Category: Mineral Industry Subcategory: 2.A.2 - Lime prod Sheet: CO2 Emissions fro Data	uction								
					Equat	ion 2.7 (1)			
Subdivision			Carbonate type		Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)	Fraction calcination achieved for carbonate (Fraction)		ions from carbonate onnes CO2)
	ΔΥ		- i	ΔV	Mi	EFi	Fi	Ei -	= EFi * Mi * Fi
Plant #1		CaCO3			250	0.44	1		109.
		MgCO3			200	0.52	1		104
Plant#2		CaCO3			100	0.44	1		43.
Tokyo		MgCO3			120	0.52	h		62.
Unspecified		CaCO3			1,000	0.44	1		439.
*									
Total									
					1,670				760.6

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 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.</u>
- 3. <u>Column | EFd |</u>: input the EF for the uncalcined carbonate in LKD, tonnes CO₂/tonne carbonate <u>Note that because calcium carbonate is overwhelmingly the dominant carbonate in the raw materials</u>, 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

* Total						
Tokyo		200	0.9	1	0.44	
Plant#2		200	0.9	0.97	0.44	2
Plant #1		1,000		0.95	0.44	21
	∆ 🏹			Fd	EFd	Ed = Md*Cd*(1-Fd)*EFd
	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)
ata				Equation 2.7 (2)		
ubcategory: neet:	2.A.2 - Lime production CO2 Emissions from uncalcine	d LKD - Tier 3 (2/3)				
ector: itegory:	Industrial Processes and Produ Mineral Industry	ict Use				
me Production - /orksheet	cine production The	2 CO2 Emissions nomea	rbonates - Tier 3 (1/3) CO2	Emissions from uncalcined L	COZEINISS	ions summary - Tier 3 (3/3) Capture and

Results

CO₂ 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
- ✓ CO₂ Emissions summary Tier 3 (3/3)

Total CO₂ emissions from lime production is the sum of all emissions in the above worksheets, taking into account any CO₂ capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO₂ capture and storage.

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

- 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| collect and input information on the amount of CO₂ captured (with subsequent storage), in tonnes.</u>
- 3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO₂ (e.g., re-conversion to carbonates), in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.

ne Production	Lime production - Tier	2 CO2 Emissions from carbona	ates - Tier 3 (1/	3) CO2 Emissions from un	calcined LKD - Tier 3 (2/3)	CO2 Emissions summary - Tier 3 (3/3) Capture and storag	e or oth	er reduct	ion	
rksheet ector: tegory: bcategory: eet: ata	Industrial Processes and Produce Mineral Industry 2.A.2 - Lime production Capture and storage or other re									19	990
	ON DIOXIDE (CO2)	~									
	Subdivision	Source	1	Amount CO2 captured and stored	Other reduction	Total reduction	Total reduction				
				(tonne)		(tonne)	(Gg)				
	s av	SRC	۵V	(tonne) A	(tonne) B	(tonne) C = A + B	(Gg) C / 1000	-			
Unspecified		SRC Unspecified	۵V							2	*
			∆ ⊽					3	6	2	,
Unspecified tal			۵V					-	a	2	3

Example: capture and storage or other reduction

2.A.3 Glass Production

Information

<u>Section 2.4</u> of the 2006 IPCC Guidelines provides three Tiers to estimate CO₂ 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

- \checkmark <u>Tier 1:Equations 2.10</u> and <u>2.13</u>
- ✓ <u>Tier 2: Equation 2.11</u>
- $\checkmark \quad \underline{\text{Tier 3}: \text{Equation 2.12}}$

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 CO₂ 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 CO₂ EF and cullet ratio factor. The worksheet calculates the associated CO₂ emissions.
- ✓ Glass Production Tier 3: contains for each subdivision information on the type and amount of carbonate consumed, the CO₂ EF and the calcination fraction. The worksheet calculates the associated CO₂ emissions.
- ✓ Capture and storage or other reduction: contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, not accounted previously in the worksheets for different Tiers.

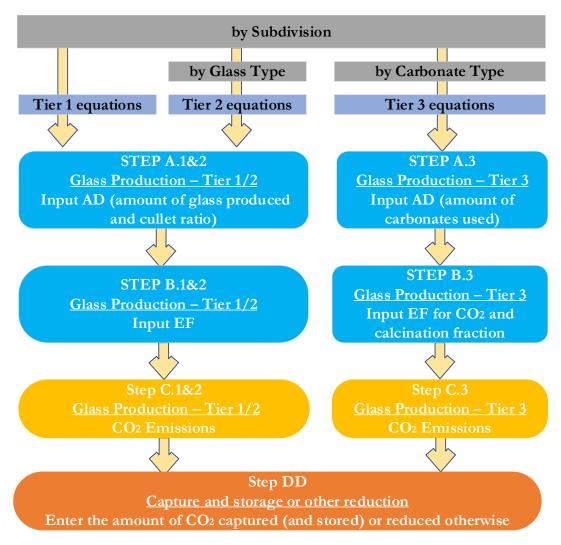
User's Work Flowchart

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-specific¹ 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 regionspecific 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 CO₂ 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 CO₂ emissions for each subdivision in mass units (tonnes and Gg) for Tier 3. In addition, total CO₂ emissions are calculated.

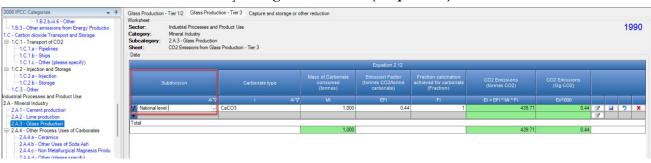
Then, for each tier, as appropriate:

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., reconversion 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 <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> [subdivision] for each subdivision.



Example: single subdivision (unspecified)

Example: multiple subdivisions

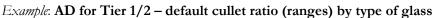
□ 1.8.2.billi 6 - Other 1.8.3 - Other emissions from Energy Productio 1.C - Carbon dioxide Transport and Storage □ 1.C.1 - Transport of CO2 □ 1.C.1 a - Pipelines □ 1.C.1 b - Ships	Worksheet Sector: Industrial Processes a Category: Mineral Industry Subcategory: 2.A.3 - Glass Producti Sheet : C02 Emissions from G Data Data	ion									199
1.C.1.c - Other (please specify)					Equation 2.10, 2.11						
- 1.C.2 Injection and Storage - 1.C.2.a - Injection - 1.C.2.b - Storage - 1.C.3 - Other	Subdivision	Тур	e of melted glass produc	ed 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)			
ndustrial Processes and Product Use 2.A - Mineral Industry	Δ'	7		ΔV A		CRi	Ei = A*EFi*(1-CRi)	Ei/1000			
- 2.A.1 - Cement production	Kanagawa	Conta	iner (Amber/Green)	1,00	0.21	0.55	94.5	0.09	1		
2.A.2 - Lime production		Conta	iner (Flint)	50	0.21	0.45	57.75	0.06	3		
2.A.3 - Glass Production	Rest of Japan	All gla	ass production	56	0.2	0.5	56	0.06	1	i.	2)
3 2.A.4 - Other Process Uses of Carbonates									3		
	Total			2.06			208.25	0.21	1		

When Tier 1 and Tier 2 Equations are applied:

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

- 1. <u>Column |i|</u>: 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. <u>Column |A|</u>: input the mass of that type of glass produced, in tonnes.
- 3. <u>Column |CRi|</u>: 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.

<u>Note that</u> 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 (<u>Table 2.6</u>), 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.



orksheet ector: Industrial Processes and	ction - Tier 3 Capture and st											10	990
tegory: Mineral Industry bcategory: 2.A.3 - Glass Production												18	99
				Equation 2.1	10, 2.11								
Subdivision	Type of melted glass proc	luced	Production of glass type (tonne)	Emission factor manufacturing of type (tonnes CO2/tor Glass)	glass	Cullet ratio for manufacturing of glass type (Fraction)		Emissions Ines CO2)	CO2 Emissions (Gg CO2)				
Δ 🖓		ΔΥ											
Kanagawa	Container (Amber/Green		1,000		0.21	0.55		94.5					
	Container (Flint)		500		0.21	0.45		57.75		3		_	_
rest	Float		750		0.21	0.18		129.94	0.13	And Distances		-	-
Rest of Japan	All glass production	_	560	-	0.2	0.5		56		2		5	-
7 Unspecified	All glass production	V	200		0.2	0.5		20	0.02	2		2)
otal	Type of melted glass produced		ion factor for manufactur (tonnes CO2/tonne)	ing of glass type Glass)		ratio for manufacturing o (Fraction)	f glass type					1-	_
	All glass production			0.2			0.5	Tier 1					
	Float			0.21			10% - 25%					11-	
	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 <u>Column |Subdivision|</u>, data are entered in worksheet **Glass production – Tier 3**, row by row, as follows:

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

Vorksheet Category: Category: Category: Category: Category: Category:	Tier 1/2 Glass Production Industrial Processes and Mineral Industry 2.A.3 - Glass Production CO2 Emissions from Glass	Product Use		rage or or	ner reduction				
						Equation 2.12			
	ubdivision		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)
	ΔΥ			ΔV	Mi	EFi	Fi	Ei = EFi * Mi * Fi	Ei/1000
Plant#1		CaCO3			1,000	0.44	1	439.71	0
Plant#2		MgCO3			2,000	0.52	1	1,043.94	1.
Plant#3		CaCO3			1,500	0.44	1	659.57	0.
Flant#3		FeCO3			1,500	0.38	1	569.81	0.
ĸ									
otal									
					6,000			2,713.02	2

Example: AD for Tier 3 – amount of carbonates consumed

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) CO₂ EF for glass produced in tonne CO₂ per tonne of glass produced Tier 1&2 (<u>Table 2.6</u>)
- ii) $CO_2 EF$ for carbonates consumed (based on stoichiometry of carbonates) in tonnes of CO_2 per tonne of carbonate used Tier 3 (<u>Table 2.1</u>). 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. <u>Column |EFi|</u>: the default CO₂ EF is automatically populated based on the type of melted glass produced in <u>Column |Type of melted glass produced|</u>. The user may overwrite this value with user-specific information, in tonnes CO₂/tonne glass produced.

Worksheet Sector: Industrial Processes and Category: Mineral Industry Subcategory: 2.A.3 - Glass Production		e or other reduction						
Subdivision	Type of melted glass produce	Production of glass d type (tonne)	Equation 2.10, Emission factor to manufacturing of gla type (tonnes CO2/tonn Glass)	or ass	Cullet ratio for nanufacturing of glass type (Fraction)		emissions nes CO2)	CO2 Emissions (Gg CO2)
ΔV	1	A V A	EFi		CRi	Ei = A	*EFi*(1-CRi)	Ei/1000
Kanagawa	Container (Amber/Green	1,000	C	0.21	0.55		94.5	0.09
	Container (Flint)	500	0	0.21	0.45		57.75	0.06
rest	Float	750	0	0.21	0.18		129.94	0.13
Rest of Japan	All glass production	560		0.2	0.5		56	0.06
10 Unspecified	All glass production	200		0.2	0.5		20	0.02
* Total	Type of melted glass E produced	mission factor for manufactur (tonnes CO2/tonne)	ng of glass type C ilass)	Cullet r	atio for manufacturing of gl (Fraction)			Remark
	All glass production		0.2			0.5	Tier 1	
	Float		0.21		1	10% - 25%		
	Container (Flint)		0.21		3	30% - 60%		
	Container (Amber/Green)		0.21		3	30% - 80%		
	Fiberglass (E-glass)		0.19			0% - 15%		
	Fiberglass (Insulation)		0.25		1	10% - 50%		
	Specialty (TV Panel)		0.18		2	20% - 75%		
	Specialty (TV Funnel)		0.13		2	20% - 70%		

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. <u>Column |EFi|</u>: 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 <u>Column |EFi|</u>, in tonne of CO₂ per tonne of carbonate.

2. <u>Column |Fi|:</u> enter fraction of calcination achieved for carbonate. <u>Note that</u> 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.

$\mathit{Example:}$ Tier 3 EF for glass production

ctor: Industrial Processes and Itegory: bcategory: 2.A.3 - Glass Production CO2 Emissions from Glas ata									
			L.		Equation 2.12				
Subdivision	Carbonate type		Mass of Carbonat consumed (tonnes)	e	Emission Factor (tonnes CO2/tonne carbonate)		action calcination ieved for carbonate (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
<u>۵</u> 7	Ť	۵V	Mi		EFI		Fi	Ei = EFi * Mi * Fi	Ei/1000
Plant#2	MgCO3		2.	000	0.52		1	1,043.94	
Plant#3	CaCO3		1.	500	0.44		1	659.57	
1	FeCO3			500	0.38		1	569.81	14
Unspecified	CaCO3			000	0.44		1	439.71	
·	MgCO3	~	2.	000	0.52		1	1,043.94	
otal	Carbonate		lineral Name	(to	Emission Factor ines CO2/tonne carbona	te)		Remark	
	CaCO3	Calcite	or aragonite		0.43	971	high-magnesium or dol relatively small substit	mineral in limestone. Terms like omitic limestones refer to a ution of Mg for Ca in the general only shown for limestone.	
	MgCO3	Magnes	ite		0.52	197			
	CaMg(CO3)2	Dolomit	e		0.47	732	high-magnesium or dol relatively small substit	mineral in limestone. Terms like omitic limestones refer to a ution of Mg for Ca in the general only shown for limestone.	
	FeCO3	Siderite			0.37	987			
	Ca(Fe,Mg,Mn)(CO3)2	Ankerite	•		0.44	197	Fe. Mg. and Mn are pre	shown for ankerite assumes that sent in amounts of at least 1.0 ght range: 185.0225-215.6160. : 0.40822-0.47572	
	MnCO3	Rhodoci	hrosite		0.38	286			
	Na2CO3	Codium	carbonate or soda.		0.41	102	1		

Results

CO₂ 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. <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| collect and input information on the amount of CO₂ captured (with subsequent storage), in tonnes.</u>
- 3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO₂ (e.g., re-conversion to carbonates), in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.

Example: capture and storage or other reduction

tor: egory: category: et: a	Industrial Processes and Prod Mineral Industry 2.A.3 - Glass Production Capture and storage or other r						
	ON DIOXIDE (CO2)	~					
	Subdivision	Sou	irce	Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
		200		stored			

2.A.4 Other Process Uses of Carbonates

Information

Section 2.5 of the 2006 IPCC Guidelines provides common methodological guidance for the following subcategories:

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 <u>Section 2.3.1.1</u>, 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.

<u>GHGs</u>

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

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
X						

IPCC Equations

- $\checkmark \quad \underline{\text{Tier 1}}: \underline{\text{Equation 2.14}}$
- ✓ <u>Tier 2: Equation 2.15</u>
- \checkmark <u>Tier 3</u>: <u>Equation 2.16</u>

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 CO₂ from Other Process Uses of Carbonates using worksheets:

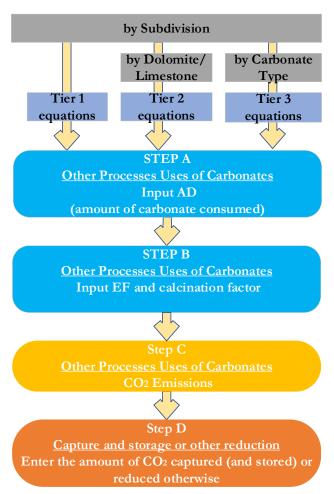
- ✓ Other Process Uses of Carbonates Tier 1/2/3: contains for each subdivision information on the amount of carbonate consumed either at the national level (Tier 1, undifferentiated by type of carbonate, total) or by specifying the amount of dolomite and limestone used (Tier 2) or by individual type of carbonate used (Tier 3), and the calcination fraction achieved. The worksheet calculates the associated CO₂ emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, 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-specific¹ 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 CO₂ 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 CO₂ emissions for each subdivision in mass units (tonnes and Gg). In addition, total CO₂ emissions are calculated.

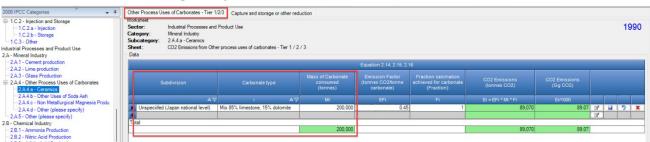
Step D, in the worksheet Capture and storage or other reduction, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., reconversion to carbonates).

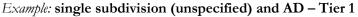
Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the country-specific EF.

Activity Data Input

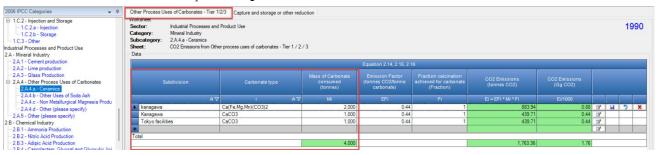
Section 2.5.1.3, in Chapter 2 Volume 3 of the 2006 IPCC Guidelines contains information on the choice of AD for Other Process Uses of Carbonates.

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 <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: multiple subdivisions – AD Tier 2 and Tier 3



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

- 1. <u>Column |i|</u>: select the type of carbonate from the drop-down menu or input a user-specific type.
- 2. <u>Column | Mi</u>]: input the mass of individual carbonate consumed, in tonnes. <u>Note that</u> in the Tier 1 method, the inventory compiler should collect AD for total carbonate consumption for emissive uses (see <u>Table 2.7</u>). 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 <u>Table 2.1</u>.

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. <u>Column |EFi|</u>: 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 <u>Column |EFi|</u>, in tonne of CO₂ per tonne of carbonate.
- 2. <u>Column |Fi|:</u> 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 <u>Column [Fi]</u>.

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

orksheet ector: Industrial Processes and f ategory: Mineral Industry ubcategory: 2.A.4.a - Ceramics heet: CO2 Emissions from Other Jata	Product Use						
			Equation 2.14, 2.15, 2.16	3			
Subdivision	Carbonate type	Mass of Carbonate consumed (tonnes)	Emission Factor (tonnes CO2/tonne carbonate)		ction calcination wed for carbonate (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
۵	i ۵۲	7 Mi	EFi		Fi	Ei = EFi * Mi * Fi	Ei/1000
kanagawa	Ca(Fe,Mg,Mn)(CO3)2	2,000	0.44		1	883.94	C
Kanagawa	CaCO3	1,000	0.44		1	439.71	C
 Tokyo facilities 	CaCO3	1,000	0.44		1	439.71	(
* Total	Carbonate	Mineral Name	Emission Factor (tonnes CO2/tonne carbo	onate)		Remark	
- Star	Mix 85% limestone, 15% dolomite		0	.44535			1
	CaCO3	Calcite or aragonite	٥	.43971	high-magnesium or relatively small sub	pal mineral in limestone. Terms like dolomitic limestones refer to a stitution of Mg for Ca in the general amonly shown for limestone.	
	MgCO3	Magnesite	0	.52197			
	CaMg(CO3)2	Dolomite	a	.47732	high-magnesium or relatively small sub	pal mineral in limestone. Terms like dolomitic limestones refer to a stitution of Mg for Ca in the general amonly shown for limestone.	
	FeCO3	Siderite	0	.37987			
	Ca(Fe,Mg,Mn)(CO3)2	Ankerite	Q	.44197	Fe, Mg, and Mn are percent. Formulae v	nge shown for ankerite assumes that present in amounts of at least 1.0 veight range: 185.0225-215.6160. nge: 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. <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| collect and input information on the amount of CO₂ captured (with subsequent storage), in tonnes.</u>
- 3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO₂ (e.g., re-conversion to carbonates), in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.

Example: capture and storage or other reduction

ksheet								
tor:	Industrial Processes and Product	Use						
	Mineral Industry							
	2.A.4.a - Ceramics							
et:	Capture and storage or other red	uction						
	ON DIOXIDE (CO2)	~						
	DN DIOXIDE (CO2)	~						
	DN DIOXIDE (CO2)	~						
ta carbo carbo		~			Amount CO2 captured and	Other reduction	Total reduction	Total reduction
	DN DIOXIDE (CO2) Subdivision	~	Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
			Source	۵Ÿ	stored (tonne)			
	Subdivision		and the definition of the second	۵Ţ	stored (tonne)	(tonne)	(tonne)	(Gg)

2.A.5 Other

Information

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

According to <u>Section 2.4.1</u> 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.

<u>GHGs</u>

The Software includes the following GHGs for the Other (mineral industry) source category:

CO_2	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
Χ	Χ	Χ				

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. <u>Tier 2</u>: 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:

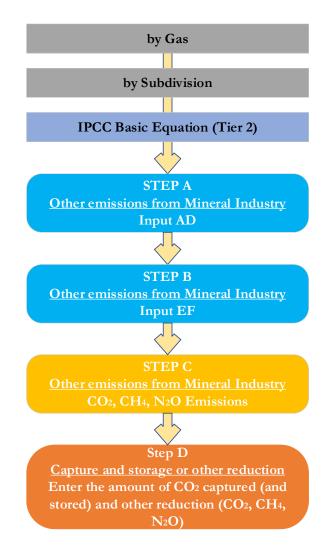
- ✓ Other: contains for each subdivision and source of emissions, information on the activity type, data and unit, and corresponding EFs. The worksheet calculates the associated CO₂, CH₄ and N₂O emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent 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-specific¹ 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 <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>.

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

- 1. <u>Column |SRC|</u>: describe the type of activity emitting GHG emissions from this category (e.g. rock wool production).
- 2. <u>Column |AT|</u>: input the activity type corresponding to the source selected.
- 3. <u>Column |AD|</u>: input AD (quantity of the activity type input in <u>Column |AT|</u> and following the units in <u>Column |U|</u>).
- 4. <u>Column |U|</u>: input the unit of the AD.

Emission Factor Input

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

 <u>Column | EF |</u>: input CH₄ or CO₂ or N₂O EF;. <u>Note that</u> user shall select "Carbon dioxide (CO₂)" or "Methane (CH₄)" or "Nitrous Oxide (N₂O)" in the "Gas" bar at the top, to enter data for each GHG one by one.



Example: multiple subdivisions, by gas

Results

Total CO₂, CH₄ and N₂O emissions from Other (mineral industry) is the sum of all subdivisions in worksheet **Other**, taking into account any CO₂ capture with subsequent storage or other GHG reduction. The worksheet **Capture** and storage or other reduction is provided in the *Software* to estimate CO₂ capture and storage and other GHG 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other reduction of GHGs, in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.

ector:	Industrial Processes an	nd Product Use						
tegory:	Mineral Industry							
bcategory:	2.A.5 - Other (please s	specify)						
neet:	Capture and storage o							
ata			-					
	SON DIOXIDE (CO2)	~	1					
	ION DIOXIDE (CO2)							
METH	ANE (CH4) OUS OXIDE (N2O)				Amount CO2 captured and			-
METH	HANE (CH4)		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
METH	IANE (CH4) OUS OXIDE (N2O)	۵ <u>.</u>	Source	۵ 7	stored (tonne)			
METH	IANE (CH4) OUS OXIDE (N2O) Subdivision S	∆ ⊽ Unspeci	SRC	<u>م</u> م	stored (tonne)	(tonne)	(tonne)	(Gg)

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).

<u>GHGs</u>

The Software includes the following GHGs for the Ammonia Production source category:

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
X	Χ	Χ				

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 "CH₄ and N_2O emissions from ammonia production" is provided as a default dropdown in <u>Column |SRC|</u>. For further information, see description under section **2.B.11 Other**.

IPCC Equations

- \checkmark <u>Tier 1</u>: <u>Equation 3.1</u>
- ✓ <u>Tier 2: Equations 3.2 and 3.3</u>
- ✓ <u>Tier 3</u>: <u>Equations 3.3 and 3.4</u>

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 CO2 from Ammonia Production using worksheets:

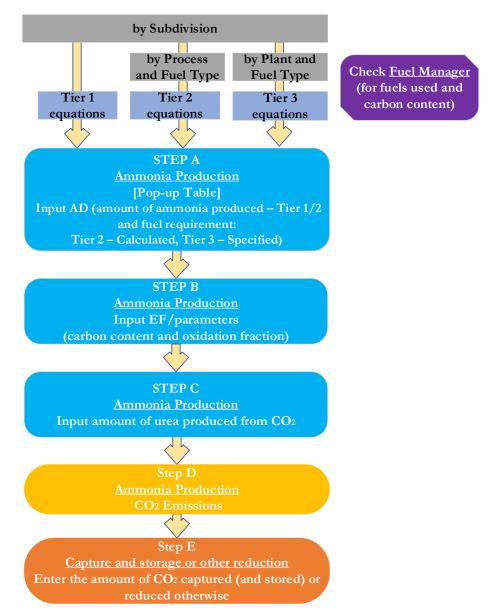
- ✓ 1.1.1 Fuel Manager: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ Ammonia Production: contains for each subdivision (and for each process fuel type) information on the amount of ammonia produced and fuel requirement (Tier 1 and Tier 2) or only total fuel requirement (Tier 3), carbon content of fuels, oxidation factor and amount of urea produced from produced CO₂. The worksheet calculates the associated CO₂ emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, 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-specific¹ 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.

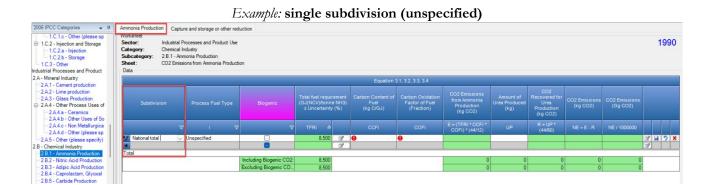
Step E, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) not accounted in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

-1.C.1.c - Other (please sp	Ammonia Production C Worksheet	apture and storage or other re	0000011											
1.C.2 - Injection and Storage 1.C.2.a - Injection 1.C.2.b - Storage 1.C.3 - Other strial Processes and Product	Sector: Indust Category: Chemi Subcategory: 2.8.1	tal Processes and Product Use cal Industry Ammonia Production missions from Ammonia Product											1	990
- Mineral Industry 2.A.1 - Cement production						Equation :	3.1, 3.2, 3.3, 3.4							
2A1 - Cement production 2A2 - Lime production 2A3 - Glass Production 2A4 - Other Process Uses of -2A4.a - Ceramics -2A4.b - Other Uses of So	Subdivision	Process Fuel Type	Biogenic	Total fuel requ (GJ(NCV)/tonr ± Uncertaint		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)		
2.A.4.c - Non Metallurgica 2.A.4.d - Other (please sp								E = (TFRi * CCFi * COFi) * (44/12)		R = UP * (44/60)				
A.5 - Other (please specify)	Plant#23 - Tier 3	Natural Gas (Dry)		4,228	1	15.3	1	237,190.8	24	17.6	237,173.2	0.24	7 .	5
Chemical Industry	Ammonia - Tier 2	Natural Gas (Dry)	0	6,040	3	15.3	1	338,844	5	3.67	338,840.33	0.34	2	
B.1 - Ammonia Production	Ammonia- Tier 1	Landfill Gas		7,550	1	14.9	1	412,481.67	15	11	412,470.67	0.41	3	
B.2 - Nitric Acid Production	*		8		3								2	
B.3 - Adipic Acid Production B.4 - Caprolactam, Glyoxal	Totar													
2.B.5 - Carbide Production			Including Biogenic CO.					988,516.47	44					
B.6 - Titanium Dioxide Prod			Excluding Biogenic CO	- 10,268				576,034.8	29	21.27	576,013.53	0.58		

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 <u>Column |Subdivision|</u>, data are entered in worksheet **Ammonia Production**, row by row, as follows:

- 1. <u>Column |i|</u>: 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*.
 - <u>Note that</u> fuels shown in the drop-down menu are those listed in the Fuel Manager.
- 2. <u>Column | Biogenic |</u>:indicate with a check if the process fuel is of biogenic origin.
- 3. <u>Column |TFRi |:</u> 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:

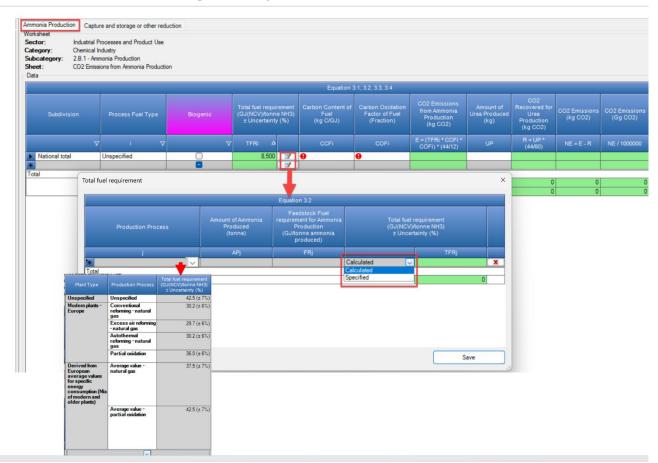
If *Calculated* is selected in <u>Column | TFRi |</u> (Tier 1 and Tier 2)

- 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 |APi|</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 NH₃ produced.

Note that 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 CO2 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 CO₂ generated from ammonia production. When a deduction is made for CO₂ 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 CO₂ recovered for urea production is zero (i.e. <u>Column |UP|</u> =0). <u>Note that the quantity of urea produced can be estimated by dividing the total CO₂ consumed for urea production by 0.733 tonnes of CO₂ required per tonne urea production.</u>

Example: input of urea production

	re and storage or other red	uction									
ategory: Chemical Ir ubcategory: 2.B.1 - Amr	rocesses and Product Use idustry nonia Production ons from Ammonia Productio	on									
					Equation 3	3.1, 3.2, 3.3, 3.4		-			
Subdivision	Process Fuel Type	Biogenic	Total fuel requir (GJ(NCV)/tonn ± Uncertainty	e NH3)	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 Emissio (Gg CO2)
	i V	V	TFRi 🛆		CCFi	COFi	E = (TFRi * CCFi * COFi) * (44/12)	UP	R = UP * (44/60)	NE = E - R	NE / 100000
Unspecified	Gas Coke		2,970	3	30	1	326,700	0	0	326,700	C
	Lignite	0	3,020	2	27.6	1	305,624	1,000	733.33	304,890.67	
0	Natural Gas (Dry)		4,250	2	15.3	1	238,425	100	7.33	238,417.67	0
*		_		3							
Total											
		Including Biogenic CO2:					870,749	1,010	740.67		(
		Excluding Biogenic CO	10,240				870,749	1,010	740.67	870,008.33	0

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

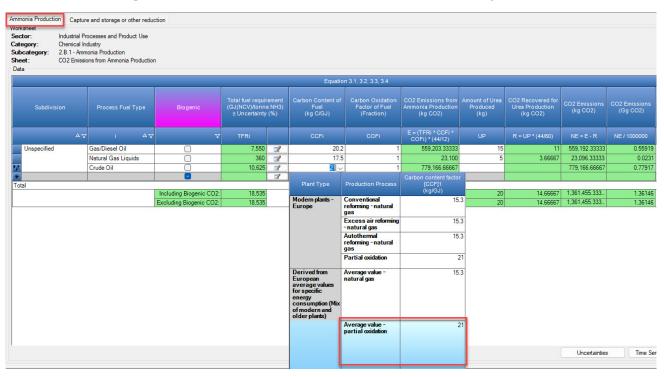
For each combination of subdivision/process fuel type/production process in worksheet **Ammonia Production**, enter information, row by row, as follows:

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

Note that: if Unspecified is selected in <u>Column |i|</u>, in accordance with good practice the value for <u>partial oxidation</u> shall be selected from the drop-down menu in column CCFi.

<u>Note that</u> 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. <u>Column |COFi</u>|: select from the drop-down menu the default carbon oxidation factor or enter a usercarbon oxidation factor.



Example: Tier 1 default EFs for ammonia production - select highest value

Results

CO₂ 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. <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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂, 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.
- 4. <u>Column | Biogenic |:</u> indicate with a check if the process fuel is of biogenic origin. <u>Note that consistent with the 2006 IPCC Guidelines, capture of biogenic CO₂ for long-term storage may lead to negative CO₂ emissions.</u>

rksheet								
tor.	Industrial Processes and Produc	t Use						
egory:	Chemical Industry							
category:	2.B.1 - Ammonia Production							
eet:	Capture and storage or other re-	duction						
ta								
s CARB	SON DIOXIDE (CO2)	\sim						
				Amount CO2 captured and				_
	Subdivision	Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	Biogen
	Subdivision S ∆⊽	Source SRC	۵7	stored				Biogen
Unspecified	s av		۵۷	stored (tonne)	(tonne)	(tonne)	(Gg)	Biogen
Unspecified	s av	SRC	۵V	stored (tonne) A	(tonne)	(tonne) C = A + B	(Gg) C / 1000	Biogen
	s av	SRC	۵¥	stored (tonne) A	(tonne)	(tonne) C = A + B	(Gg) C / 1000	Biogen
Unspecified	s av	SRC	۵ 7	stored (tonne) A	(tonne)	(tonne) C = A + B	(Gg) C / 1000	Biogeni

Example: capture and storage or other reduction

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 CO₂ 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**. CO₂ emissions from the individual source categories are provided as a default dropdown in <u>Column |SRC|</u>. For further information, see description under section **2.B.11 Other**. CO₂ emissions from nitric acid production are not included in the *Software* or the CRT.

IPCC Equations

- ✓ <u>Tier 1</u>: <u>Equation 3.5</u> (Nitric Acid), <u>Equation 3.7</u> (Adipic Acid), <u>Equation 3.9</u> (Caprolactam, Glyoxal and Glyoxylic Acid)
- ✓ <u>Tier 2: Equation 3.6</u> (Nitric Acid), <u>Equation 3.8</u> (Adipic Acid), <u>Equation 3.10</u> (Caprolactam, Glyoxal and Glyoxylic Acid)
- ✓ <u>Tier 3:</u> 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:

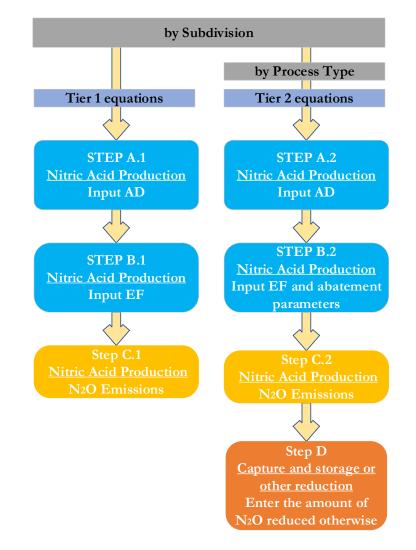
- ✓ Nitric Acid Production or Adipic Acid Production or Caprolactam, Glyoxal and Glyoxylic Acid Production: contains for each subdivision (and for each production process/technology, and in the case of caprolactam, glyoxal and glyoxylic acid production, chemical) information on the amount of product produced, EFs, and abatement parameters (destruction factor and utilization factor – Tier 2). These worksheets calculate the associated N₂O emissions for the source category.
- ✓ Capture and storage or other reduction: contains information on other reduction of N₂O, not accounted previously in the worksheet for different Tiers.

User's Work Flowchart

Consistent with the key category analysis and the decision trees in <u>Figure 3.2</u> (Nitric Acid Production), <u>Figure 3.3</u> (Adipic Acid Production) and <u>Figure 3.4</u> (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-specific¹ 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 N₂O EF (N₂O 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), N₂O 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 N₂O emissions for each subdivision/process type, and in the case of caprolactam, glyoxal and glyoxylic acid production, chemical, in mass units (kg and Gg).

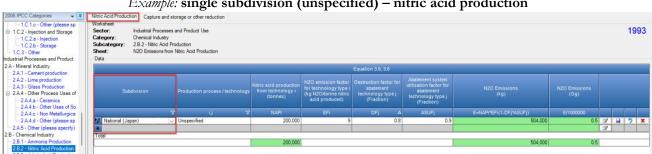
Step D, in the worksheet Capture and storage or other reduction, users collect and input information on the amount of other reduction of N₂O not accounted in Step C.2.

Activity Data Input

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

- ✓ <u>Section 3.3.2.3</u> 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 dropdown 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

Here Process Uses of La - Ceramics 4.b - Other Uses of So 4.c - Non Metallurgica 4.d - Other (please sp	Category: Chemical Industry Subcategory: 2.8.4 - Caprolactar	is and Product Use m, Glyoxal and Glyoxylic Acid Produc m Caprolactam, Glyoxal and Glyoxylii									19	90
ther (please specify) al Industry					uation 3.9, 3.10							
try Production d Production id Production tam, Glyoxal Production	Subdivision	Chemical	Type of Technology	Chemical production from technology type i (tonnes)	N2O emission factor for technology type i (kg N2O/tonne chemical produced)	Destruction factor for abatement technology type j (Fraction)	Abatement system utilisation factor for abatement technology type j (Fraction)	N2O Emissions (kg)	N2O Emissions (Gg)			
rod	Δ 7							E=CPi*EFi(1- DFj*ASUFj)				
ar	Unspecified	Caprolactam	Unspecified	150,000	9	0.9	0.95	195,750	0.2	2	1 2	X
		Glyoxal	Unspecified	750	100	0		75,000	0.08	2		-
		Glyoxylic Acid	Unspecified	60,080	20	0.8	0.95	288,384	0.29	3		
chlori	<u></u>									2		
Ethylene Oxide Acrylonitrile	Total									and the second s		-
				210,830				559,134	0.56			

Example: multiple subdivisions – adipic acid production

2 A 3 - Glass Production	Worksheet									
2.A.4 - Other Process Uses of	Sector: Industrial Processes a	and Product Use								1990
2 A.4.a - Ceramics	Category: Chemical Industry									1000
-2.A.4.b - Other Uses of So	Subcategory: 2.B.3 - Adipic Acid Pre	nduction								
-2.A.4.c - Non Metallurgica		Adipic Acid Production								
-2.A.4.d - Other (please sp	Data									
A.5 - Other (please specify)									_	_
Chemical Industry				Equa	tion 3.7, 3.8					
2 B.1 - Ammonia Production	and the second s					Abatement system				
2 B.2 - Nitric Acid Production			Adipic acid production from	N2O emission factor for technology type i	Destruction factor for abatement technology type		N2O Emissions	N2O Emissions		
2 B.3 - Adipic Acid Production	Subdivision		technology i	(kg N2O/tonne adipic acid	abatement technology type	abatement technology type	(kg)	(Gg)		
2.B.4 - Caprolactam, Glyoxal			(tonnes)	produced)	(Fraction)	J (Fraction)				
B.5 - Carbide Production			Alternation A.			(Fracuoli)				
B.6 - Titanium Dioxide Prod	AV	ii AV	AAPi	EFi	DFj	ASUFj	E=AAPi*EFi(1-	E/1000000		
B.7 - Soda Ash Production							DFj*ASUFj)			
2.B.8 - Petrochemical and Car	Plant#1	Unspecified	1,200	300	0.925	0.94	46,980	0.05	2	
2.B.8.a - Methanol	Rest of Japan	Default processes	1,700	300	0.985	0.89	62,908.5	0.06	2	1 🤈 🗴
- 2.B.8.b - Ethylene									2	
	Total									
-2.B.8.c - Ethylene Dichlori	lota									

For each subdivision in <u>Column |Subdivision|</u>, 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. <u>Column |Chemical|:</u> select from the drop-down menu the name of the chemical produced (caprolactam, glyoxal, or glyoxylic acid).

Then, for all three worksheets:

- 2. <u>Column |i,j|</u>: 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. <u>Column |NAPi</u>|(nitric acid)/<u>Column |AAPi</u>|(adipic acid)/<u>Column |CPi|(c</u>aprolactam, 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:

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

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

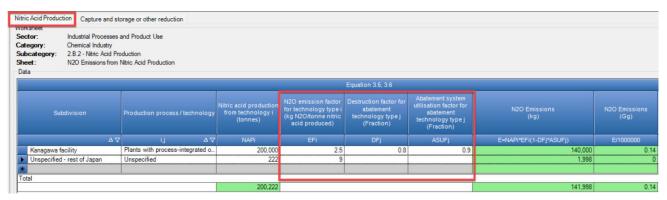
- \checkmark N₂O emissions/ tonne of product produced.
- \checkmark destruction factor for abatement technology, fraction.
- ✓ abatement system utilisation factor for abatement technology, fraction.

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

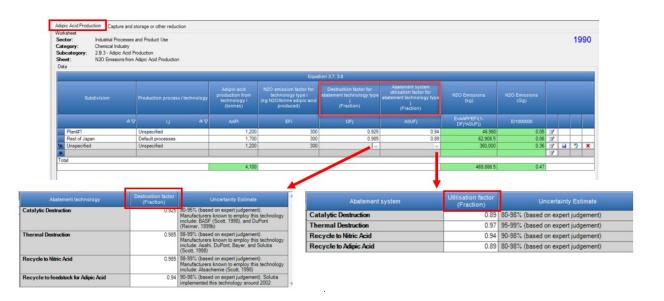
- <u>Column | EFi</u> |: select from the drop-down menu the default N₂O EF or overwrite this value with user-specific information, in kg N₂O/tonne product produced. <u>Note that</u> in the case of worksheets Nitric Acid Production and Caprolactam, Glyoxal and Glyoxylic Acid Production, the default N₂O EF for the technology type, i, and abatement technology, j, is automatically populated in <u>Column | EFi</u> |, in kg N₂O/tonne product produced, depending on the production process/technology selected in <u>Column | ij</u> |. <u>Note that</u> 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 <u>Column | ij</u> | and leave blank cells for abatement in <u>Column | DFj</u> | and <u>Column | ASUFj |</u>.
- <u>Column |DFj|</u>: 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. <u>Note that. for users applying a Tier 1 method, DFi shall be 0.</u> <u>Note that: at Tier 2, destruction and/or abatement of N2O 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.
 </u>
- 3. <u>Column |ASUFj|</u>: 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.

$\mathit{Example:}$ 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

ategory: C ubcategory: 2	hemical Industry .B.4 - Caprolactan	s and Product Use n, Glyoxal and Glyoxyli n Caprolactam, Glyoxa			uction									
							Eq	nation	2.0, 2.10	_				
Subdivi	sion	Chemica	sl	Туре	of Technology	pro tech	Chemical oduction from hnology type i (tonnes)	for t) emission echnolog kg N2O/to mical pro	y type i nne	Destruction factor for abatement technology type j (Fraction)	Abatement system utilisation factor for abatement technology type j (Fraction)	N2O Emissions (kg)	N2O Emissions (Gg)
	۵V		۵v		ij ∆⊽							ASUFj	E=CPi*EFi(1- DFj*ASUFj)	E/1000000
Plant@2		Caprolactam		user speci	fic		1,000			9			9,000	(
Unspecified				Unspecifie	d		150,000			100	0.9	0.95	2,175,000	1
		Glyoxal		Unspecifie	d		750			100	0		75,000	(
		Glyoxylic Acid	~	Unspecifie	d		60,080			20	0.8	0.95	288,384	0
* Total		Chemical		n Process	N2O Emission Fa (kg N2O/tonne cher		Uncertaint							
		Caprolactam	Raschig			9	± 40%						2,547,384	
		Glyoxal	-			100) ± 10%							
		Glyoxylic Acid	-) ± 10%	_						

Results

N₂O 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. <u>Column |SRC|</u>: select from the drop-down menu, or preferably, input information on the source where the other reduction of N₂O occurs (e.g. the facility, stream, or other identifying information).
- 2. <u>Column | A |</u>: this column is not applicable for this category.
- 3. Column |B|: collect and input information on any other long-term reduction of N2,O in tonnes..

Example: capture and storage or other reduction

ector:	Industrial Processes a	and Product Use						
ategory:	Chemical Industry							
ubcategory:	2.B.2 - Nitric Acid Pro	roduction						
neet:	Capture and storage	e or other reduction						
ata								
	OUS OXIDE (N2O)		~					
	OUS OXIDE (N2O)		~					
	DUS OXIDE (N2O)		~					
				4	Amount CO2 captured and	Other reduction	Total reduction	Total reduction
	DUS OXIDE (N2O) Subdivision		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
		△ ▽			stored			

2.B.5 Carbide Production

Information

GHG emissions are associated with production of two types of carbides – silicon carbide (SiC) and calcium carbide (CaC₂). 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. CaC₂ 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 CH₄ EF.

<u>GHGs</u>

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

- \checkmark <u>Tier 1</u>: <u>Equation 3.11</u>
- ✓ <u>Tier 2</u>: Same equation as Tier 1, although with plant-specific production data, data on the use of CaC₂ for production of acetylene used in welding applications, and user-specific or default EFs
- ✓ <u>Tier 3</u>: Same equation as Tier 1, although with plant-specific coke consumption and CH₄ 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 (CaC₂ or SiC) and corresponding EFs. The worksheet calculates the associated CO₂ and CH₄ 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 CO₂ emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent storage) or other reductions, not accounted previously.

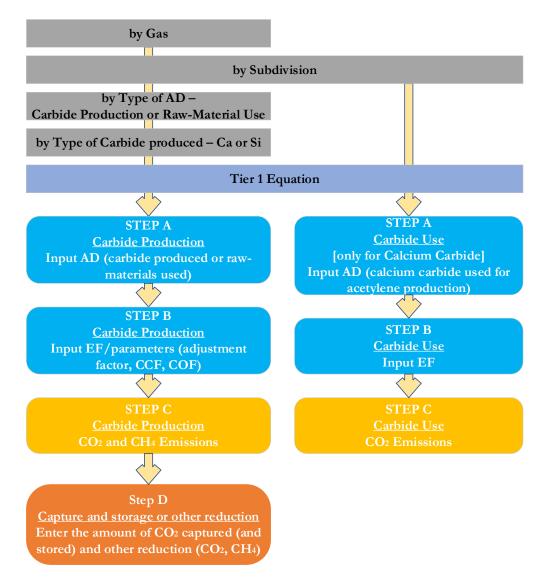
User's Work Flowchart

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-specific¹ 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 (CaC₂ 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 CO₂, kg CH₄, and Gg).

Step D, in worksheet **Capture and storage or other reduction**, users collect and input information on the amount of CO₂ 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 CaC₂ used in acetylene production.

Step B, in worksheet Carbide Use, users input the CO₂ EF.

Step C, in worksheet **Carbide Use**, the *Software* calculates the associated emissions for each subdivision for CaC₂ 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 <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

Other Process Uses of A.4.a - Ceramics A.4.b - Other Uses of So A.4.c - Non Metallurgica A.4.d - Other (please sp - Other (please specify)	Category: Chemical Industry Subcategory: 2.8.5 - Carbide Pr	es and Product Use - Carbide Production eduction issions from Carbide Production							1990
emical Industry 1 - Ammonia Production				Equation 3.11					
 Nitric Acid Production Adipic Acid Production Caprolactam, Glyoxal 	Subdivision		Type of Carbide Produced	Activity Data (tonne)	Emission Factor (kg CH4/tonne AD)	CH4 Emissions (kg)	CH4 Emissions (Gg CH4)		
Carbide Production Titanium Dioxide Prod		Δ Δ Δ.	A ک	AD	EF	E = AD * EF	E / 1000000		
Soda Ash Production	north	Carbide produced	Silicon Carbide (SiC)	122	1.2	146.4	0		
trochemical and Car	test	Raw material used	Calcium Carbide (CaC2)	50	2	100	0		
- Methanol			Silicon Carbide (SiC)	40	2.5	100	0		
- Ethylene	Unspecified	Carbide produced	Calcium Carbide (CaC2)	400	11	4,400	0		
Ethylene Dichlori			Silicon Carbide (SiC)	200	5.3	1,060	0		
d - Ethylene Oxide		Raw material used	Calcium Carbide (CaC2)	300	2.1	630	0		7 ×
8.e - Acrylonitrile			Silicon Carbide (SiC)	100	6	600	0		
8.f - Carbon Black								12	
9.8.x - Other petrochem	total							-	
Fluorochemical Produ									

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

- 1. <u>Column |Type of Activity Data</u>]: select from the drop-down menu the type of AD to be used carbide produced or raw materials used.
- 2. <u>Column |Biogenic|</u>: indicate with a check, if known, if the process fuel is of biogenic origin.
- 3. <u>Column |Type of Carbide Produced|</u>: select from the drop-down menu the type of carbide produced SiC or CaC₂. The user may enter directly another type of carbide.

<u>Note that</u> 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. <u>Note that</u> for users reporting to the UNFCCC ETF Reporting Tool that report carbide production other than SiC and CaC₂, AD emissions from this other carbide production will be reported under CRT category 2.B.10.b Other (chemical production).

4. <u>Column |AD|</u>: 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 (CaC₂ or SiC), in tonnes.

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

- 1. <u>Column |AD|</u>: enter information on the amount of CaC₂ used in acetylene production, in tonnes.
- 2. <u>Column | Biogenic |</u>: indicate with a check if the process fuel used to produce the CaC₂ was of biogenic origin.

Example: AD for calcium carbide used in acetylene production

tegory: bcategory: eet: ata	Industrial Processes and Product Chemical Industry - Carbide Use 2.B.5 - Carbide Production CO2 Emissions from Use of CaC2					
				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)
	V	AD	7	EF	E = AD * EF 🗛	E / 1000
		33		1.7	56.1	
test		55		1.1	60.5	
test Unspecified		55				

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:

- ✓ CO₂ and CH₄ EFs based on carbide production AD in tonnes of CO₂ and kg of CH₄ per tonne of carbide produced (<u>Tables 3.7 and 3.8</u>).
- ✓ CO₂ and CH₄ EFs based on raw materials consumption (petroleum coke) in tonne of CO₂ and kg of CH₄ per tonne of petroleum coke (<u>Tables 3.7 and 3.8</u>)
- \checkmark CO₂ EF for CaC₂ used in acetylene production in tonne of CO₂ per tonne of CaC₂ used (<u>Table 3.8</u>).

CO2 and CH4 EFs based on carbide production

Where *Carbide Produced* 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:

 <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 CO₂ per tonne of carbide produced or kg of CH₄/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: CO₂ and CH₄ EFs for carbide production – Tier 1

category: 2.B.5 - Carb	dustry - Carbide Pro	duction											
et: CO2 and CH	ide Production 14 Emissions from C	arbide Pro	duction										
ta													
IS CARBON DIOXIDE (CO	02) ~												
	Type of Activity		Type of Carbide	Activity Data			Emission Factor			CO2 Emissions	CO2 Emissions		
	Data		Produced	(tonne)			tonnes CO2/tonne	AD)		(tonnes CO2)	(Gg CO2)		
									(
							Carbon content factor	Carbon oxidation	EF = (1-AF) *CCF*COF*				
۵V	△ ▽		▲			factor AF	r (t Crtonne raw factor (44/12) material used) COF er specified						
	-	-					CCF		or specified				
east	Carbide produ		Calcium Carbide (CaC2) 🗸	10	0 Specified				1.09	109		2	
	-		Carbide		Process	Emission Factor (tonnes CO2/tonne)		ictor Remain	2.62	31.44	0.03144		4
north	Raw material u		Silicon Carbide (SiC)	Ci Ci	licon carbide		2.62		2.06039	251.36778	0.25137	0.000	+
south	0.111		Calcium Carbide (CaC2)	1000	stroleum coke		1.09		_			3	+
Unspecified	Carbide produ			2881			1.03		1.09	436		A REAL PROPERTY AND A REAL	+
			Silicon Carbide (SiC)		0 Specified				2.62	524		Contraction of the local division of the loc	+
	Raw material u		Calcium Carbide (CaC2)		0 Specified				1.7	510			4
			Silicon Carbide (SiC)	10	0 Specified				2.3	230	0.23		1
												2	1
tal													Ĩ
				123	4				Including Bioge	2091.80778	2.09181	1	

CO2 and CH4 EFs based on raw materials consumption (e.g. petroleum coke)

Where Raw Material Used 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 | Emission Factor |: 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. 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 CO₂ per tonne of carbide produced or kg of CH₄/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".

- ... 11. If Calculated is selected (Tier 2 or Tier 3)
- 2. Column |AF|: 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.
- Column |CCF|: Select from the drop-down menu the CCF for the raw material used, or the user may 3. overwrite this value with use-specific information, in t C/tonne raw material used.
- Column |COF|: A COF of 1 will automatically populate, or the user may overwrite this value with 4. user-specific information.

tegory: Chemical In bcategory: 2.8.5 - Carb	ocesses and Produ dustry - Carbide Pro ide Production H4 Emissions from C	duction	duction								
as CARBON DIOXIDE (CO	02) ~					Equation 3.11					
Subdivision	Type of Activity Data	Biogenic	Type of Carbide Produced	Activity Data (tonne)			Emission F (tonnes CO2/to			CO2 Emissions (tonnes CO2)	CO2 Emiss (Gg CO
Y	V	V	v	AD		Adjustment factor AF	Carbon conter factor (t C/tonne rav material used CCF	Carbon oxidation v factor	EF = (1-AF) *CCF*COF* (44/12) or specified	E = AD * EF	E/100
Unspecified	Carbide produ		Silicon Carbide (SiC)	200	Specified				2.62	524	
	1		Calcium Carbide (CaC2)	400	S				1.09	436	
east	1		Silicon Carbide (SiC)	12	S Higher t	ier EF specified	Tio	r 1 EF specified	2.62	31.44	0.0
			Calcium Carbide (CaC2)	100	Specmea	1		i i Er specilled	1.09	10	
Unspecified	Raw material		Silicon Carbide (SiC)	100	Specified				2.6789	267.89	0.2
			Calcium Carbide (CaC2)	300	Specified			é :	1.7	100 C	
north] [Silicon Carbide (SiC)	122	Calculated	0.35		8645	2.06039		0.2
south] [Calcium Carbide (CaC2)		Calculated	0.67	0.1	8645	1 1.04605	127.61749	100
Northeastern			Calcium Carbide (CaC2)	1000	Calculated	0.67	0.1	8645	1 1.04605	1046.045	1.0
otal		8	Higher tier EF o	calculated							

$\mathit{Example:}\ CO_2 \ and \ CH_4 \ EFs$ for raw materials used – all tiers

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. <u>Column |EF|: input the EF for CaC₂ used for acetylene production in tonne of CO₂/tonne of CaC₂ used.</u>

Example: EF for calcium carbide used in acetylene production

ector: ategory: ubcategory: heet: Data	Industrial Processes and Product Chemical Industry - Carbide Use 2.8.5 - Carbide Production CO2 Emissions from Use of CaC2					
				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)
	Δγ	AD	V	EF	E = AD * EF	E / 1000
Plant#22		33		1.7	56.1	
Unspecified		55		1.1	60.5	
*			-			
Total						
		88		Including Biogenic CO2:	116.6	
				Excluding Biogenic CO2:	116.6	

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. <u>Column |SRC|</u>: select from the drop-down menu, or preferably, input information on the source where CO₂ 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂ or CH₄, 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.
- 4. <u>Column |Biogenic|</u>: indicate with a check if the process fuel is of biogenic origin. <u>Note that consistent with the 2006 IPCC Guidelines, capture of biogenic CO_2 for long-term storage may lead to negative CO_2 emissions.</u>

		1	1	0				
	ure and storage or other reduct	ion						
rksheet ctor: Industrial Processes an tegory: Chemical Industry beategory: 2.8.5 - Carbide Product eet: Capture and storage or	on							
ata								
as CARBON DIOXIDE (CO2)	~							
<u> </u>								
Subdivision	Type of Carbide			Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	
S A7	СН	ΔŸ	SRC AV	A	В	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	0
	culture (cucc)		Chopconica	-	-			
fotal								
otai					Total:	10	0.01	-
					Total Biogenic CO2:	10	0.01	

Example: capture and storage or other reduction

2.B.6 Titanium Dioxide Production

Information

There are three processes that are used in the production of titanium dioxide (TiO₂) that lead to process GHG emissions: titanium slag production in electric furnaces, synthetic rutile production using the Becher process, and rutile TiO₂ 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 TiO₂ Production. The Tier 1 method calculates emissions using national aggregate data on production of titanium slag, synthetic rutile or rutile TiO₂ 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 ₂ O	HFCs	PFCs	SF ₆	NF ₃
X						

IPCC Equations

- \checkmark <u>Tier 1</u>: <u>Equation 3.12</u>
- $\checkmark \quad \underline{\text{Tier 2: Equation 3.13}}$
- ✓ <u>Tier 3:</u> 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 CO₂ from Titanium Dioxide Production using worksheets:

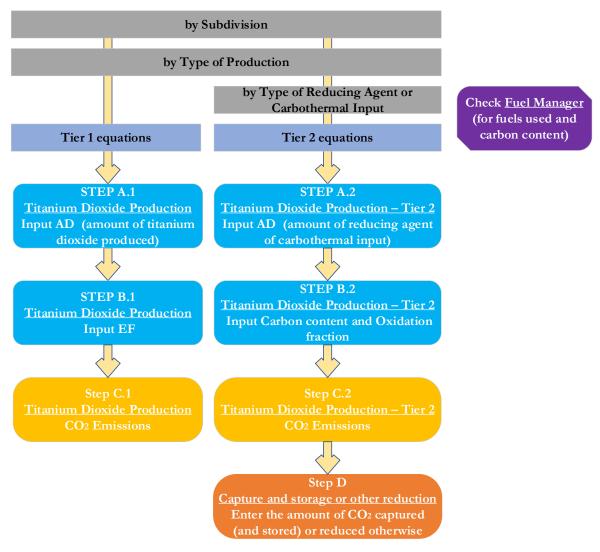
- ✓ 1.1.1 Fuel Manager: contains data on *carbon content* and *calorific value* of each fuel used in the NGHGI.
- ✓ **Titanium Dioxide Production:** contains for each subdivision information on the amount of TiO₂ produced by each type of production process (slag, synthetic rutile and rutile) and default CO₂ EFs. The worksheet calculates the associated CO₂ 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 CO₂ emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, 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-specific¹ 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 TiO₂ produced by each type (titanium slag, synthetic rutile or rutile TiO₂).

Step B.1, in worksheet **Titanium Dioxide Production,** users input CO₂ EFs per unit of production of titanium slag, synthetic rutile or rutile TiO₂.

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 TiO₂).

Step C.2, in worksheet **Titanium Dioxide Production – Tier 2**, for each subdivision and each production type, the *Software* calculates the associated CO₂ emissions in mass units (kg and Gg). In addition, the total CO₂ emissions are calculated.

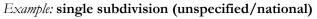
Step D, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input in the *Software* information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 .

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.

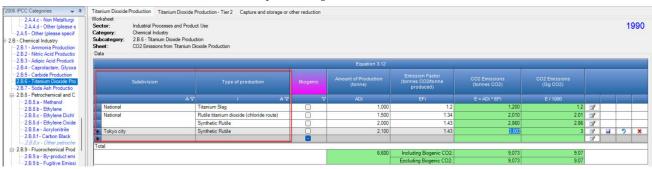
As a **starting step**, users ensure that the **1.1.1 Fuel Manager** contains all fuels to be reported for titanium dioxide production (Tier 2 only); and for each fuel listed in the Fuel Manager, the *calorific value* and the *carbon content* are entered or, for IPCC default fuels, are selected from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



When the Tier 1 Equation is applied:

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

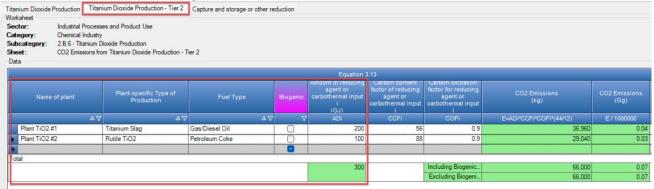
1. <u>Column |i|</u>: select the type of production process for titanium dioxide from the drop-down menu- titanium slag, synthetic rutile or rutile TiO₂, or the user may overwrite

- <u>Column | Biogenic |</u>: indicate with a check, if known, if the process fuel is of biogenic origin. <u>Note that</u> as this is a Tier 1, the type of fuel is not required to be known. By default, the assumption is that the TiO₂ is produced using reducing agents of fossil origin, and therefore this column should remain unchecked.
- 3. <u>Column | ADi |</u>: input the mass of TiO₂ produced using each production process, in tonnes <u>Note that</u> 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 <u>Column |Subdivision|</u>, data are entered in worksheet **Titanium Dioxide Production – Tier 2**, row by row, as follows:

- 1. <u>Column | Name of plant |</u>: enter the name of each plant; the Tier 2 requires plant level AD.
- 2. <u>Column |Plant-specific Type of Production |</u>: select the type of production process for titanium dioxide from the drop-down menu- titanium slag, synthetic rutile or rutile TiO₂, or the user may overwrite.
- 3. <u>Column | Reducing agent/Carbothermal input|</u>: select each reducing agent or carbothermal input used as a reducing agent from the drop-down menu (one row for each fuel type). <u>Note that</u> 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. <u>Column | Biogenic |</u>: indicate with a check if the reducing agent/carbothermal input is of biogenic origin.
- 5. <u>Column |ADi|:</u> enter the mass/amount of reducing agent or carbothermal input used for each plant, in GJ. <u>Note that</u> to avoid double counting, the amount of reducing agent or carbothermal input used for titanium dioxide production should be subtracted from fuel use included in the Energy Sector.



Example: AD for titanium dioxide production – Tier 2

Emission Factor Input

Section 3.7.2.2 in Chapter 3 Volume 3 of the 2006 IPCC Guidelines contains information on the choice of EFs for Titanium Dioxide Production.

There are two types of EFs:

- ✓ Default CO₂ EF for Tier 1 in tonne of CO₂ per tonne of product produced (<u>Table 3.9</u>).
- ✓ Plant-specific CO₂ 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. <u>Column |EFi</u>|: the CO₂ EF is automatically populated based on the selection of synthetic rutile or rutile titanium dioxide in <u>Column |i</u>|. Users can overwrite these values with user-specific information, if available, in tonne of CO₂/tonne of product produced. In the case of TiO₂ produced via the titanium slag production process, users must directly enter the CO₂ EF in this column.

Example: EFs for titanium dioxide production – Tier 1

Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Produc Chemical Industry 2.B.6 - Titanium Dioxide Produc CO2 Emissions from Titanium D	tion								
							Equation 3.12			
	Subdivision	Type of	production	Biog	enic		of Production tonne)	Emission Factor (tonnes CO2/tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	Δγ	i	ΔV		V		ADi	EFi	E = ADi * EFi	E / 1000
National		Titanium Slag)		1,000	1.2	1,200	
National		Rutile titanium dioxi	de (chloride route))		1,500	1.34	2,010	2.
		Synthetic Rutile)		2,000	1.43	2,860	2.
Tokyo city		Synthetic Rutile - cou	ntry 🗸 🗸)		2,100	1.43	3,003	
* Total		Chemical	Emission Fact (tonnes CO2 / tonne			emark				
		Titanium Slag			Not ava	ailable	6,600	Including Biogenic CO2:	9,073	9.
		Synthetic Rutile		1.43	± 10%	(Excluding Biogenic CO2:	9,073	9.
		Rutile titanium d	F	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:

- <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</u> <u>|Reducing agent/Carbothermal input|</u>, the user must insert a user-specific value for the carbothermal input.
- 2. Column [COFi]: input the carbon oxidation factor for the reducing agent or carbothermal input, fraction

Example: EFs for titanium dioxide production – Tier 2

ate	egory: () category: () et: ()	Chemic 2.B.6 -	ial Processes and Prod cal Industry Titanium Dioxide Produ missions from Titanium	uction	- Tie	er 2							1	99	0
							Equation 3.1								
	Name of plan	t	Plant-specific Type of Production	Fuel Type		Biogen ic	Amount of reducing agent or carbotherma I input i (GJ)	Carbon content factor of reducing agent or carbotherma I input i	Carbon oxidation factor for reducing agent or carbotherma I input i	CO2 Emissions (kg)	CO2 Emissions (Gg)				
		V	V		V	V	ADi	CCFi	COFi 🛆	E=ADi*CCFi*COFi *(44/12)	E / 1000000				
0	Plant TiO2 #1		Titanium Slag	Gas/Diesel Oil			200	20.2	0.9	13332	0.01333	2		2	
	Plant TiO2 #2		Rutile TiO2	Petroleum Coke			100	26.6	0.9	8778	0.00878	2			Γ
*						8						2			
Tota	al														
							300		Including Bi	22110					
									Excluding	22110	0.02211				

Results

CO₂ 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. <u>Column |SRC|</u>: select from the drop-down menu, or preferably, input information on the source where CO₂ 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|</u>: collect and input information on any other long-term reduction of CO₂, 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.
- 4. <u>Column | Biogenic |:</u> indicate with a check if the process fuel is of biogenic origin. <u>Note that consistent with the 2006 IPCC Guidelines, capture of biogenic CO₂ for long-term storage may lead to negative CO₂ emissions.</u>

tanium Dioxide Production Titanium Diox orksheet	ide Production - Tie	r 2 Capture and	storage or o	other reduction				
ector: Industrial Processes and P ategory: Chemical Industry ubcategory: 2.B.6 - Titanium Dioxide Pr heet: Capture and storage or oth	oduction							
Gas CARBON DIOXIDE (CO2)	~							
Subdivision		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	Biogenic
	∆ ∀	Source SRC	م	stored				Biogenic
	4 장 Unspecified		<u>م</u>	stored (tonne)	(tonne)	(tonne)	(Gg)	Biogenic
S			۵ 7	stored (tonne)	(tonne)	(tonne)	(Gg)	Biogenic
S Unspecified			۵ ۷	stored (tonne)	(tonne) B	(tonne)	(Gg)	Biogenic
S			<u>ک</u> ک	stored (tonne)	(tonne)	(tonne)	(Gg)	Biogenic

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 <u>use</u> 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 ₂ O	HFCs	PFCs	SF ₆	NF ₃
X						

IPCC Equations

- \checkmark <u>Tier 1</u>: <u>Equation 3.14</u>
- ✓ <u>Tier 2:</u> IPCC Tier 1 equation, although with plant-specific AD, and if available EFs
- ✓ <u>Tier 3:</u> 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:

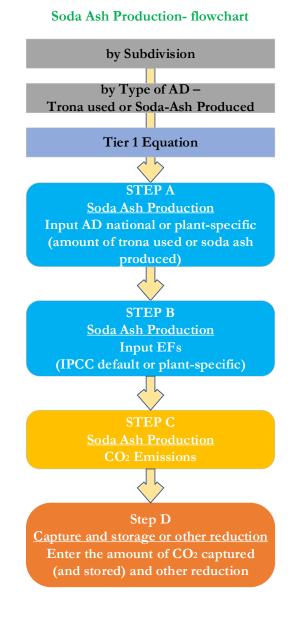
- ✓ Soda Ash Production: contains for each subdivision and each type of AD (e.g. trona used or soda ash produced) information on the amount of trona consumption or natural soda ash produced and EFs. The worksheet calculates the associated CO₂ emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, 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-specific¹ 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.



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 CO₂ EFs for each type of AD.

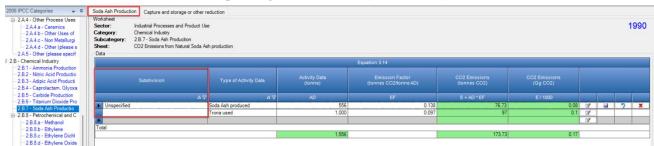
Step C, in worksheet **Soda Ash Production,** the *Software* calculates the associated CO₂ emissions for each subdivision (and each type of AD) in mass units (tonne and Gg). In addition, total CO₂ emissions are calculated

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 <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> [subdivision] for each subdivision.



Example: single subdivision (unspecified)

Example: multiple subdivisions

Process Uses Works Ceramics Sect. Dther Uses of Cate Non Metallurgi Subc Other (please specif Data	pr: Industrial Processes and Product Us gory: Chemical Industry ategory: 2.B.7 - Soda Ash Production t: CO2 Emissions from Natural Soda A							1	990
dustry				Equation 3.14					
roduction Productio Glyoxa	Subdivision	Type of Activity Data	Activity Data (tonne)	Emission Factor (tonnes CO2/tonne AD)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
	۵ ب		AD		E = AD * EF	E / 1000			
	Rest of Japan	Soda Ash produced	556	0.138	76.73	0.08	3		
		Trona used	1,000	0.097	97	0.1	3		
12	lokyo	Soda Ash produced	22,000	0.138	3,036	3.04		2	×
							22		
hl Tota									
ene Oxide			23,556		3,209.73	3.21			

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

- 1. <u>Column | Type of Activity Data |</u>: select from the drop-down menu the type of AD, based on either input (trona used) or output (soda ash produced).
- 2. <u>Column |AD|</u>: 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 CO₂ EFs are presented in the 2006 IPCC Guidelines: CO₂ EF for Trona = 0.097 tonnes CO₂/tonne of trona, CO₂ EF for soda ash = 0.138 tonnes CO₂/tonnes natural soda ash produced.

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

1. <u>Column |EF|:</u> select from the down-down menu the default CO₂EFs (Tier 1) or input manually plantspecific CO₂ EFs (Tier 2) in tonnes of CO₂ per tonne of soda ash produced or trona used.

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

da Ash Production Capture and storage or other n	eduction				
orksheet ector: Industrial Processes and Product Us ategory: Chemical Industry abcategory: 2.8.7 - Soda Ash Production heet: CO2 Emissions from Natural Soda As ata					
			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)
۵ <u>۷</u>	۵V	AD	EF	E = AD * EF	E / 1000
Rest of Japan	Soda Ash produced	556	0.138	76.73	0
	Trona used	1,000	0.097	97	
Tokyo	Soda Ash produced	22,000	0.138 🗸	3,036	3
otal			Type of Activity Data	CO2 Emission Factor (tonnes CO2/tonne AD)	
		23,556	Soda Ash production	0.138	

Results

CO₂ emissions from Soda Ash Production are estimated in mass units (tonne and Gg) by the *Software* in the worksheet **Soda Ash Production.**

Total CO₂ emissions from soda ash production is the sum of all emissions in the above worksheet, taking into account any CO₂ capture with subsequent storage. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO₂ capture and storage.

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

- 1. <u>Column |SRC|</u>: select from the drop-down menu, or preferably, input information on the source where CO₂ 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO₂, in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.

	Example:	capture and	storage or	other reducti	on
d					

iector: Category: Gubcategory: Cheet: Data	Industrial Processes and Product U Chemical Industry 2.8.7 - Soda Ash Production Capture and storage or other reduct						
	BON DIOXIDE (CO2)	~					
	Subdivision	Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
	Subdivision S ∆⊽		ΔV	stored			
19 Plant#2 *	s av	SRC	ΔV	stored (tonne)	(tonne)	(tonne)	(Gg)

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. <u>Section 3.9</u> 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.

<u>GHGs</u>

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	Χ					

IPCC Equations

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

CO₂ emissions:

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

CH₄ emissions:

- ✓ <u>Tier 1</u>: <u>Equations 3.23 and 3.24 and 3.25</u>
- \checkmark <u>Tier 2:</u> No Tier 2 Equations exist for CH₄ emissions in the 2006 IPCC Guidelines

<u>Tier 3: Equation 3.26</u> or <u>Equations 3.27</u> and <u>3.28 and 3.29</u> <u>Note that</u> 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 CH₄ 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 CO₂ and CH₄ 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.
- ✓ CO₂ Emissions Tier 1: contains for each subdivision/production process the amount of the specific chemical produced and the CO₂ EFs. The worksheet calculates the associated CO₂ emissions.
- ✓ CH₄ Emissions Tier 1: contains for each subdivision/production process the amount of the specific chemical produced and the CH₄ EFs, by source (total, fugitive and venting). The worksheet calculates the associated CH₄ emissions through use of a sub-table.
- ✓ CO₂ 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 CO₂ emissions for Tier 2 (based on carbon/mass-balance).
- ✓ CO₂ and CH₄ 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 CO₂ and CH₄. The worksheet calculates the associated plant-specific CO₂ and CH₄ emissions from combustion.
- ✓ CO₂ and CH₄ 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 CO₂ and CH₄. The worksheet calculates the associated plant-specific CO₂ and CH₄ emissions from flaring.
- ✓ CO₂ and CH₄ 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 CO₂ and CH₄ emissions from combustion, flaring and venting.
- ✓ Atmospheric measurement data CH₄ Emissions Tier 3: contains for each subdivision/plant (and each measurement campaign) the measured atmospheric concentrations of VOC/CH₄ and other parameters (fraction of CH₄ in VOC, background/reference concentrations, wind speed and plume area). The results of CH₄ emissions from measurements campaigns are summed over time to present annual CH₄ emissions.
- ✓ **Capture and storage or other reduction:** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂ and CH₄, 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-specific¹ EFs or direct measurements for that source category.

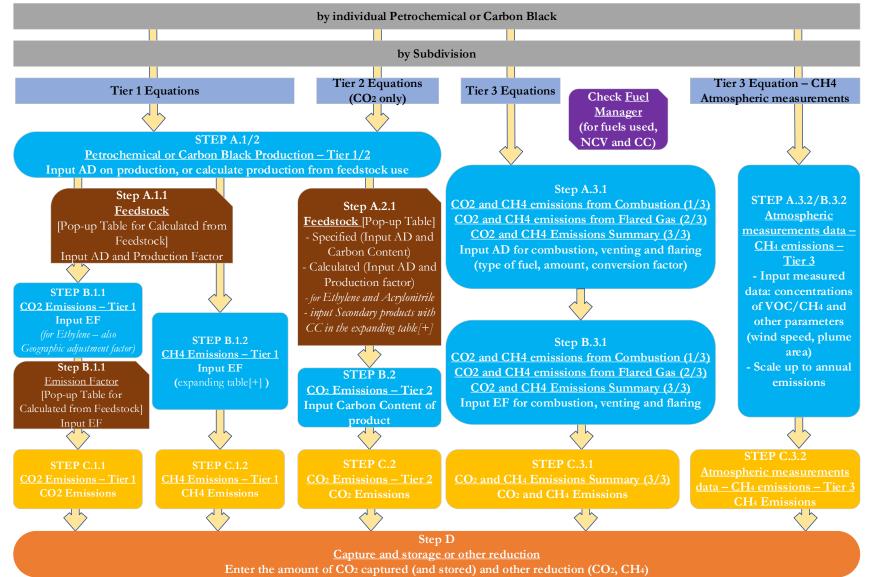
To ease the use of the *Software* as well as to avoid its misuse, for the Petrochemical and Carbon Black Production source category, users follow the following two flowcharts for CO₂ and CH₄ emissions. As the emissions from petrochemical and carbon black production vary both with the process used and 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 – CO2 and CH4– 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 CO₂ 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 CO₂ EF is based on feedstock consumption, the CO₂ EF is calculated in a pop-up table (Step B.1.1).

Step B.1.2, in worksheet CH₄ Emissions – Tier 1, users input CH₄ 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 CH₄ emissions for each type of production process/ source (total/fugitive/venting in mass units (tonne and Gg). In addition, total CH₄ 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:

For the Plant-specific Data Approach

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 – CH₄ Emissions – Tier 3**, users collect and input in the *Software* for each plant and each measurement campaign, the atmospheric concentrations of VOC/CH₄ and other parameters (fraction of CH₄ 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 – CH₄ Emissions – Tier 3**, the *Software* calculates the associated CH₄ emissions for each plant in mass units (kg and Gg).

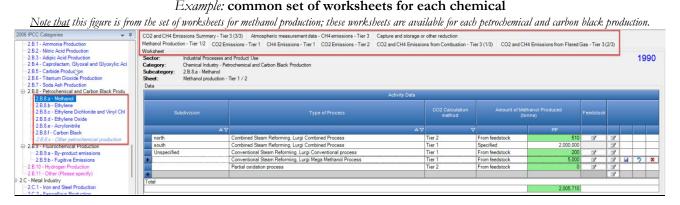
Then, for each tier, as appropriate:

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.

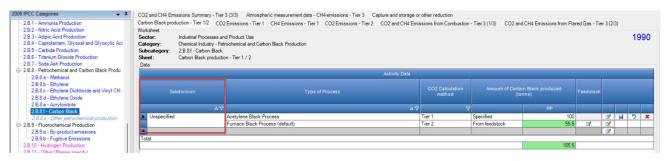
Input of AD for Petrochemical and Carbon Black Production requires the user first to navigate to the relevant chemical in the navigation tree on the left-hand side of the screen, and then select the worksheet for AD entry. The AD entry worksheet is labelled as **[Name of chemical] Production-Tier 1/2**.



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 <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)

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

2006 IPCC Categories 🗢 🗘	CO2 and CH4 Emissio	ons Summary - Tier 3	3 (3/3) Atmospheric measurement data - CH4 emissions - Tier 3 Capture and storage of	r other reduction						
2.B.1 - Ammonia Production 2.B.2 - Nitric Acid Production 2.B.3 - Adipic Acid Production	Worksheet	ction - Tier 1/2 CO	2 Emissions - Tier 1 CH4 Emissions - Tier 1 CO2 Emissions - Tier 2 CO2 and CH4 E I Product Use	missions from Combustic	n - Tier3 (1/3) CO2 a	nd CH4 Emissions from Fl	ared Gas - T	er 3 (2/3)		990
2.8.4 - Caprolactam, Glyoxal and Glyoxylic Aci 2.8.5 - Carbide Production 2.8.6 - Titanium Dioxide Production 2.8.7 - Soda Ash Production	Subcategory: 2.8	nemical Industry - Petro B.8.d - Ethylene Oxide hylene Oxide production								
2.B.8 - Petrochemical and Carbon Black Produ 2.B.8 a - Methanol			Activity Data							
2.8.8.6 - Ethylene 2.8.8.c - Ethylene Dichloride and Vinyl Chl 2.8.8.d - Ethylene Oxide	Subdiv			CO2 Calculation method		ne Oxide produced nne)	Feedstock			
- 2.B.8.e - Acrylonitrile - 2.B.8.f - Carbon Black			Δ.2							
2.B.8.x - Other petrochemical production	Northern region		Air Process [default]	Tier 2	From feedstock	900	- 2	3	0 7	X
2.8.9 - Fluorochemical Production	Unspecified		Air Process [default]	Tier 1	Specified	200		3		
- 2.B.9.a - By-product emissions			Oxygen Process	Tier 2	Specified	150	2	2		
2.B.9.b - Fugitive Emissions	*							2		
	Total									
2.B.11 - Other (Please specify)						1,250				_
1-2 C - Matal Industry										

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 <u>Column |Subdivision|</u> input information in a single row, or in a number of rows, as follows:

- <u>Column |Product Type|</u> (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). <u>Note that:</u> Users should use either EDC production or VCM production (not both) as AD.
- 2. <u>Column |Type of Process</u>]: 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. <u>Column $|CO_2 Calculation method|</u>: select from the drop-down whether Tier 1 or Tier 2 is applied.</u>$
- 4. <u>Column | Amount of [Chemical] Produced, PP|</u>: 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 1 or 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 <u>Column | Feedstock |</u>, row by row, the following:
 - i. <u>Column |Type of Feedstock|</u> 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 <u>Table 3.11</u>.
 - ii. <u>Column |Biogenic|</u> indicate with a check, if known, if the process fuel is of biogenic origin. <u>Note that</u> CO₂ emissions from flared gas of biogenic origin will not be included in national totals.
 - iii. <u>Column |FA|</u> enter the amount of feedstock consumed, in tonnes.
 - iv. <u>Column |SPP|:</u> 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. <u>Column | Feedstock |</u>: 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 <u>Column |CO₂ Calculation method|</u>, which requires information on the amount and carbon content of feedstock(s) consumed.

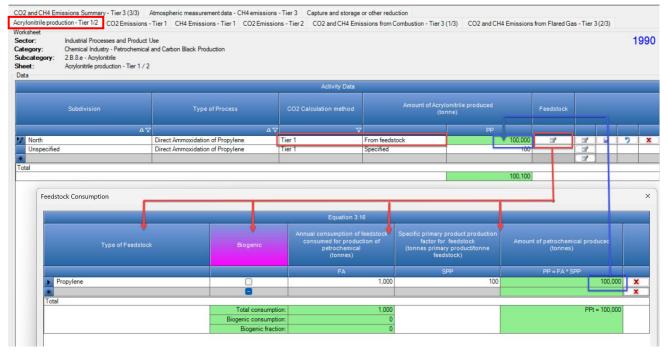
Example: AD input Tier 1 and Tier 2-chemical produced is specified directly in |Column PP|

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

tegory: Chemical Indust bcategory: 2.B.8.c - Ethyler	uses and Product Use y - Petrochemical and Carbon Black le Dichloride and Vinyl Chloride Mon ide and Vinyl Chloride Monomer pro	nomer						1	99
		Activity Data							
Subdivision	Product type		CO2 Calculation method	Amount of pro (ton	duct produced ne)	Feedsto ck			
Δ	7 47	۵۵	V		PP				
Unspecified	Ethylene Dichloride	Balanced Process [default]	Tier 1	Specified	100				
	and the second	Integrated EDC/VCM Production Plant	Tier 2	Specified	300	3			
		Integrated EDC/VCM Froduction Franc							
	Vinyl Chloride Monomer	Balanced Process [default]	Tier 1	Specified	200				
	Vinyl Chloride Monomer			Specified From feedstock	200 1,952.7	3	No. of Concerns, of Concerns, of Concerns, or Concerns, o		2

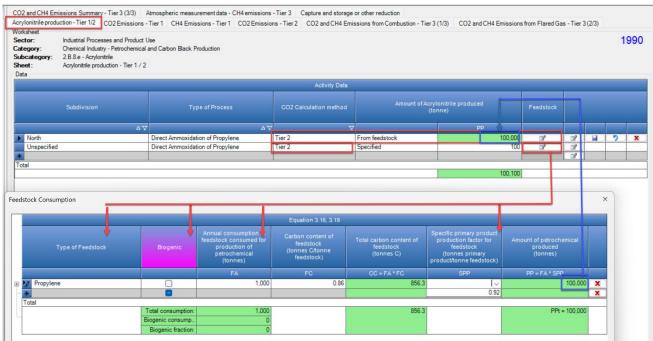
Example: AD input Tier 1-chemical produced calculated from feedstock

Note that 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 from feedstock use

Note that 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 | CO₂</u> <u>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.

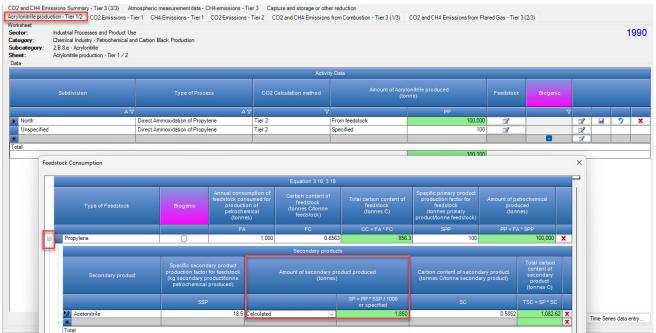
<u>Note that</u>: In the absence of country specific information, the user shall enter one row for every secondary product available in the drop-down menu to ensure that the carbon content of these secondary products is considered in the mass balance at Tier 2.

- 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 dropdown 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 <u>Table 3.25</u> (for ethylene) and <u>Table 3.26</u> (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

Note that this figure is for ethylene production; this sub-table (with different secondary products) is available for acrylonitrile production CO2 and CH4 Emissions Summary - Tier 3 (3/3) Atmospheric measurement data - CH4 emissions - Tier 3 Capture and storage or other reduction ion - Tier 112 CO2 Emissions - Tier 1 CH4 Emissions - Tier 1 CO2 Emissions - Tier 2 CO2 and CH4 Emissions from Combustion - Tier 3 (1/3) CO2 and CH4 Emissions from Flared Gas - Tier 3 (2/3) Ethylene Product Worksheet Industrial Processes and Product Use Chemical Industry - Petrochemical and Carbon Black Production Sector: Categor 1990 d Glyoxylic Aci Feedstock Consumption × 85.6 ¥ = Ethane 0.86 of secondary product pr SP = FA* SSP / 1000 Calculated **4***** High Value C 0.856 Ethylene 803 Propylene 0.8563 Butadiene 0.888 157 Fuel grade products and backflows Hydrogen 60 0.749 Methane 61 Ethane and propane after recycle Other C4 C5/C6 26 Save C7+ non-<430C Time Series data entr >430C Losse 1 000

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.

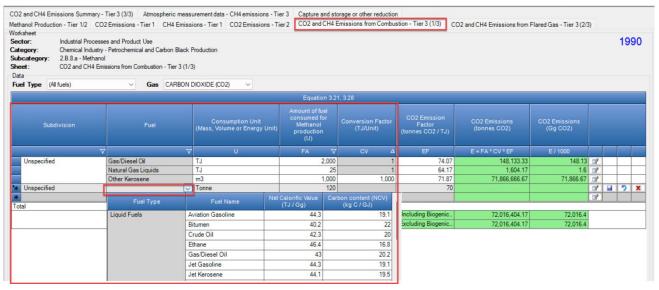
Tier 3 using plant-specific data (CO₂ and CH₄ emissions)

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 fuels shown in the drop-down menu are those listed in the Fuel Manager.</u>
- <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.
 <u>Column |U|</u>: select the unit of fuel consumption data (e.g. tonne, TJ, m³) 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

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



Then, for each chemical, and each subdivision for that chemical in worksheet CO₂ and CH₄ 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> CO₂ 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, m³) 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

			ent data - CH4 emissions - Tier 3								
hylene Oxide production - Tier 1/2	2 CO2 Emissions - Tier 1	CH4 Emiss	ions - Tier 1 CO2 Emissions -	Tier 2 CO2 and CH	4 Emissions from Com	bustion - Tier 3 (1/3)	CO2 and CH4 Emissions fi	from Flared Gas - Tier	3 (2/3)		
ategory: Chemical Industr abcategory: 2.8.8.d - Ethylen	ses and Product Use y - Petrochemical and Carbon e Oxide missions from Flared Gas - Tie		ction							19)9
				Equation 3.22, 3	.29				12		
Subdivision	Flared gas		Consumption Unit (Mass, Volume or Energy Unit)	Amount of gas flared during Ethylene Oxide production (U)	Conversion Factor (TJ/Unit)	CO2 Emission Factor (tonnes CO2 / TJ)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
Subdivision			(Mass, Volume or Energy	flared during Ethylene Oxide production		Factor					T
			(Mass, Volume or Energy Unit)	flared during Ethylene Oxide production (U)	(TJ/Unit) CV	Factor (tonnes CO2 / TJ)	(tonnes CO2)	(Gg CO2) E / 1000		a 🤊	
Unspecified	7 Δ7		(Mass, Volume or Energy Unit) U	flared during Ethylene Oxide production (U) FG V	(TJ/Unit) CV	Factor (tonnes CO2 / TJ) EF	(tonnes CO2) E = FG * CV * EF	(Gg CO2) E / 1000		a 🤊	
Δ7	7 Δ7		(Mass, Volume or Energy Unit) U	flared during Ethylene Oxide production (U) FG V	(TJ/Unit) CV 1	Factor (tonnes CO2 / TJ) EF	(tonnes CO2) E = FG * CV * EF	(Gg CO2) E / 1000 11.2	3	a 🤊	

Tier 3 using atmospheric measurements (CH₄ 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. <u>Column |Petrochemical type|</u>: 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.

<u>Table 3.11</u> 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 CO₂ and CH₄ EFs the following worksheets are used for different Tiers:

- ✓ CO₂ Emissions Tier 1
- ✓ CH₄ Emissions Tier 1
- \checkmark CO₂ Emissions Tier 2
- \checkmark CO₂ and CH₄ Emissions from Combustion Tier 3 (1/3)
- ✓ CO₂ and CH₄ 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)	<u>Table 3.16</u>
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)	<u>Table 3.21</u>
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)	<u>Table 3.24</u>
2.B.8.x Other petrochemical production	User -specified	User -specified

When Tier 1 Equations are applied (CO₂ and CH₄):

CO2 emissions

The CO₂ 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 CO₂ 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.

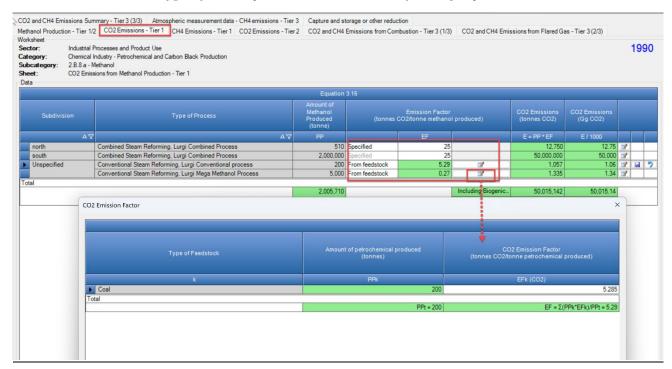
<u>Note that</u>: for the subcategory Ethylene Dichloride and Vinyl Chloride Monomer, the rows are further stratified by product type (either EDC or VCM). For the subcategory Other petrochemical production, rows are further stratified by petrochemical type entered by the user.

Then, 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:

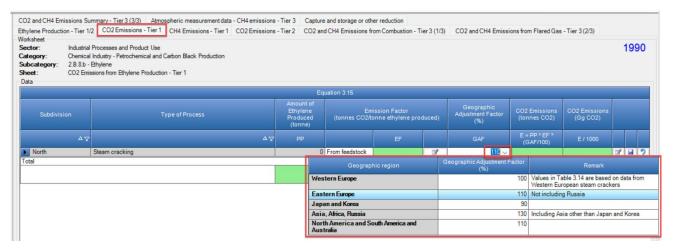
- 1. <u>Column | EF |:</u> select whether the CO₂ EF is specified or calculated from feedstock.
 - a. *Specified:* when selected, the user inputs the CO₂ EF directly.
 - b. *From feedstock:* to calculate the $CO_2 EF$ from the feedstock, select the icon for the drop-down table. Any feedstock entered 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 <u>|Column EFk (CO_2)|</u>.
- <u>Column |GAF|</u> (applicable for Ethylene production only): select from the drop-down the geographic adjustment factor corresponding to the relevant region.
 <u>Note that</u> Tier 1 CO₂ EFs for ethylene production have been developed based on data for ethylene steam crackers operating in Western Europe. Geographic Adjustment Factors are applied to the Tier 1 EF to account for regional variability in steam cracker operating efficiency.

Example: Tier 1 CO₂ 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

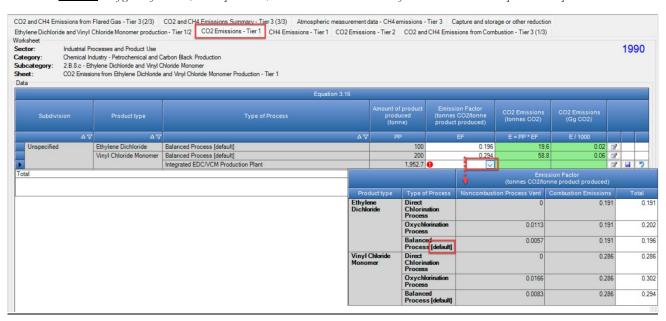


Then enter EF information for 2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer, 2.B.8.f Carbon Black and 2.B.8.x Other petrochemical production in worksheet CO₂ Emissions Tier 1, as follows:

 <u>Column |EF|</u>: select from the drop-down the IPCC default value for the relevant type of process, if available, or enter a user-specific value, in tonnes CO₂/tonne product produced. <u>Note that:</u> the drop-down identifies the "default process" in accordance with Table 3.11 for EDC/VCM.

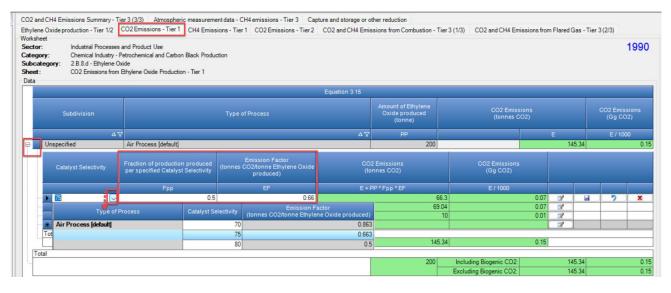
Example: Tier 1 CO₂ EFs for 2.B.8.c EDC/VCM, 2.B.8.f carbon black, and other 2.B.8.x petrochemical production

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. <u>Column | Catalyst selectivity |:</u> in the sub-table, select from the drop-down the catalyst selectivity (see <u>Table</u> <u>3.20</u> of the *2006 IPCC Guidelines*, and accompanying guidance), otherwise input user-specific information.
- <u>Column | Fpp |:</u> input the fraction (0-1) of the production produced using the catalyst selectivity identified in <u>Column | Catalyst selectivity |</u> <u>Note that:</u> The total in <u>Column | Fpp |</u> for each subdivision should equal 1.
- <u>Column |EF|</u>: the *Software* automatically populates the IPCC default CO₂ EF based on the selection in <u>Column |Catalyst selectivity|</u>. The user may overwrite this value, in tonnes CO₂/tonne ethylene oxide produced.



Example: Tier 1 CO₂ EFs for 2.B.8.d ethylene oxide production

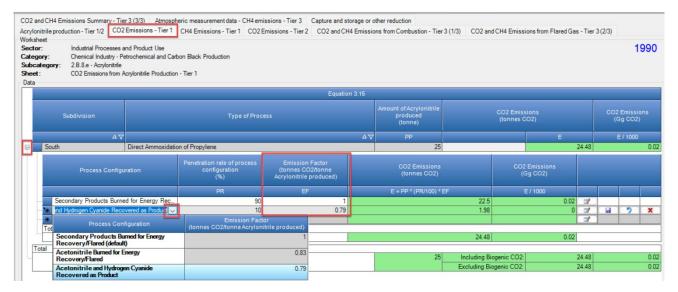
Then enter EF information for 2.B.8.e Acrylonitrile as follows:

- 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. <u>Column |Process Configuration|</u>: in the sub-table, select from the drop-down the process configuration (see <u>Table 3.22</u> of the 2006 IPCC Guidelines, and accompanying guidance), otherwise input user-specific information.
- 3. <u>Column |PR|:</u> input the penetration rate (%) of the process configuration identified in <u>Column |Process</u> <u>Configuration|</u>

Note that: The total in Column | PR | for each subdivision should equal 1.

 <u>Column |EF|</u>: the *Software* automatically populates the IPCC default CO₂ EF based on the selection in <u>Column |Process Configuration|</u>. The user may overwrite this value, in tonnes CO₂/tonne acrylonitrile produced.

Example: Tier 1 CO₂ EFs for 2.B.8.e acrylonitrile production



CH4 emissions

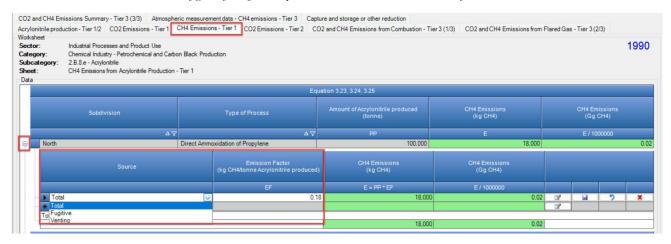
The CH₄ Emissions – Tier 1 worksheet is prefilled by the *Software* with a number of rows corresponding to the number of subdivision/type of process combinations entered in worksheet [Methanol] [Ethylene] [Ethylene Dichloride and Vinyl Chloride Monomer][Ethylene Oxide][Acrylonitrile][Carbon Black][Other petrochemical] Production – Tier 1/2.

<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, 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 CH₄ emissions.
- <u>Column | Source |:</u> select from the drop-down whether the CH₄ EFs to be entered are based on fugitive, vented or total emissions.
 <u>Note that:</u> the IPCC default CH₄ EFs are for <u>total</u> CH₄ emissions; if user has specific information separate CH₄ EFs could be entered for fugitive and vented emissions.
- 3. <u>Column |EF|</u>: select IPCC default CH₄ EFs from the drop-down, if available, otherwise enter in user-specific information, in kg CH₄/tonne product produced.

Example: Tier 1 CH₄ 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 CH₄ EFs to be entered are based on fugitive, vented or total emissions.
- 3. <u>Column | EF |:</u> select whether the CH₄ EF is *specified* or *based on feedstock*.
 - a. If specified, directly input the CH₄ 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 CH₄ 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 CH₄- 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 CH₄ 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(CH₄)|:</u> select the IPCC default CH₄ EF, otherwise input a user-specific EF.

Example: Tier 1 CH₄ EFs for 2.B.8.b ethylene production

hylene Production - Tier 1/2 CO2 Emissions - orksheet	Tier 1 Ch4	Emissions - Tier 1 CO2 Emis	ssions - Lier 2 CO2	and CH4 Emis	ssions from Con	nbustion - 1	ier 3 (1/3) CO2 and	CH4 Emissions from Flared (aas - Her 3 (2/3)	
ector: Industrial Processes and Produ ategory: Chemical Industry - Petrochemic ubcategory: 2.B.8.b - Ethylene heet: CH4 Emissions from Ethylene P Jata	cal and Carbor									199
			Equ	uation 3.23, 3.	.24, 3.25					
Subdivision			255		of Ethylene Pro (tonne)			nissions CH4)	CH4 Emissior (Gg CH4)	
	ΔV		۵ ۷		PP	_		E	E / 1000000	
- North		Steam cracking				2,24	4	0		
Source		(kg CH4	Emission Factor tonne ethylene produ				l4 Emissions (kg CH4)	CH4 Emissions (Gg CH4)		
			EF				E = PP * EF	E / 1000000		
Total		From feedstock			2				3	2 2
Total			I							
mission Factor									×	
	_									s
Type of Feeds				etrochemical ((tonnes)				H4 Emission Factor nne petrochemical produce	ed)	
				PPk				EFk (CH4)		
Ethane						2,000			~	
Naphtha I						244	Type of Feedstoc	K (kg CH4/tonne petroch		
						2,244	Ethane		6	

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:

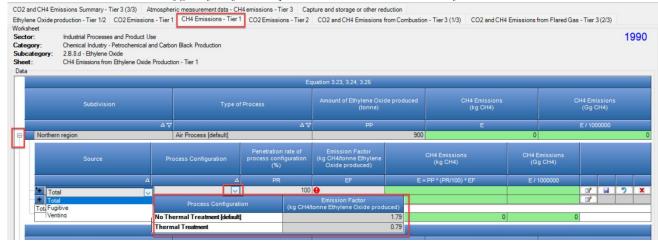
- 1. For each row, users click the symbol "⊞" on the left of the row to open a drop-down table where EF values are to be compiled based on the source, process configuration (type and penetration rate).
- 2. <u>Column |Source|</u>: select from the drop-down whether the CH₄ EFs to be entered are based on fugitive, vented or total emissions.
- 3. <u>Column |Process Configuration|</u>: in the sub-table, select from the drop-down the appropriate process configuration. The default configurations as contained in <u>Table 3.21</u> (ethylene oxide) and <u>Table 3.24</u> (carbon black) of the *2006 IPCC Guidelines* are identified.
- 4. <u>Column |PR|:</u> enter in the penetration rate (%) of the process configuration identified in <u>Column |Process</u> <u>Configuration|</u>

Note that: The total in Column | PR | for each subdivision should equal 1.

5. <u>Column |EF|</u>: the *Software* automatically populates the IPCC default CH₄ EF based on the selection in <u>Column |Process Configuration|</u>, otherwise enter in the user-specific value, in kg CH₄/tonne chemical produced.

Example: Tier 1 CH4 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 (CO₂ only):

The CO₂ 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 CO₂ 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 <u>Table 3.10</u>; otherwise enter in the user-specific value

Example: Tier 2 CO₂ carbon content of primary products

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

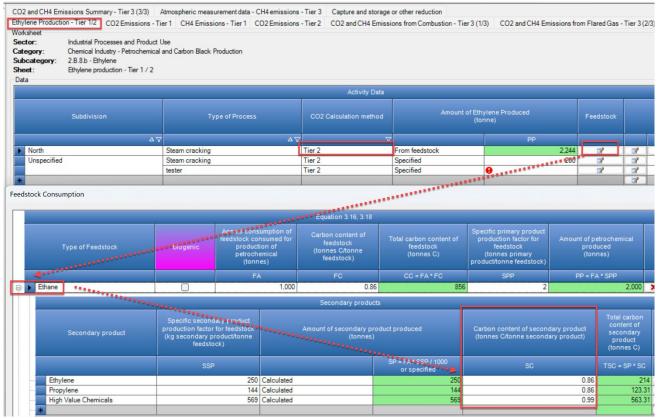
02 and CH4 Emis	sions Sum	mary - Tier 3 (3/3) Atmospheric measurement data - CH4 emissions - Tier 3	Capture and storage or o	ther reduction						
	n - Tier 1/2	CO2 Emissions - Tier 1 CH4 Emissions - Tier 1 CO2 Emissions - Tier 2	CO2 and CH4 Emissions	from Combustion - 1	Tier 3 (1/3) CO2 and CH4	4 Emissions from Flared G	aas - Tier 3 (2/3)			
Subcategory:	Chemical In 2.B.8.a - Me	ocesses and Product Use dustry - Petrochemical and Carbon Black Production sthanol ons from Methanol Production - Tier 2 (Mass Balance method)							199	90
			Equation 3.17							
Subdivisi	on	Type of Process	Total carbon content of feedstock (tonnes C)	Amount of Methanol Produced (tonne)	Carbon content of Methanol (tonnes C / tonne Methanol)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
	۵Ţ	Δ \	CC = FA * FC	PP	PC	E = (CC - (PP * PC)) * 44/12	E / 1000			
Unspecified		Partial oxidation process	32.4	100	0.04	105.05	0.11	2		2
Fotal								_		
				100		105.05	0.11			
					Excluding Biogenic CO2:	105.05	0.11			

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 CO₂ carbon content of secondary products (2.B.8.b ethylene and 2.B.8.e acrylonitrile production)

Note that 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

Note that this figure is for ethylene production; a similar worksheet is available for acrylonitrile production

		mmary - Tier 3 (3/3) Atmospheric measurement data - CH4 emissions 2 CO2 Emissions - Tier 1 CH4 Emissions - Tier 1 CO2 Emissions	and the second se	nd storage or other CH4 Emissions from		1/3) CO2 and CH4	Emissions from Flared Gas	- Tier 3 (2/3)		
Worksheet Sector: Category: Subcategory: Sheet: Data	Chemical 2.B.8.b -	Processes and Product Use Industry - Petrochemical and Carbon Black Production Ethylene sions from Ethylene Production - Tier 2 (Mass Balance method)							19	990
			Equa	ition 3.17						
Subdivis			Total carbon content of feedstock (tonnes C)	Amount of Ethylene Produced (tonne)	Carbon content of Ethylene produced (tonnes C / tonne Ethylene)		CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)		
	۵V	ΔŢ				SPC	E = (CC - (PP * PC + SPC)) * 44/12			
Morth		Steam cracking	975.56	2,244	0.856	965.93	-7,007.85	-7.01	2	12
Total				2,244		Carbon content of pe (tonnes C / tonne pet				

When the Tier 3 Equations are applied:

Tier 3 CO2 and CH4 EFs using plant-specific data

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 userspecific value, in tonnes CO₂/TJ or kg CH₄/TJ.

Note that user shall select "Carbon dioxide (CO2)" or "Methane (CH4)" in the "Gas" bar at the top, to enter data for each GHG one by one.

$\mathit{Example:}$ 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

ategory::::::::::::::::::::::::::::::::::::		tion - Tier 1/2 CO2	Emissions - Tier 1	CH4 Emissi	ons - Tier 1 CO2 Emissions -	Tier 2 CO2 and CH4 E	Emissions from Combus	stion - Tier 3 (1/3)	CO2 and CH4 Emissions from I	Flared Gas - Tier 3 (2/3)		
Luel Type (Al fuels) Gas CARBON DIOXIDE (CO2) CARBON DIOXIDE (CO2) METHANE (CH4) Equation 3.21, 3.28 CO2 Emission Factor (TJ/Unit) CO2 Emission Conversion Factor (TJ/Unit) CO2 Emission Factor (TJ/Unit) CO2 Emission Conversion Factor (TJ/Unit) CO2 Emission Factor (TJ/Unit) CO2 Emission (TJ/Unit)	ector: ategory: abcategory: neet:	Chemical Industry 2.B.8.b - Ethylene	Petrochemical and Ca									19	9
METHANE (CH4) Equation 321, 328 Conversion 521, 328		All fuels)	 ✓ Gas 	CARBON D	DIOXIDE (CO2)								
Subdivision Fuel Consumption Unit (Mass, Volume or Energy Unit) consumed for Ethylene production (U) Conversion Factor (TJ/Unit) CO2 Emission Factor (TJ/Unit) CO2 Emissions (for nes CO2 / TJ) CO2 Emission						Equation 3.2	1, 3.28						
Biodiesels TJ 233 1 70.77 16,488.63 16.49 27 Crude Oil Tonne 4,000 0.04 73.33 12,408 12,41 27 2 Gas/Diesel Oil m3 100 6 74.07 44,440 44.44 27 2 1 tal 73.33.653 73.34 1		bdivision				consumed for Ethylene production		Factor					
Crude Oil Tonne 4.000 0.04 73.33 12.408 12.41 27 4 Gas/Diesel Oil m3 100 6 74.07 44.440 47 4		۵ . ۲		۵V	U	FA 🛛	CV	EF	E = FA * CV * EF	E / 1000			ſ
Gas/Diesel Oil m3 100 6 74.07 44.440 44.44 27 24 val 4,333 Including Biogenic 73,336.63 73.34	Unspecifie	ed	Biodiesels		TJ	233	1	70.7	7 16,488.63	16.49	2		Г
Image: Contract of the second secon			Crude Oil		Tonne	4,000	0.04	73.3	3 12,408	12.41	2		Γ
4,333 Including Biogenic 73,336.63 73.34			Gas/Diesel Oil		m3	100	6	74.0	7 44,440	44.44		2	ſ
4,333 Including Biogenic 73,336.63 73.34											2		l
	tal					1 000			70.000.00	70.04	_		_
Excluding Biogenic. 56,848 56,85						4,333		Excluding Biogenic					

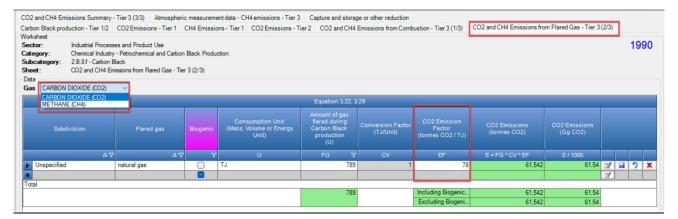
Then, for each chemical, and each subdivision for that chemical in worksheet CO_2 and CH_4 Emissions from Flared Gas – Tier 3 (2/3), the user will input information in a single row, or in a number of rows, plant-specific information as follows:

1. <u>Column |EF|</u>: select from the drop-down menu the IPCC default value for the given GHG or enter a user-specific value, in tonnes CO₂/TJ or kg CH₄/TJ.

Note that user shall select "Carbon dioxide (CO2)" or "Methane (CH4)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: Tier 3 CO₂ and CH₄ 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 (CO₂)" is selected in the "Gas" bar at the top:

- 1. <u>Column |Ev Fossil</u>: input user-specific value for CO₂ emissions from process vents that are of fossil origin, in tonnes CO₂.
- 2. <u>Column |Ev Biogenicl</u>]: input user-specific value for CO₂ emissions from process vents that are of biogenic origin, in tonnes CO₂.

When "Methane (CH₄)" is selected in the "Gas" bar at the top:

1. <u>Column | Ev |</u>: input a user-specific value for total CH₄ emissions from process vents, in kg CH₄.

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

O2 and CH4 Emissions	and the second se				er 3 Capture and s			CO2 and CH4 Emissions	silon Fideo Gas -	1161 3 (2/3)	
ategory: Chemic ubcategory: 2.8.8.8	- Ethylene nd CH4 Emissions Su	oduct Use emical and Carbon Bla immary - Tier 3 (3/3)	ack Production								1990
CARBON DIOXIDI METHANE (CH4)					Equation 3.	20, 3.27					_
Subdivision		ions from Fuel obustion nes CO2)	CO2 Emissions (tonne:		CO2 Emissions fro (tonnes		Total CO2 (tonne:		Total CO2 E (Gg C		
Δ.	Fossil	Ec Biogenic	Ef Fossil	Ef Biogenic	Ev Fossil	Ev Biogenic	E = Ec + Ef + Ev Fossil	E = Ec + Ef + Ev Biogenic	E / 1000 Fossil	E / 1000 Biogenic	
		8 16,488,63	168,000		25	55	224,873	16,543.63	224.87	16.54	3 🖬 🦉
Unspecified	56,84	0 10,400.00									

Tier 3 using atmospheric measurements (CH₄ 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 - CH₄ Emissions– Tier 3, input plantspecific information in a single row, or in a number of rows, as follows:

- 1. <u>Column | Measurement Campaign |</u>: enter name or dates of measurements campaigns. <u>Note that</u>: the dates of the measurement campaigns, when summed, must cover the entire reporting year.
- <u>Column |CtotalVOCs|</u>: for each measurement campaign input concentration of total measured VOCs, in μg/m³.
- 3. <u>Column | CH_{4frac} |:</u> input the CH₄ fraction in total VOC concentration, fraction.
- 4. <u>Column | CH₄bglevel</u>]: input the ambient CH₄ concentration at the background location, in μ g/m³.
- 5. <u>Column |WS|:</u> input the wind speed at the plant in, m/s.
- 6. <u>Column |PA|:</u> input the plume area in m².

Then the *Software* calculates CH₄ emissions in μ g/s. To convert it to kg per year, the factor 0.03154 is used, which is the conversion from μ g to kg and from second to year.

7. <u>Column |AEF|:</u> 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 <u>Column |Measurement Campaign|</u> indicates "January – June" <u>Column |AEF|</u> =0.5 to reflect half the year. <u>Note that</u> the sum of the fractions in column AEF for a given subdivision should =1.

Example: CH₄ atmospheric measurements – Tier 3

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

ategory: Chemica ubcategory: 2.B.8.d	I Processes and Prod I Industry - Petrocherr Ethylene Oxide eric measurement dat	uct (Use and Carbon Black		-n4 emissions - i	Capture a	and storage or oth	er reduction						19	90
						Equa	ation 3.26								
Subdivision (facility)	Measurement campaign (e.g. date)		VOC concentration at the facility (µg / m²)	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)			
	7	7			CH4bglevel			Em = (CtotalVOCs * CH4frac - CH4bglevel) * WS * PA			E = Em * SF * AEF				
Petrochemical#1	Jan-June		500	0.8	2	56	44	980,672	0.03	0.5	15,463.24	0.02	3	1 2	Л
	July-Dec		1,000	0.6	5	66	42	1,649,340	0.03	0.5	26,006.79	0.03			1
													3		
otal		-	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:

- \checkmark CO₂ Emissions Tier 1
- \checkmark CH₄ Emissions Tier 1
- \checkmark CO₂ Emissions Tier 2
- \checkmark CO₂ and CH₄ Emissions Summary Tier 3 (3/3)
- ✓ Atmospheric measurement data CH₄ Emissions Tier 3

Where the user has indicated use of biogenic feedstock in the production of a petrochemical or carbon black in the *Software*, CO₂ emissions are totalled including and excluding biogenic CO₂.

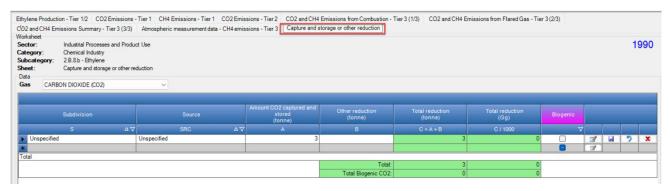
Total CO_2 and CH_4 emissions from the production of each chemical, is the sum of all emissions in the above worksheets for that chemical, taking into account any capture and storage or other reduction. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate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

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

- 1. <u>Column |SRC|</u>: select from the drop-down menu, or preferably, input information on the source where CO₂ 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂ or CH₄, 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.
- 4. <u>Column |Biogenic|:</u> indicate with a check if the process fuel is of biogenic origin. <u>Note that consistent with the 2006 IPCC Guidelines, capture of biogenic CO₂ for long-term storage may lead to negative CO₂ emissions.</u>

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, SF₆ and NF₃ 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 byproduct 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 <u>footnote 2</u> 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 (inprocess measurements in a reactor when HFC-23 emissions related to HCFC-22 production).

<u>GHGs</u>

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
			Χ			

IPCC Equations

- $\checkmark \quad \underline{\text{Tier 1}: \text{Equations 3.30}}$
- ✓ <u>Tier 2</u>: <u>Equations 3.31, 3.32</u> and <u>3.33</u>
- ✓ <u>Tier 3</u>: Tier 3a (Direct measurement of vent streams): <u>Equations 3.34</u> and <u>3.37</u>, Tier 3.b (Proxy method): <u>Equations 3.35</u>, <u>3.38</u>, and <u>3.39</u>, and Tier 3c (Monitoring reactor product): <u>Equations 3.36</u> and <u>3.40</u>

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:

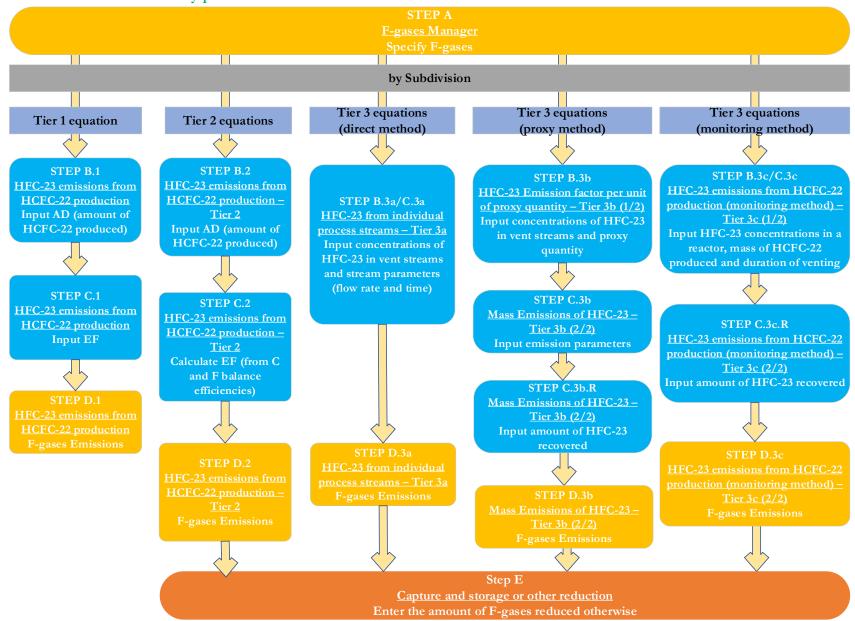
- ✓ F-gases Manager: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ HFC-23 emissions from HCFC-22 production: this worksheet contains for each subdivision the amount of HCFC-22 produced and HFC-23 default EFs. The users may input country-specific EFs. 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-specific¹ EFs or direct measurements.

To ease the use of the *Software* as well as to avoid its misuse users follow the following flowchart for By-product Emissions – HFC-23 emissions from HCFC-22 production.

¹ Where the inventory of the source-category is stratified by subdivisions instead of a single nation-wide aggregate, subdivision-specific AD and EFs may be applied to prepare estimates at Tier 2. For instance, Region A and Region B are 2 subdivisions of country's X estimates, a Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the country-specific EF.



By-product emissions-HFC-23 emissions from HCFC-22 Production - flowchart

Thus, for the source-category:

Step A, 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.

<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.

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.

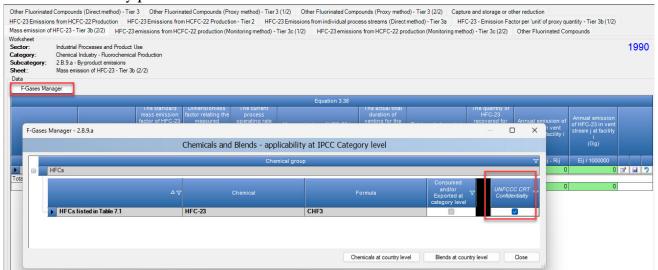
Activity Data Input

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 CO₂ 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 <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)

2006 IPCC Categories • 4 - 2.8.6 - Titanium Dioxide P - 2.8.7 - Soda Ash Producti	Capture and storage or other reduction HFC-23 emissions Mass emission of HFC-23 - Tier 3b (2/2) HFC-23 emission HFC-23 Emissions from HCFC-22 Production HFC-23 Emi	s from HCFC-22 production (Monitoring)	method) - Tier 3c (1/2) Other Fluorinated C	Compounds (Proxy method) - Tier 3 (1/2)	Other Fluorinated Compounds (Pr			
2.8.8 - Petrochemical and - 2.8.8 - Methanol - 2.8.8 - Ethylene - 2.8.8 - Ethylene Dic - 2.8.8 - Ethylene Dic - 2.8.8 - Ethylene Dic - 2.8.8 - Carbon Black - 2.8.8 - Carbon Black - 2.8.8 - Carbon Black	vonstreet Sector: Industrial Processes and Product Use Category: Onesical Industry - Ruron-cherical Product Subcategory: 2 8 9 a - By round emissions Sheet: By product HFC-23 emissions from HCFC-22 Data FGases Manager							2000
2.B.9 - Fluorochemical Pr 2.B.9.a - By-product e			Equation 3.30					
2.8.9.b - Fugitive Emis	Subdivision	Amount of HCFC-22 Produced (kg)	Emission Factor (kg HFC-23/kg HCFC-22 produced)	By-product HFC-23 emissions from HCFC-22 production (kg)	By-product HFC-23 emissions from HCFC-22 production (Gg)			
- 2.B.11 - Other (Please sp								
- 2.B.11 - Other (Please sp B-2.C - Metal Industry	۵ <u>۷</u>	P	EF	E = P * EF	E / 1000000			
2.B.11 - Other (Please sp	▲ ▼ ▶ Unspecified	P 255	EF 0.03		E / 1000000 0.00001	3		7 X
- 2.B.11 - Other (Please sp - 2.C - Metal Industry - 2.C.1 - Iron and Steel Pro						3	ia -	? ×

Example: multiple subdivisions

 2.B.6 - Titanium Dioxide P 2.B.7 - Soda Ash Producti 2.B.8 - Petrochemical and 	Mass emission of HFC-23 - Tie HFC-23 Emissions from HCFC- Worksheet		-23 emissions from HFC-23 Emission						xy method) - Tier 3 (1/2) act method) - Tier 3a H				
2.8.8.a - Methanol 2.8.8.b - Ethylene 2.8.8.c - Ethylene Dic 2.8.8.d - Ethylene Oxi 2.8.8.d - Ethylene Oxi 2.8.8.e - Acrylonitrile	Sector: Industrial Pri Category: Chemical Int Subcategory: 2.8.9.a - By	ocesses and Produ dustry - Ruorochen product emissions IFC-23 emissions f		uction - Tier 2									19
-2.B.8.x - Other petroch	F-Gases Manager												
2.B.9 - Fluorochemical Pr						Equation							
2.B.9.a - By-product e 2.B.9.b - Fucitive Emis		Equation 3.31, 3.32, 3.33 HH-C-23 emission factor calculated from carbon balance HT-C-23 emission factor calculated from fluorine balance efficiency											
- 2.B.10 - Hydrogen Produc		Amount of	Fraction of the year that this	Carbon	Factor to assign	EF Carbon balance	Fluorine	Factor to assign	EF Fluorine balance (kg HFC-23/kg HCFC-	HFC-23 calculated emission factor	By-product HFC-23 emissions from	By-product HFC-23 emissions from	
C - Metal Industry -2.C.1 - Iron and Steel Pro -2.C.2 - Ferroalloys Produc	Subdivision	HCFC-22 Produced (kg)	stream was released to atmosphere untreated	balance efficiency (Percent)	efficiency loss to HFC-23 (Fraction)	(kg HFC-23/kg HCFC- 22)	efficiency (Percent)	efficiency loss to HFC-23 (Fraction)	22)	(kg HFC23/kg HCFC-22)	HCFC-22 production (kg)	HCFC-22 production (Gg)	
C - Metal Industry 2.C.1 - Iron and Steel Pro	Subdivision		released to atmosphere	efficiency	to HFC-23		efficiency	to HFC-23		(kg HFC23/kg	production	production	
C - Metal Industry - 2.C.1 - Iron and Steel Pro - 2.C.2 - Ferroalloys Produc - 2.C.3 - Aluminium producti		Produced (kg)	released to atmosphere untreated	efficiency (Percent)	to HFC-23 (Fraction)	22) EFcb=(100-	efficiency (Percent)	to HFC-23 (Fraction) Fel	22) EFfb=(100-	(kg HFC23/kg HCFC-22) EF=	production (kg) E=P*EF*Fr	production (Gg) E / 1000000	7 4 7
- 2.C.2 - Ferroalloys Produc - 2.C.3 - Aluminium producti - 2.C.4 - Magnesium produc	44	Produced (kg) P	released to atmosphere untreated Fr	efficiency (Percent) CBE	to HFC-23 (Fraction) Fel	22) EFcb=(100- CBE)/100*Fel*0.81	efficiency (Percent) FBE	to HFC-23 (Fraction) Fet 0.8	22) EFfb=(100- FBE)/100*FeI*0.54	(kg HFC23/kg HCFC-22) EF= (EFcb+EFfb)/2	production (kg) E=P*EF*Fr	production (Gg) E / 1000000 0.00759 0.00759	

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

					*	-							
apture and storage or o	other reduction H	FC-23 emissions from	HCFC-22 product	tion (Monitoring m	ethod) - Tier 3c (2/2)	Other Fluorinated (Compounds Ot	her Fluorinated Compound	ds (Direct method) -	Tier 3			
ass emission of HFC-2	23 - Tier 3b (2/2)	IFC-23 emissions fro	m HCFC-22 produ	ction (Monitoring r	nethod) - Tier 3c (1/2)	Other Fluorinated	Compounds (Pro	oxy method) - Tier 3 (1/2)	Other Fluorinate	Compounds (Pro	xy method) - Tier	3 (2/2)	
C-23 Emissions from orksheet	HCFC-22 Production	HFC-23 Emission	ns from HCFC-22 I	Production - Tier 2	HFC-23 Emissions f	rom individual proc	ess streams (Dire	ect method) - Tier 3a H	FC-23 - Emission F	actor per 'unit' of pr	roxy quantity - Tier		
ategory: Chem abcategory: 2.8.9	strial Processes and P nical Industry - Ruoroc 9.a - By-product emissi roduct HFC-23 emissio	chemical Production	duction - Tier 2										199
F-Gases Manager													
					Equatio								
		_		on factor calculate efficiency		HFC-23 emissio	in factor calculate efficiency	ed from fluorine balance					
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)		
					EFcb=(100- CBE)/100*Fel*0.81			EFfb=(100- FBE)/100*Fel*0.54	EF= (EFcb+EFfb)/2	E=P'EF'Fr			
Northern region	500	0.0	88	0.8	0.07776	0.8	0.8	0.42854	0.25315	7594.56	0.00759	36	19
Southern region	220	000 0.98	45	0.5	0.22275	0.9	0.9	0.48163	0.35219	7593.17328	0.00759		
6												2	
otal	720											_	
										15187.73328	0.01519		

When Tier 3 Equations are applied:

Tier 3.a Direct method

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

Tier 3.b Proxy method

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

Tier 3.c Monitoring method

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

Emission Factors Input

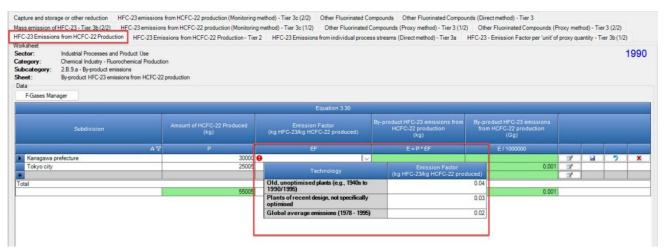
Section 3.10.1.2 in Chapter 2 Volume 3 of the 2006 IPCC Guidelines contains information on the choice of EFs for By-product emissions of HFC-23 from HCFC-22. Tier 1 default EFs are provided in <u>Table 3.28</u>. Higher-tier methods rely on plant-specific measurements or sampling.

When the Tier 1 Equation is applied:

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 |EF|</u>: 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,

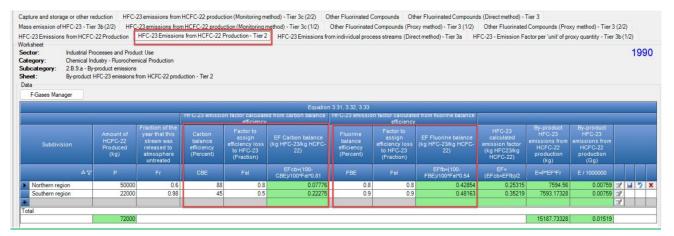
if there is a vent treatment system, the length of time that this stream was in operation, and treatment of that vent stream should also be available from plant records.

To calculate the EF, for each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **By-product** emissions of HFC-23 from HCFC-22 Production - Tier 2, row by row, as follows:

- 1. <u>Column |Fr|:</u> input the fraction of the year when the vent stream was released to the atmosphere without treatment.
- 2. <u>Column |CBE|</u>: input the carbon balance efficiency taken from the plant operator, in percent.
- 3. <u>Column |Fel|:</u> input the efficiency loss factor, fraction. <u>Note that</u> 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. <u>Column |FBE|</u>: input the fluorine balance efficiency taken from the plant operator, in percent.
- 5. <u>Column |Fel|:</u> input the efficiency loss factor, fraction. <u>Note that</u> 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



Direct measurement

Tier 3.a Direct method

For each subdivision in <u>Column |i|</u>, data are input in worksheet **HFC-23 emissions from individual process** streams (Direct Method) – Tier 3a, row by row, as follows:

- 1. <u>Column [j]</u>. enter a name for the individual process stream.
- 2. <u>Column |Measurement campaign|:</u> for each subdivision/process stream input the name or dates of the measurement campaign.
- 3. <u>Column |Cij|</u>: 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. <u>Column | f_{ii} |:</u> For each subdivision/process stream/measurement campaign input the flow rate of the gas, in kg of gas stream per hour.
- 5. <u>Column |t|</u>: For each subdivision/process stream/measurement campaign input the length of time in hours, these parameters are measured.

<u>Note that</u> 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

emission of HFC-23 - Tier 3b (2/2)	HFC-23 emissions from HCF	C-22 production (Monitoring me	thod) - Tier 3c (1/2) 0	ther Fluorinated Compou	nds (Proxy method) - Tier	3 (1/2) Other Fluorinated	Compounds (Proxy method)) - Tier	3 (2/2)	
-23 Emissions from HCFC-22 Produ sheet							ctor per 'unit' of proxy quanti			
agory: Industrial Processes a gory: Chemical Industry - Fl category: 2.B.9.a - By-product of	uorochemical Production	t method) - Tier 3a								19
			Equation	n 3.34, 3.37						
			HFC-23 concentration in the gas stream	Mass flow of the gas	Length of time in the year over which these					
Subdivision (facility)		Measurement campaign (e.g. date)	actually vented from process stream j at facility i (kg HFC-23 / kg gas stream)	stream from process stream j at facility i (kg gas stream / hour)	parameters are measured and remain constant (hours)	'Instantaneous' HFC-23 emissions (kg)	Instantaneous' HFC-23 emissions (Gg)			
			process stream j at facility i (kg HFC-23 / kg gas	stream from process stream j at facility i	parameters are measured and remain constant	emissions	emissions			
(facility)		(e.g. date)	process stream j at facility i (kg HFC-23 / kg gas stream) Cij 0.004	stream from process stream j at facility i (kg gas stream / hour) fij 3100	parameters are measured and remain constant (hours) t 672	emissions (kg) Eijt = Cij * fij * t 8332.8	emissions (Gg) Eijt / 1000000 0.00833		6	2
(facility) i Δ*	∀	(e.g. date) ́ 	process stream j at facility i (kg HFC-23 / kg gas stream) Cij	stream from process stream j at facility i (kg gas stream / hour) fij	parameters are measured and remain constant (hours) t	emissions (kg) Eijt = Cij * fij * t	emissions (Gg) Eijt / 1000000		ia I	2

Tier 3.b Proxy method

For each subdivision in <u>Column |i| (Tier 3 requires plant- or facility- specific input)</u>, data are input in worksheet **HFC-23 Emission Factor per unit of proxy quantity – Tier 3b (1/2)**, row by row, as follows:

- 1. <u>Column |j|</u> enter a name for the individual vent stream.
- 2. <u>Column |T|:</u> for each subdivision (plant)/vent stream, input the name or date of the trial campaigns.
- 3. <u>Column |days, ij|</u>: 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 <u>Column |Sij|</u> is weighted based on the length of each trial campaign.
- 4. <u>Column |CT_{ii}|</u>: 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. <u>Column $|fT_{ij}|$:</u> 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 <u>|PORT_{ij}|</u>:for each subdivision/vent stream/trial campaign, input the proxy quantity (e.g. operating rate) in units per hour.

<u>Note that</u> 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 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. <u>Column | F_{ij}|</u>. input a dimensionless factor relating the measured standard mass emission rate to the emission rate at the actual plant operating rate. <u>Note that</u> 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. <u>Column |POR_{ij}|:</u> input the current process operating rate applicable to that vent stream, j, averaged over time, in 'unit/hour'.

<u>Note that</u> the units of this parameter must be consistent between the plant trial establishing the standard emission rate and the estimate of ongoing, operational emissions.

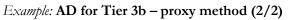
9. <u>Column |t|.</u>: input the time, in hours, of actual venting for the year, or the period if the process is not operated continuously.

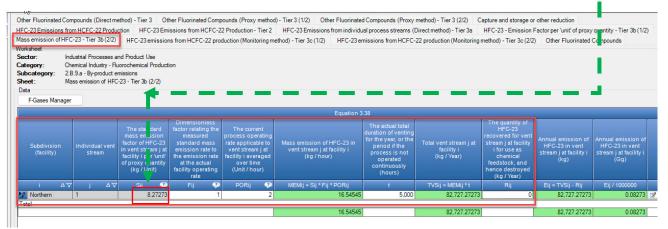
<u>Note</u> that annual emissions become the sum of all the periods during the year. The periods during which the vent stream is processed in a destruction system should not be counted here. For a given vent stream, the total in <u>Column |t|</u> should not exceed 8,760 (the number of hours in a year)

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

	(2/2) HFC-23 emissi	ons from HCFC-22 produc	tion (Monitoring met	thod) - Tier 3c (1/2)	HFC-23 emission	is from HCFC-22 proc	I) - Tier 3 (2/2) Capture and storage duction (Monitoring method) - Tier 3c (2)	
sheet or: Industrial Proce gory: Chemical Indus category: 2.8.9.a - By-pro	sses and Product Use try - Fluorochemical Produ duct emissions					ess succins (Direct)		
-Gases Manager					Equation 3.39			
Subdivision (facility)	Individual vent stream	Trial campaign (e.g. date)	Days	i ne average mass fractional concentration of HFC-23 in vent stream j at facility i during the trial T (kg HFC-23 / kg cas 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 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 AV		days,ij	CT,ij	fT,ij	PORT,ij 🌮	ST,ij = CT,ij * fT,ij / PORT,ij	Sij = Σ[ST,ij * days,ij / d <mark>ays iil</mark>
Northern	1	April Jan-Apr	10 100	0.1	10	1	1	8.27273

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





Tier 3.c Monitoring method

For each subdivision in <u>Column |i|</u>, 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. <u>Column | M |</u> users input the name or time for individual release period(s).
- 2. <u>Column $|C_i|$ </u>: 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. <u>Column |P_i|:</u> input the mass of HCFC-22 produced during individual release period M, in kg.
- 4. <u>Column |tF|: input the fraction of the period during which this HFC-23 is actually vented to the atmosphere rather than destroyed.</u>

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 $|R_i|$: enter the amount of HFC-23 recovered from the facility for use as chemical feedstock and hence destroyed.</u>

<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.

FC-23 Emissions from HCFC-22 Production FC-23 emissions from HCFC-22 production	- Tier 2 HFC-23 Emissions from	m individual process stream	s (Direct method) - Tier 3a		inds (Proxy method) - Tier 3 (1/2)	ICEC-22 Production			
C-23 - Emission Factor per 'unit' of proxy q rksheet ctor: Industrial Processes and Pn tegory: Chemical Industry - Fluoroci beategory: 2, 8, 9, a - By-product emissio	uantity - Tier 3b (1/2) Mass emi oduct Use nemical Production	ssion of HFC-23 - Tier 3b (2	Contractor of the second		nitoring method) - Tier 3c (1/2)			19	90
			Equation 3	40					
Subdivision (facility)	Individual release period	Concentration of HFC-23 in the reactor product at facility i during individual release period M (kg HFC-23 / kg HCFC- 22)		is actually vented to the	HFC-23 vented from an individual facility i during individual release period M (kg)	Annual HFC-23 vented from an individual facility i (kg / Year)			
i Δ7	M AV	ci	PI	tF	VM,i = Ci * Pi * tF	Vi = SUM(VM,i)			
Facility UniCHEM	january-june July-Dec	0.02	1200000 1000002	0.2	4800 12000.024	16800.024	3	2	×

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

HFC-23 - Emission Factor per 'unit' of proxy quantity - Tie	ar 3b (1/2) Mass emission of HFC-23 - Tir	er 3b (2/2) HFC-23 emissions from HCFC	C-22 production (Monitoring method) - Tier 3	c (1/2) HFC-23 Emissions from HCFC-2	2 Productiv	on - Tier 2	
FC-23 emissions from HCFC-22 production (Monitoring							
forksheet ector: Industrial Processes and Product Use ategory: Chemical Industry - Ruorochemical Pro- ubcategory: 2.8.9.a - By-product emissions							199
F-Gases Manager							
		Equation 3.40					
Subdivision (facility)	Annual HFC-23 vented from an individual facility i (kg)	Annual quantity of HFC-23 recovered from facility i for use as chemical feedstock, and hence destroyed (kg)	Annual HFC-23 emissions from an individual facility i (kg)	Annual HFC-23 emissions from an individual facility i (Gg)			
i 🗛 🗸			Ei = Vi - Ri	Ei / 1000000			
	16800.024	3	16797.024	0.0168	3	6	2
Facility UniCHEM							
Facility UniCHEM							

Results

By-product Emissions- HFC-23 emissions from HCFC-22 production are estimated in mass units (kg and Gg) by the *Software* for each row, and the total for all rows, in the following worksheets.

- ✓ HFC-23 emissions from HCFC-22 production
- ✓ HFC-23 emissions from HCFC-22 production Tier 2
- ✓ HFC-23 emissions from individual process streams (Direct Method) Tier 3a
- ✓ Mass emissions of HFC-23 Tier 3b (2/2)
- ✓ HFC-23 emissions from HCFC-22 (Monitoring Method) Tier 3c (2/2)

Total HFC-23 emissions from 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. <u>Column |SRC|</u>: enter any identifying information for the source, if applicable.
- 3. <u>Column |A|:</u> 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

IFC-23 emissions from HCFC-22 proc											
FC-23 Emissions from individual proc	ess streams (D	irect method) - Tier	3a Other Flux	prinated Compounds (Prop	xy method	I) - Tier 3 (1/2) Other Flui	orinated Compounds (Prox	ty method) - Tier 3 (2/2)	Capture and storage or othe	er reduction	
orksheet ector: Industrial Processes ategory: Chemical Industry ubcategory: 2.B.9.a - By-product heet: Capture and storage lata	missions	n									199
Gas HFC-23 (CHF3)		✓ F-Gat	ses Manager								
Subdivision	Туре	of Fluorinated Com produced		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)		_
Subdivision	Туре	of Fluorinated Con		Source SRC	24	and stored					
Subdivision		of Fluorinated Con produced CH	npound A V		<u>۵</u> ۷	and stored (tonne)	(tonne)	(tonne)	(Gg)		•

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, SF₆ and NF₃ 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 byproduct 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 <u>footnote 2</u> 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, SF₆ 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.

<u>GHGs</u>

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
			Χ	Χ	Χ	X

IPCC Equations

- ✓ <u>Tier 1</u>: <u>Equation 3.41</u>
- ✓ <u>Tier 2</u>: no IPCC Tier 2 Equation provided in the 2006 IPCC Guidelines
- ✓ <u>Tier 3</u>: <u>Equation 3.42</u> (Direct method) and <u>Equation 3.43</u>, <u>3.38 and 3.39</u> (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.

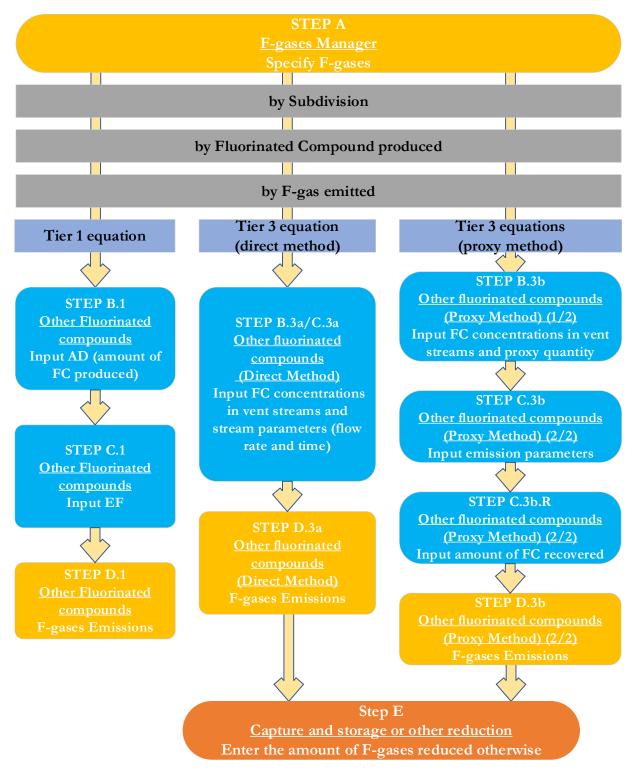
- ✓ Other Fluorinated Compounds: contains for each subdivision and each principal fluorinated compound produced the amount of production of principal compound and a default EF. The worksheet calculates the by-product emissions of other fluorinated compounds.
- ✓ Other Fluorinated Compounds (Direct Method) 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-specific¹ 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.

<u>Note that</u> 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 <u>abore</u>.

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

tegory: Chemical Indu ategory: 2.B.9.a - By-p	lustry - Fluc product em	d Product Use prochemical Production hissions e Emissions from Production of O	ther Fluorinated Compounds								1
Gases Manager											
				Equation 3.41							
Subdivision		Principal Fluorinated Compound Produced		Amount of Principal Fluorinated Compound Produced (kg)	Emission Factor (kg by-product gas emitted/kg F-compound produced)	Emissions (kg)	Emissions (Gg)				
		ΔV	7	√ Pk	EFk	Ek = Pk * EFk	Ek / 1000000				
Unspecified		any gas	PFC-14 (CF4)	10000000	0.005	500000		3		2	
			HFC-23 (CHF3)	1000		5	0.00001			-	+
		test	HFC-32 (CH2F2)		0.005	5	0.00001				
				1000					<u>+</u>	+	+
F-Gases	s Manage	er - 2.8.9.a	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3)	nds - applicability at	0.005	500	0.00001 0.0005	2			+
			HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3)	1000 100000	0.005	5	0.00001 0.0005	×			
	HFCs		HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3)	nds - applicability at Chemical group Gases	0.005 0.005	5	0.00001 0.0005	×			
	HFCs		HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3)	nds - applicability at Chemical group Gases select	0.005 0.005	5	0.00001 0.0005	×			
	HFCs PFCs		HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble	nds - applicability at Chemical group Gases select	1PCC Category level	5 500 Consumed and/or Exported at		×			
	HFCs PFCs	er - 2.8.9.a	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble	nds - applicability at Chemical group Gases select cat	1PCC Category level that may be ted for this ategory	5 500 Consumed and/or Exported at category level	0.0001 0.005 	×			
	HFCs PFCs	er - 2.8.9.a	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble	nds - applicability at Chemical group Gases selec cat	0.005 0.005	5 500 Consumed Exported Exported Category Ieel	0.0001 0.0005	×			
	HFCs PFCs	er - 2.8.9.a	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble	nds - applicability at Chemical group Gases cal CF4 C2F6	0.005 0.005	5 500 Consumed and/or Exported at category level	0.00001 0.0005 	×			
	HFCs PFCs	er - 2.8.9.a Cs listed in Table 7.1	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble ▲マ Chemicals and Ble PFC-14 PFC-116 PFC-218 PFC-31-10 PFC-31-10	nds - applicability at Chemical group Gases select cat CF4 C2F6 C3F8 C4F1 n-C6F	1PCC Category level that may be ted for this ategory	5 500 Consumed and/or Exported at category level © © ©	0.00001 0.0005 	×			
	HFCs PFCs	er - 2.8.9.a	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble ▲▼ Chemicals and Ble PFC-14 PFC-16 PFC-18 PFC-31-10	nds - applicability at Chemical group Gases select cal CF4 C2F6 C3F8 C4F1 n-C6f c3F8 C4F1	0.005 0.005	5 500 Consumed and/or Exported at Category level C C C	0.0001 0.0005 	×			
	HFCs PFCs	er - 2.8.9.a Cs listed in Table 7.1	HFC-41 (CH3F) HFC-43-10mee (CF3CHFCHFCF2CF3) Chemicals and Ble ▲マ Chemicals and Ble PFC-14 PFC-116 PFC-218 PFC-31-10 PFC-31-10	nds - applicability at Chemical group Gases select cat CF4 C2F6 C3F8 C4F1 n-C6F	1PCC Category level that may be teed for this ategory	5 500 Consumed and/or Exported at category level © © ©	0.0001 0.0005 	×			

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)

- 2.8.6 - Titanium Dioxide P - 2.8.7 - Soda Ash Producti - 2.8.8 - Petrochemical and	HFC-23 Emissions from individual pro HFC-23 emissions from HCFC-22 pro Worksheet		r 3a Other Fluorinated Compounds (Pros 3c (2/2) Other Fluorinated Compounds					er reduction	
28.8.a - Methanol 28.8.b - Ethylene Dic 28.8.c - Ethylene Dic 28.8.d - Ethylene Dic 28.8.d - Ethylene Oxi 28.8.f - Carbon Black 28.8.f - Carbon Black 28.8.x - Other petroch	Sector: Industrial Processes Category: Chemical Industry - Subcategory: 2.8.9.a - By-product	Ruorochemical Production	ther Ruorinated Compounds						6
2.B.9 - Fluorochemical Pr 2.B.9.a - By-product e				Equation 3.41					
			ſ	Amount of Principal	Emission Factor		200		
2.8.9.b - Fugitive Emis 2.8.10 - Hydrogen Produc 2.8.11 - Other (Please sp	Subdivision	Principal Fluorinated Compound Produced		Fluorinated Compound Produced (kg)	(kg by-product gas emitted/kg F-compound produced)	Emissions (kg)	Emissions (Gg)		
2.8.9.b - Fugitive Emis 2.8.10 - Hydrogen Produc 2.8.11 - Other (Please sp - Metal Industry	Subdivision	Compound Produced			emitted/kg F-compound				
2.8.9.b - Fugitive Emis 2.8.10 - Hydrogen Produc 2.8.11 - Other (Please sp • Metal Industry 2.C.1 - Iron and Steel Pro		Compound Produced		Produced (kg)	emitted/kg F-compound produced)	(kg)	(Gg) Ek / 1000000	3	2
2.8.9.b - Fugitive Emis 8.10 - Hydrogen Produc 8.11 - Other (Please sp Metal Industry	^	Compound Produced		Produced (kg) V Pk	emitted/kg F-compound produced) EFk	(kg) Ek = Pk * EFk	(Gg) Ek / 1000000	3 1	2

Example: multiple subdivisions

- 2.8.6 - Titanium Dioxide P - 2.8.7 - Soda Ash Producti	HFC-23 Emissions from individual p									ction	
2.8.8 - Petrochemical and	HFC-23 emissions from HCFC-22 p Worksheet	roduction (Monitoring metho	d) • Tier 3c (2/2) Other	Fluorinated Compounds	Other Fluorinated	Compounds (Direct m	ethod) - Tier 3 HFC-23	Emissions from HCFC-22 Producti	ion		
2.B.8.a - Methanol 2.B.8.b - Ethylene 2.B.8.c - Ethylene Dic 2.B.8.d - Ethylene Oxi 2.B.8.d - Ethylene Oxi	Sector: Industrial Process Category: Chemical Industry Subcategory: 2.8.9.a · By-produ	es and Product Use r - Ruorochemical Production uct emissions ns from individual process stre		3							1
-2.B.8.f - Carbon Black -2.B.8.x - Other petroch	Gas HFC-23 (CHF3)	~	F-Gases Manager								
- 2.8.9 - Fluorochemical Pr					Equation 3.34, 3	37, 3.42					
28.9.a - Sysproduct e 28.9.b - Fugitive Emis 2.8.10 - Hydrogen Produc 2.8.11 - Other (Please sp 2.C - Metal Industry 2.C.1 - Iron and Steel Pro 2.C.2 - Ferroalloys Produc	Subdivision (facility)	Individual process stream	Measurement campaign (e.g. date)	FC concentration in the gas stream actually vented from process stream j at facility i (kg FC / 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)		eous' FC emissions (kg)	'Instantaneous' FC emissions (Gg)		
- 2.C.3 - Aluminium producti	i V							Eijaverage = AVG(Eijt)	Eijaverage / 1000000		
- 2.C.4 - Magnesium produc - 2.C.5 - Lead Production	North	Northern	Jan - December	0.7	25	5000	87500	17.5	0.00002	3	T
-2.C.6 - Zinc Production	East	#456	Jan-December	0.9	34	5000	153000	30.6	0.00003	3	T
- 2.C.7 - Rare Earths Produ	Total	1								-	1
-2.C.8 - Other (please spec											

When the Tier 1 Equation is applied:

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

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

Example: AD for other fluorinated compounds - Tier 1

in G-20 - Linission Factor per unit of	proxy quantity - Tier 3b (1/2) Ma	ass emission of HFC-23 - Tier 3b (2/2) HFC-2	23 emissions from HCFC-2	2 production (Monitoring method	i) - Tier 3c (1/2) HFC-23	Emissions from HCFC-22 F	Product	tion - Tie	2
FC-23 Emissions from individual pro	cess streams (Direct method) - Tie	r 3a Other Fluorinated Compounds (Proxy m	nethod) - Tier 3 (1/2) Oth	her Fluorinated Compounds (Pro	oxy method) - Tier 3 (2/2)	Capture and storage or oth	er redu	uction	
IFC-23 emissions from HCFC-22 pro	duction (Monitoring method) - Tier	3c (2/2) Other Fluorinated Compounds Ot	her Fluorinated Compounds	s (Direct method) - Tier 3 HF	C-23 Emissions from HCFC-	22 Production			
/orksheet									
Subcategory: 2.8.9.a - By-product	Fluorochemical Production	ther Ruomated Compounds							1990
F-Gases Manager									
F-Gases Manager			Equation 3.41						
F-Gases Manager Subdivision	Principal Fluorinated Compound Produced	Gas emitted	Equation 3.41 Amount of Principal Fluorinated Compound Produced (kg)	Emission Factor (kg by-product gas emitted/kg F-compound produced)	Emissions (kg)	Emissions (Gg)		_	
Subdivision			Amount of Principal Fluorinated Compound Produced	(kg by-product gas emitted/kg F-compound					
Subdivision	Compound Produced		Amount of Principal Fluorinated Compound Produced (kg)	(kg by-product gas emitted/kg F-compound produced)	(kg)	(Gg)	3		

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 <u>Column | Subdivision |</u>, in data in worksheet **Other Fluorinated Compounds,** row by row, as follows:

1. <u>Column |EFk</u>|: select from the drop-down menu the IPCC default EF, otherwise input a user-specific value, in kg of by-product gas emitted per kg of principal gas produced.

Example: Tier 1 EFs – other fluorinated compounds

		ass emission of HFC-23 - Tier 3b (2/2) HFC-	23 emissions from HCFC+2	22 production (Monitoring method)	- rier 30(1/2) HFC-23 t		LITOUDU		CI 2
FC-23 Emissions from individual pr	ocess streams (Direct method) - Tie	er 3a Other Fluorinated Compounds (Proxy r	method) - Tier 3 (1/2) Ot	her Fluorinated Compounds (Prox	ky method) - Tier 3 (2/2)	Capture and storage or o	ther red	uction	
FC-23 emissions from HCFC-22 pr	oduction (Monitoring method) - Tier	3c (2/2) Other Fluorinated Compounds O	ther Fluorinated Compound	Is (Direct method) - Tier 3 HFC	-23 Emissions from HCFC-	22 Production			
rksheet									
ctor: Industrial Processe	es and Product Use								19
egory: Chemical Industry	- Fluorochemical Production								
category: 2.8.9.a - By-produc									
et: By-product and Fu	gitive Emissions from Production of C	ther Fluorinated Compounds							
ta									
F-Gases Manager									
			AND THE REPORT OF THE PARTY OF						
		2	Equation 3.41						
			Amount of Principal	Emission Factor			1	_	_
Subdivision	Principal Fluorinated	Gas emitted	Amount of Principal Fluorinated Compound	(kg by-product gas	Emissions	Emissions			-
Subdivision	Principal Fluorinated Compound Produced	Gas emitted	Amount of Principal		Emissions (kg)	Emissions (Gg)			
			Amount of Principal Fluorinated Compound Produced	(kg by-product gas emitted/kg F-compound					
	Compound Produced		Amount of Principal Fluorinated Compound Produced (kg)	(kg by-product gas emitted/kg F-compound produced)	(kg)	(Gg) Ek / 1000000	5 7		2 ×
	Compound Produced △▽ △ ▽	7	Amount of Principal Fluorinated Compound Produced (kg) 7 Pk	(kg by-product gas emitted/kg F-compound produced) EFk 0.005 ▼	(kg) Ek = Pk * EFk	(Gg) Ek / 1000000	and the second division of the local divisio	-	2 ×
	Compound Produced △▽ △ ▽	PFC-14 (CF4)	Amount of Principal Fluorinated Compound Produced (kg) 7 Pk 100000000	(kg by-product gas emitted/kg F-compound produced) EFk 0005	(kg) Ek = Pk * EFk 500000	(Gg) Ek / 1000000 0.	actor		? ×
	Compound Produced	7 FFC-14 (CF4) HFC-23 (CHF3)	Amount of Principal Fluorinated Compound Produced (kg) 7 Pk 100000000 1000	(kg by-product gas emitted/kg F-compound produced) EFk 0005	(kg) Ek = Pk * EFk 500000	(Gg) Ek / 1000000 0. Emission Fa	actor		? ×

Direct Measurement

Tier 3a Direct method

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

- 1. <u>Column |j|:</u> input a name for individual process stream.
- 2. <u>Column |Measurement campaign|:</u> for each subdivision/process stream input the name or dates of the measurement campaign(s).
- 3. <u>Column |Cij|</u>: 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. <u>Column |f_{ij}|:</u> For each subdivision/process stream/measurement campaign input the flow rate of the gas, in kg of gas stream/ hour.
- 5. <u>Column |t|</u>: For each subdivision/process stream/measurement campaign enter the length of time in hours, these parameters are measured.

<u>Note that</u> 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**

FC-23 - Emission Factor per 'unit							Tier 3c (1/2) HFC-23 Emissions f			r2
							method) - Tier 3 (2/2) Capture an		ction	
ategory: Chemical Industr abcategory: 2.8.9.a - By-proc heet: Other FC Emission lata	ises and Product Use y - Fluorochemical Production	eams (Direct method) - Tier 3		s Uther Fluorinated	Compounds (Linect m	HFC-2	3 Emissions from HCFC-22 Producti	ion		19
as HFC-23 (CHF3)	~	F-Gases Manager								
				Equation 3.34, 3						
Subdivision (facility)	Individual process stream	Measurement campaign (e.g. date)	FC concentration in the gas stream actually vented from process stream j at facility i (kg FC / 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)		ieous' FC emissions (kg)	'Instantaneous' FC emissions (Gg)		
	7 j AV	∧∆					Eijaverage = AVG(Eijt)	Eijaverage / 1000000		
	#456	Jan-December	0.9	34	5000	153000	30.6	0.00003	2	
East	1400				5000	87500	17.5	0.00000	2 5	1 7
East North	Northern	Jan - December	0.7	25	5000	0/00/6	17.5	0.00002		a /
		Jan - December	0.7	25	5000	8/500		0.00002	3	1

Tier 3b Proxy method

For each subdivision in <u>Column |i| (Tier 3 requires plant- or facility- specific input)</u>, data are entered in worksheet **Other Fluorinated Compounds (Proxy method) – Tier 3 (1/2)**, row by row, as follows:

- 1. <u>Column |j|</u> enter a name for the individual vent stream.
- 2. <u>Column |T|:</u> for each subdivision (plant)/vent stream, input the name or date of the trial campaign(s).
- 3. <u>Column |days, ij|</u>: 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 <u>Column |Sij|</u> is weighted based on the length of each trial campaign.
- 4. <u>Column |CT_{ij}|</u>: 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. <u>Column $|fT_{ij}|$:</u> for each subdivision/vent stream/trial campaign, input the average mass flow rate of the vent stream, in kg of vent stream/hour.
- 6. <u>Column | PORT_{ij} |</u>: for each subdivision/vent stream/trial campaign, input the proxy quantity (e.g. operating rate) in units per hour.

<u>Note that</u> 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. <u>Column $|F_{ij}|$ </u> input a dimensionless factor relating the measured standard mass emission rate to the emission rate at the actual plant operating rate.

<u>Note that</u> 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. <u>Column |POR_{ij}|:</u> input the current process operating rate applicable to that vent stream, j, averaged over the time period, t, in 'unit/hour'.

<u>Note that</u> 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. <u>Column |t|</u>: input the time, in hours, of actual venting for the year, or the period if the process is not operated continuously.

<u>Note</u> 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. <u>Column |Rij|</u>: 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. <u>Column |CH|</u>: 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. <u>Column |A|:</u> this column is not applicable for this source category.
- 3. <u>Column |SRC|</u>: input any identifying information for the source, if applicable.
- 4. <u>Column |B|:</u> collect and input information on any other long-term reduction of fluorinated GHGs emitted, in tonnes.

Example: capture and storage or other reduction

	unit of proxy	quantity - Tier 3b (1/2)	Mass emissio	n of HFC-23 - Tier 3b (2/2)	HEC-23 em	issions from HCEC-22 produ	ction (Monitoring method) - Tier 3c (1/2) HEC-2	3 Emissions from HCFC-22 P	roductio	n - Tier	2
and the second				Other Fluorinated Compounds			and the second se					
				er Fluorinated Compounds (P					Capture and storage or othe	r raduo	tion	
ksheet	ual process s	treams (Direct method)- Hersa Oth	er Fluorinated Compounds (F	roxy method	a) - Her 3 (1/2) Other Pluc	orinated Compounds (Pro	xy method) - Tier 3 (2/2)	Capture and storage of othe	Teuuc		
tegory: Chemical In bcategory: 2.8.9.a - By-	product emiss storage or oth	ions ner reduction	F-Gases Manage	er 📄								199
		Type of Fluorinate produc		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)		. 40	
						Honney						
Subdivision S	۵V	СН	ΔŢ	SRC	۵V	A	B	C = A + B	C / 1000			
	۵V	CH Unspecified	ΔV	SRC Stream #1121	∆ ⊽ ∨		В	C = A + B	C / 1000	3		?)
S	۵V		∆ ⊽				В	C = A + B		3		"
S	ΔŸ						B	C=A+B				"

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, SF₆ and NF₃ 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 byproduct 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 <u>footnote 2</u> 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
			Χ	X	Χ	Χ

IPCC Equations

- \checkmark <u>Tier 1: Equation 3.41</u>
- ✓ <u>Tier 2</u>: no IPCC Tier 2 Equation provided in the 2006 IPCC Guidelines
- ✓ <u>Tier 3</u>: 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

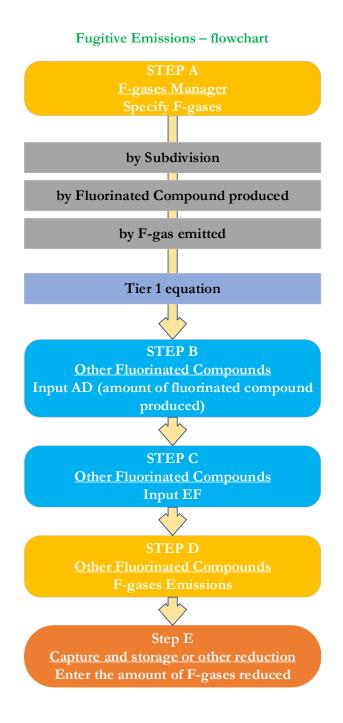
GHG emissions from the Fugitive emissions source category are estimated using the following worksheets:

- ✓ 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.



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.

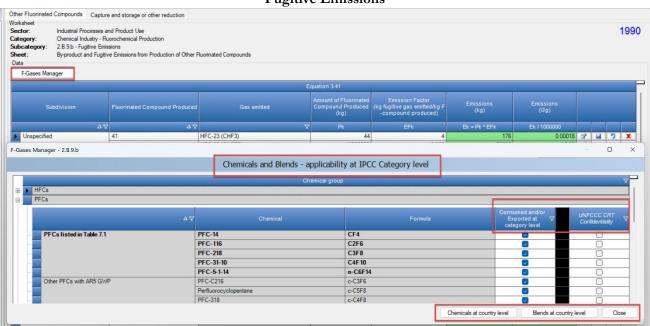
Activity Data Input

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.

<u>Note that</u> 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 <u>above</u>.

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, SF₆ or NF₃, 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 <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)

2006 IPCC Categories + 4	Other Fluorinated Compounds	Capture and storage or other reduction								
2.8.5 - Carbide Production 2.8.6 - Titanium Dioxide Productio 2.8.7 - Soda Ash Production 2.8.8 - Netrochemical and Carbon 2.8.8 - Methanol 2.8.8 - Ethylene 2.8.8 - Ethylene	Category: Chemical Indu Subcategory: 2.8.9.b - Fugi	cesses and Product Use ustry - Ruorochemical Production twe Emissions nd Fugitive Emissions from Production of Other I	Ruorinated Compounds						199	
-2.B.8.d - Ethylene Oxide -2.B.8.e - Acrylonitrile	Equation 3.41									
2.8.8.f - Carbon Black 2.8.8.x - Other petrochemical 2.8.9 - Fluorochemical Production 2.8.9.a - By-product emissions	Subdivision	Fluorinated Compound Produced		Amount of Fluorinated Compound Produced (kg)	Emission Factor (kg fugitive gas emitted/kg F -compound produced)	Emissions (kg)	Emissions (Gg)			
2.B.9.b - Fugitive Emissions		2 44	7	7 Pk	EFk	Ek = Pk * EFk	Ek / 1000000			
- 2.B.10 - Hydrogen Production	Unspecified	SF6	HFC-23 (CHF3)	44	4	176	0.00018	3		
2.B.11 - Other (Please specify)		HFC-152a	HFC-134a (CH2FCF3)	1000000	0.005	50000	0.05	3		
C - Metal Industry		HFC-134a	HFC-32 (CH2F2)	1000000	0.005	50000	0.05	3		
2.C.1 - Iron and Steel Production			HFC-41 (CH3F)	10000000	0.005	50000	0.05	3		
- 2.C.2 - Ferroalloys Production			HFC-43-10mee (CF3CHFCHFCF2CF3)	10000000	0.005	50000	0.05	3 1	7 X	
- 2.C.3 - Aluminium production			HFC-134 (CHF2CHF2)	1000000	0.005	50000	0.05	3		

Example: multiple subdivisions

B.5 - Carbide Production B.6 - Titanium Dioxide Productio B.7 - Soda Ash Production B.8 - Petrochemical and Carbon 2.8.8.a - Methanol 2.8.8.a - Ethylene	Subcategory: 2.B.9.b - Fugitive E	Fluorochemical Production	Ruorinated Compounds						199
B.8.c - Ethylene Dichloride a B.8.d - Ethylene Oxide	F-Gases Manager								
B.8.e - Acrylonitrile				quation 3.41					
2.8.8.f - Carbon Black 2.8.8.x - Other petrochemical 2.8.9 - Fluorochemical Production 2.8.9.a - By-product emissions	Subdivision	Fluorinated Compound Produced		Amount of Fluorinated Compound Produced (kg)	Emission Factor (kg fugitive gas emitted/kg F -compound produced)	Emissions (kg)	Emissions (Gg)		
B.9.b - Fugitive Emissions	1	V V V			EFk	Ek = Pk * EFk	Ek / 1000000		
- Hydrogen Production	South	SF6	HFC-23 (CHF3)	44	4	176	0.00018		
- Other (Please specify)	North	HFC-152a	HFC-134a (CH2FCF3)	1000000	0.005	50000	0.05	3	
I Industry	Rest of Country	HFC-134a	HFC-32 (CH2F2)	10000000	0.005	50000	0.05	3	
- Iron and Steel Production			HFC-134 (CHF2CHF2)	1000000	0.005	50000	0.05		

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

- 1. <u>Column | Fluorinated compound produced |:</u> Select from the dropdown menu one of the primary identified fluorinated compounds (HFC-134a, SF₆ or NF₃) or directly input the fluorinated compound produced.
- 2. <u>Column | Gas emitted |:</u> select from the drop-down menu, the gas emitted. <u>Note that</u> the selection of gases in the drop-down menu will be consistent with those selected in the IPCC Category level F-Gases Manager.
- 3. <u>Column | Pk |</u>: 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 <u>Column |Subdivision|</u>, input data in worksheet **Other Fluorinated Compounds,** row by row, as follows:

1. <u>Column |EFk</u>|: select from the drop-down menu the IPCC default EF, otherwise input a user-specific value, in kg of fugitive gas emitted/kg of principal gas produced.

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



Results

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

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

In the worksheet Capture and storage or other reduction, for each subdivision and each F-gas:

- 1. <u>Column |CH|</u>: 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. <u>Column |SRC|</u>: input any identifying information for the source, if applicable.
- 3. <u>Column | A |:</u> this column is not applicable for this source category.
- 4. <u>Column |B|:</u> collect and input information on any other long-term reduction of fluorinated GHGs emitted, in tonnes.

Example: capture and storage or other reduction

Cast	re and a	torage or other reduction											
er Fluorinated Compounds Capt ksheet	ure and s	torage or other reduction											
ctor: Industrial Processes	and Proc	uct Line											199
egory: Chemical Industry	dina i roc												100
category: 2.8.9.b - Fugitive E	nissions												
et: Capture and storage		reduction											
		Cuuchon											
a													
as HFC-245ca (CH2FCF2CHF2	0	v FG	ases Manager	r									
ta	0	∀ FG	ases Manager	r									
ta)	~ FG	ases Manage	r	_			1					
ata HFC-245ca (CH2FCF2CHF2)	V FG	-		_	Amount CO2 captured	Other reduction	Total reduction		Total reduction			
ta)		-	r Source		and stored	Other reduction (tonne)	Total reduction (tonne)		Total reduction (Gg)			_
ta HFC-245ca (CH2FCF2CHF2		Type of Fluorinated Co	-	Source	ΔV	and stored (tonne)							
ta BB HFC-245ca (CH2FCF2CHF2 Subdivision S	Δ∇	Type of Fluorinated Co produced CH	mpound	Source SRC	۵⊽	and stored (tonne)	(tonne) B	(tonne) C = A + B		(Gg) C / 1000		7	2
ta as HFC-245ca (CH2FCF2CHF2	Δ∇	Type of Fluorinated Co produced	mpound	Source	۵۷	and stored (tonne)	(tonne)	(tonne) C = A + B	25	(Gg) C / 1000	0.025	3	 2

2.B.10 Hydrogen Production

Information

Section 3.11 in Chapter 3, Volume 3 of the 2019 IPCC Guidelines provides three Tiers to estimate CO₂ 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 CO₂ 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 CO₂. 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 CO₂ only.

As for CH₄ and N₂O emissions, steam reforming and gasification produce very minor emissions of CH₄ and N₂O, in addition to CO₂ emissions. The available literature indicates that emissions of CH₄ and N₂O 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 CH₄ and N₂O 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 ₂ O	HFCs	PFCs	SF ₆	NF ₃
X	Χ	Χ				

IPCC Equations

 $\underline{CO_2}$

- ✓ <u>Tier 1</u>: <u>Equations 3.44 (New), 3.45 (New) and 3.46 (New)</u>
- ✓ <u>Tier 2</u>: <u>Equations 3.47 (New) and 3.48 (New)</u>
- ✓ Tier 3: Equations 3.49 (New) and 3.50 (New)

CH₄ and N₂O

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.

- ✓ <u>Tier 1</u>: no IPCC Tier 1 Equation provided in the 2006 IPCC Guidelines
- ✓ Tier 2: IPCC basic equation with user-specific EF
- ✓ <u>Tier 3</u>: 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.
- ✓ CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b): contains for each subdivision, individual type of process and feedstock, information on the <u>amount of hydrogen produced</u> and feedstock requirement (with carbon content) and amount of CO₂ recovered. The worksheet calculates the associated CO₂ emissions.

¹ See page. 3.35 of Chapter 3 Volume 3 of the 2019 Refinement.

- ✓ CO₂ Emissions from Hydrogen Production (Tier 1c/2c): contains for each subdivision, individual type of process (if known) and type of feedstock information on the <u>amount of feedstock</u> used (with carbon content) and amount of CO₂ recovered. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ recovered, and solid C stored. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ Emissions from Hydrogen Production (Tier 3c): contains for each subdivision, individual type of process and type of feedstock information on the <u>amount of feedstock</u> used (with plant-specific carbon content) and amount of CO₂ recovered and solid C stored. The worksheet calculates the associated CO₂ emissions.
- ✓ CH₄ and N₂O Emissions from Hydrogen Production: contains for each subdivision and production process information on AD (type and amount) and EF for CH₄ and N₂O. The worksheet calculates the associated CH₄ and N₂O emissions.
- ✓ Capture and storage or other reduction: contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, N₂O and CH₄, not accounted previously in the worksheets for different Tiers.

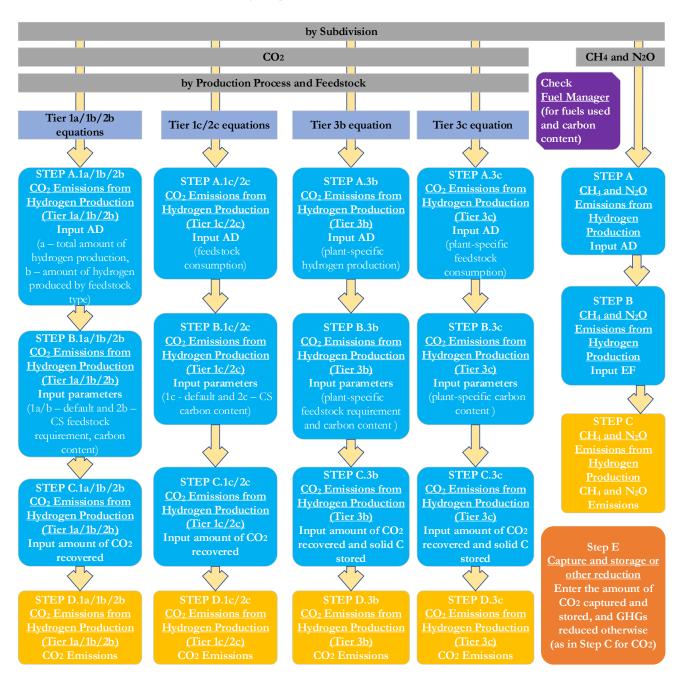
User's Work Flowchart

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-specific¹ 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 CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b) and/or CO₂ 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 CO₂ recovered (if no information available it is good practice to assume 0 recovery).

Step D.1a, D.1b and D.1c, in worksheet **CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b)** and/or **CO₂ Emissions from Hydrogen Production (Tier 1c/2c),** for each subdivision, CO₂ emissions are calculated in mass units (tonnes and/or Gg). In addition, total CO₂ 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 CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b) and/or CO₂ 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 CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b) and/or CO₂ Emissions from Hydrogen Production (Tier 1c/2c), users input in the *Software* information on CO₂ recovered.

Step D.2b and D.2c, in worksheet CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b) and/or CO₂ Emissions from Hydrogen Production (Tier 1c/2c), for each subdivision, type of production process and type of feedstock, CO₂ emissions are calculated in mass units (tonnes and/or Gg). In addition, total CO₂ emissions are calculated.

When the Tier 3 Equation is applied:

Step A.3b and A.3c, in worksheet CO₂ Emissions from Hydrogen Production (Tier 3b) and CO₂ 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 CO₂ Emissions from Hydrogen Production (Tier 3b) and/or CO₂ 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 CO₂ Emissions from Hydrogen Production (Tier 3) and/or CO₂ Emissions from Hydrogen Production (Tier 3c), users input in the *Software* information on CO₂ recovered and the amount of solid carbon stored.

Step D.3b and D.3c, in worksheet CO₂ Emissions from Hydrogen Production (Tier 3b) and/or CO₂ Emissions from Hydrogen Production (Tier 3c), for each subdivision, type of production process and type of feedstock, CO₂ emissions are calculated in mass units (tonnes and/or Gg). In addition, total CO₂ emissions are calculated.

Then as appropriate:

i) if emissions of CH_4 and N_2O are estimated

Step A, in worksheet CH₄ and N₂O Emissions from Hydrogen Production, users collect and input in the *Software* information on AD relevant for CH₄ and N₂O emissions.

Step B, in worksheet CH₄ and N₂O Emissions from Hydrogen Production, users collect and input in the *Software* information on EFs relevant for CH₄ and N₂O 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 CO₂

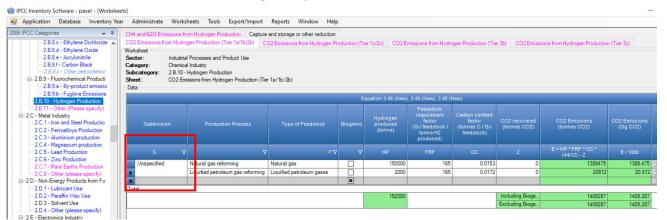
Step E, in the worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO_2 captured (with subsequent storage) and other reduction of CO_2 (e.g., re-conversion to carbonates) and reduction of CH_4 and N_2O .

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

IPCC Inventory Software - pavel - [Worksheets] 🛃 Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help Capture and storage or other reduction 2.B.8.c - Ethylene Dichloride CO2 Emissions from Hydrogen Production (Tier 3b) CO2 Emissions from Hydrogen Production (Tier 3c) 2.B.8.d - Ethylene Oxide 2.B.8.e - Acrylonitrile Industrial Processes and Product Use 2.B.8.f - Carbon Black Categ Chemical Industry 2.B.10 - Hydrogen Product 2.B.9 - Fluorochemical Product She CO2 Er om Hydrogen Production (Tier 1a/1b/2b) 2.B.9.a - By-pro Data al Industry 2 - Ferroalloys Product - Magnesium produ - Lead Production 2.C.6 - Zinc Production Rare Earths Pr Natural gas ural cas reforming 150000 165 138847 1388.47 - Other (please spec -Energy Products fro Liquified pet 2000 165 0.0173 20812 20.81 2.D.1 - Lubricant Use 2.D.2 - Paraffin Wax Use 2.D.3 - Solvent Use 2.D.4 - Other (please spe - Electronics Industry 15300

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:

- ✓ <u>Tier 1a:</u> requires total national production of hydrogen.
- \checkmark <u>Tier 1b/2b</u>: requires total national production, by type of feedstock.
- \checkmark <u>Tier 1c/2c</u>: 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 <u>Column |Subdivision|</u>, data are entered in worksheet **CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b)**, row by row, as follows:

- 1. <u>Column | Production process |</u>: 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. <u>Column |Type of feedstock</u>]: 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. <u>Column | Biogenic |</u>: indicate with a check if the process feedstock is of biogenic origin.
- 4. <u>Column |HP|</u>: input the amount of hydrogen produced, in tonnes.

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

ksheet ctor: tegory: bcategory: eet: ta	Chemical I 2.B.10 - H	Processes and Product Use ndustry ydrogen Production ions from Hydrogen Produ										19	99
				Eq	uation 3.46 (New), 3.45 (New), 3.4	8 (New)						
Subdivis	ion	Production Process	Type of Feedstock	Biogeni c	Hydrogen produced (tonne)	Feedstock requirement factor (GJ feedstock / tonne H2 prod	Carbon content factor (tonnes C / GJ feedstock)	CO2 recovered (tonnes CO2)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
	ΔŢ	۵Ţ	۵Ţ	V		FRF			E = HP * FRF * CC * (44/12) - Z	E / 1000			
Unspecified		Default	Unspecified		2000	175	0.0183	0	23485	23.485	2		
		Natural gas reforming	Natural gas		1000	165	0.0153	0	9256.5	9.2565	2		2

For the Tier 1c and Tier 2c methods: for each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO₂ Emissions from Hydrogen Production (Tier 1c/2c)**, row by row, as follows:

1. <u>Column |Type of feedstock</u>]: 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. <u>Column | Biogenic |</u>: indicate with a check if the process feedstock is of biogenic origin.
- 3. <u>Column |FC|</u>: input the amount of feedstock consumed, in GJ.

IPCC Inventory Software - pavel - [Worksheets] Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help **—** A 2.B.8.c - Ethylene Dichlor 2.B.8.d - Ethylene Oxide Worksheet Sector: Category Subcateg Industrial Processes and Product Use 2.B.8.e - Acrylonitrile 2.B.8.f - Carbon Black Chemical Industry 2.B.10 - Hydrogen Production CO2 Emissions from Hydrogen 2.B.9 - Fluorochemical Product 2.B.9.a - By-product emiss 2.B.9.b - Fugitive Emission Production (Tier 1c/2c CO2 En CO2 Emissions (tonnes CO2) ral Gas (Drv) -Energy Products from Fu

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 3b)**.

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 <u>Table 3.30 (New)</u>.

The Tier 1 assumes default parameters and no capture of CO₂. 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 CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b), row by row, as follows.

- 1. <u>Column | FRF|</u>: input feedstock requirement in GJ feedstock per tonne of hydrogen produced.
- 2. <u>Column |CC|</u>: 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 <u>Column |Production Process|</u> (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)

IPCC Categories 🗸 🗸	CH4 and N2O Emissions	from Hydrogen Production	Capture and storage of	or other reducti	ion						
−2.8.8.c - Ethylene Dichloride −2.8.8.c - Ethylene Oxide −2.8.8.e - Acrylonithile −2.8.8.f - Carbon Black −2.8.8.x - Other petrochemic ⊂2.8.9.x - Other petrochemic ⊂2.8.9.x - Uther petrochemic	Worksheet Sector: Indust Category: Chemi Subcategory: 2.8.10	Irogen Production (Tier 1a/1b/ rial Processes and Product Use cal Industry 0 - Hydrogen Production missions from Hydrogen Produc		from Hydroge	n Production (Tier 1c	/2c) CO2 En	tissions	from Hydrogen Pro	duction (Tier 3b) C	O2 Emissions from Hydrogen Production	n (Tier 3c)
2.B.9.a - By-product emissio 2.B.9.b - Fugitive Emissions	Data										
2.B.10 - Hydrogen Production					Equat	ion 3.46 (New),	3.45 (N	ew), 3.48 (New)			
2.B.11 - Other (Please specify) 2.C - Metal Industry 2.C.1 - Iron and Steel Productio 2.C.2 - Ferroalloys Production	Subdivision			Biogenic	Hydrogen produced (tonne)	Feedstock equirement fa (GJ feedstoc inne H2 produ	ctor k /	Carbon content factor (tonnes C / GJ feedstock)	O2 recovered tonnes CO2)	CO2 Emissions (tonnes CO2)	CO2 Emission (Gg CO2)
- 2.C.3 - Aluminium production	S AV			7 7	HP	FRF		CC	Z	E = HP * FRF * CC * (44/12) - Z	E/1000
- 2.C.4 - Magnesium production - 2.C.5 - Lead Production	East Region	Default	Unspecified		1000		175	0.0183	0	11742.5	11.7
- 2.C.6 - Zinc Production	West Region	Naphtha reforming	Naphtha		2000		160	0.022	0	25813.33333	25.81
- 2.C.7 - Rare Earths Production		Natural gas reforming	Natural gas		150000		170	0.015	0	1402500	14
2.C.8 - Other (please specify) 2.D - Non-Energy Products from Fu	* Total	Produc on P	rov ess		Type of Feedstock	B	iogenic	Feedstock re (GJ feedstock /	equirement factor tonne H2 produced)	Carbon content factor (tonnes C / GJ feedstock)	
- 2.D.1 - Lubricant Use	Total	Default		Unspecified					175 (± 30%		1440.05
2.D.2 - Paraffin Wax Use		Natural gas reformin		Natural gas					165 (± 10%	0.0153 (0.0148 - 0.0159) 142 2.5	1414.3
2.D.3 - Solvent Use 2.D.4 - Other (please specify)		Liquified petroleum gas refe	orming	Liquified petr	oleum gases				165 (± 15%	0.0172 (0.0168 - 0.0179)	
2.E - Electronics Industry		Naphtha reforming		Naphtha					165 (± 15%	0.0200 (0.0189 - 0.0208)	
- 2.E.1 - Integrated Circuit or Sem		Methanol reforming		Methanol					165 (± 20%	0.0188 (0.0186 - 0.0190)	
- 2.E.2 - TFT Flat Panel Display		Biosteam reforming, other I	quid	Bioethanol					175 (± 20%	0.0217 (0.0183 - 0.0260)	
2.E.3 - Photovoltaics		Coal gasification		Coking Coal					215 (± 20%	0.0258 (0.0238 - 0.0276)	
2.E.4 - Heat Transfer Fluid		Plastic gasification		Other Petrole	eum Products				185 (± 10%	0.0200 (0.0160 - 0.0240)	
>		Mixed waste gasification (n	on-biomass fraction)	Municipal Wa	astes (non-biomass	fraction)			275 (± 15%) 0.0250 (0.0200 - 0.0330)	
heet notes 🗸 🗸 🖡		Wood waste gasification		Wood / Wood	Waste				260 (± 10%	0.0305 (0.0259 - 0.0360)	
		Wood sludge gasification		Wood sludge					195 (± 15%) 0.0305 (0.0259 - 0.0360)	
		Black liquor gasification		Sulphite hung	(black liquor)			1	150 (± 10%	0.0260 (0.0220 - 0.0300) rcet ainti	es Ti

For the Tier 1c/2c methods: for each combination of subdivision/production process/type of feedstock, data are input in worksheet CO₂ Emissions from Hydrogen Production (Tier 1c/2c), row by row, as follows.

1. <u>Column |CC|</u>: input carbon content of feedstock in tonnes of C per GJ of feedstock. This value is automatically populated based on the selection made in <u>Column |Type of Feedstock|</u> (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 CO₂ Emissions from Hydrogen Production (Tier 3b), row by row, as follows.

- 1. <u>Column |FRF|</u>: input plant-specific feedstock requirement in GJ feedstock per tonne of hydrogen produced.
- <u>Column |CC|</u>: 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.
 <u>Note that</u> 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 CO₂ Emissions from Hydrogen Production (Tier 3c), row by row, as follows.

1. <u>Column |CC|</u>: input carbon content of feedstock in tonnes of C per GJ of feedstock. This value is automatically populated based on the selection made in <u>Column |Type of Feedstock|</u>. <u>Note that</u> 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

Application Database Inventory Ye	ar Administrate Works	heets Tools Export/Imp	port Reports Window	Help							
6 IPCC Categories 🚽 🤻	CH4 and N2O Emissions fro	om Hydrogen Production Ca	apture and storage or other rec	luction							
2.B.8.c - Ethylene Dichloride	CO2 Emissions from Hydro	gen Production (Tier 1a/1b/2b)	CO2 Emissions from Hydr	ogen Produc	tion (Tier 1c/2c) C	O2 Emissions from H	lydroge	en Productio	n (Tier 3b) CO2	Emissions from Hydrogen Productio	n (Tier 3c)
2.B.8.d - Ethylene Oxide	Worksheet										
2.B.8.e - Acrylonitrile		Processes and Product Use									
- 2.B.8.f - Carbon Black - 2.B.8.x - Other petrochemic	Category: Chemica Subcategory: 2.B.10 -	l Industry Hydrogen Production									
= 2.B.9 - Fluorochemical Producti		ssions from Hydrogen Productio	on (Tier 3c)								
2.B.9.a - By-product emissio	Data	salona nom nydrogen i roddodo	an (ner se)								
2.B.9.b - Fugitive Emissions					-	ation 3.49 (New)					
- 2.B.10 - Hydrogen Production					Equ	lation 3.49 (New)	_				
L-2.B.11 - Other (Please specify)						arbon content					
2.C - Metal Industry	Subdivision	Production Process	Type of Feedstock	Biogenic	Feedstock			ecovered	Stored solid		
- 2.C - Metal Industry - 2.C.1 - Iron and Steel Productio	Subdivision				Feedstock Consumption (GJ)	factor tonnes C / GJ		ecovered es CO2)	Stored solid carbon (tonnes)	CO2 Emissions (tonnes CO2)	
2.C - Metal Industry	Subdivision				Consumption	factor			carbon		CO2 Emissic (Gg CO2)
2.C - Metal Industry 2.C.1 - Iron and Steel Productio 2.C.2 - Ferroalloys Production 2.C.3 - Aluminium production 2.C.4 - Magnesium production					Consumption (GJ)	factor tonnes C / GJ feedstock)			carbon (tonnes)		(Gg CO2)
- 2.C - Metal Industry - 2.C.1 - Iron and Steel Productio - 2.C.2 - Ferroalloys Production - 2.C.3 - Aluminium production - 2.C.4 - Magnesium production - 2.C.5 - Lead Production	s		7 47		Consumption (GJ) FC	factor tonnes C / GJ feedstock) CC			carbon (tonnes) Sc	(tonnes CO2) E = (FC * CC * (44/12)) - (Z + Sc * (44/12))	(Gg CO2) E / 1000
					Consumption (GJ)	factor tonnes C / GJ feedstock)			carbon (tonnes)	(tonnes CO2) E = (FC * CC * (44/12)) - (Z + Sc * (44/12))	(Gg CO2) E / 1000
→ 2 C - Metal Industry 2.C.1 - Iron and Steel Production 2.C.2 - Ferroalloys Production 2.C.3 - Atuminium production 2.C.4 - Magnesium production 2.C.5 - Lead Production 2.C.5 - Lead Production 2.C.7 - Marc Earths Production 	S Unspecified		7 47		Consumption (GJ) FC	factor tonnes C / GJ feedstock) CC		es CO2) Z	carbon (tonnes) Sc	(tonnes CO2) E = (FC * CC * (44/12)) - (Z + Sc * (44/12))	(Gg CO2 E / 1000
	s		7 47		Consumption (GJ) FC	factor tonnes C / GJ feedstock) CC		es CO2) Z	carbon (tonnes) Sc	(tonnes CO2) E = (FC * CC * (44/12)) - (Z + Sc * (44/12))	(Gg CO2 E / 1000 0.5

CH4 and N2O 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 <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>.

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

- 1. <u>Column | Production Process |</u>: describe the type of production process emitting GHG emissions from this category (e.g. consider those identified for estimating CO₂ emissions).
- 2. <u>Column |AT|</u>: input the activity type corresponding to the production process identified.
- 3. Column |AD|: input AD (quantity), in tonnes.

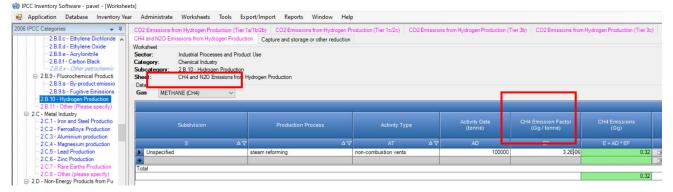
Emission Factor Input

For each row of data entered in worksheet CH₄ and N₂O Emissions from Hydrogen Production, data are input as follows:

1. <u>Column |EF|: input CH₄ or N₂O EF;</u>

<u>Note that</u> user shall select "Methane (CH₄)" or "Nitrous Oxide (N₂O)" in the "Gas" bar at the top, to enter data for each GHG one by one.

Example: CH₄ emissions from Hydrogen Production



Results

The Tier 1/2 and Tier 3 worksheets all include the possibility to account for CO₂ 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 CO₂ emitted into the atmosphere, the amount of CO₂ released from that subdivision that has been instead recovered is to be entered in Gg CO₂ in <u>Column |Z|</u> of the following worksheets:

- ✓ CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 1c/2c)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 3b)
- ✓ CO₂ 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 <u>Column |Sc|</u> of the following worksheets:

- \checkmark CO₂ Emissions from Hydrogen Production (Tier 3b)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 3c)

Example: carbon recovered and solid carbon stored for Tier 3 for Hydrogen Production



Then, CO₂ 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:

- ✓ CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 1c/2c)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 1a/1b/2b)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 1c/2c)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 3b)
- ✓ CO₂ Emissions from Hydrogen Production (Tier 3c)

CH₄ and N₂O Emissions from Hydrogen Production are estimated in Gg by the *Software* in the following worksheet CH₄ and N₂O 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. Column |A| collect and input information on the amount of CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|</u>: collect and input information on other long-term reduction of CO₂ (e.g., re-conversion to carbonates), in tonnes. <u>Column |B|</u> may include short-term CO₂ capture only in cases where the subsequent CO₂ 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.

2 Emissions from Hydrogen Produ	ction (Tier 3c) CH4 a	and N2O Emissions from Hydro	en Producti	ion Capture and storage or o	ther reduction CO2 Emissio	ons from Hydrogen Production (Tier 1a/1b/2b)
ksheet	calon (moreos) - orne				COL LINGON		(interference)
tegory: Chemical Industry bcategory: 2.B.10 - Hydrogen eet: Capture and storag	es and Product Use Production ge or other reduction						
AS METHANE (CH4)	`	<u>~</u>					
CARBON DIOXIDE (CO2)							
METHANE (CH4)							· · · · · · · · · · · · · · · · · · ·
METHANE (CH4) NITROUS OXIDE (N2O) Subdivision		Source		mount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
NITROUS OXIDE (N2O)	ΔV	Source		stored			
NITROUS OXIDE (N2O) Subdivision	∆ ⊽ Unspeci	SRC		stored (tonne)	(tonne)	(tonne)	(Gg)

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:

- ✓ CH₄ and N₂O emissions from Ammonia Production
- ✓ CO₂ emissions from Adipic Acid, Caprolactam, Glyoxal and Glyoxylic Acid Production

<u>GHGs</u>

Other emissions from the chemical industry include the following GHGs:

CO ₂	CH ₄	N_2O	HFCs	PFCs	\mathbf{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.

- ✓ <u>Tier 1:</u> no IPCC Tier 1 Equation provided in the 2006 IPCC Guidelines or the 2019 Refinement
- ✓ Tier 2: IPCC basic equation with user-specific EF
- ✓ <u>Tier 3</u>: 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:

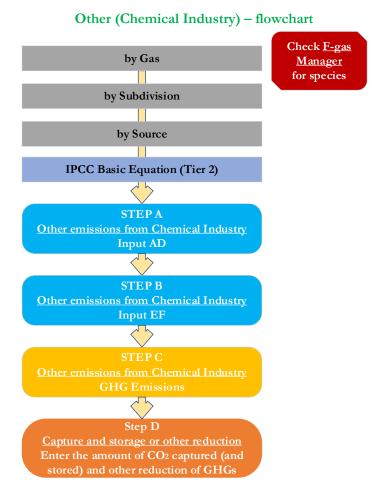
- ✓ Other: contains source, AD (type, amount and unit), and EF for each GHG, and calculates associated emissions.
- ✓ **Capture and storage or other reduction**: Capture and storage or other reduction: contains information on CO₂ capture (with subsequent storage) and other reduction of GHGs, not accounted 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-specific¹ 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.



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 <u>above</u>.

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.

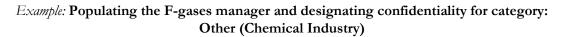
Step D, in worksheet **Capture and storage or other reduction**, if applicable for higher-tiered methods, users collect and input information on the amount of CO₂ captured (with subsequent storage) and/or other reduction of GHG.

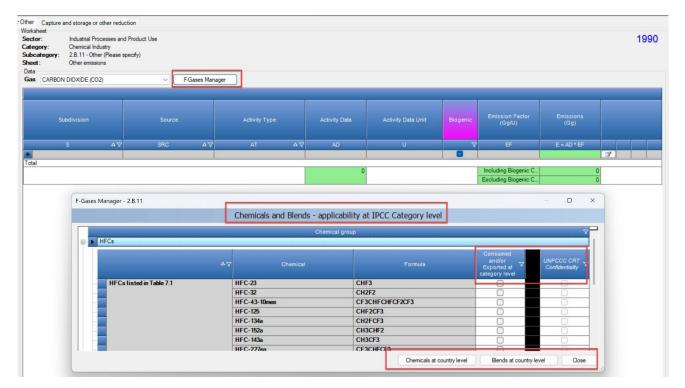
Activity Data Input

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.

<u>Note that</u> 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, 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 <u>above</u>.

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, SF6 or NF3, as appropriate.





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 <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>.

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

 <u>Column |SRC|</u>: describe the type of activity emitting GHG emissions from this category. The user may select from the drop-down (which includes pre-defined categories that are included in the UNFCCC ETF Reporting Tool (see Annex I) or enter user-specific categories. <u>Note that</u> 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

<u>Note that</u> 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. <u>Column |AT|:</u> input the activity type corresponding to the source selected.
- 3. <u>Column |AD|</u>: input AD (quantity), in units corresponding to the unit type in in <u>Column |U|</u>.
- 4. <u>Column |U|</u>: input the user-defined unit of the AD.

5. <u>Column | Biogenic |</u> (CO₂ 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. <u>Column |EF|</u>: 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. <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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other reduction of GHGs, in tonnes. <u>Column |B|</u> may include short-term CO₂ capture or reduction of other GHGs only in cases where the subsequent CO₂ 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 CO₂ for long-term storage may lead to negative CO₂ emissions.

Example: capture and storage or other reduction

Other	Capture a	nd storage or other reduc	tion							
Worksh	leet									
Secto	r:	Industrial Processes and	Product Use							
Categ	ory:	Chemical Industry								
Subca	ategory:	2.B.11 - Other (Please sp	ecify)							
Sheet	:	Capture and storage or o	ther reduction							
Data										
Gas	CARBON	DIOXIDE (CO2)	~	F-Gases Manager						
	CARBON	DIOXIDE (CO2)		-	_					
	METHAN	E (CH4)								
	NITROUS	OXIDE (N2O)				Amount CO2 captured and	Other reduction	Total reduction	Total reduction	
		Subdivision				stored (tonne)	(tonne)	(tonne)	(Gg)	Biogenic
			AV	SRC	ΔV					<u>v</u>
U	nspecified		Unspecified			1		1	0.001	
*										-
Total										
							Total:	1	0.001	
							Total Biogenic CO2:	1	0.001	

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 – massbalance 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 CH₄, 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.

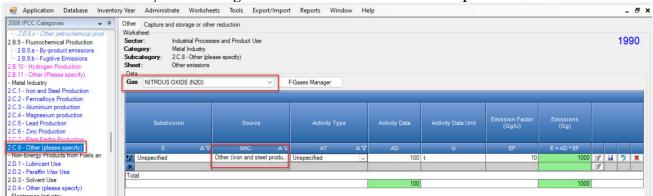
GHGs

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	Χ					

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

<u>Coke Production</u> 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 (CO₂, CH₄): Equation 4.1 or, for CO₂ only, 4.1B (New)
- $\checkmark \quad \text{Tier 2 (CO_2): Equation 4.2 (Updated)}$
- ✓ Tier 3 (CO₂, CH₄): Either measure emissions or, for CO₂ only, apply the Tier 2 equations, using plantspecific carbon contents of all materials used and produced

Iron and Steel Production (2006 IPCC Guidelines):

- \checkmark Tier 1 (CO₂): Equations 4.4, 4.5, 4.6, 4.7 and 4.8
- $\checkmark \quad \underline{\text{Tier 1 (CH_4)}}: \underline{\text{Equations 4.12, 4.13 and 4.14}}$
- ✓ <u>Tier 2 (CO₂): Equations 4.9, 4.10</u> and <u>4.11</u>
- \checkmark <u>Tier 3 (CO₂)</u>: 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 CO₂ and CH₄ 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.
- ✓ CO₂ and CH₄ emissions from Coke Production: contains for each subdivision information on the coke production process, the amount of coke produced and CO₂ and CH₄ EFs. The worksheet calculates the associated CO₂ and CH₄ emissions for Tier 1.
- ✓ CO₂ 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 CO₂ emissions.

The Software calculates emissions of CO₂ and CH₄ 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.
- ✓ CO₂ and CH₄ 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 CO₂ and CH₄ EFs. The worksheet calculates the associated CO₂ and CH₄ emissions for Tier 1.
- ✓ CO₂ 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 CO₂ emissions.
- ✓ CO₂ 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 CO₂ emissions.
- ✓ CO₂ emissions from Pellet Production Tier 2/3: contains for each subdivision information on fuel consumption and fuel carbon content. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ emissions.
- ✓ Capture and storage or other reduction contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂ and CH₄, 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-specific¹ EFs or direct measurements.

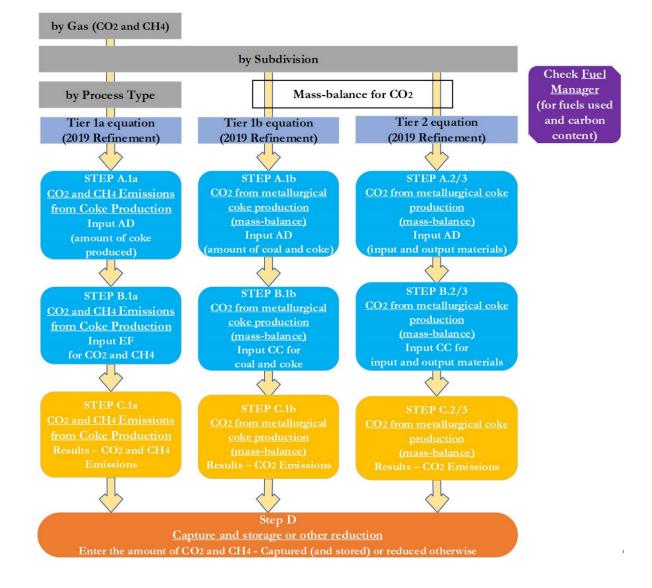
Similarly, consistent with the key category analysis and the decision trees in <u>Figure 4.7</u> for CO_2 and <u>Figure 4.8</u> for CH_4 of the 2006 IPCC Guidelines, GHG estimates are calculated for Iron and Steel Production.

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 CO₂ and CH₄ Emissions from Coke Production, users collect and input in the *Software* information on the amount of coke produced.

Step B.1a, in worksheet CO₂ and CH₄ Emissions from Coke Production users input CO₂ and CH₄ EFs.

Step C.1a in worksheet CO₂ and CH₄ 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 CO₂ 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:

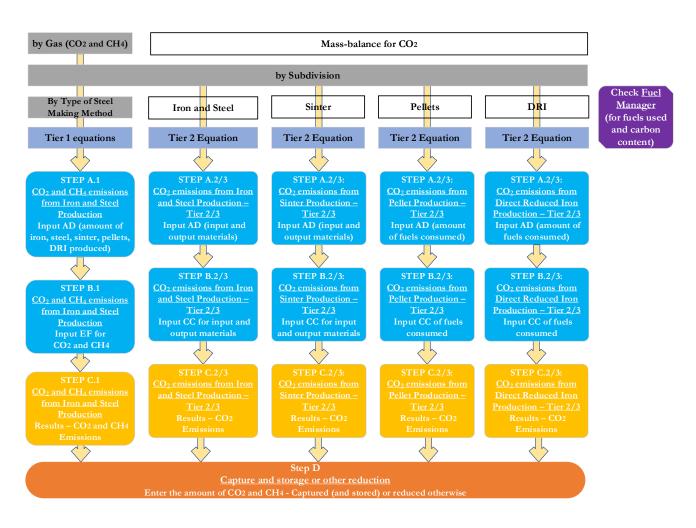
Step A.2/3, in worksheet **CO₂ Emissions from metallurgical coke production (mass balance)**, users collect and input in the *Software* information on the amount of each input and output. National statistics are appropriate for the Tier 2 method; for Tier 3 plant-level data are required.

Step B.2/3, in worksheet CO₂ 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 -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 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 CO₂ emissions from Iron and Steel Production – Tier 2/3, CO₂ emissions from Sinter Production – Tier 2/3, CO₂ emissions from Pellet Production – Tier 2/3, and CO₂ 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

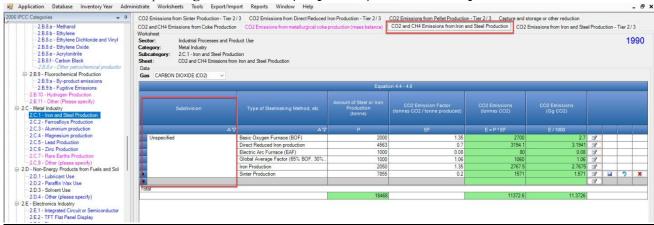
Section 4.2.2.4 in Chapter 4 Volume 3 of the 2006 IPCC Guidelines contains information on the choice of AD for Coke Production and Iron and Steel Production. The collection of the AD for this source category is challenging, particularly the overlap between emissions to be reported in the Energy Sector 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.

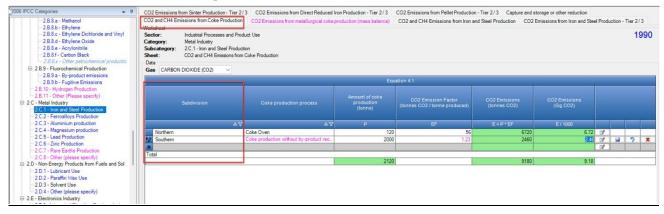
Second, input of AD for Iron and Steel Production requires the user first to enter information on the subdivisions in the country for both Coke Production and Iron and Steel Production. Users compile the calculation worksheets either with a single row of data for the entire category (in the case of Iron and Steel Production, for each steelmaking method), with its univocal name/code entered in <u>Column |Subdivision|</u> [e.g. "country name" or "Unspecified" as selected from the dropdown menu] or where subnational aggregations are input, provide the univocal name/code into <u>Column |Subdivision|</u> 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



Then, for Coke Production

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

2.B.8.e - Acrylonitrile	CO2 and CH4 Emissions from Coke Production	CO2 Emissions from metallurgical coker	production (mass balance)	CO2 and CH4 Emissions from Iron a	nd Steel Production CO2 E	Emissions from Iron and Ste	el Produc	ion - Tier	2/3
28.81 - Carbon Black 28.84 - Char perdochemical productio 28.95 - Fluorechemical Production 28.95 a - Spurroduct emissions 28.95 - Fugitive Emissions 28.95 - Fugitive Emissions 28.10 - Hydrogen Production -28.11 - Other (Please specify)	Viorkenneet Sector: Industrial Processes and Pro Category: Metal Industry Subcategory: 2.C.1 - Iron and Steel Produc Sheet: CO2 and CH4 Emissions from Data Gas CARBON DIOXIDE (CO2)	tion						:	2022
2.C - Metal Industry 2.C.1 - Iron and Steel Production			Equ	ation 4.1					
2.C.2 - Ferroalloys Production 2.C.3 - Aluminium production 2.C.4 - Magnesium production 2.C.5 - Lead Production 2.C.6 - Zine Production	Subdivision		Amount of coke production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
- 2.C.7 - Rare Earths Production	ΔV		P	EF	E = P * EF	E / 1000			
2.C.8 - Other (please specify)	Kanagawa prefecture	Coke production using by-product reco.	15000	0.51	7650	7.65	2		
2.D - Non-Energy Products from Fuels and Sol	National (all the rest)	Coke Oven	100000	0.56	56000	56	3	G 7	
- 2.D.1 - Lubricant Use - 2.D.2 - Paraffin Wax Use	M						3		
2.D.3 - Solvent Use 2.D.4 - Other (please specify)	Total		115000		63650	63.65			
20 - Our clease specify 22 - Electronic Industry 22.1 - Integrated Circuit or Semiconductor 22.2 - TFT Flat Panel Display 22.3 - Photovoltaics 22.4 - Heat Transfer Fluid									

In worksheet CO₂ Emissions from metallurgical coke production (mass balance)

- 1. <u>Column |CC|</u>: input the amount/mass of coking coal consumed for coke production, in tonnes.
- 2. <u>Column |CO|</u>: 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.

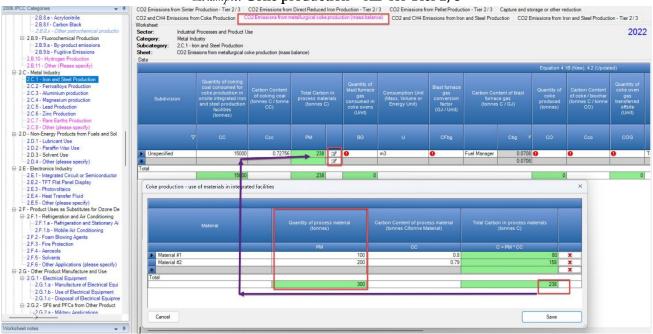
When the Tier 2 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, 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. <u>Column |CC|</u>: input the amount/mass of coking coal consumed for coke production, in tonnes.
- 2. <u>Column |PM|</u>: this information is input through selection of the sub-table associated with <u>Column |PM|</u>. Select the edit box and input information for:
 - a. <u>Column | Material |</u>: select from the drop-down menu the fuel material used (taken from the Fuel Manager)
 - b. <u>Column |PM|:</u> input the amount of process materials used for coke production, in tonnes.
- 3. <u>Column |BG|</u>: input the amount/mass blast furnace gas consumed in coke ovens, using the unit input by the user in <u>Column |U|</u>.
- 4. <u>Column |U|</u>: input the unit of the blast furnace gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 5. <u>Column | CFbg|</u>: input the conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ, TJ or tonnes of fuel are selected in <u>Column |U|</u>, CFbg is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³ or a user defined unit) the user shall enter the relevant conversion unit here.



Example: Coke production – AD for Tier 2/3

Output materials

- 6. <u>Column |CO|</u>: input the amount/mass of coke produced, in tonnes.
- 7. <u>Column |COG|</u>: input the amount/mass of coke oven gas transferred offsite, using the unit input by the user in <u>Column |U|</u>.
- 8. <u>Column |U|</u>: input the unit of the coke oven gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 9. <u>Column |CFcog|</u>: input a conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ, TJ or tonnes of fuel are selected in <u>Column |U|</u>, CFcog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³ or a user defined unit) the user shall enter the relevant conversion unit here.
- 10. <u>Column |BPC|</u>: this information is input through selection of the sub-table associated with <u>Column |BPC|</u>. Select the edit box and input information for:
 - a. <u>Column |By-product|</u>: directly input the by-product produced.
 - b. <u>Column |COB|</u>: 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 <u>Column |Subdivision|</u>, data are input in worksheet CO_2 and CH_4 emissions from Iron and Steel Production, row by row:

- 1. <u>Column |Type of Steel Making Method, etc</u>]: 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. <u>Column |P|</u>: 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 <u>Column |Subdivision|</u>, 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. CO₂ 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. <u>Column |PC|</u>: input the quantity of coke or biochar consumed in iron and steel production, in tonnes.
- 2. <u>Column |Biochar instead of coke|</u>: check if biochar is used instead of coke for iron and steel production. By default, this column is unchecked.
- 3. <u>Column |BPC|</u>: this information is input through selection of the sub-table associated with <u>Column</u> <u>|BPC|</u>. Select the edit box and input information for:
 - a. <u>Column | By-product |</u>: directly input the by-product produced.
 - b. <u>Column |COB|</u>: input the amount of on-site coke oven by-product consumed in the blast furnace, in tonnes.
- 4. <u>Column |CI|</u>: input the quantity of coal directly injected into the blast furnace, in tonnes.
- 5. <u>Column | Biochar instead of coal |</u>: check if biochar is used instead of coal.
- 6. <u>Column |L|</u>: input the quantity of limestone consumed in iron and steel production, in tonnes.
- 7. <u>Column |D|</u>: input the quantity of dolomite consumed in iron and steel production, in tonnes.
- 8. <u>Column |CE|</u>: input the quantity of carbon electrodes consumed in EAFs, in tonnes.
- 9. <u>Column |PM|</u>: this information is input through selection of the sub-table associated with <u>Column |PM|</u>. Select the edit box and input information for:
 - a. <u>Column | Material |</u>: select from the drop-down menu the fuel material used (taken from the Fuel Manager).
 - b. <u>Column |PM|</u>: input the quantity of other carbonaceous process materials consumed, in tonnes.
- 10. <u>Column |COG|</u>: input the quantity of coke oven gas consumed in the blast furnace, using the unit input by the user in <u>Column |U|</u>.
- 11. <u>Column |U|</u>: input the unit of the coke oven gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 12. <u>Column |CFcog|</u>: enter the conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ, TJ or tonnes of fuel are selected in <u>Column |U|</u>, CFcog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³ or a user defined unit) the user shall enter the relevant conversion unit here.

Output Materials

- 13. <u>Column |S|:</u> input the quantity of steel produced, in tonnes.
- 14. <u>Column |IP|</u>: input the quantity of iron production not converted to steel, in tonnes.
- 15. <u>Column |BG|</u>: input the quantity of blast furnace gas transferred offsite, using the unit input by the user in <u>Column |U|</u>.
- 16. <u>Column |U|</u>: input the unit of the blast furnace gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 17. <u>Column |CFbg|</u>: input the conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ, TJ or tonnes of fuel are selected in <u>Column |U|</u>, CFbg is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³ or a user defined unit) the user shall enter the relevant conversion unit here.



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

co	02 and CH4 Emis	sions from Iron a	and Steel Produc	tion CO2 Em		and Steel Produc		CO2 Emissions from	Sinter Productio	n - Tier 2/3	CO2 Emissions fr	om Direct Reduced Iron Productic	on - Tier 2/3		20:	22
					_		_	_								
	Carbon Conter gr (tonnes		Quantity of steel produced (tonnes)	Carbon Content of steel produced (tonnes C / tonne Steel)	Quantity of iron production not converted to steel (tonnes)	Carbon Content of iron production not converted to steel (tonnes C / tonne Iron)	Quantity of blast furnace gas transferred offsite (Unit)	Consumption Unit (Mass, Volume or Energy Unit)	Blast furnace gas conversion factor (GJ / Unit)		ntent of blast ce gas s C / GJ)	Annual non-Energy CO2 emissions (tonnes CO2)	Annual non- Energy CO2 emissions (Gg CO2)			
		Ccog	s	Cs	IP	Cip	BG	UΔ	CFbg		Cbg	E = [PC * Cpc + BPC + Cl * Cci + L * Cl + D * Cd + CE * Cce + PM + COG * CFcog * Ccog - S * Cs - IP * Cip - BG * CFbg * Cbg] * 44/12	E / 1000			
.7	Fuel Manager	0.0121	10	200	0	0	1000	GJ	1	Fuel Manager	0.0708	23003.12667	23.00313		1 7	X
		0.0121									0.0708			2		1
_			10		0		1000				Including Bio	23003.12667	23.00313			_
											Excluding Bi	23003.12667	23.00313	_		_

ii. CO₂ 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. <u>Column |CBR|</u>: input the quantity of coke breeze/biochar purchased and produced onsite for sinter production, in tonnes.
- 2. <u>Column |Biochar instead of coke breeze|</u>: check if biochar is used instead of coke breeze for sinter production. By default, this column is unchecked.
- 3. <u>Column |COG|</u>: input the quantity of coke oven gas consumed in the blast furnace for sinter production, using the unit input by the user in <u>Column |U|</u>.

- 4. <u>Column |U|</u>: input the unit of the coke oven gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 5. <u>Column | CFcog</u>|: input the conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ, TJ or tonnes of fuel are selected in <u>Column | U|</u>, CFcog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³ or a user defined unit) the user shall enter the relevant conversion unit here.
- 6. <u>Column |BG|</u>: input the quantity of blast furnace gas consumed in sinter production, using the unit input by the user in <u>Column |U|</u>.
- 7. <u>Column |U|</u>: input the unit of the blast furnace gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 8. <u>Column | CFbg|</u>: input the conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ, TJ or tonnes of fuel are selected in <u>Column |U|</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. <u>Column |OPM|</u>: this information is input through selection of the sub-table associated with <u>Column</u> |<u>OPM|</u>. Select the edit box and input information for:
 - a. <u>Column | Material |</u>: select from the drop-down menu the fuel material used (taken from the Fuel Manager).
 - b. <u>Column |OPM|</u>: input the quantity of other process materials consumed, in tonnes.

Output Materials

- 10. <u>Column |SOG|:</u> 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 <u>Column |U|</u>.
- 11. <u>Column |U|</u>: input the unit of the sinter off gas entered (e.g. Gg, TJ, m³, tonne), or manually input a user-specific unit (e.g. BTUs).
- 12. <u>Column |CFsog|</u>: input the conversion factor to convert the consumption unit to GJ. <u>Note that</u>, where GJ or TJ of fuel is selected in <u>Column |U|</u>. CFsog is sourced from the Fuel Manager and compiled by the Software as a conversion factor. Where other units are applied (e.g. m³, tonnes, or a user defined unit) the user shall enter the relevant conversion unit here.

iii. CO₂ emissions from Direct Reduced Iron Production – Tier 2/3 and CO₂ 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. <u>Column |NG|</u>: input the amount of natural gas used in DRI/pellet production, in GJ.
- 2. <u>Column |CBR|</u>: input the amount of coke breeze/biochar used in DRI/pellet production, in GJ.
- 3. <u>Column |Biochar instead of coke breeze |</u>: check if biochar is used instead of coke breeze for DRI/pellet production. By default, this column is unchecked.
- 4. <u>Column |CM|</u>: input the amount of metallurgical coke /biochar used in DRI/pellet production, in GJ.
- 5. <u>Column |Biochar instead of metallurgical coke|</u>: 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 CO₂ (<u>Table 4.1</u>), and, additionally for coke production, <u>Table 4.1 (Updated</u>)
- \checkmark Tier 1 EFs for CH₄ (<u>Table 4.2</u>)
- \checkmark Tier 2/3 EFs for CO₂ carbon content of materials/fuels (<u>Table 4.3</u>)

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:

 <u>Column |EF|</u>: select from the drop-down menu the IPCC default value for the given GHG or input a userspecific value, in tonnes CO₂/tonne coke produced or kg CH₄/tonne coke produced. <u>Note that</u> user shall select "Carbon dioxide (CO₂)" or "Methane (CH₄)" in the "Gas" bar at the top, to enter data for each GHG one by one.



Alternatively, where data are input following the simplified Tier 1b method, for each subdivision in worksheet CO₂ Emissions from metallurgical coke production (mass balance), data are input row by row, as follows:

- 1. <u>Column |Ccc|</u>: 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. <u>Column | Cco |</u>: 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 CO₂ Emissions from metallurgical coke production (mass balance):

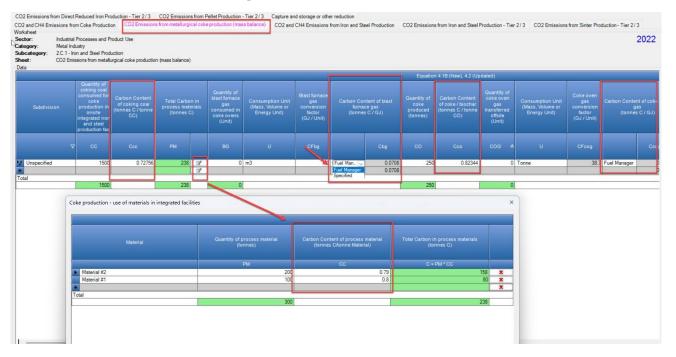
- 1. <u>Column |Ccc|</u>: select from the drop-down menu the carbon content for coking coal taken from the **Fuel** Manager or input a user-specific value, in tonnes C/tonne coking coal.
- 2. <u>Column |PM|</u>: select the edit box to open the sub-table associated with <u>Column |PM|</u>. In <u>Column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

3. <u>Column |Cbg|</u>: 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. <u>Column |Cco|</u>: 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. <u>Column |Ccog|</u>: 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 CO₂ and CH₄ Emissions from Iron and Steel Production data are input, row by row, as follows:

 <u>Column | EF |</u>: select from the drop-down menu the IPCC default value for the given GHG or enter a userspecific value, in tonnes CO₂/tonne produced or kg CH₄/tonne produced. <u>Note that</u> user shall select "Carbon dioxide (CO₂)" or "Methane (CH₄)" 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

CO2 Emissions from metallurgical coke p	production (mass balance)	CO2 and CH4 Emissions	from Iron and Steel Production	CO2 Emissions from Iron and St	teel Productio	n - Tier 2/3
duct Use tion I fron and Steel Production						20
	Equa	ation 4.4 - 4.8				
Type of Steelmaking Method, etc	Amount of Steel or Iron Production (tonne)	CO2 Emission Fac		CO2 Emissions (Gg CO2)		
$\Delta \nabla$	Р	EF	E = P * EF	E / 1000		
Electric Arc Furnace (EAF)	2000	00	0.08 🗸	1600 1.	6 📝 🖬	2
			CO2 Emission Factor (tonnes CO2 / tonne produce	ed) Re		
	200	Electric Arc Furnace (EAF)	C	Environmental Performance I	Indicators 200	3 STEEL
	CO2 Emissions from metallurgical coke duct Use tion Iron and Steel Production Type of Steelmaking Method, etc △ マ	CO2 Emissions from metallurgical coke production (mass balance) auct Use tion Iron and Steel Production Type of Steelmaking Method, etc Amount of Steel or Iron Production (tonne) Electric Arc Furnace (EAF) 2000	CO2 Emissions from metallurgical coke production (mass balance) CO2 and CH4 Emissions Auct Use tion Iron and Steel Production Type of Steelmaking Method, etc Amount of Steel or Ir Production CO2 Emission Fac (tonnes CO2 / tonne pro tone) Electric Arc Furnace (EAF) CO2 Emission Fac Description Description	CO2 Emissions from metallurgical coke production (mass balance) CO2 and CH4 Emissions from Iron and Steel Production auct Use tion Iron and Steel Production Iron and Steel Production Type of Steelmaking Method, etc Amount of Steel or Iron Production CO2 Emission Factor (tonnes CO2 / tonne produced) CO3 Emission Factor (tonnes CO3 / tonne produced)	CO2 Emissions from metallurgical coke production (mass balance) CO2 and CH4 Emissions from Iron and Steel Production CO2 Emissions from Iron and Steel Production Auct Use Lion and Steel Production Equation 4.4 - 4.8 Type of Steelmaking Method, etc Amount of Steel or it on Production (tonnes CO2 / tonne produced) CO2 Emissions from Iron and Steel Production (G g CO2) CO2 Emissions (G g CO2) Electric Arc Furnace (EAF) 2000 000 v 1600 1 Description CO2 Emission Factor (tonnes CO2 / tonne produced) CO2 Emission Factor (tonnes CO2 / tonne produced) CO3 Emission Factor (tonnes CO2 / tonne produced) Total Factor (tonnes CO2 /	CO2 Emissions from metallurgical coke production (mass balance) CO2 and CH4 Emissions from Iron and Steel Production Auct Use Co2 and CH4 Emissions from Iron and Steel Production tion Iron and Steel Production Iron and Steel Production Equation 4.4 - 4.8 Type of Steelmaking Method, etc Amount of Steel or Iron (tonnes CO2 / tonne produced) CO2 Emission Factor (tonnes CO2) CO2 Emissions (Gg CO2) Electric Arc Furnace (EAF) 2 CO2 Emission Factor (tonnes CO2 / tonne produced) CO2 Emission Factor (tonnes CO2) CO2 Emission Iron Iron Iron Iron Iron Iron Iron Ir

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:

<u>Note that</u> 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.

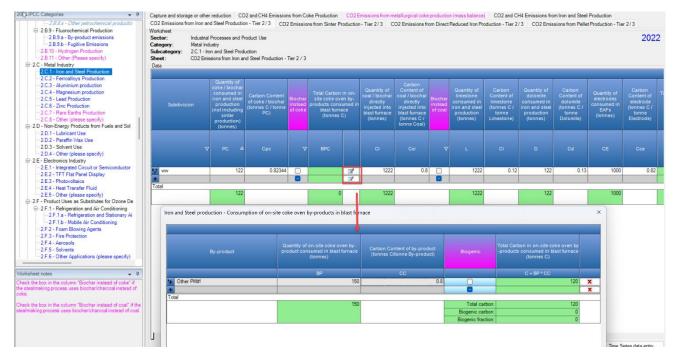
- 1. <u>Column |Cpc|</u>: select from the drop-down menu the IPCC default value for coke or enter a user-specific value, including for biochar, in tonnes C/tonne coking coal/biochar.
- 2. <u>Column |BPC|</u>: select the edit box to open the sub-table associated with <u>Column |BPC|</u>. In <u>Column |CC|</u> input the carbon content of each by-product selected, in tonnes C/tonne by-product.
- 3. <u>Column |CCi|</u>: 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. <u>Column |Cl|</u>: input the carbon content of limestone, in tonnes C/tonne limestone.
- 5. <u>Column |Cd|</u>: input the carbon content of dolomite, in tonnes C/tonne dolomite.
- 6. <u>Column | Cce |</u>: input the carbon content of electrodes, in tonnes C/tonne electrode.
- 7. <u>Column |PM|</u>: select the edit box to open the sub-table associated with <u>Column |PM|</u>. In <u>Column |CC|</u> input the carbon content of each material selected, in tonnes C/tonne material.
- 8. <u>Column |Ccog</u>|: 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.

<u>Note that:</u> section **1.1.1 Fuel Manager** provides further information on populating the Fuel Manager.

- 9. <u>Column | Cs |</u>: 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. <u>Column |Cbg|</u>: 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. <u>Column |Ccbr|</u>: input the carbon content of coke breeze/ biochar, in tonnes C/tonne coke breeze or biochar, in tonnes.
- 2. <u>Column |Ccog|</u>: 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. <u>Column |Cbg|</u>: 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. <u>Column |OPM|</u>: select the edit box to open the sub-table associated with <u>Column |OPM|</u>. In <u>Column |CC|</u> input the carbon content of each material selected, in tonnes C/tonne material.
- 4. <u>Column | Csog|</u>: input the carbon content of sinter off-gas, in tonnes C/unit (as indicated in <u>Column | U|</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. <u>Column |Cng|</u>: 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.

<u>Note that:</u> section **1.1.1 Fuel Manager** provides further information on populating the Fuel Manager.

- 2. <u>Column | Ccbr |</u>: input the carbon content of coke breeze/biochar, in tonnes C/GJ coke breeze or biochar.
- 3. <u>Column |Ccm|</u>: 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:

- ✓ CO₂ and CH₄ emissions from Coke Production
- ✓ CO₂ 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 <u>Column |Eflaring|</u>, CO₂ 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

CO₂ and CH₄ emissions from Iron and Steel Production are estimated in mass units (tonnes and Gg for CO₂ and kg and Gg for CH₄) by the *Software* in the following worksheets:

- ✓ CO₂ and CH₄ emissions from Iron and Steel Production Tier 1
- ✓ CO₂ emissions from Iron and Steel Production Tier 2/3
- ✓ CO₂ emissions from Sinter Production Tier 2/3
- \checkmark CO₂ emissions from Pellet Production Tier 2/3
- ✓ CO₂ emissions from Direct Reduced Iron Production Tier 2/3

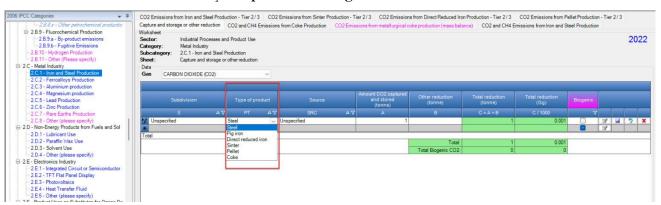
For both coke production and iron and steel production, where the user has indicated use of biochar in production in the *Software*, CO₂ emissions are totalled including and excluding biogenic CO₂.

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. <u>Column |PT|</u>: select from the drop-down menu the category where capture/reduction is taking place (e.g. steel, coke, etc).
- 2. <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).
- 3. <u>Column |A|</u>: collect and input information on the amount of CO₂ captured (with subsequent storage), in tonnes.
- 4. <u>Column |B|: collect and input information on any other long-term reduction of CO₂ or CH₄, in tonnes. <u>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.</u></u>
- 5. <u>Column | Biogenic |:</u> indicate with a check if the reducing agent/fuel is of biogenic origin. <u>Note that consistent with the 2006 IPCC Guidelines, capture of biogenic CO₂ for long-term storage may lead to negative CO₂ emissions.</u>

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 CO₂ and CH₄ 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 (CO₂) and 4.18 (CH₄ from ferrosilicon and silicon metal production)
- \checkmark Tier 2: Equation 4.16
- \checkmark Tier 3: <u>Equations 4.17</u> and <u>4.19</u>

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 CO2 and CH4 from Ferroalloys Production using the following worksheets:

- ✓ CO₂ and CH₄ 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 CO₂ and CH₄ EFs. The worksheet calculates the associated CO₂ and CH₄ emissions.
- ✓ CO₂ 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 CO₂ EFs. The worksheet calculates the associated CO₂ emissions from reducing agents.
- ✓ CO₂ 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 CO₂ emissions from reducing agents.
- ✓ CO₂ 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 CO₂ emissions from ore.
- ✓ CO₂ 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 CO₂ emissions from slag forming material.
- ✓ CO₂ 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 CO₂ "contained" in ferroalloys produced.

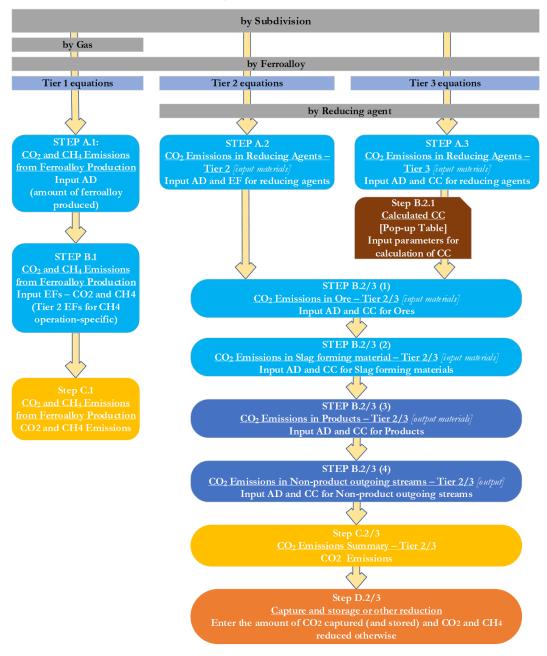
- ✓ CO₂ Emissions in Non-product outgoing streams Tier 2/3: contains for each subdivision, each type of ferroalloy produced and each non-product outgoing stream, information on the amount and carbon content of non-product outgoing streams. The worksheet calculates the associated CO₂ "contained" in non-product outgoing streams.
- ✓ CO₂ Emissions Summary Tier 2/3: (non-editable table) contains for each subdivision and each type of ferroalloy produced, the results of the estimation of CO₂ 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 CO₂ capture (with subsequent storage) and other reduction of CO₂ and CH₄, not accounted previously in the worksheets for different Tiers.

User's Work Flowchart

Consistent with the key category analysis and decision trees in <u>Figure 4.9</u> of the 2006 IPCC Guidelines (for CO₂) and <u>Figure 4.10</u> 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-specific¹ 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 <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> [subdivision] for each subdivision.

2.8.8.4. Cathon Black 2.8.9.4. Cath	d storage	je or oti	her reduc
28.9 a - By-product emissions Category: Metal Industry 28.9 b - Fugitive Emissions Subcategory: 22.9 - Fugitive Emissions 28.10 - Hydrogen Production Subcategory: 2C.2 - Fermalloys Production 28.11 - Other (Please specify) Data CO2 and CH4 Emissions from Fermalloy Production			202
2.C.1-icm and Skel Production Equation 4.16			
2 2.3 - Administre production 2 2.4 - Magnesium production 2 2.6 - Lag Production 2 2.6 - Lag Production 2 2.6 - Zen Production 2 2.6 - Zen Production (connel)			
2.8-Other (please specify) Δ7 Δ7 Δ7 P EF E P*EF E/1000			
Ion-Energy Products from Fuels Unspecified	5 3		2
Performanganeses (1% C) Unspectined 100 1.5 150 0.15			
7.2 - Ferrosilicon 65 % Si Unspecified 12 3.6 43.2 0.0432			
24 - Other (please specify)	3		

Example: single subdivision (unspecified)

Example: multiple subdivisions

2.B.8.f - Carbon Black	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 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 3 CO2 Emissions in Co2 Emissions in Reducing Agents - Tier 3								2/3 CO2 Emissions summary - Tier 2/3 Capture and storage or other redu				
	Works Sector Subc Subc Shee Data Gas	or: gory: ategory: t:	Industrial Proces Metal Industry 2.C.2 - Ferroalloy CO2 and CH4 Er	s Produ									2022
2.C.1 - Iron and Steel Production 2.C.2 - Ferroalloys Production	ction T												
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					Type of Ferroalloy	Operation at furnace	Amount of Ferroalloy Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
				Δ.Δ	ΔV	A 7	Р	EF	E = P * EF	E/1000			
D - Non-Energy Products from Fuels		Northern			Ferrochromium Ferromanganeses (1% C)	Unspecified Unspecified	125		162.5 150	0.1625	3		_
2.D.2 - Paraffin Wax Use 2.D.3 - Solvent Use	*	Southern		V	Ferrosilicon 65 % Si	Unspecified	1.	2 3.6	43.2	0.0432	3		? ×
2.D.4 - Other (please specify) E - Electronics Industry 2.E.1 - Integrated Circuit or Semico	Tota	1					23	7	355.7	0.3557			

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 Ferroalloy Production, row by row, as follows:

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

O2 Emissions in Non-product outgoing strea	ms - Tier 2/3 CO2 Emissions summary - 1	Tier 2/3 Capture and storage or other redu	uction					
O2 and CH4 Emissions from Ferroalloy Prod	uction CO2 Emissions in Reducing Agent	s - Tier 2 CO2 Emissions in Reducing Ag	ents - Tier 3 CO2 Emissio	ons in Ore - Tier 2/3 CO2 Emission	s in Slag forming material - Tier 2/3	CO2 Emissions in P	roducts	- Tier 2
oksheet ector: Industrial Processes and Pro ategory: Metal Industry ubcategory: 2.C.2 - Ferroalloys Productio heet: CO2 and CH4 Emissions fro Jata as CARBON DIOXIDE (CO2)	n							
			Equation 4.15					
	Type of Ferroalloy	Operation at furnace	Amount of Ferroalloy Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions ((tonnes CO2)	CO2 Emissions (Gg CO2)		
Δ 🖓	۵7	Δ 🖓	P	EF	E = P * EF	E / 1000		
National	Ferrochromium	Batch-charging	2,500	1.3	3,250	3.25		
	Ferromanganeses (7% C)	Unspecified	2,500	1.3	3,250	3.25		
¥	Ferrosilicon 75% Si	Sprinkle-charging and >750°C	1,250	4 🗸	5,000	5		
Fotal								
			6,250		11,500	11.5		

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 <u>Column |Subdivision|</u>, 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:

<u>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.</u>

- 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 |Reducing agent type|</u>: 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. <u>Column |i|:</u> select from the drop-down menu the type of reducing agent (e.g. coke) or input manually country-specific reducing agent.
- 4. <u>Column | Mi</u>|: input the amount/mass of reducing agent, in tonnes.

Example: AD input for reducing agents – Tier 2 and Tier 3

02 and CH4 Emissions from Ferroalloy	Production CO2 Emissions in Redu	ucing Agents - Tier 2 (CO2 Emissions in Reducing Age	nts - Tier 3 CO2 Emiss	ions in Ore - Tier 2/3	CO2 Emissions in Non-pro	duct outgoing streams - 1	lier?
vrksheet ctor: Industrial Processes an ategory: Metal Industry abcategory: 2.C.2 - Ferroalloys Prod weet: CO2 Emissions in Redu ata	luction							
			Equation 4	16				
Subdivision	Type of Ferroalloy	Reducing agent type	Reducing agent	Mass of reducing agent (tonnes)	Emission Factor (tonnes CO2 / tonne i)	CO2 Emissions in Reducing Agents (tonnes CO2)	CO2 Emissions in Reducing Agents (Gg CO2)	
۵۷	7	V	i dv	Mi	EFI	Ei = Mi * EFi	Ei / 1000	
Unspecified	Ferrosilicon 45% Si	Other Biogenic	biochar	100	2.3	230	0.23	
	Ferrosilicon 65 % Si	Fossil	Coal (for FeSi and Si-metal)	255	3.1	790.5	0.7905	
	Ferrosilicon 90% Si	Fossil	Coke (for FeMn and Si_	100	3.2	320	0.32	
é.								1
otal						2		
				455	Including Biogenic CO	1340.5	1.3405	
					Excluding Biogenic C.	1110.5	1,1105	4

Then, for both Tier 2 and Tier 3

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

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

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

O2 and CH4 Emissions from Ferroall	oy Production CO2 Emissions in Rec	ducing Agents - Tier 2 CO2	Emissio	ons in Reducing Agents	- Tier 3 CO2 Emissions in	Ore - Tier 2/3 CO2 Emissions in Non-p	roduct outgoing streams
orksheet ctor: Industrial Processes ategory: Metal Industry bubcategory: 2.C.2 - Ferroalloys F heet: CO2 Emissions in O lata	roduction						
				Equation 4.16, 4	17		
Subdivision	Type of Ferroalloy			Mass of Ore (tonnes)	Carbon Content of Ore (tonnes C / tonne Ore)	CO2 Emissions in Ore (tonnes CO2)	CO2 Emissions in O (Gg CO2)
	۵7	∀ h		Mh	CCh	Eh = Mh * CCh * 44/12	Eh / 1000
Kanagawa prefecture	Ferrochromium	Ore for Ferrochromium		200	0.05	366.66667	0.366
Plant Ferroal	Ferrosilicon 45% Si	Ore for FeSi45		100	0.03	110	0.
otal				300		476.66667	0.476

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

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

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

	Capture and storage or other reduction	CO2 Emissions in Slag forming ma	terial - Tier 2/3 CO2 Em	issions in Products - Tier 2/3	CO2 and CH4 Emissions from Ferr	oalloy Production
forksheet ector: Industrial Processes ategory: Metal Industry ubcategory: 2.C.2 - Ferroalloys P heet: CO2 Emissions in SI 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 SI forming material (Gg CO2)
	<u>۷</u>	J AV	Mj	CCj	Ej = Mj * CCj * 44/12	Ej / 1000
Kanagawa prefecture	Ferrochromium	Slag forming for Kanagawa	1000	0.07	256.66667	0.256
Plant ferroal	Ferrosilicon 75% Si	Slag forming for plant	200	0.05	36.66667	0.036
Total			1200		293.33333	0.293

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.

CO2 Emissions in Non-product outgoing strea						in Reducing Agents - T	ier 3
02 Emissions summary - Tier 2/3 Capture /orksheet Sector: Industrial Processes and Pro Category: Metal Industry)2 Emissi	ons in Slag forming material -	Tier 2/3 CO2 Emissions in P	roducts - Tier 2/3 CO2 En	nissions in Ore - Tier 2	3
Subcategory: 2.C.2 - Ferroalloys Productio Sheet: CO2 Emissions in Products Data							
			E	quation 4.16, 4.17			
Subdivision	Type of Ferroalloy		Mass of Product (tonnes)	Carbon Content of Product (tonnes C / tonne k)	CO2 Emissions ir (tonnes Co		CO2 Emissions in Products (Gg CO2)
Δ.	√ k	Δγ	Mk	CCk	Ek = Mk * CCk	* 44/12	Ek / 1000
 Kanagawa prefecture 	Ferromanganeses (1% dfdfd		122	0.7		313.13333	0.313
Plant Ferroal	Ferrosilicon 45% Si		100	0.05		18.33333	0.018
*							
Total			222			331,46667	0.331

Example: AD input for products (ferroalloys) - Tier 2/3

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 [1]</u>: input manually the name of the non-product outgoing stream from ferroalloy production.
- 3. <u>Column |MI|</u>: input the amount/mass of non-product outgoing stream, in tonnes.

Example: AD input for non-product outgoing streams – Tier 2/3

apture and storage or other reduction C O2 Emissions in Non-product outgoing str	International Contraction of the				2 Emissions in Reducing Agents - Tier 3	CO2 Emissions sum
Vorksheet iector: Industrial Processes and iategory: Metal Industry iubcategory: 2.C.2 - Ferroalloys Produc	Product Use		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 I)	CO2 Emissions in Non-product outgoing streams (tonnes CO2)	CO2 Emissions in No product outgoing streams (Gg CO2)
<u>۵</u> 7	7		м	CCI	EI = MI * CCI * 44/12	EI / 1000
Kanagawa prefecture	Ferrochromium	Stream A	25	0.04	3.66667	0.0036
Plant Ferroal	Ferrosilicon 45% Si	Stream B	30	0.09	9.9	0.00
k otal						
						0.013

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:

- \checkmark Tier 1 EFs for CO₂ (<u>Table 4.5</u>)
- \checkmark Tier 2 EFs for CO₂ (<u>Table 4.6</u>)
- \checkmark Tier 1 EFs for CH₄ (<u>Table 4.7</u>)
- \checkmark Tier 2 EFs for CH₄ (<u>Table 4.8</u>)

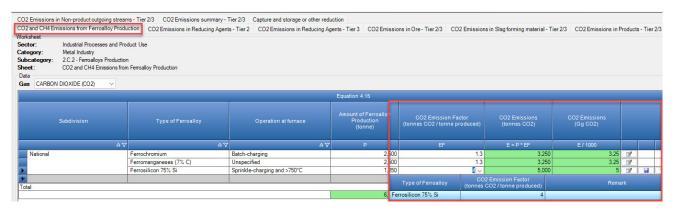
When the Tier 1 Equation is applied:

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

1. <u>Column |EF|</u>: select from the drop-down menu the default EF (based on the process selected in <u>Column</u> |<u>Operation of furnace|</u> 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 CO₂



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 <u>Column |Subdivision|</u>, EF information is input in worksheet **CO**₂ **Emissions** in **Reducing Agents – Tier 2**, row by row, as follows:

1. <u>Column |EFi|</u>: 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 CO₂/tonne reducing agent.

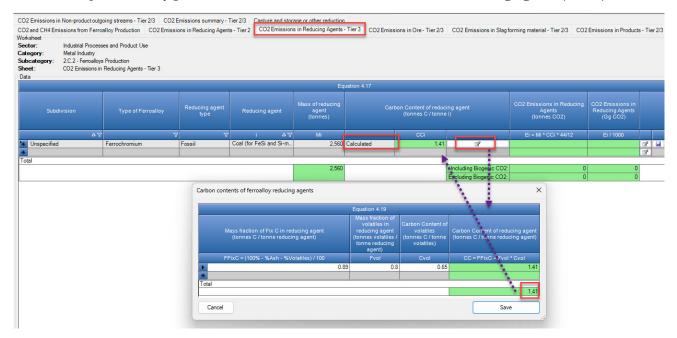
Example: ferroalloy production – Tier 2 EFs for CO₂

CO2 Emissions in Non-product outgoing stre	ams - Tier 2/3 CO2 Emissions summa	ary - Tier 2/3 Capture and	storage or other reduction					
CO2 and CH4 Emissions from Ferroalloy Pro	duction CO2 Emissions in Reducing /	Agents - Tier 2 CO2 Emis	sions in Reducing Agents - Tier	3 CO2 Emissions in Or	e - Tier 2/3 CO2 Emissions in	Slag forming material - Tier 2	3 CO2 Emissions in P	roducts - Tier 2/3
Worksheet Sector: Industrial Processes and F Category: Metal Industry Subcategory: 2.C.2 - Fernalloys Product Sheet: CO2 Emissions in Reducin Data	ion					<u>- 03</u>		
			Equation					
Subdivision		Reducing agent type	Reducing agent	Mass of reducing ag (tonnes)	ent Emission Factor (tonnes CO2 / tonne i)	CO2 Emissions in Reducing Agents (tonnes CO2)	CO2 Emissions in Reducing Agents (Gg CO2)	
Δ 🖓	2	7 7		V Mi	EFi	Ei = Mi * EFi	Ei / 1000	
🔭 Unspecified	Ferromanganeses (1% C)	Fossil	Coal (for FeSi and Si-metal)	~ 2.	500 3.1	7,750	7.75	
* Total			Reducing agent	Emission Factor (tonnes CO2 / tonne i)	Rema			
			Coal (for FeSi and Si-metal)	3.1			7.75	
			Coal (for other ferroalloys)		Inventory compilers are encour specific values based on avera coke for each ferroalloy produc	ge blend of coal and/or	7.75	
			Coke (for FeMn and SiMn)	3.2	3.2 - 3.3			
			Coke (for other ferroalloys)		Inventory compilers are encour specific values based on avera coke for each ferroalloy produc	ge blend of coal and/or		
			Coke (for Si and FeSi)	3.3	3.3 - 3.4			
			Electrode paste	3.4				
			Petroleum coke	3.5				
			Prebaked electrodes	3.54				

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. <u>Column |CCi|</u>: 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. <u>Column |FFixC|</u>: collect and input the mass fraction of fixed C in the reducing agent, in tonnes of carbon/ tonne of reducing agent.
 - b. <u>Column |Fvol</u>]: collect and input the mass fraction of volatiles in reducing agent, in tonnes volatiles/ tonne reducing agent.
 - c. <u>Column |Cvol|</u>: 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 <u>Column |CCh|</u>, in tonnes C/tonne ore.

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

Then, in worksheet CO_2 Emissions in Products – Tier 2/3 input a user-specific EF in <u>Column |CCk|</u>, 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 <u>Column |CCl|</u>, in tonnes C/tonne outgoing stream.

Results

CO₂ and CH₄ emissions from Ferroalloy Production are estimated in mass units (tonnes and Gg for CO₂ and kg and Gg for CH₄) by the *Software* in the following worksheets:

- ✓ CO₂ and CH₄ emissions from Ferroalloy Production
- ✓ CO₂ Emissions Summary Tier 2/3.

Total CO₂ and CH₄ emissions from ferroalloy production is the sum of all emissions in the above worksheets, taking into account any CO₂ capture with subsequent storage or other GHG reduction. For Tier 2/3, note that the CO₂ emissions include both CO₂ of biogenic and fossil origin, and totals are provided both including and excluding biogenic CO₂. The worksheet **Capture and storage or other reduction** is provided in the *Software* to estimate CO₂ capture and storage.

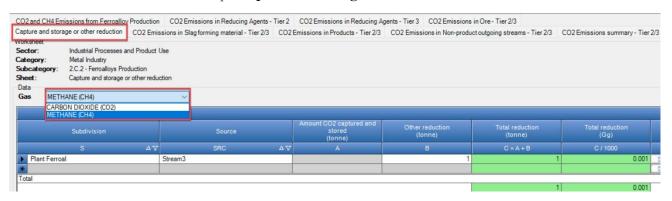
CO2 Emissions in Non-pro CO2 Emissions summary						Tier 2/3 CO2 E				-		
Category: Metal In Subcategory: 2.C.2 -	al Processes and Produc ndustry Ferroalloys Production nissions summary - Tier 2											2022
						Equation 4.16, 4.1						
Subdivision	Type of Ferroalloy	CO2 Emission Agents (tonnes	- Tier 2		is in Reducing - Tier 3 s 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)
۵Ţ	V	Fossil Ei(T2)	Biogenic Ei(T2)	Fossil Ei(T3)	Biogenic EI(T3)						E = Ei(T2) + Ei(T3) + Eh + Ej - Ek - El	
Kanagawa prefect	Ferrochromium					366.66667	256.66667		3.66667		619.66667	0.619
	Ferromanganeses							313.13333			-313.13333	-0.313
Plant Ferroal	Ferrosilicon 45% Si					110		18.33333	9.9		81.76667	0.081
	Ferrosilicon 75% Si						36.66667				36.66667	0.036
Unspecified	Ferrosilicon 65 % Si	790.5		2282.5							3073	3.0
	Ferrosilicon 45% Si		230								230	0.
	Ferrosilicon 90% Si	354									354	0.3
	Ferromanganeses			20570							20570	20.
Total												
		1144.5	230	22852.5	C	476.66667	293.33333	331.46667	13.56667	Including Biogenic	24651.96667	24.651
										Excluding Biogenic	24421.96667	24421,966

Example: Results of CO₂ emissions – Tier 2/3.

In the worksheet Capture and storage or other reduction, for each subdivision and each gas (CO₂ and CH₄):

- 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|</u>: collect and input information on any other long-term reduction of CO₂, 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 CO₂ for long-term storage may lead to negative CO₂ emissions.

Example: capture and storage or other reduction



2.C.3 Aluminium Production

Information

Section 4.4 in the 2006 IPCC Guidelines provides guidance for estimation of CO_2 and PFC (CF₄ and C_2F_6) emissions from Aluminium Production.

For CO₂, the Tier 1 method for calculating CO₂ 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 CF₄ 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 CF₄ and C₂F₆, the two gases should be considered together (C₂F₆ emissions are calculated as a fraction of CF₄ 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 SF₆ 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
Χ				X		

IPCC Equations

For CO₂

- ✓ <u>Tier 1: Equation 4.20</u>
- ✓ <u>Tier 2/3: Equations 4.21, 4.22, 4.23 (Prebake)</u> and <u>4.24 (Søderberg)</u>

For PFCs

- ✓ <u>Tier 1: Equations 4.25</u>
- ✓ <u>Tier 2/3: Equations 4.26 (Prebake)</u> and <u>4.27 (Søderberg)</u>

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 CO2 and PFC emissions from Aluminium Production using the following worksheets:

CO₂ emissions:

- ✓ CO₂ 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 CO₂ EFs. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ emissions.

- ✓ CO₂ 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 CO₂ emissions.
- ✓ CO₂ 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 CO₂ emissions.
- ✓ CO₂ 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 CO₂ 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 CF₄ and C₂F₆ 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 CF₄ and weight fraction of C₂F₆ per CF₄. 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 CF₄, process current efficiency and weight fraction of C₂F₆ per CF₄. The worksheet calculates the associated PFCs emissions.

Capture and storage or other reduction (CO₂ and PFCs):

✓ **Capture and storage or other reduction** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂ and PFCs, not accounted previously in the worksheets for different Tiers.

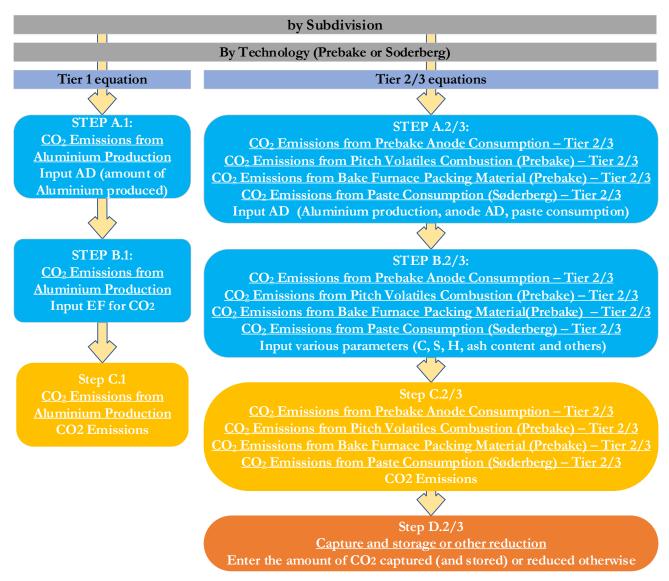
User's Work Flowchart

Consistent with the key category analysis and the decision trees in Figure 4.11 (for CO₂) 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-specific¹ 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 – CO₂ – 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ Emissions from Bake Furnace Packing Material (Prebake) – Tier 2/3, users collect and input information and packing coke consumption. For Tier 3, plant-specific AD should be input by users manually.

Step B.2/3, in worksheet CO₂ Emissions from Prebake Anode Consumption – Tier 2/3, users collect and input sulphur and ash content in baked anodes; in worksheet CO₂ 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 CO₂ 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.

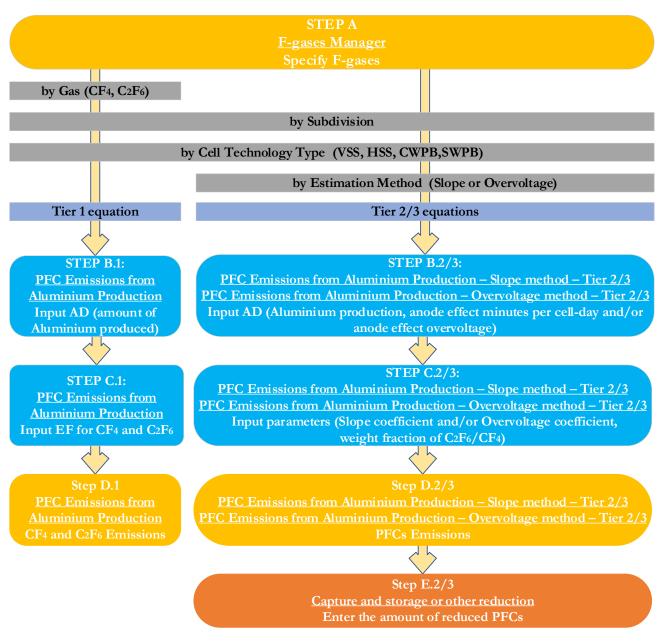
Step B.2/3, in worksheet CO₂ Emissions from Paste Consumption (Søderberg) – Tier 2/3, users collect and input emissions of cyclohexane soluble matter, binder content in paste, sulphur, hydrogen and ash content in pitch, sulphur and ash content in calcined coke, and carbon in skimmed dust from Soderberg cells.

Step C.2/3, in worksheet CO₂ Emissions from Paste Consumption (Søderberg) – Tier 2/3, the *Software* calculates the associated CO₂ 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 CF₄, process current efficiency and weight fraction of C_2F_6 per CF₄.

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

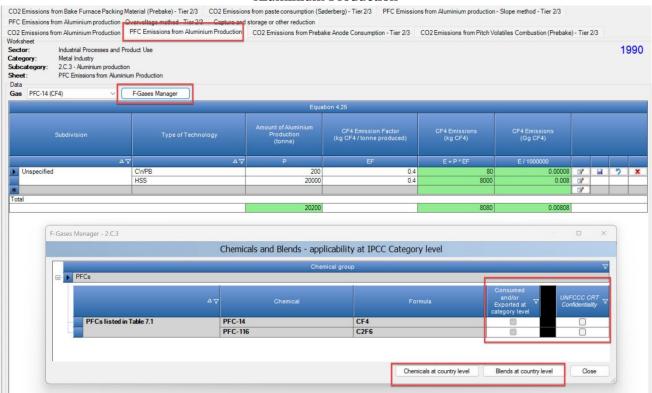
Section 4.4.2.5 in Chapter 4 Volume 3 of the 2006 IPCC Guidelines contains information on the choice of AD for Aluminium Production.

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 .

<u>Note that</u> 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. CF4 and C₂F₆. 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 <u>above</u>.

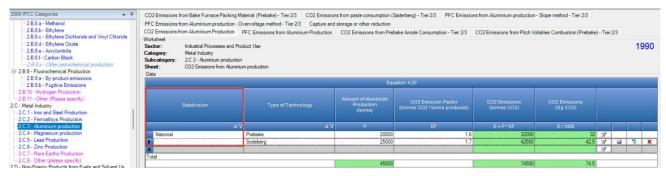
<u>For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool:</u> If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated 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 CO₂ 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 <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> [subdivision] for each subdivision.

Example: single subdivision



Example: multiple subdivisions

2006 IPCC Categories 👻 👎			terial (Prebake) - Tier 2/3 CO2 Emissio ervoltage method - Tier 2/3 Capture and		Søderberg) - Her 2/3 PPC Emissio	ins from Auminium production -	Slope method - Her 2/3			
2.8.8.5. Ethylene 2.8.8.6. Ethylene Dichloride and Vinyl Chloride 2.8.8.4. Ethylene Dichloride 2.8.8.4. Ethylene Oxide 2.8.8.4. Acynohmia 2.8.8.4. Carbon Black 2.8.8.4. Ca	Worksheet Sector: I Category: I Subcategory: 2	Aluminium Production P ndustrial Processes and Prod Atal Industry 2.C.3 - Aluminium production 302 Emissions from Aluminium		CO2 Emissions from Prel	bake Anode Consumption - Tier 2/3	CO2 Emissions from Pitch Vol	atiles Combustion (Prebake) - Tier 2/	3	1990
-2.B.9.a - By-product emissions -2.B.9.b - Fugitive Emissions	1			Equ	uation 4.20					
2.B.10 - Hydrogen Production 2.B.11 - Other (Please specify) 2.C - Metal Industry C.1 - from and Steel Production	Su			Amount of Aluminium Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
2.C.2 - Ferroalloys Production										
2.C.3 - Aluminium production		Δ.V					E / 1000			
- 2.C.4 - Magnesium production	National		Sodeberg	25000	1.7		42.5	3		
2.C.5 - Lead Production	Southern		Prebake	20000	1.6	32000	32	3		
2.C.6 - Zinc Production	*		Sodeberg	1000	1.7	1700	1.7	3		2 1
2.C.7 - Rare Earths Production	*							3		
2.C.8 - Other (please specify) - Non-Energy Products from Fuels and Solvent Us	Total									
- 2.0.1 - Lubricant Lise				46000		76200	76.2			

When Tier 1 Equations are applied:

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheets **CO**₂ **Emissions from Aluminium Production** and **PFC Emissions from Aluminium Production,** row by row, as follows:

- <u>Column | Type of Technology |</u>: 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).
 <u>Note that, for CO₂ emissions, the distinction is between Prebake or Søderberg. For PFC Emissions, the user has the choice of CWPB, SWPB, HSS, and VSS.</u>
- 2. <u>Column | P |</u>: input the amount/mass of aluminium produced by each type of technology, in tonnes.

Example: AD input for CO₂ – Tier 1

CO2 Emissions fr	rom Bake Furnace Packing Ma	terial (Prebake) - Tier 2/3	CO2 Emission	s from paste consumption (Se	derberg) - Tier 2/3 PFC Em	issions from Aluminium production	- Slope method - Tier 2/3
PFC Emissions fr	om Aluminium production - Ov	vervoltage method - Tier 2/3	Capture and	storage or other reduction			
CO2 Emissions fr	om Aluminium Production F	FC Emissions from Aluminium	n Production	CO2 Emissions from Preba	ke Anode Consumption - Tier 2	2/3 CO2 Emissions from Pitch V	olatiles Combustion (Prebake) ·
Worksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Proc Metal Industry 2.C.3 - Aluminium production CO2 Emissions from Aluminiur						
				Equa	tion 4.20		
	Subdivision	Type of Technolo	gy	Amount of Aluminium Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produc	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	ΔΥ		۵V			E = P * EF	E / 1000
National		Sodeberg		25000		1.7 42500	42.5
Southern		Prebake		20000		1.6 32000	32
*							
Total				45000		74500	74 5

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

PFC Emissions from Aluminium production - O	Vervoltage method - Tier 2/3 Capture and	storage or other reduction			
CO2 Emissions from Bake Furnace Packing	laterial (Prebake) Tier 2/3 CO2 Emission	s from paste consumption (Se	derberg) - Tier 2/3 PFC Emission	ns from Aluminium production	- Slope method - Tier 2/3
CO2 Emissions from Aluminium Production	PFC Emissions from Aluminium Production	CO2 Emissions from Preba	ke Anode Consumption - Tier 2/3	CO2 Emissions from Pitch Vo	latiles Combustion (Prebake)
Sector: Industrial Processes and Pro Category: Metal Industry Subcategory: 2.C.3 - Aluminium production Sheet: PFC Emissions from Aluminiu Data	n m Production				
Gas PFC-116 (C2F6) ~	F-Gases Manager				
		Equa	tion 4.25		
Subdivision	Type of Technology	Amount of Aluminium Production (tonne)	C2F6 Emission Factor (kg CF4 / tonne produced)	C2F6 Emissions (kg CF4)	C2F6 Emissions (Gg CF4)
$\land \forall$	7 47	P	EF	E = P * EF	E / 1000000
Unspecified	CWPB	200	0.04	8	0.00001
20	HSS	20000	0.03	600	0.0006
*	Type of Technology				
Total	CWPB	20200		200	0.00004
	HSS	20200		608	0.00061
	SWPB				
	VSS				

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 CO₂ emissions, followed by PFC emissions.

i. CO2 Emissions

Prebake:

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet CO_2 Emissions from Prebake Anode Consumption-Tier 2/3, row by row, as follows:

- 1. <u>Column |MP|</u>: input the amount/mass of aluminium produced by Prebake technology in tonnes.
- 2. <u>Column |NAC|</u>: input net prebaked anode consumption per tonne of aluminium produced, in tonnes of C per tonne Al.

CO2 Emissions from Bake Furnace Packin			from paste consumption (S	iøderberg) - Tier 2/3 F	PFC Emissions from Aluminium production - Slo	pe method - Tier 2/3
PFC Emissions from Aluminium production	n - Overvoltage method - T	ier 2/3 Capture and st	torage or other reduction			
CO2 Emissions from Aluminium Production Vorksheet Sector: Industrial Processes and Category: Metal Industry Subcategory: 2.C.3 - Aluminium produ Sheet: CO2 Emissions for Preb-	l Product Use		CO2 Emissions from Preb	ake Anode Consumption	- Tier 2/3 CO2 Emissions from Pitch Volatile	es Combustion (Prebake)
Data			Equ	ation 4.21		
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)
Δγ	MP	NAC	Sa	ASHa	E = [NAC * MP * (100-Sa-ASHa)/100] * 44/12	E / 1000
ALUMICO	5000	0.3	0.2	2	537	9 5.3
*						
Total						
	5000	0.3			537	9 5.3

Example: AD input for prebake anode consumption – Tier 2/3

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

- 1. <u>Column |GA|</u>: input the amount/mass of the initial weight of green anodes, in tonnes.
- 2. <u>Column |BA|</u>: input the amount/mass of baked anode production, in tonnes.

Example: AD input for pitch volatiles combustion – Tier 2/3

PFC Emissions from Aluminium production	on - Overvoltage method	d - Tier 2/3 Capture and	d storage or other reduct	tion				_		
D2 Emissions from Aluminium Producti orksheet ector: Industrial Processes a ategory: Metal Industry ubcategory: 2.C.3 - Aluminium proc heet: CO2 Emissions from P bata	nd Product Use		CO2 Emissions from	Prebake Anode Consump	ion - Tier 2/3 CO2 Emissions from Pitch Vole	tiles Com	nbustion (Prebake) - Ti	er 2/3		199
				Equation 4.22						
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)			
Subdivision	anodes	green anodes	production							
	anodes (tonne)	green anodes (tonne) Hw	production (tonne)	(tonne)	(tonnes CO2)	2178	(Gg CO2)		e l	2

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

- 1. <u>Column |BA|:</u> input the amount/mass of baked anode production, in tonnes.
- 2. <u>Column |PCC|:</u> input the amount/mass of packing coke consumed per tonnne of based anode production.

Example: AD input for bake furnace packing material (Prebake) – Tier 2/3

O2 Emissions from Aluminium Produc	tion PEC Emissio	ne from Aluminium Pro	duction CO2 Emissi	ions from Prebake Anode C	CO2 Emissions from Pitch Volatiles Comb	ustion (Prebake) - Ti
CO2 Emissions from Bake Furnace Pa	cking Material (Preba	ke) - Tier 2/3 CO2	Emissions from paste o	onsumption (Søderberg) - T	Fier 2/3 PFC Emissions from Aluminium production - Slope metho	d - Tier 2/3
Vorksheet Sector: Industrial Processes Category: Metal Industry Subcategory: 2.C.3 - Aluminium pri Sheet: CO2 Emissions for P Data	oduction	umace Packing Materia	I - Tier 2/3			
				Equation 4.23		_
Subdivision	Baked anode production (tonne)	Packing coke consumption (tonnes / tonne BA)	Sulphur content in packing coke (%)	Ash content in packing coke (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
44	BA	PCC	Spc	ASHpc	E = [PCC * BA * (100-Spc-ASHpc)/100] * 44/12	E / 1000
ALUMICO	32000	0.25	5	2.5	27133.33333	27.133

Søderberg:

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet CO_2 Emissions from paste consumption (Søderberg) - Tier 2/3, row by row, as follows:

- 1. <u>Column |MP|</u>: input the amount/mass of aluminium produced by Soderberg technology, in tonnes.
- 2. <u>Column |PC|:</u> input the amount/mass of paste consumption, in tonnes per tonne of aluminium produced.

Example: I	AD input for paste consumption – Tier $2/3$	
vervoltage method - Tier 2/3	Capture and storage or other reduction	

O2 Emissions from A					and an an other state of the second state of t	and the second se	and the state of t	A Design of the second s				atiles Combustion (Preba	ke) - 1 ier 2/3
ategory: Me ubcategory: 2.0	ustrial tal Ind .3 - Ali	Processes and I ustry uminium product	Product Use	ike) - Tier 2/3		s from paste con	sumption (Søder	berg) - Tier 2/3	PFC Emissio	ons from Alumin	ium production -	Slope method - Tier 2/3	
							Equation	1 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 Emission (Gg CO2
				CSM			ASHp					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)	
Primary ALUMI		35000	0.429	4	34	0.4	0.2	0.1	0.5	0.1	0.1	41359.28463	41.359
						j j							
* otal	_												

ii. PFC Emissions

Slope method

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

- 1. <u>Column | Type of Technology |</u>: 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. <u>Column |MP|</u>: input the amount/mass of aluminium produced, in tonnes.
- 3. <u>Column | AEM |</u>: manually input the anode effect in minutes per cell-day.

Example: AD for PFC emissions from aluminium production (slope method) – Tier 2/3

O2 Emissions from Al	uminium Production PFC	Emissions from Al	uminium Production	CO2 Emissions from F	Prebake Anode Consu	mption - Tier 2/3 CC	2 Emissions from Pitch	Interview Combustion (F	rehake) - Tier 2
	ake Furnace Packing Materia						rom Aluminium productio		
ategory: Met ubcategory: 2.C. heet: PFC Data	istrial Processes and Product al Industry 3 - Aluminium production Emissions from Aluminium Pro		thod - Tier 2/3						
F-Gases Manager									
					Equation 4.26				
Subdivision	Type of Technolo	Amount Aluminiu Productio (tonne)	minutes per cell -day, AEM	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 fi aluminiur productio (Gg C2F6
	7	V MP	AEM	SCF4	ECF4 = SCF4 * AEM * MP A	F	EC2F6 = ECF4 * F	ECF4 / 1000000	EC2F6 / 1000000
ALUMIA	HSS		1000 5	0.099	495	0.085	42.075	0.0005	0.00
	SWPB		1500 2	0.272	816	0.252	205.632	0.00082	0.00
	CW/PB		2000 4	0.143	1144	0.121	138.424	0.00114	0.00
3	VSS	×	3000 5	0.092	1380	0.053	73.14	0.00138	0.0
ŧ	CWPB								
otal	SWPB VSS								
	V35		7500		3835		459.271	0.00384	0.0

Overvoltage method

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

- 1. <u>Column |Type of Technology</u>|: 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. <u>Column | MP |:</u> input the amount/mass of aluminium produced, in tonnes.
- 3. <u>Column | AEO</u> |: input anode effect overvoltage, in mV.

Example: AD for PFC emissions from aluminium production (overvoltage method) - Tier 2/3

otal											
ALUMICO		CWPB	5000	400	1.16	100	2320000	0.121 🗸	280720	2.32	0.28
	7	V	MP	AEO	ovc	CE	ECF4 = OVC * AEO / (CE/100) * MP	F	EC2F6 = ECF4 * Δ F	100000	EC2F6 / 1000000
Subdivisi		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 emission from aluminiur productio (Gg C2F6
F-Gases Mana	iger					Equation 4.2	7				
ector: ategory: ubcategory: heet: Data	Metal Indu 2.C.3 - Alu PFC Emiss	Processes and Product Use ustry uminium production sions from Aluminium Produc		e method - Tier 2/	3						
FC Emissions fro orksheet	om Alumini	ium production - Overvoltag	ge method - Tier 2	2/3 Capture a	nd storage or other re	duction					
		urnace Packing Material (P					g) - Tier 2/3 PFC E	missions from Alumin	ium production - Slope	e method - Tier 2/3	
									ns from Pitch Volatiles		

Emission Factor Input

Sections <u>4.4.2.2</u> and <u>4.4.2.4</u> 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:

- \checkmark Tier 1 EFs for CO₂ (<u>Table 4.10</u>)
- ✓ Tier 2/3 EFs for CO₂ (Tables 4.11, 4.12, 4.13 and 4.14)
- $\checkmark \qquad \text{Tier 1 EFs for PFCs (<u>Table 4.15</u>)}$
- \checkmark Tier 2/3 EFs for PFCs (<u>Table 4.16</u>)

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 CO₂ emissions, followed by PFCs emissions, for different Tiers below.

When Tier 1 Equations are applied:

i. CO2 Emissions

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **CO**₂ **Emissions from Aluminium Production,** row by row in <u>Column |EF</u>|. 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.

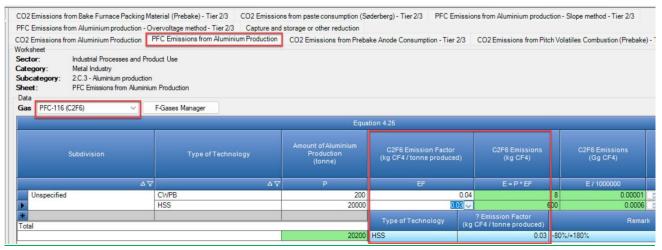
Example: Tier 1 EFs for CO₂

CO2 Emissions f	rom Bake Furnace Packing Ma	terial (Prebake) - Tier 2/3 CO2 Emission	ns from paste consumption (Se	øderberg) - Tier 2/3 PFC Emis	sions from Aluminium production	- Slope method - Tier 2/3
PFC Emissions fr	om Aluminium production - Ov	vervoltage method - Tier 2/3 Capture and	storage or other reduction			
02 Emissions fr	om Aluminium Production P	PFC Emissions from Aluminium Production	CO2 Emissions from Preba	ake Anode Consumption - Tier 2/3	CO2 Emissions from Pitch Vo	latiles Combustion (Prebak
Vorksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Proc Metal Industry 2.C.3 - Aluminium production CO2 Emissions from Aluminium					
Data			Equa	ation 4.20		
	Subdivision	Type of Technology	Amount of Aluminium Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	۵ <u>.</u>	۵7 ۲	P	EF	E = P * EF	E / 1000
National		Sodeberg	25000	1.7	✓ 42500	42
Southern *		Prebake	20000	Type of Technology	CO2 Emission Factor tonnes CO2 / tonne produced)	
Total				Sodeberg	1.7	+-10%
			45000		745001	74

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 <u>Column |EF|</u>. 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. <u>Note that</u> 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:

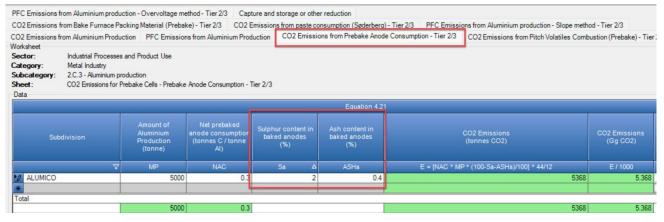
i.CO2 Emissions

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. <u>Column |Sa|</u> input either the default Tier 2 value of 2% sulphur content in baked anodes or plant-specific Tier 3 parameters, in %.
- <u>Column | ASHa |</u> 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 CO2



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. <u>Column |Hw</u>|: the user has the option to specify the hydrogen content in green anodes directly, in tonnes, or calculate it, as follows:
 - a. <u>Specified:</u> 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 <u>Column |GA|</u> for the initial weight of green anodes processed.
 - b. <u>Calculated (to be added in a future release)</u>: 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 <u>Column |GA|</u> to calculate the total hydrogen content in green anodes processed.
- 2. <u>Column |WT|</u>: the user has the option to specify the waste tar collected, in tonnes, or calculate it, as follows:
 - a. <u>Specified:</u> 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 <u>Column |GA</u>| (for Riedhammer furnaces), and insignificant for all other furnace types.
 - b. <u>Calculated (to be added in a future release)</u>: 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 <u>Column |GA|</u> to calculate the total tonnes of waste tar collected.

Example: Tier 2/3 EFs (parameters) input for pitch volatiles combustion for CO2

CO2 Emissions from Bake Furnace Pack	ing Material (Prebake) -	Tier 2/3 CO2 Emissio	ns from paste consumption	on (Søderberg) - Tier 2/3	PFC Emissions from Aluminium production - Slope	method - Tier 2/3	_	
O2 Emissions from Aluminium Producti					ion - Tier 2/3 CO2 Emissions from Pitch Volatiles	Combustion (Prebake) - Ti	ier 2/3	
Vorksheet ector: Industrial Processes ar Category: Metal Industry Pubcategory: 2.C.3 - Aluminium prod heet: CO2 Emissions from Pi Data		(Prebake) - Tier 2/3						19
				Equation 4.22				
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)		
۵ ۲	GA	Hw	BA	wт	E = (GA - Hw - BA - WT) * 44/12	E / 1000		
ALUMICO	1500	5	900	1	217	2.178		1 2
							2	
* Total							the second se	

Then, for each subdivision in worksheet CO₂ Emissions from Bake Furnace Packing Materials (Prebake) – Tier 2/3 data are input, row by row, as follows:

- 1. <u>Column |Spc</u>| input either the default Tier 2 value of 2% of sulphur content in packing coke (wt %) or plant-specific Tier 3 parameters.
- 2. <u>Column |ASHpc|</u> 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 CO2

O2 Emissions from Aluminium Producti	on PFC Emissions from	Aluminium Production	CO2 Emissions from Pre	bake Anode Consumption	- Tier 2/3 CO2 Emissions from Pitch Volatiles (Combustion (Prebake)
CO2 Emissions from Bake Furnace Pack	ing Material (Prebake) - Tie	er 2/3 CO2 Emissions f	rom paste consumption (Søderberg) - Tier 2/3 P	FC Emissions from Aluminium production - Slope	method - Tier 2/3
Vorksneet Sector: Industrial Processes a Category: Metal Industry Subcategory: 2.C.3 - Aluminium prod Sheet: CO2 Emissions for Pre Data		acking Material - Tier 2/3				
	-		Eq	uation 4.23		
	Baked anode	Packing coke	Sulphur content in	Ash content in packing	CO2 Emissions	CO2 Emissions
Subdivision	production (tonne)	consumption (tonnes / tonne BA)	packing coke (%)	coke (%)	(tonnes CO2)	(Gg CO2)
Subdivision	(tonne)					
	(tonne)	(tonnes / tonne BA)	(%)	(%)	(tonnes CO2) E = [PCC * BA * (100-Spc-ASHpc)/100] *	(Gg CO2)

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. <u>Column |CSM|:</u> 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. <u>Column |BC|</u>: 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. <u>Column |Sp|:</u> 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. <u>Column | ASHp|</u>: 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. <u>Column |Hp|</u>: 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. <u>Column |Sc|</u>: 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. <u>Column | ASHc|</u>: 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. <u>Column |CD|</u>: 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.

			and the second second	to ment on street	2/3 Capture an								
O2 Emissions fr	rom Alur	minium Produc	tion PFC Emi	ssions from Alun	ninium Production	the second se	the second second second second second	and the second se		CO2 Emissions	s from Pitch Vola	tiles Combustion (Preb	oake) - Tier 2/3
O2 Emissions fr orksheet	rom Bak	e Furnace Pac	cking Material (P	rebake) - Tier 2/3	3 CO2 Emissio	ons from paste c	onsumption (Søde	erberg) - Tier 2/3	PFC Emissio	ons from Aluminiu	um production - S	Slope method - Tier 2/3	
ector: ategory: ubcategory: heet: Data	Metal 2.C.3	Industry - Aluminium pro		aste Consumptior	1 - Tier 2/3								
							Equatio	on 4.24					
Subdivision		Amount of Aluminium Production (tonne)	Paste consumption (tonnes / tonne AI)	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)
	V	MP	PC		вс		ASHp			ASHc		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)	
Primary ALL	JMI	35000	0.429	4	24	0.6	0.2	3.3	1.9	0.2	0.01	51837.91433	51.8379
ŧ													
otal													
		35000	0.429									51837.91433	51.837

Example: Tier 2/3 EFs (parameters) input for paste consumption for CO₂

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. <u>Column |SCF4</u>|: select from the drop-down menu the default slope coefficient for CF4 or input a plant-specific Tier 3 parameter, in (kg CF4/tonne Al)/(AE-Mins/cell-day).
- 2. <u>Column |F|</u>: select from the drop-down menu the weight fraction of C₂F₆ per CF₄ or input a plant-specific Tier 3 parameter in kg C₂F₆ per kg CF₄.

Example: Tier 2/3 EFs (parameters) input for aluminium production (slope method) for PFCs

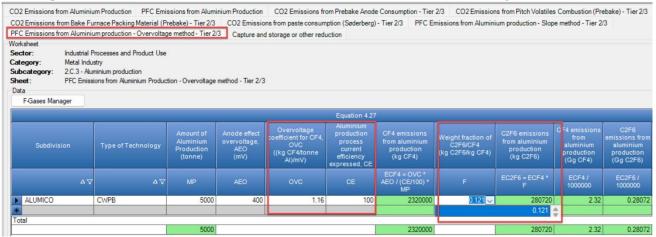
2 Emissions from A	Juminiur	Production PFC Emiss	ions from Alumini	um Production	CO2 Emissions from P	rebake Anode Consun	nption - Tier 2/3 CC	2 Emissions from Pitch	/olatiles Combustion (P	rebake) - Tier
02 Emissions from E rksheet ctor: Ind tegory: Me bcategory: 2.0	Bake Fur lustrial Pr tal Indust C.3 - Alum C Emissio	nace Packing Material (Pre accesses and Product Use	bake) - Tier 2/3	CO2 Emissions				rom Aluminium productio		
					E	equation 4.26	ũ.			
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 from aluminium production (kg C2F6)	CF4 emissions from aluminium production (Gg CF4)	C2F6 emissions fi aluminiur productio (Gg C2F6
	AV	۵۷	MP	AEM	SCF4	ECF4 = SCF4 * AEM * MP	F	EC2F6 = ECF4 * F	ECF4 / 1000000	EC2F6 / 1000000
ALUMIA		CWPB	2000	4	0.143	1144	0.121	138.424	0.00114	0.00
		HSS	1000	5	0.099	495	0.085	42.075		0.0
		SWPB	1500	1	0.272	816	0.252	205.632	0.00082	0.0
		VSS	3000	5	0.092 🗸	1380	0.053 🗸	73.14	0.00138	0.0
						0.092 🔺		0.053 🔺		

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. <u>Column |OVC</u>|: select from the drop-down menu the default overvoltage coefficient for CF₄ or input a plant-specific Tier 3 parameter, in (kg CF₄/tonne Al) per mV.
- 2. <u>Column |CE|</u>: input the aluminium production process current efficiency expressed in % (<u>Equation 4.27</u> provides an example of 95 %).
- 3. <u>Column |F|</u>: select from the drop-down menu the default weight fraction of C₂F₆ per CF₄ or input a plant-specific Tier 3 parameter, in kg C₂F₆ per kg CF₄.

Example: Tier 2/3 EFs (parameters) input for aluminium production (overvoltage method) for PFCs



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:

CO₂ emissions:

- ✓ CO₂ 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 (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. <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 CO₂ captured (with subsequent storage), in tonnes.

3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂ 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

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 - CO2 Emissions from Prebake Anode Consumption - Tier 2/3 CO2 Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissions from Pitch Volatiles Combustion (Prebake) - Tier 2/3 PFC Emissi Sector: Category: Subcategory: Sheet: Industrial Processes and Product Use Metal Industry 2.C.3 - Aluminium production Capture and storage or other reduction Data Gas CARBON DIOXIDE (CO2) Other reduction (tonne) Total reduction (tonne) Total reduction (Gg) stored (tonne) ΔV C = A + B $\Delta \nabla$ C/100 Stream#A ALUMINA 0.002 2 0.002

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 CO₂, 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 SF₆, 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 SF₆ in the industry and default EFs. Tier 3 methods for both CO₂ and SF₆ 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 CO₂ and SF₆ are provided in the *2006 IPCC Guidelines*.

<u>Note that</u> for users using the Software for reporting to the UNFCCC ETF Reporting Tool, the MPGs allow for reporting of all F-gases (except NF₃) for this category. Users may consider whether the methods for SF₆ 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	\mathbf{SF}_{6}	NF ₃
Χ			X	X	X	Χ

IPCC Equations

For CO₂

- ✓ <u>Tier 1</u>: <u>Equation 4.28</u>
- ✓ <u>Tier 2</u>: <u>Equation 4.29</u>
- ✓ <u>Tier 3:</u> no IPCC Tier 3 Equation provided in the 2006 IPCC Guidelines; emissions based on direct measurement

For SF_6

- ✓ Tier 1: Equation 4.30
- ✓ <u>Tier 2</u>: <u>Equation 4.31</u>
- ✓ <u>Tier 3:</u> 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 CO₂ and F-gas emissions from the Magnesium Production source category using the following worksheets:

CO₂ emissions:

- ✓ CO₂ 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 CO₂ EFs. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ Emissions from Magnesium Production Tier 2: contains for each subdivision information on the amount of magnesium produced and country/plant-specific CO₂ EFs. The worksheet calculates the associated CO₂ 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 (SF₆ 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 (CO₂ and F-gas):

✓ **Capture and storage or other reduction** contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂ and SF₆ not accounted previously in the worksheets for different Tiers.

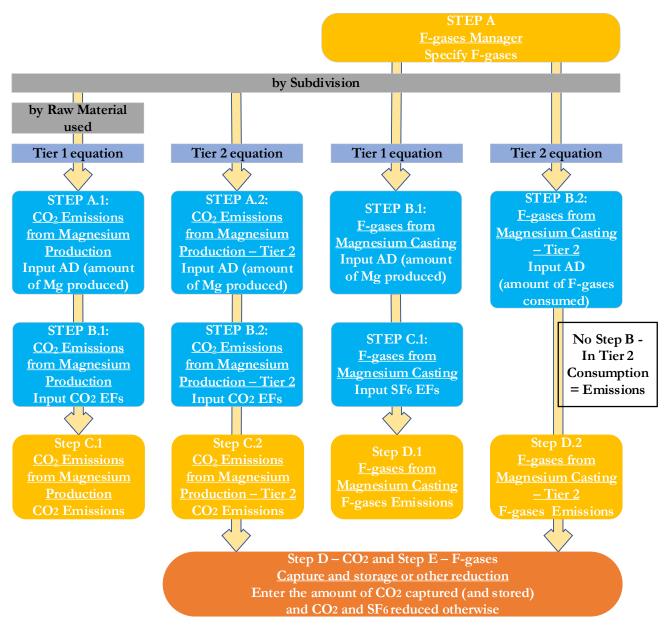
User's Work Flowchart

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-specific¹ 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:

i. CO2 emissions

Step A.1, in worksheet CO₂ 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 **CO₂ Emissions from Magnesium Production,** for each type of raw material used users input the respective CO₂ 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 SF₆ 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. CO2 emissions

Step A.2, in worksheet CO₂ 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 CO₂ Emissions from Magnesium Production – Tier 2, users input country/plant-specific CO₂ 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 (CO₂)/Step E (F-gases), in worksheet Capture and storage or other reduction, if applicable for highertiered 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

<u>Section 4.5.2.3</u> 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.

<u>Note that</u> 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 <u>above</u>.

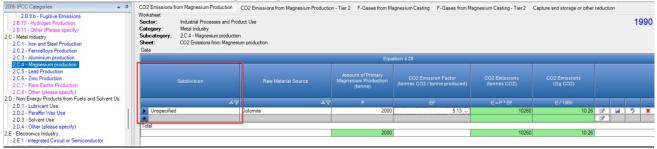
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the CRT. All confidential gases will be reported together as unspecified mix of HFCs and PFCs, SF₆ or NF₃, as appropriate.

Example: Populating the F-gases manager and designating confidentiality for category: magnesium production

heet nr: Industrial Processes	and Product Line				
pr: Industrial Processes gory: Metal Industry	and Product Use				
ategory: 2.C.4 - Magnesium p	roduction				
t: F-Gases from Magne					
. i dabee nom magne	and a dating				
HFC-125 (CHF2CF3)	 F-Gases Mana 	2007			
Hrc-125 (Chrzers)					
		Equ	ation 4.30		
e and the second		Amount of Magnesium Casting	Emission Factor	Emissions	Emissions
Subdivision	Casting System	(tonne)	(kg F-Gas / tonne casting)	(kg F-Gas)	(Gg F-Gas)
	AV	AT C	EF	E = C * EF	E / 1000000
Unspecified	All Casting Processes	3000		2-0 6	
on opeoned			•		
1					
		3000		1	0
F-Gases Manager - 2.C.4					- 🗆 X
F-Gases Manager - 2.C.4	Chem	nicals and Blends - applicabili	ty at IPCC Category level		- 0 X
	Chem	nicals and Blends - applicabili Chemical gro			- 0 X
+ HFCs	Chem				- 0 X
B HFCs PFCs	Chem				X
+ HFCs	Chem				×
B HFCs PFCs	Chem			Consum	~
B HFCs PFCs		Chemical gro		and/o	ed UNFCCC CRT
HFCs PFCs	Chem 			and/o Exporter	ed f UNFCCC CRT 7
HFCs PFCs SF6	ΔŢ	Chemical gro	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
HFCs PFCs	ΔŢ	Chemical gro Chemical	Formula	and/o Exporter	ed r at ∀ evel UNFCCC CRT Confidentiality v
 PFCs PFCs SF6 	ΔŢ	Chemical gro	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
HFCs FFCs SF6 SF6 NF3	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
HFCs FFCs SF6 SF6 NF3 Ethers and Halogenated	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
 HFCs PFCs SF6 SF6 Ethers and Halogenated Other GHGs 	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
HFCs FFCs SF6 SF6 NF3 Ethers and Halogenated	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exporter category	ed f UNFCCC CRT f at V Confidentiality
	∆ ⊽ Sulph	Chemical gro Chemical	Formula	and/o Exportes category	ed f UNFCCC CRT f at V Confidentiality

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

2006 IPCC Categories 🗸 🗸		on CO2 Emissions from Magnesium Producti	on - Tier 2 F-Gases from M	lagnesium Casting F-Gases from M	agnesium Casting - Tier 2	Capture and storage or other	reductio	n	
2.8.9.5 - Fugitive Emissions 2.8.10 - Hydrogen Production 2.8.11 - Other (Please specify) 2.6 - Metal Industry 2.C.1 - Iron and Steel Production 2.C.2 - Ferrollays Production	tive Emissions Withstheet Production see specify) teel Production B Production B Production B Production B Production B Production B Production B Subdivision Casting System Casting System Casting System Casting System Casting System Casting Castin		1990						
2.C.3 - Aluminium production 2.C.4 - Magnesium production	Gas Sulphur Hexafluoride (SF6)	✓ F-Gases Manager							
2.C.5 - Lead Production			Equ	ation 4.30					
- 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 Solvent Us	Subdivision	Casting System	Casting						
- 2.D.1 - Lubricant Use - 2.D.2 - Paraffin Wax Use									
-2.D.2 - Paranin Wax Ose -2.D.3 - Solvent Use	and the second			ER					-
2.D.4 - Other (please specify)	Northern	All Casting Processes	3000	1	3000	0.003			
E - Electronics Industry	Southern	All Casting Processes	2000	1	2000	0.002	and the second second		2 ×
2.E.1 - Integrated Circuit or Semiconductor							3		
2.E.2 - TFT Flat Panel Display	Total		5000		5000	0.005			
-2.E.3 - Photovoltaics			5000		5000	0.000			

When Tier 1 Equations are applied

i.CO2 emissions

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet **CO**₂ **Emissions from Magnesium Production** row by row, as follows:

- 1. <u>Column |Raw Material Source|</u>: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. <u>Column |P|</u>: input the amount/mass of magnesium produced, in tonnes.

loiksheet		CO2 Emissions from Magnesium Product		•	-				
iector: Industrial Processe iategory: Metal Industry iubcategory: 2.C.4 - Magnesium iheet: CO2 Emissions from Data	production							1	99
			Equ	ation 4.28		,			
Subdivision		Raw Material Source	Amount of Primary Magnesium Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
	ΔV	Δ.	7 P	EF	E = P * EF	E / 1000			
 Unspecified 		Dolomite	2000	5.13	10260	10.26	3	2	
*							2		
Total						y			
			2000		10260	10.26			

ii. F-gas emissions

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

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

Example: Tier 1 AD input for SF₆

	on CO2 Emissions from Magnesium Producti	on - Tier 2 F-Gases from Ma	gnesium Casting F-Gases from M	agnesium Casting - Tier 2	Capture and storage or other	reduction		
Category: Metal Industry Subcategory: 2.C.4 - Magnesium proc	luction							1990
Gas Sulphur Hexafluoride (SF6)	V F-Gases Manager							
	-	Equa	ition 4.30					
Industrial Processes and Product Use Itegrory: Metal Industry biocetry: Gases from Magnesium production uset: FGases from Magnesium Casting states Subpliver Hexafluonde (SF6) FGases Manager Equation 4.30 Subpliver Hexafluonde (SF6) FGases Manager Subpliver Hexafluonde (SF6) Amount of Magnesium Casting (tonne) Emission Factor (kg F-Gas) / Casting System Amount of Magnesium Casting (tonne) Emission Factor (kg F-Gas) / Casting System Casting Casting System Casting								
	70 70	7 C	EF	E = C * EF	E / 1000000			
Northern	All Casting Processes	3000	1	3000	0.003	3		
Southern	All Casting Processes	2000	1	2000	0.002			> ×
Total	H.			Emissions (kg F-Gas) E = C * EF 2000 2000 0.003	_			
		5000		5000	0.005			

When Tier 2 Equations are applied

i.CO2 emissions

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet CO_2 Emissions from Magnesium Production – Tier 2 row by row, as follows:

1. <u>Column |P|</u>: input the amount/mass of primary magnesium produced, in tonnes.

Example: Tier 2 AD input for CO₂

CO2 Emissions fr Vorksheet	rom Magnesium Production	CO2 Emissions from	Magnesium Production - Tier 2 F-Gases	from Magnesium Casting F-Gases from Ma	agnesium Casting - Tier 2 Capture and stor	age or other reduction
Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Pro Metal Industry 2.C.4 - Magnesium production CO2 Emissions from Magnesi	on				
				Equation 4.29		
	Subdivision		Amount of Primary Magnesium Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		ΔΫ	Р	EF	E = P * EF	E / 1000
National			233	5.8	1,351.4	1.351
Total			233		1.351.4	1.351

ii. F-gas emissions

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

1. <u>Column |Ci|</u>: input the amount of F-gas consumed in magnesium smelters and foundries, in tonnes.

Example: Tier 2 AD for SF_{6f}

-	nissions from	Magnesium Production - Tier 2 F-Gases from	m Magnesium Casting F-Gases from Ma	gnesium Casting - Tier 2 Capture
Vorksheet Sector: Industrial Processes and Product Use Category: Metal Industry Subcategory: 2.C.4 - Magnesium production Sheet: F-Gases from Magnesium casting - Tie Data				
Gas Sulphur Hexafluoride (SF6)	✓ F-Gi	ases Manager		
			Equation 4.31	
Subdivision (subnational / facility)		Consumption of F-Gas in magnesium smelters and foundries (tonne)	Emissions (tonne F-Gas)	Emissions (Gg F-Gas)
T.	۵V	Ci	Ei = Ci	E / 1000
Magnesium CO	~	2500	2500	
*				
Total		2500	2500	

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:

- \checkmark Tier 1 EFs for CO₂ (<u>Table 4.19</u>)
- \checkmark Tier 1 EFs for SF₆ (<u>Table 4.20</u>)

When the Tier 1 Equations are applied:

i. CO2 emissions

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **CO**₂ **Emissions from Magnesium Production,** row by row in <u>Column |EF</u>|. The user selects either default CO₂ EFs from the drop-down menu or inputs manually user-specific EFs, in tonne of CO₂ per tonne of magnesium produced.

CO2 Emissions fr	om Magnesium Production	CO2 Emissions from Magnesium Productio	n - Tier 2 F-Gases from Ma	agnesium Casting F-Gases fro	m Magnesium Casting - Tier 2	Capture and storage or othe	r reductio	on		
Vorksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Proc Metal Industry 2.C.4 - Magnesium production CO2 Emissions from Magnesi	n							199	
		1	Equi	ation 4.28						
	Subdivision	Raw Material Source	Amount of Primary Magnesium Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produce	CO2 Emissions d) (tonnes CO2)	CO2 Emissions (Gg CO2)				
	ΔV	۵ <i>\</i>	Р	EF	E = P * EF	E / 1000				
Unspecified		Dolomite	2000	5.13	10260	10.26	6 🕜		2	X
* Total				Raw Material Source	CO2 Emission Factor (tonnes CO2 / tonne produced)		Remark			
			2000	Dolomite	5.1	3			-	

Example: Tier 1 EFs for CO₂

ii. F-gas emissions

For each gas and each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **F-Gases from Magnesium Casting,** row by row in <u>Column |EF|</u>. The user selects either default EFs from the drop-down menu (available for SF₆ only) or inputs manually user-specific EFs, in kg F-gas per tonne of magnesium casting. <u>Note that</u> 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 SF₆

O2 Emissions from lorksheet	m Magnesium Production	CO2 Emissions from Magnesium Production	on - Tier 2 F-Gases fr	om Magnesium Casting	F-Gases from Ma	agnesium Casting - Tier	r 2 Capture and storag	e or other	reduct
ategory: ubcategory:	Industrial Processes and Pro Metal Industry 2.C.4 - Magnesium productio F-Gases from Magnesium Ca	n							
Gas Sulphur He	xafluoride (SF6)	✓ F-Gases Manager							
			r	Equation 4.30					
	ubdivision	Casting System	Amount of Magnesi Casting (tonne)	Emissio	n Factor onne casting)	Emissions (kg F-Gas)	Emission: (Gg F-Gas		
-	۵V	ΔΥ	С	E	F	E = C * EF	E / 100000	0	
Northern		All Casting Processes		3000	1		3000	0.003	
Southern		All Casting Processes		2000	1~		2000	0.002	2
* Total				Casting Sy		Emission Factor F-Gas / tonne casting)		Remar	
				5000 All Casting Proce					

When Tier 2 Equations are applied:

i. CO2 emissions

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

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

CO₂ and SF₆ emissions from Magnesium Production are estimated in mass units (tonnes/kg and Gg) by the *Software* in the following worksheets:

CO₂ emissions:

- ✓ CO₂ Emissions from Magnesium Production
- ✓ CO₂ 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. <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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂ or F-gas 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.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.

<u>GHGs</u>

The Software includes the following GHG for the Lead Production and Zinc Production source categories:

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
Χ						

IPCC Equations

- ✓ <u>Tier 1</u>: <u>Equation 4.32</u> (Lead) and <u>Equations 4.33 and 4.34</u> (Zinc)
- ✓ <u>Tier 2</u>: No Tier 2 Equation provided; the *Software* implements the description for Tier 2 in <u>Section 4.6.2.1</u> (Lead) and <u>Section 4.7.2.1</u> (Zinc) of Chapter 4 Volume 3 of the *2006 IPCC Guidelines*
- ✓ <u>Tier 3</u>: 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

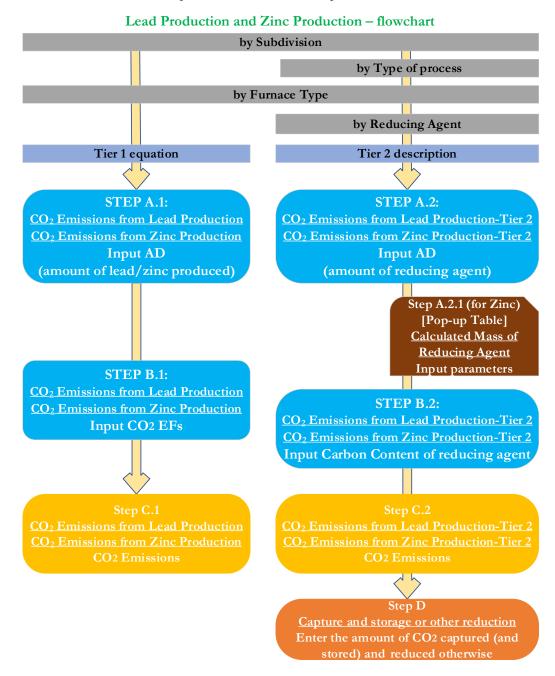
CO₂ emissions from the Lead Production source category are estimated using the following three worksheets:

- ✓ CO₂ Emissions from Lead Production and CO₂ 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 CO₂ EFs. The worksheets calculate the associated CO₂ emissions.
- ✓ CO₂ Emissions from Lead Production- Tier 2 and CO₂ 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 CO₂ emissions.
- ✓ Capture and storage or other reduction contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, 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-specific¹ 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.



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 CO₂ Emissions from Lead Production or CO₂ 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 CO₂ Emissions from Lead Production or CO₂ Emissions from Zinc Production, for each type of furnace/source/process users input respective CO₂ EFs.

Step C.1, in worksheet CO₂ Emissions from Lead Production or CO₂ Emissions from Zinc Production, the *Software* calculates the associated CO₂ 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., reconversion to carbonates), not otherwise captured in the worksheets above.

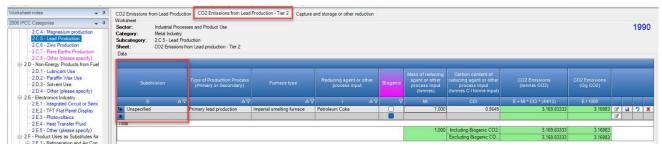
Activity Data Input

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

- ✓ <u>Section 4.6.2.3</u> contains information on the choice of AD for Lead Production.
- \checkmark 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 <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) - lead production



Example: multiple subdivisions – zinc production



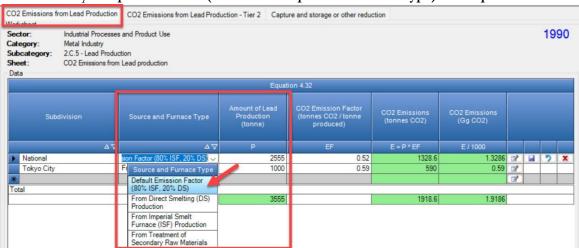
When the Tier 1 Equation is applied:

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 if the type of furnace is unknown, select Default, which assumes the default allocation of 80% imperial smelting furnace and 20% direct smelting</u>

for lead production and 60% imperial smelting furnace and 40% Waelz Kiln for zine 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 <u>Column |Subdivision|</u>, data are entered in worksheet CO_2 Emissions from Lead Production – Tier 2 or CO_2 Emissions from Zinc Production – Tier 2, row by row, as follows:

- 1. <u>Column |Type of Production (Primary or Secondary)</u>: select from the drop-down menu whether emissions are estimated for primary production or secondary production.
- 2. <u>Column |Furnace type|</u>: select from the drop-down menu the default type of furnace or input manually a user-specific type of furnace.
- 3. <u>Column |i|</u>: select from the drop-down menu the default type of reducing agent or input manually a user-specific type of carbon input.

<u>Note that</u> the selections in the drop-down menu are from the Fuel Manager. If the user selects a fuel from the Fuel Manager, the carbon content of that fuel will automatically be populated in <u>Column |CCi|</u>. If a user-specific reducing agent or process fuel is input, the user will be required to manually enter <u>Column |CCi|</u>. See section **Fuel Manager** for more information on how to populate the Fuel Manager.

- 4. <u>Column | Biogenic |</u>: indicate with a check if the reducing agent or other process input is of biogenic origin.
- 5. <u>Column |Mi|</u>: input the amount/mass of reducing agent or other process input consumed, in tonnes. <u>Note that</u> for **Zinc Production**, the user has the choice to **specify** directly the mass of reducing agent or other process input used (the same as lead production), or 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. <u>Column |D|:</u> first, indicate whether the total amount of EAF dust produced is to be **Specified** (thus input directly) or **Calculated**.
 - i. If <u>Column |D|</u> is *Specified*, <u>Column |P|</u> and <u>Column |DF|</u> are grayed out and the user inputs the amount of EAF dust production in <u>Column |D|</u>.
 - ii. <u>If Column |D|</u> is *Calculated*, input the amount of zinc produced, in tonnes in <u>Column |P|</u>. Select or insert the IPCC default EAF dust factor of 1.23 t EAF dust/t zinc in <u>Column |DF|</u>, or input a user-specific value.
- b. <u>Column |CF|:</u> 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.

egory: Metal Indust category: 2.C.6 - Zinc	ry Production	er 2										19
Subdivision	Type of Production Process (Primary or Secondary)		Reducing agent or other process input			input		Carbon content of reducing agent or other process input (tonnes C / tonne input)				
s 4v	6 - Znc Production - Ter 2											
National	Primary zinc production	Waelz Kiln	Petroleum Coke		Calculated	492	2	0.8645		58 1.55956	2	
Unspecified	Primary zinc production	Pyrometallurgical (Imp	Petroleum Coke				12	0.8645		0 0	2	19
				8	Calculated						2	
N	Aass of reducing agent o	r other process input						Excluding Biogenic		58 1.55956		
					uction	Coke factor (t Coke / t Dust	t)	or other process inp	ent ut			
		DF										
	* 10	00 1.		7	1230		0.4	4				
	*								X			
	Total		opechied	_			-	4	92			
									_			

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:

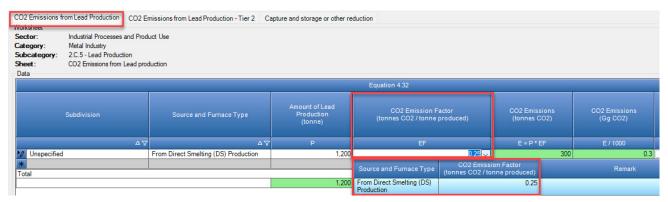
- ✓ <u>Section 4.6.2.2</u> contains information on the choice of EFs for Lead Production. Tier 1 CO₂ EFs are presented in <u>Table 4.21</u>. Tier 2 default carbon contents for input materials are presented in <u>Table 4.22</u>, but are to be used only if the compiler does not have user-specific information.
- ✓ <u>Section 4.7.2.2</u> contains information on the choice of EFs for Zinc Production. Tier 1 CO₂ EFs are presented in <u>Table 4.24</u>.

When the Tier 1 Equation is applied:

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

 <u>Column | EF |:</u> Select from the drop-down menu or manually overwrite the EFs with user-specific values. <u>Note that:</u> for Lead Production, the user selection for the default in <u>Column | EF |</u> depends on the type of furnace in <u>Column | Source and Furnace Type |</u>. For zinc production, Column | EF | is automatically populated based on the selection in <u>Column | Source and Furnace Type |</u>.

Example: Tier 1 EFs for CO₂ – lead production



Example: Tier 1 EFs for CO₂-zinc production

Vorksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Product U Metal Industry 2.C.6 - Zinc Production CO2 Emissions from Zinc production								
Data					Equation 4.	33, 4.34	24		
	Subdivision	Type of Proce	SS	Amount of Zin (toni		CO2 Emission Factor (tonnes CO2 / tonne produced)		2 Emissions nnes CO2)	CO2 Emissions (Gg CO2)
- 11	Δ 🗸		Δγ	P		EF		E = P * EF	E / 1000
Unspecified		Electro-thermic		_	1,200	2		2,400	
* Unspecified						1.72			
* Total		Type of Process	COLEmiss (tonnes CO2 / to		-	Remark			
		Default Factor		1.72		based on weighting of known en nperial Smelting, 40% Waelz Kiln		2,400	
		Electro-thermic			Unknown				
		Pyrometeallurgical (Imperial Smelting Furnace)	0.42 Siardia 2002 CO2 Emiss			CO2 Emission Factors for Non-Er ous Metal, Ferroalloys and Inorg micus Institute, Utrecht, The Net	nergy Use anics nerlands.		
		Waelz Kiln		3.66	Derived from V the Environmer Galvanized Ste 292-299.	iklund-White C. (2000) The Use on Ital Evaluation of the Recycling of the ISIJ International. Volume 40	of LCA for vf No. 3:		

When the Tier 2 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet CO_2 Emissions from Lead **Production – Tier 2** or CO_2 Emissions from Zinc Production – Tier 2, row by row, in <u>Column |CCi|</u>. 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 <u>Column |CCi|</u>. Users may manually over-write the carbon content with user-specific values.

<u>Note that if</u> 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 <u>Column | CCi |</u> will not automatically change and the user-defined carbon content must be input.

Results

CO₂ emissions from Lead Production are estimated in mass units (tonnes and Gg) by the *Software* in the following worksheets:

✓ CO₂ Emissions from Lead Production

✓ CO₂ Emissions from Lead Production – Tier 2

CO₂ emissions from Zinc Production are estimated in mass units (tonnes and Gg) by the *Software* in the following worksheets:

- ✓ CO₂ Emissions from Zinc Production
- ✓ CO₂ Emissions from Zinc Production Tier 2

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

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

- 1. <u>Column |SRC|</u>: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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|</u>: collect and input information on any other long-term reduction of CO₂, in tonnes. <u>Note that</u>: <u>Column |B|</u> may include short-term reductions only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.
- 4. <u>Column | Biogenic</u> |: indicate with a check if the reductant/process input material is of biogenic origin. Note that consistent with the 2006 IPCC Guidelines, capture of biogenic CO₂ for long-term storage may lead to negative CO₂ emissions.

Example: capture and storage or other reduction-lead production

/orksheet					_						
ector: ategory: ubcategory: heet: Data	Meta 2.C.	al Industry .5 - Lead Produ	es and Product Use uction ge or other reduction								19
Gas CAF	RBON DI	IOXIDE (CO2)		~							
Su	bdivisio	'n	Source		Amount CO2 captured and stored	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	Biogenic		
Su	ibdivisio S	on A T		۵V	captured and				Biogenic V		
	S			△ \	captured and stored	(tonne)	(tonne)	(Gg)		3	2
	S		SRC		captured and stored A	(tonne) B	(tonne) C = A + B	(Gg) C / 1000			 2
1/ Tokyo Sm *	S		SRC		captured and stored A	(tonne) B	(tonne) C = A + B	(Gg) C / 1000			2
	S		SRC		captured and stored A	(tonne) B	(tonne) C = A + B	(Gg) C / 1000			 2

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.

<u>GHGs</u>

The Software includes the following GHGs for the Rare Earths Production source category:

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	\mathbf{SF}_{6}	NF ₃
X			-	X	-	

IPCC Equations

For CO₂

- ✓ <u>Tier 1</u>: <u>Equation 4.35 (NEW)</u>
- ✓ <u>Tier 3</u>: <u>Equation 4.36 (NEW)</u>

For PFCs

- ✓ Tier 1: Equation 4.37 (NEW)
- ✓ <u>Tier 3</u>: 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

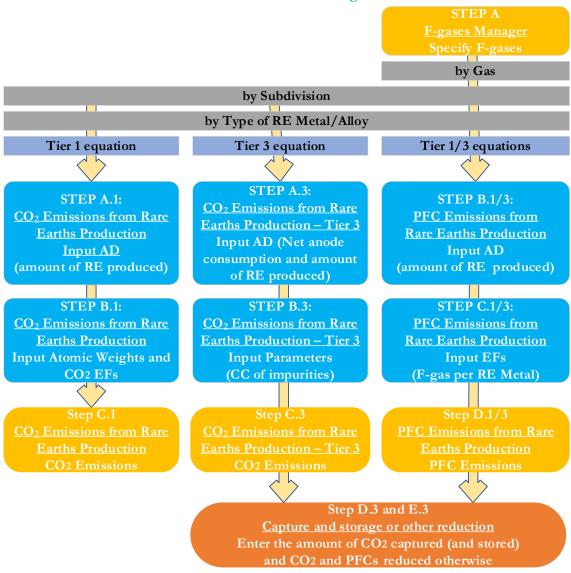
The Software calculates CO2 and PFC emissions from Rare Earths Production using the following worksheets:

- ✓ CO₂ 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 CO₂ EFs. The worksheet calculates the associated CO₂ emissions.
- ✓ CO₂ 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 CO₂ 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 CO₂ capture (with subsequent storage) and other reduction of CO₂ 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 <u>Figure 4.17 (NEW)</u> (for CO₂) and <u>Figure 4.18</u> (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-specific¹ 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 – CO2 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. CO₂ emissions

When the Tier 1 Equation is applied:

Step A.1, in worksheet CO₂ 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 **CO₂ Emissions from Rare Earths Production**, users collect and input CO₂ 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 **CO₂ Emissions from Rare Earths Production,** the *Software* calculates the associated CO₂ 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 CO₂ 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 CO₂ 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.

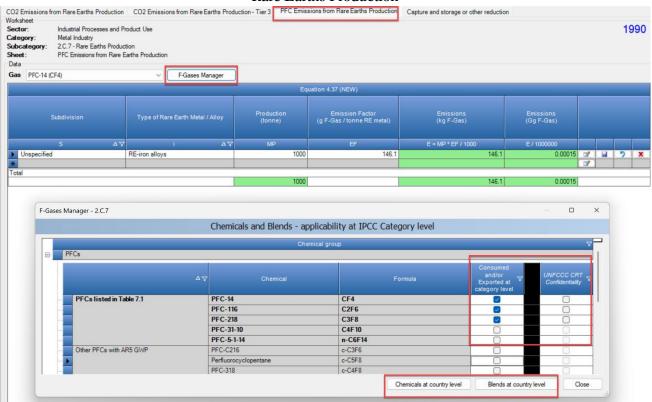
Activity Data Input

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.

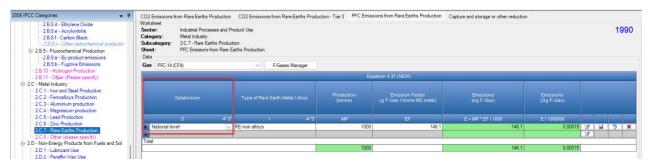
<u>Note that</u> if it is not possible to select a gas for estimation, the category-level F-gas Manager must be filled in. If data entry is not possible, select the **F-Gases Manager** in worksheet **PFC Emissions from Rare Earths Production**. This will open the F-gases Manager – applicability at IPCC 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 <u>above</u>. <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 CO₂ 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> [subdivision] for each subdivision.

Example: single subdivision



Example: multiple subdivisions

2.8.8.4 - Ethylene Oxide 2.8.8.e - Acrylonitrile 2.8.8.e - Acrylonitrile 2.8.8.e - Other petrochemical productio 2.8.9 Fluorochemical Production 4.8.9.a - By-product emissions	Category: Met Subcategory: 2.C.	strial Processes a al Industry 7 - Rare Earths Pr 2 Emissions from R								19	990
2.B.9.b - Fugitive Emissions 2.B.10 - Hydrogen Production					Equation 4.36	(New)					
2.B.11 - Other (Please specify) 2.C - Metal Industry 2.C.1 - Iron and Steel Production	Subdivis	ion		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)			
2.C.2 - Ferroalloys Production 2.C.3 - Aluminium production	s	۵ . ۷		NACI	MPi	IMPa	E = (NACi * MPi) * [(100 - IMPa)/100] * (44/12)	E/1000			
- 2.C.4 - Magnesium production - 2.C.5 - Lead Production	Plant 2342		Cerium	344	300	3	367048	367.048	3		
- 2.C.6 - Zinc Production	Plant X		Scandium	1000	150	2.2	537900	537.9	3	4 2	×
2.C.7 - Rare Earths Production 2.C.8 - Other (please specify) 2.D - Non-Energy Products from Fuels and Sol	Total			1344	450		904948	904.948			-

When the Tier 1 Equations are applied (CO₂ and PFCs):

For each subdivision in <u>Column |Subdivision|</u>, 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. <u>Column |i|</u>: select from the drop-down menu the RE metal/alloy produced, or manually input a user-specific RE metal/alloy.
- 2. <u>Column | MPi |</u>: input the amount/mass of RE metal/alloy produced, in tonnes.

Example: **AD** input for **CO**₂ – Tier 1

ector: Category: Gubcategory: Gheet: Data	Industrial Processe Metal Industry 2.C.7 - Rare Earths CO2 Emissions from							
				Equat	ion 4.35 (New)			
Subo	livision	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 Emission (Gg CO2)
	۵v	i A T	MPi	AWbase	AWi	EFCO2	E = MPi * (AWbase / AWi) * EFCO2	
		Erbium	122	144.24	167.259	0.56	58.91747	0.05
 Unspecified 								

When the Tier 3 Equation is applied (CO₂):

For each subdivision in <u>Column |Subdivision|</u>, data are entered in worksheet CO₂ Emissions from Rare Earths Production – Tier 3, row by row, as follows:

- 1. <u>Column |i|</u>: select from the drop-down menu the RE metal/alloy produced, or manually input a user-specific RE metal/alloy.
- 2. <u>Column |NACi|</u>: input facility-specific net anode consumption, in tonnes anode/t RE metal produced.
- 3. <u>Column | MPi</u>]: input the amount/mass of RE metal/alloy produced, in tonnes.

Example: **AD** input for **CO**₂ – Tier 3

							2 1010		
O2 Emissions fro	om Rare Earths Produ	ction (CO2 Emis	sions from Rare B	arths Production - Tier 3	PFC Emissions from F	Rare Earths Production	Capture and storage or other reduction	
orksheet ector: ategory: ubcategory: heet:)ata	Industrial Processes a Metal Industry 2.C.7 - Rare Earths P CO2 Emissions from P	roduction	ı	on - Tier 3					
		_				Equation 4.36	(New)	4	
Sub	division	Туре о	of Rare Ea	rth 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	s Av		i.	Δ 7	NACI	MPi	ІМРа	E = (NACi * MPi) * [(100 - IMPa)/100] * (44/12)	E / 1000
Plant 2342		Cerium	1		344	300	3	367048	367.
Plant X		Scandi	um		1000	150	2.2	537900	53
K									
otal									
					1344	450		904948	904.

Emission Factor Input

Sections <u>4.8.2.2</u> and <u>4.8.2.4</u> in Chapter 4 Volume 3 of the *2019 Refinements* contain information on the choice of CO₂ and PFC EFs, respectively, for Rare Earths Production; specifically:

- Tier 1 EFs for CO₂ (<u>Table 4.26 (NEW</u>)) <u>Note that</u>: the CO₂ 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 <u>4.8.2.1</u>.
- 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. CO2 Emissions

For each subdivision in <u>Column |Subdivision|</u>, in worksheet **CO₂ Emissions from Rare Earths Production**, the *Software* automatically populates the following columns after the user enters information in <u>Column |i|</u>:

- 1. <u>Column |EF|</u>: the *Software* automatically populates the default EF; the user may manually overwrite.
- 2. <u>Column |AW_{base}|</u>: the *Software* automatically populates the atomic weight of the base case RE metal, Nd; in g/mole.
- 3. <u>Column $|AW_i|$: the *Software* automatically populates the atomic weight of the produced RE metal, i, in g/mole.</u>

CO2 Emissions fr Vorksheet	om Rare Earths P	roduction CO2 Emissi	ons from Rare Earths Produ	uction - Tier 3 PFC	C Emissions from Ran	e Earths Production	Capture and storage or other reduction	
Vorksneet Sector: Category: Subcategory: Sheet: Data	Metal Industry 2.C.7 - Rare Earl	ses and Product Use hs Production om Rare Earths Productio	n					
					Equation 4.35 (N	ew)		
Subdi	vision	Type of Rare Earth Me Alloy	tal / 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 Emission: (Gg CO2)
S	7	1	∆ \ MPi	AWbase	AWi	EFCO2	E = MPi * (AWbase / AWi) * EFCO2	E / 1000
Unspecified		Promethium	200	144.24	145	0.56	111.41297	0.111
		Yttrium	1000	144.24	88.90585	0.56	908.53864	0.908
*								
Total								
			1200				1019.9516	1.019

Example: Tier 1 EFs for CO₂

ii. PFC Emissions

For each subdivision in <u>Column |Subdivision|</u>, in worksheet **PFC Emissions from Rare Earths Production**, the *Software* automatically populates <u>Column |EF|</u> after the user enters information in <u>Column |i|</u>, 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. <u>Note that</u> 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)

02 Emissions from Rare Earths Production orksheet	CO2 Emissio	ns from Rare Earths Product	tion - Tier 3 PFC Emiss	ions from Rare Earths Production	Capture and storage or other reduction	
ector: Industrial Processes and F ategory: Metal Industry sbcategory: 2.C.7 - Rare Earths Produc neet: PFC Emissions from Rare f ata	tion					
ias PFC-14 (CF4)	~	F-Gases Manager				
			Equ	uation 4.37 (NEW)		
Subdivision	Type of Rai	re Earth Metal / Alloy	Production (tonne)	Emission Factor (g F-Gas / tonne RE metal)	Emissions (kg F-Gas)	Emissions (Gg F-Gas)
S ∆⊽		i AV	MP	EF	E = MP * EF / 1000	E / 1000000
National level	RE-iron alloys		1000	146.1	146.1	0.000
Unspecified	RE-iron alloys		2000	146.1	292.2	0.00
otal					100.0	0.00
			3000		438.3	0.00

When the Tier 3 Equation is applied:

For each subdivision in <u>Column |Subdivision|</u>, 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 <u>Column |IMPa|</u>, in wt%.

Example: EFs input for CO₂ (Tiers 3)

02 Emissions fr /orksheet	rom Rare Earths Produ	ction CO.	2 Emissions I	rom Kare E	arths Production - Tier 3	PFC Emissions from I	Rare Earths Production	Capture and storage or other reduction	
iector: Category: Subcategory: Sheet: Data	Industrial Processes Metal Industry 2.C.7 - Rare Earths F CO2 Emissions from	roduction		ier 3					
						Equation 4.36	(New)		
Sul	bdivision	Type of F	Rare Earth Me	etal / 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 A7		i	۵v	NACI	MPi	IMPa	E = (NACi * MPi) * [(100 - IMPa)/100] * (44/12)	E / 1000
Plant 2342		Cerium			344	300	3	367048	367.0
Plant X		Scandium			1000	150	2.2	537900	53
Total									

Results

CO₂ and PFC emissions from Rare Earths Production are estimated in mass units (tonnes and Gg for CO₂ and kg and Gg for PFCs) by the *Software* in the following worksheets:

CO₂ emissions:

- ✓ CO₂ Emissions from Rare Earths Production
- ✓ CO₂ Emissions from Rare Earths Production-Tier 3

PFCs emissions:

✓ PFC Emissions from Rare Earths Production

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

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

- 1. <u>Column |SRC|</u>: 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂ 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

O2 Emissions fr	rom Rare Earths Production	CO2 Emissio	ons from Rare Earths Pr	roduction	- Tier 3 PFC Emissions from	Rare Earths Production	Capture and storage or other re	eduction
orksheet								
ector:	Industrial Processes and Pro	duct Use						
ategory:	Metal Industry							
ubcategory:	2.C.7 - Rare Earths Production	n						
heet:	Capture and storage or other	reduction						
ata								
DEC 14 //			E Ganna Managar					
Gas PFC-14 (CF4)	~	F-Gases Manager					
Gas PFC-14 (CF4)	~	F-Gases Manager					
Gas PFC-14 (CF4)		F-Gases Manager		Amount CO2 centured and			
Gas PFC-14 (~			Amount CO2 captured and stored	Other reduction	Total reduction	Total reduction
Gas PFC-14 (CF4) Subdivision		F-Gases Manager Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
Gas PFC-14 (stored (tonne)			
ias PFC-14 (Subdivision S A		Source	∆ 7	stored (tonne)	(tonne) B	(tonne)	(Gg) C / 1000
	Subdivision S A	7	Source	Δ7	stored (tonne)	(tonne) B	(tonne) C = A + B	(Gg) C / 1000
	Subdivision S A	7	Source	_ ▲ ▽	stored (tonne)	(tonne) B	(tonne) C = A + B	(Gg) C / 1000

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:

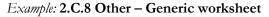
- ✓ F-gases used in Aluminium Foundries
- ✓ CH_4 and N_2O emissions from Rare Earths Production

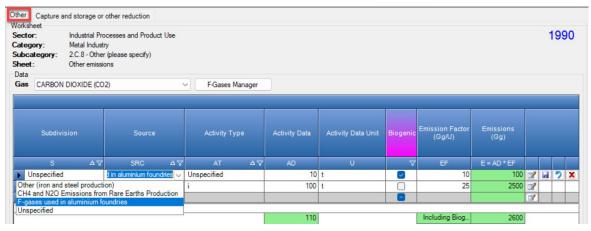
GHGs

Other emissions from the metal industry source category include the following GHGs:

CO ₂	CH ₄	N_2O	HFCs	PFCs	\mathbf{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).





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 CO₂, CH₄ and N₂O 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 nonenergy 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 CH₄ and N₂O 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 "CH₄ and N₂O emissions from lubricant use" and "CH₄ and N₂O emissions from paraffin wax" are provided as a default options in the drop-down menu in <u>Column</u> <u>|SRC|</u>. For further information, see section 2.D.4 Other.

IPCC Equations

- ✓ <u>Tier 1</u>: <u>Equation 5.2</u> (Lubricant Use), <u>Equation 5.4</u> (Paraffin Wax Use)
- ✓ <u>Tier 2: Equation 5.3</u> (Lubricant Use), <u>Equation 5.5</u> (Paraffin Wax Use)
- ✓ <u>Tier 3:</u> 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:

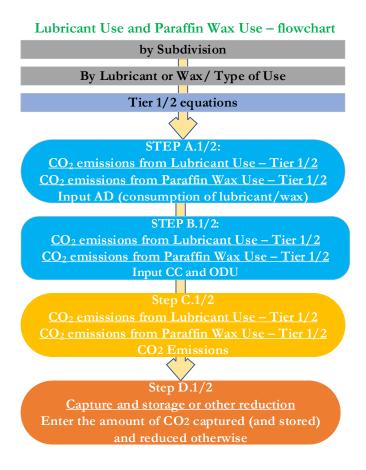
- ✓ CO₂ emissions from Lubricant Use Tier 1/2 or CO₂ emissions from Paraffin Wax Use Tier 1/2: contains for each subdivision and each NEU product type/use (e.g. lubricating oil, grease, paraffin wax) information on the amount of lubricant/paraffin wax consumed, its carbon content and ODU factor. The worksheet calculates the associated CO₂ emissions.
- Capture and storage or other reduction contains information on CO₂ capture (with subsequent storage) and other reduction of CO₂, 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-specific¹ 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:



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., reconversion to carbonates).

Activity Data Input

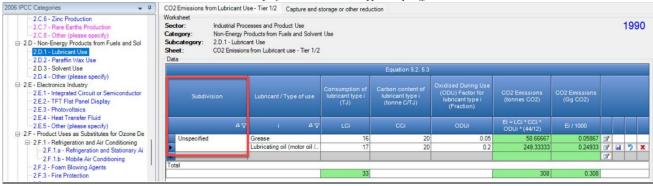
The following sections in Chapter 3, Volume 5 of the 2006 IPCC Guidelines contain information on the choice of AD:

- ✓ Section 5.2.2.3 contains information on the choice of AD for Lubricant Use.
- \checkmark 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 <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.

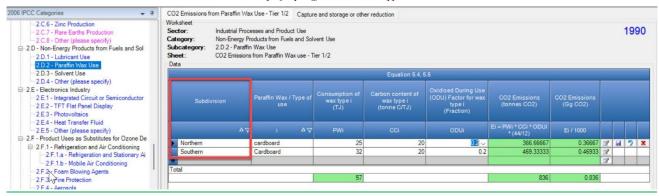
Example: single subdivision (unspecified)

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 <u>Column |Subdivision|</u>, 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:

 <u>Column |i|</u>: 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.

<u>Note that:</u> 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".

<u>Recall that</u> 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. <u>Column |LCi | (Lubricant Use)</u>: input the amount/mass of lubricant consumed in TJ.
- 3. <u>Column | PWi | (Paraffin Wax Use)</u>: 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

Cato	egory: Non-Energy Pr category: 2.D.2 - Paraffin eet: CO2 Emissions	esses and Product Use oducts from Fuels and So 1 Wax Use from Paraffin Wax use -							19	90
				Equation 5.4, 5						
	Subdivision	Paraffin Wax / Type of use	Consumption of wax type i (TJ)	Carbon content of wax type i (tonne C/TJ)	Oxidised During Use (ODU) Factor for wax type i (Fraction)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)			
	ΔŢ	i 47	PWi	CCi	ODUi	Ei = PWi * CCi * ODUi * (44/12)	Ei / 1000			
0	Northern	Cardboard	25	20	0.2	366.66667	0.36667	2	2	
	Southern	Cardboard	32	20	0.2	469.33333	0.46933	2		Γ
								2		

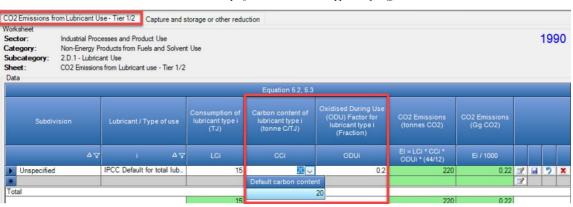
Emission Factor Input

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

- ✓ <u>Section 5.2.2.2</u> contains information on the choice of EF for Lubricant Use. Default values are presented in <u>Table 5.2</u>.
- ✓ <u>Section 5.3.2.2</u> 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. <u>Column |CCi|</u>: 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. <u>Column |ODUi|</u>: 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 CO₂

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 CO₂ 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 CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of CO₂, 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

stor: egory: ocategory: set: a	Industrial Processes Non-Energy Product 2.D.2 - Paraffin Wax Capture and storage	s from Fuels and Solvent U Use	lse						19
CARB	ON DIOXIDE (CO2)	~							
	ON DIOXIDE (CO2)	Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)		
Sub		Source	۵ 7	captured and stored					
Sub	odivision S ∆⊽	Source	Δγ	captured and stored (tonne)	(tonne)	(tonne)	(Gg)		5

2.D.3 Solvent Use

Category 2.D.3 Solvent Use is not a source category that emits direct GHGs (CO₂, CH₄, N₂O 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 CO₂, CH₄ and N₂O 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:

- ✓ CH₄ and N₂O emissions from Lubricant Use
- \checkmark CH4 and N2O emissions from Paraffin Wax Use
- ✓ CO₂, CH₄ and N₂O emissions from Solvent Use
- ✓ CO₂, CH₄ and N₂O emissions from Road Paving with Asphalt
- ✓ CO₂, CH₄ and N₂O 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 ₂ O	HFCs	PFCs	SF ₆	NF ₃
X	Χ	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

ector: ategory: ubcategory: heet:	Non-Energ	Processes and Product Use gy Products from Fuels and Solvent Us her (please specify) isions	e							199
ias CARBON	DIOXIDE (0	CO2) ~								
Subdivis		Source		Activity Type	Activity Data	Activity Data Unit	Emission Factor (Gg/U)	Emissions (Gg)		
Subdivis	iion ∆∵⊽		۵V			Activity Data Unit	Factor			
	ΔV		△ ▽			U	Factor (Gg/U)	(Gg) E = AD * EF		1 2
S	ΔŢ	SRC Asphalt roofing Solvent use		AT AV	AD	U	Factor (Gg/U) EF	(Gg) E = AD * EF		1 7
S	۵V	SRC Asphat rooing Solvent use Road paving with asphalt		AT ∆⊽ Unspecified	AD 3000	U t t	Factor (Gg/U) EF 156	(Gg) E = AD * EF 468000	2	1 7
S	۵V	SRC Asphalt roofing Solvent use	V	AT △マ Unspecified Unspecified	AD 3000 2000	U t t t	Factor (Gg/U) EF 156 20	(Gg) E = AD * EF 468000 40000 25000		4 2

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 N₂O.

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 <u>all</u> 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).

<u>GHGs</u>

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

- ✓ <u>Tier 1: Equation 6.1</u>
- ✓ <u>Tier 2a: Equations 6.2, 6.3, 6.4, 6.5 and 6.6</u>
- ✓ <u>Tier 2b: Equations 6.7, 6.8, 6.9, 6.10 and 6.11</u>.
- ✓ <u>Tier 3:</u> 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 (m² 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 N₂O) 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 2a¹: 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 2a²: 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 3³: 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 3⁴: 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.

² Ibid.

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.

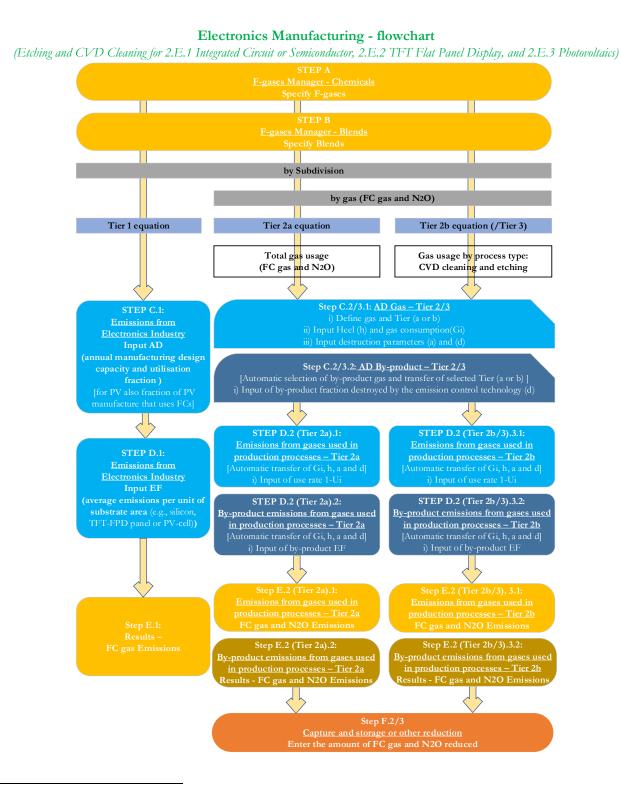
³ Ibid.

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-specific¹ 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.



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 (m² 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 m² 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 CO₂ 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.

<u>First,</u>

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.

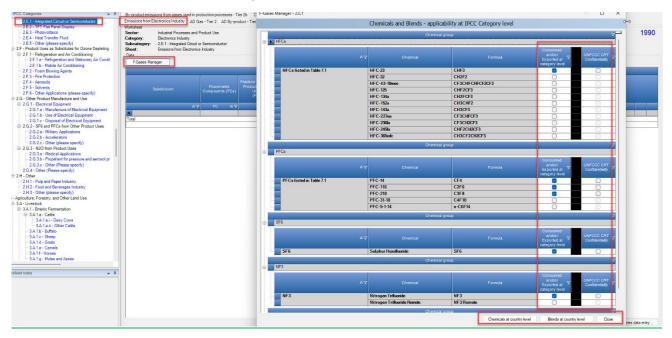
As a **starting step**, users must ensure that the **F-gases Manager** has been populated for all F-gases to be reported for the different activities. When considering the F-gases to add, note that the Tier 1 method for these categories must include estimates for a basket of gases, so all the following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

- ✓ 2.E.1. Integrated Circuit or Semiconductor: HFC-23, CF₄, C₂F₆, C₃F₈, NF₃, and SF₆
- ✓ 2.E.2 TFT Flat Panel Display: CF₄, NF₃ and SF₆
- ✓ 2.E.3 Photovoltaics: CF_4 , and C_2F_6

<u>Note that</u> 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 <u>above</u>.

<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 CO₂ 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 N₂O as being emitted as a by-product, the 2006 IPCC Guidelines list only four gases emitted as by-products: CF4, C2F6, C3F8 and HFC-23. The 2019 Refinement adds C₄F₆, C₄F₈, C₅F₈, CH₃F 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: Semi	iconduct	or manufa	cturing- Re	elevant by	-product	s for each in	put gas (fr	om Table 6	6.3)			
Process gas,	C₂F ₆	HFC-23	HFC-32	C ₃ F ₈	c-C₄F ₈	NF ₃ -Remote	NF ₃	perfluorob uta-1,3 diene*		C₄F ₈ O***	F2***	COF2***
		I			Tier 2a	a (By-products)						
CF ₄	√	√	√	\checkmark	√	√	√	√	√	√	√	√
C ₂ F ₆					√			√	√			
C ₃ F ₈										√		
I		1			Tier 2	b (By-products)		1	•	· · · · ·		
						Etch						
CF ₄	√	√	√	\checkmark	√			√	√			
C ₂ F ₆					√			√	√			
						CVD						
CF ₄	√				√	√	√		√	√	√	√
C ₂ F ₆												
C ₃ F ₈										√		
* Table 6.3 includ	des gas C ₄ F ₆ .	In the AR5 and I	PCC Software,	C ₄ F ₆ is referred	to as perfluc	probuta-1,3 diene		•	•			•

** Table 6.3 in the 2006 IPCC Guidelines and 2019 Refinement refer to C5F8, but Section 6.1.1.1 in the 2019 Refinement refers to the relevant gas as octafluorocyclopentene (c-C5F8). c-C₅F₈ has an AR5 GWP is included in the Software.

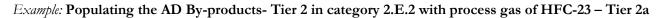
*** These gases appear under "Other GHGs" in the national -and category-level F-gases Manager

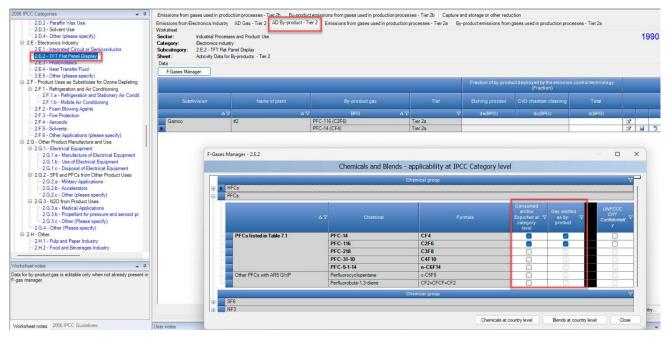
Example: List of By-products to be selected in AD By-product – Tier 2 for source category 2.E.2 TFT FPD and 2.E.3 Photovoltaics

2.E.2 LCE) Manufac	turing:
Relevant By	-products	foreach
input gas	(from Tab	le 6.3)
Process gas, i	HFC-23	c-C ₄ F ₈
Tier 2	a (By-produc	ts)
CF4	\checkmark	√
HFC-23		√
C2F6	√	
C3F8		
Tier 2	o (By-produc	ts)
	Etch	
CF4	√	√
HFC-23		√
C2F6	√	
•	CVD	
CF4		
C2F6		
C3F8		

Process gas,	C_2F_6	C ₃ F ₈	c-C ₄ F ₈	NF ₃
	Tier	2a (By-produ	cts)	
CF ₄	√	\checkmark	√	√
C ₂ F ₆			√	
C ₃ F ₈				
	Tier	2b (By-produ	icts)	
		Etch		
CF ₄	√		√	
C ₂ F ₆			√	
•		CVD	•	
CF ₄	√	√	√	
C ₂ F ₆				
C ₃ F ₈				
* Table 6.3 includ referred to as per			PCC Software,	C ₄ F ₆ is

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.





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:

- <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 <u>Table 6.2</u>. <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.
- <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° m² of substrate processed for Semiconductors and TFT-FPDs and for PV manufacturing in 10⁶ m². <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 <u>section 6.2.3</u> of the 2019 Refinement for further information on acquiring AD).
- 4. <u>Column | Cpv | (only for PVs)</u>: 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

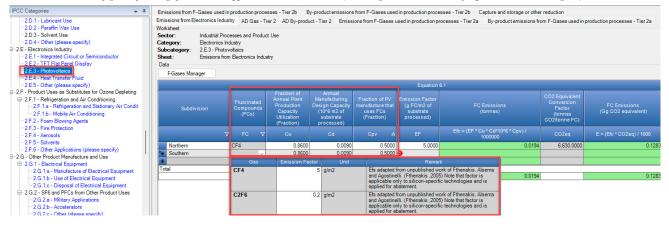
Example: single subdivision - unspecified (national) and entry of AD- Tier 1

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)

SIPCC Categories 🗸 🗣	Emissions from gases used	in produc	ction processes	Tier 2b By-produc	temissions from gase	es used in production p	rocesses - Tier 2b Capture and storage or oth	er reduction	
	Worksheet Sector: Industrial Category: Electroni Subcategory: 2.E.1 - In	Processe cs Industr itegrated (es and Product L	se nductor	er 2 Emissions fro	m gases used in produ	ction processes - Tier 2a By-product emission	is from gases used in p	roduction processes - Tier 2a
2.E.5 - Other (please specify)							Equation 6.1		
⊇.F - Product Uses as Substitutes for Ozone Depleting □ 2.F.1 - Refrigeration and Air Conditioning □ 2.F.1.a - Refrigeration and Stationary Air Condit □ 2.F.1.b - Mobile Air Conditioning □ 2.F.2 - Foam Blowing Agents	Subdivision		Fluorinated Compounds (FCs)	Fraction of Annual Plant Production Capacity Utilization (Fraction)	Annual Manufacturing Design Capacity (10^9 m2 of silicon processed)	Emission Factor (kg FC/m2 of silicon processed)	FC Emissions (tonnes)	CO2 Equivalent Conversion Factor (tonnes CO2/tonne FC)	FC Emissions (Gg CO2 equivalent)
2.F.3 - Fire Protection		$\Delta \nabla$	FC AV				Efc = (EF * Cu * Cd*10^9) / 1000	CO2eq	E = (Efc * CO2eq) / 1000
2.F.4 - Aerosols 2.F.5 - Solvents	National	(C2F6	0.8000	0.0030	1.0000	2,400.0000	11,100.0000	26,640.0
2.F.6 - Other Applications (please specify)		(C3F8	0.8000	0.0030	0.0500	120.0000	8,900.0000	1,068.
2.G - Other Product Manufacture and Use			CHF3	0.8000	0.0030	0.0400	96.0000	12,400.0000	1,190
B-2.G.1 - Electrical Equipment			NF3	0.8000	0.0030	0.0400	96.0000	16,100.0000	1,545
- 2.G.1.a - Manufacture of Electrical Equipment			SF6	0.8000	0.0030	0.2000	480.0000	23,500.0000	11,280
2.G.1.b - Use of Electrical Equipment 2.G.1.c - Disposal of Electrical Equipment	<u> </u>		CF4	0.8000	0.0030	0.9000	2,160.0000	6,630.0000	14,320
2.G.2 - SF6 and PFCs from Other Product Uses	Total								
2.G.2.a - Military Applications							5,352.0000		56,044.

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 <u>Column |Subdivision|</u>, data are input in worksheet **AD Gas - Tier 2/3**, row by row, as follows:

- 1. <u>Column | Name of Plant |</u>: input name of the plant where FC gases are used for manufacturing.
- 2. <u>Column |i|</u>: select from the drop-down menu the gas used (either FC, or for Tier 2, N₂O). <u>Recall if</u> a gas is not available for selection, it must first be selected from the F-Gases Manager (national and category-specific).
- 3. <u>Column | Tier |</u>: for each subdivision/plant/gas select the estimation Tier Tier 2a or Tier 2b/Tier 3.
- 4. <u>Column |h|</u>: input the amount of heel i.e. gas remaining in shipping container after use, fraction. <u>Note that</u>: in the absence of country-specific information, the IPCC default is 0.1.
- 5. <u>Column |Gi|</u>: input either total gas consumption (Tier 2a) or mass separated by etching and cleaning (Tier 2b/Tier 3), in kg of gas.
- 6. <u>Column |ai|</u>: 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). <u>Note that:</u> Unless ECT are installed, the default value for ai is zero.
- 7. <u>Column |di|</u>: 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 CF₄, C₂F₆, HFC-23, C₃F₈, c-C₄F₈, NF₃ and SF₆.¹ 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.

Emissions from gases Emissions from Electro Worksheet	used in production proc nics Industry AD Gas	arcer - Tier 2b B - Tier 2 AD By-pro			from gases used ssions from gase				-			production pro	cesses - Tier 2	a		
Sector: Ind Category: Ele Subcategory: 2.E	ustrial Processes and Pro ctronics industry .1 - Integrated Circuit or ! ivity Data for F-Gases - T	Semiconductor													1	99(
						Co	nsumption of g (kg)	jas i		of gas i volum es with emissio technologies (Fraction)	on control		of gas i destro on control tech (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		
	7	7 i	V	7	7 h			Gi			ai		Δ	di		
GAMCO	#1	HFC-23 (CHF3)		Tier 2a	0.10			100.00			100.00			100.00	2	
OPERO	#2	Sulphur Hexafluori	d 🗸	Tier 2b	0.10	4,500.00	2,500.00	7,000.00	0.90	0.00		0.80			2	2
*		Gas Group			Gas		2								2	
Total		_ PFCs	PFC PFC	-14 (CF4) -116 (C2F6) -218 (C3F8) luorobuta-1,3-	diene (CF2=CF0	CF=CF2)		7,100.00	č. 7.							
		SF6	Sulp	hur Hexafluori	ide (SF6)											
		NF3	Nitro	ogen Trifluorid	e (NF3)											
		Other GHGs		r (F2) conyl fluoride ((COF2)		-									

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. <u>Column |de(BPG)|</u>: (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. <u>Column |dc(BPG)|</u>: (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. <u>Column |d(BPG)|</u>: (Tier 2a only) input the total fraction of by-product gas destroyed by the ECT, fraction.

Note that when estimating all fractions above, <u>Table 6.6</u> and <u>page 21</u> 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

incione from Ela	etropice Industa	AD Gas - Tier 2 AD By-product	- Tier 2 Emissions from gases used in pro	duction processes - Tier 2	Bu product emission	s from gases used in produc	tion processes . Tier
	ectronics industry	AD Gas - Her 2 AD by product	Emissions from gases used in pro	duction processes - Tier 2	a by-product emissions	s from gases used in produc	ction processes - Tier.
orksheet							
		sses and Product Use					
	Electronics indu						
		ed Circuit or Semiconductor					
neet:	Acticvity Data for	or By-products - Tier 2					
ata							
F-Gases Mana	ider						
					Fraction of by-product	destroyed by the emission	control technology
						(Fraction)	
Subdiv	rision	Name of plant	By-product gas	Tier	Etching process	(Fraction) CVD chamber cleaning	Total
Subdiv	rision ∆⊽					CVD chamber	Total d(BPG)
Subdiv						CVD chamber cleaning	d(BPG)
		Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.	BPG A	7 7		CVD chamber cleaning	d(BPG) 100.00
		Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.	BPG A HFC-23 (CHF3)	⊽ ▽		CVD chamber cleaning	d(BPG) 100.00 2,500.00
		Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.	вра Да HFC-23 (CHF3) PFC-116 (C2F6)	v v Tier 2a Tier 2a		CVD chamber cleaning	d(BPG) 100.00 2,500.00 1,500.00
		Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.Δ.	BPG Δ' HFC-23 (CHF3) PFC-116 (C2F6) PFC-116 (C2F6) PFC-14 (CF4) PFC-218 (C3F8) PFC-218 (C3F8)	v v Tier 2a Tier 2a Tier 2a		CVD chamber cleaning	d(BPG) 100.00 2,500.00 1,500.00
GAMCO		∆⊽ #1	BPG Δ* HFC-23 (CHF3) PFC-116 (C2F6) PFC-14 (CF4) PFC-418 (C3F8) HFC-23 (CHF3) HFC-23 (CHF3)	v v Tier 2a Tier 2a Tier 2a Tier 2a Tier 2a Tier 2b	de(BPG)	CVD chamber cleaning dc(BPG)	d(BPG) 100.00 2,500.00 1,500.00
GAMCO		∆⊽ #1	BPG Δ' HFC-23 (CHF3) PFC-116 (C2F6) PFC-116 (C2F6) PFC-14 (CF4) PFC-218 (C3F8) PFC-218 (C3F8)	v v Tier 2a Tier 2a Tier 2a Tier 2a Tier 2a	de(BPG)	CVD chamber cleaning dc(BPG)	

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: <u>Table 6.2</u>: 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):
 - <u>Tables 6.3-6.5</u>: EF from use of gas, fraction.
 - <u>Tables 6.3-6.5</u>: By-product EFs, kg of by-product gas created from gas used.
 - <u>Table 6.6</u>: 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:

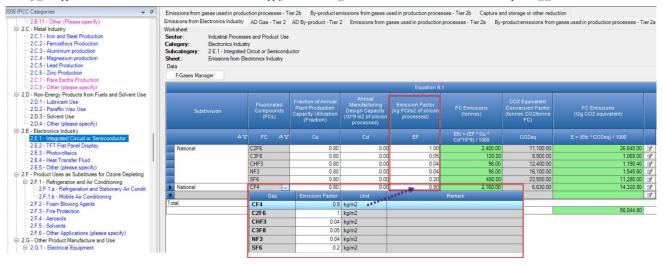
In worksheet **Emissions from Electronics Industry,** the corresponding EF from <u>Table 6.2</u> is automatically inserted in <u>Column |EF|</u>, in kg FC/m² substrate processed upon selection of the gas in <u>Column |FC|</u>.

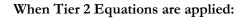
Note two critical points in use of the Tier 1 method:

- 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





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 <u>Column |1-Ui|</u>, 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 <u>Column |B|</u>, 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.

F-Gases Manager	r												
					Con	nsumption of ((kg)	gas i	processe	of gas i volum s with emissio technologies (Fraction)			f gas i destroy n control tech (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	Tota
		i AV		h			Gi			ai			di
GAMCO	#1	HFC-23 (CHF3) HFC-23 (CHF3)	Tier 2b Tier 2a	0.10		1,300.00	3,800.00	0.90		0.80	0.90		-

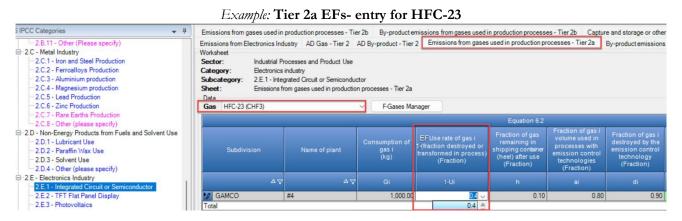
Example: Tier 2a AD entry for HFC-23

Step 2. In worksheet **AD By-product- Tier 2/3** no further additions are needed. According to <u>Table 6.3</u> the only possible by-product emission when HFC-23 is the process gas, is CF₄. The destruction factor for CF₄ 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

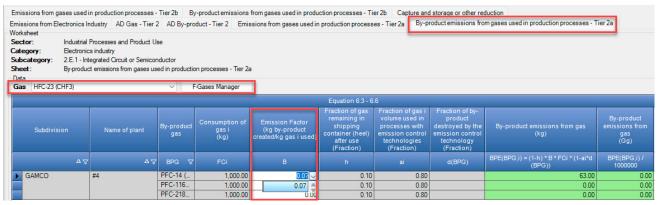
			processes - Tier 2b C			
	y AD Gas - Tier 2 AD By-product	- Tier 2 Emissions from gases used in prod	uction processes - Tier 2	 By-product emissions 	from gases used in produ	uction processes - Tier 2
tegory: Electronics indu bcategory: 2.E.1 - Integrate	sses and Product Use istry id Circuit or Semiconductor or By-products - Tier 2					
F-Gases Manager				Fraction of by-product of	lestroyed by the emissio	n control technology
					(Fraction)	
Subdivision	Name of plant	By-product gas		Etching process	CVD chamber cleaning	Total
ΔΥ	ΔΥ	BPG △ 🏹	V	de(BPG)	dc(BPG)	d(BPG)
∆ \ GAMCO	∆⊽ #1	BPG △ \ HFC-23 (CHF3)	⊽ Tier 2b	de(BPG) 0.90	dc(BPG)	d(BPG)
		And the second			dc(BPG)	d(BPG)
		HFC-23 (CHF3)	Tier 2b		dc(BPG)	d(BPG)
		HFC-23 (CHF3) PFC-116 (C2F6)	Tier 2b Tier 2b		dc(BPG)	d(BPG)
		HFC-23 (CHF3) PFC-116 (C2F6) PFC-14 (CF4)	Tier 2b Tier 2b Tier 2b		dc(BPG)	d(BPG)
	#1	HFC-23 (CHF3) PFC-116 (C2F6) PFC-14 (CF4) PFC-218 (C3F8)	Tier 2b Tier 2b Tier 2b Tier 2b		dc(BPG)	
	#1	HFC-23 (CHF3) PFC-116 (C2F6) PFC-14 (CF4) PFC-218 (C3F8) HFC-23 (CHF3)	Tier 2b Tier 2b Tier 2b Tier 2b Tier 2b Tier 2a		dc(BPG)	
	#1	HFC-23 (CHF3) PFC-116 (C2F6) PFC-14 (CF4) PFC-218 (C3F8) HFC-23 (CHF3) PFC-116 (C2F6)	Tier 2b Tier 2b Tier 2b Tier 2b Tier 2a Tier 2a		dc(BPG)	

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.



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 <u>Table 6.3</u>, for semiconductor manufacturing, the only possible by-product is CF₄. The user selects from the drop-down menu the default by-product EF for CF₄. 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. <u>Column |1-Uie|</u>: 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. <u>Column |1-Uic|</u>: 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.

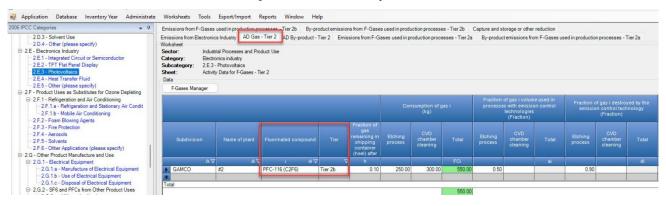
Then, in worksheet **By-product emissions from gases used in production processes – Tier 2b** for each gas/subdivision/ plant/ by-product gas the user the user inputs information, row by row, as follows:

- 1. <u>Column |Be|</u>: 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. <u>Column |Bc|</u>: select from the drop-down menu the default EF for CVD chamber cleaning of the byproducts 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 C₂F₆ in photovoltaics

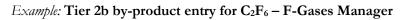
An illustration is provided below on how to estimate GHG missions in the case where GAMCO, #2 facility follows the Tier 2b method, and uses the process gas C_2F_6 for photovoltaics (category 2.E.3).E.3). <u>Note that</u> the worksheet names for photovoltaics refer specifically to F-gases (as opposed 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).

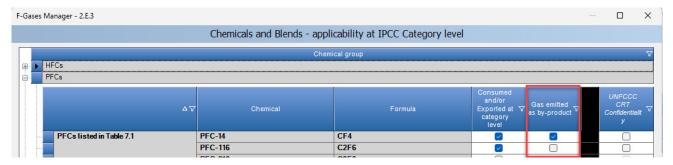
Step 1. Enter AD in worksheet **AD Gas – Tier 2/3,** including the name of the plant, process gas used, Tier, fraction of gas remaining in the heal, and the corresponding amount of gas consumed, the fraction used in processes with ECT, and the fraction of gas destroyed in those processes. In this example, 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 C₂F₆

Step 2. In worksheet **AD By-product- Tier 2/3** the user inputs the fraction of by-product gas destroyed. According to <u>Table 6.5</u> 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 – destruction

	duction processes - Tier 2b By-prod	luct emissions from F-Gases used in production p	rocesses - Tier 2b Ca	apture and storage or other i	reduction	
missions from Electronics Industry	AD Gas - Tier 2 AD By-product - Tie	er 2 Emissions from F-Gases used in production	on processes - Tier 2a	By-product emissions from	n F-Gases used in production	on processes - Tier 2a
/orksheet	-					
Sector: Industrial Process	es and Product Use					
ategory: Electronics indust	ry					
ubcategory: 2.E.3 - Photovolta	ics					
heet: Acticvity Data for	By-products - Tier 2					
)ata						
Pata F-Gases Manager						
Data F-Gases Manager				Fraction of by-produ	ct destroyed by the emission	n control technolog
				Fraction of by-produc	ct destroyed by the emissic (Fraction)	n control technolog
	Name of plant	By-product gas	Tier	Fraction of by-produce Etching process		n control technolog Total
F-Gases Manager			Tier		(Fraction)	

Step 3. Estimate the C_2F_6 emissions in worksheet **Emissions from F-gases used in production processes – Tier 2b.** According to <u>Table 6.5</u>, 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.

/orksheet		processes - Tier	by produ	ctemissions from F-0	aases used in pro	bulletion process	ses - Hel 2D C	apture and storage of	or other reduction	1		
iector: Indust Category: Electr Subcategory: 2.E.3	trial Processes and P onics industry - Photovoltaics ions from F-Gases us		processes - Tier 2	2b								
Gas PFC-116 (C2F6)		~	F-Gases Ma	anager								
						Equation 6.						
				Etching p	ocess			CVD chamber	cleaning			
Subdivision	Name of plant	Fraction of gas remaining in shipping container (heel) after use	Consumption of gas i (kg)	transformed in process)	Fraction of gas i volume used in processes with emission control techno	Fraction of gas i destroyed by the emission control technology	Consumption of gas i (kg)	Use rate of gas I (fraction destroyed or transformed in process) (Fraction)	Fraction of gas i volume used in processes with emission control techno	Fraction of gas i destroyed by the emission control technology	Emissions (kg)	Emission (Gg)
۵V	۵Ţ	h	FCie	1- Uie	aie	die	FCic	1- Uic	aic	dic	Ei = (1-h) * (FCie * (1-Uie) * (1- aie*die) + FCic * (1-Uic) * (1- aic*dic))	Ei / 10000
GAMCO	#2	0.10	250.00	0.4 ~	0.50	0.90	300.00	0.6 🗸				
GAMCO Total	#2	0.10	250.00	0.4 ~	0.50	0.90	300.00	0.6				

Example: Tier 2b EFs- entry for C₂F₆

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 <u>Table 6.5</u>, for photovoltaics, the only possible by-product is CF_4 (for both etching and CVD chamber cleaning). According to <u>Table 6.5</u>, the default EF (EtchB_{CF4}) in <u>Column |Be|</u> = 0.2 and the default EF (CVDB_{CF4}) in <u>Column |Bc|</u> = 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 C₂F

ksheet	added addrinipro	duction processes -			ns from F-Gases us			Cuptor	e and storage or othe				
tor: egory: ocategory: eet: a	Electronics industr 2.E.3 - Photovolta By-product emissio	·	-		2b								
IS PFC-116 (C2F6)		✓ F-Gas	ses Manager).								
						Equation	on 6.8 - 6.11						
					Etching p	rocess			CVD chamber	cleaning			
Subdivision	Name of plant	By-product gas	Fraction of gas remaining in shipping container (heel) after u	Consumption of gas i (kg)	Emission Factor (kg by-product created/kg gas i used)	Fraction of gas i volume used in processes with emission control techn	by product	Consumption of gas i (kg)	Emission Factor (kg by-product created/kg gas i used)	Fraction of gas i volume used in processes with emission control techn	Fraction of by -product destroyed by the emission control technology	By-product emissions from gas (kg)	By-pro emissi from <u>c</u> (Gg
	A7 A7	7 BPG 7		FCie			de(BPG)	FCic	Bc		dc(BPG)	BPE(BPG,i) = (1-h)*[Be* FCie*(1- aie*de(BPG)) + Bc*FCic* (1-aic*dc (BPG))]	BPE(BP 10000

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 GgCO₂ 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. <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>: not applicable for this category.
- 3. <u>Column |B|:</u> collect and input information on any other long-term reduction of F-gas emissions, in tonnes. <u>Note that</u>: any destruction estimated in the Tier 2 worksheet should not be included in <u>Column |B|</u>. 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

<u>Section 6.2.1.2</u> 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 ₂ O	HFCs	PFCs	SF ₆	NF ₃
			X	X	X	X

IPCC Equations

- ✓ <u>Tier 1:Equation 6.12</u>
- \checkmark <u>Tier 1:Equation 6.13</u>
- ✓ <u>Tier 3</u>: 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.

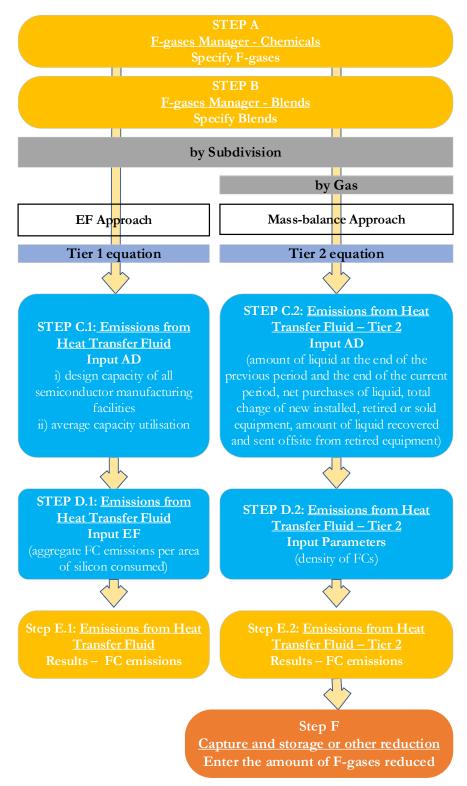
User's Work Flowchart

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-specific¹ 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 (m² 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 Gm² 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 CO₂ 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

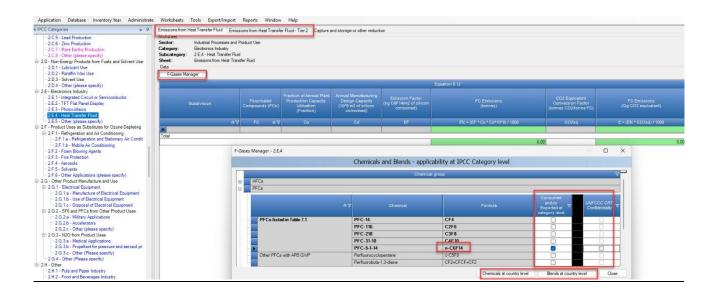
Section 6.2.3 in Chapter 4 Volume 3 of the 2006 IPCC Guidelines contains information on the choice of AD for the Heat Transfer Fluid source category.

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.

<u>Note that</u> 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.

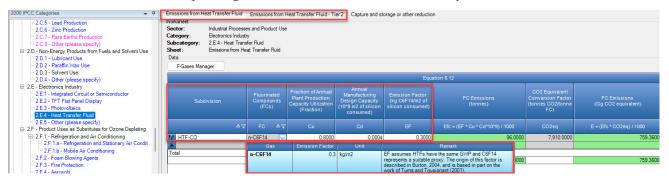
<u>For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool:</u> If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated 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 CO₂ 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 <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> [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 <u>Column |Subdivision|</u>, data are input in worksheet **Emissions from Heat Transfer Fluid** row by row, as follows:

- 1. <u>Column |FC|</u>: select from the drop-down menu the default FC fluid (C₆F₁₄).
- 2. <u>Column | Cu</u> : input the average capacity utilisation, fraction. <u>Note that:</u> when country-specific capacity utilisation data are not available, the suggested capacity utilisation for semiconductor manufacturing is 80 percent.
- 3. <u>Column |Cd|</u>: input the annual manufacturing design capacity in 10⁹ m² of silicon consumed for all semiconductor manufacturing facilities in the country. <u>Note that</u>: 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 <u>section 6.2.3</u> of the 2019 Refinement for further information on acquiring AD).

When the Tier 2 Equation is applied:

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

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

- <u>Column | FCi |</u>: select from the drop-down menu the FC fluid used (e.g. C₆F₁₄). <u>Note that</u>: 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. <u>Column |pi| input the density of the liquid FC input in Column |FCi|, in kg per litre.</u>
- 4. <u>Column | Ii_{xt-1} |</u>: input the inventory (amount) of liquid FCs at the end of the previous period, in litres.
- 5. <u>Column |Pi,t |</u>: input net purchases (amount) of liquid FCs during the period (net of purchases and any returns), in litres.
- 6. <u>Column | Ni,t |</u>: input total charge (or nameplate capacity) of new installed equipment, in litres.
- 7. <u>Column |Ri,t|</u>: input total charge (or nameplate capacity) of retired or sold equipment in litres.
- 8. <u>Column | Ii,t |</u>: input the inventory (amount) of liquid FCs at end of the period, in litres.
- 9. <u>Column |Di,t|</u>: input amount of FC fluid recovered and sent offsite from retired equipment in litres. <u>Note that</u> the value entered in <u>Column |Di,t|</u> should be equal to or less than the value entered in Column |Ri,t|.

Category: Electroni Subcategory: 2.E.4 - H	er Fluid Emissions fr Processes and Product cs Industry eat Transfer Fluid s from Heat Transfer Flui		id - T	Tier 2 Captu	re and storage (or other reductio	n					
F-Gases Manager												
						Equation 6						
Subdivision	Name of plant	Fluorinated compound		Density of liquid FCi (kg/litre)	The inventory of liquid FCi at the end of the previous period (litres)	Net purchases of liquid FCi during the period (net of purchases an	Total charge (or nameplate capacity) of new installed (litres)	Total charge (or nameplate capacity) of retired or sold equipme	Inventory of liquid FCi at end of the period (litres)	Amount of FCi recovered and sent offsite from retired equip	Emissions of FCi (kg)	Emissions FCi (Gg)
۵ ۷	۵ ۷	FCi	V								Ei = pi * [li,t-1 + Pi,t - Ni,t + Ri,t - li,t - Di,t]	Ei / 100000
HTF-CO	#2	PFC-5-1-14 (n-C	\sim	0.0017	12,000.0000	200.0000	150.0000	1,000.0000	10,000.0000	1,000.0000	3.4440	0.00
*		Gas Group			Gas							
Total		HFCs		C-23 (CHF3)							3.4440	0.00
			HF	C-125 (CHF2C	F3)						3.4440	0.00
			HFO	C-152a (CH3C	HF2)							
			HFC	C-227ea (CF30	CHFCF3)							
			HFO	C-245fa (CHF2	CH2CF3)		1					
		PFCs	PFC	C-5-1-14 (n-C6	F14)							

Example: Tier 2 AD input

Emission Factor Input

<u>Sections 6.2.2.2</u> 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 <u>Table 6.2</u>. 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. <u>Column |EF|</u>: 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. <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>: not applicable for this category.
- 3. <u>Column |B|:</u> users collect and input information on any other long-term reduction of F-gas emissions, in tonnes.

<u>Note that</u>: any recovery estimated in the Tier 2 worksheet should not be included in <u>Column |B|</u>.

Example: capture and storage or other reduction

	sions from Particle Accelerators SF	6 Emissions from Particle Accelerat	tors - Tier 2 SF6	Emissions from Particle Accelerator	s - Tier 3 Capture and storage or	other reduction	
Category: 0 Subcategory: 2	Industrial Processes and Product Use Other Product Manufacture and Use 2.G.2.b - Accelerators Capture and storage or other reduction						
	xafluoride (SF6)	- F-Gases Manager					
	Subdivision			Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
			ΔV				C / 1000
Hospital#1		stream2			2	2	0
*							
Total							

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 <u>Section 6.2.1.1</u> 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.

<u>GHGs</u>

Emissions from the Other (Electronics Industry) source category include the following GHGs:

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
Χ	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.

- ✓ <u>Tier 1:</u> no IPCC Tier 1 Equation provided in the 2006 IPCC Guidelines.
- ✓ <u>Tier 2</u>: IPCC basic equation with user-specific EF
- ✓ <u>Tier 3</u>: 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.

✓ <u>Tier 1: Equation 6.1 (Updated)</u>

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.

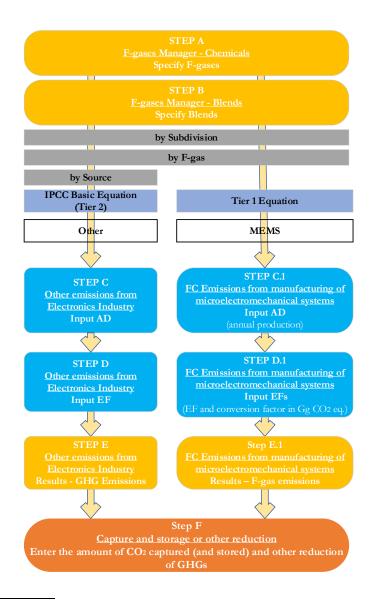
<u>Note that</u> for users intending to report emissions to the UNFCCC ETF Reporting Tool, if "Other emissions from MEMs" is selected in this worksheet in <u>Column |SRC|</u> any calculated emissions will map to the category of MEMS in the UNFCCC ETF Reporting Tool, along with any emissions estimated 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 (m² 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 CO₂ 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-specific¹ 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 CO₂ 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. <u>Note that</u> 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 <u>abore</u>.

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, SF6 or NF3, 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 <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>.

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

1. <u>Column |SRC|</u>: describe the type of activity emitting GHG emissions from this category. The user may select from the drop-down (which includes *other emissions from MEMs* in the case where higher tiered methods are used to estimate emissions from MEMs) or enter user-specific categories.

<u>Note that</u> 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.

<u>Note that</u> for users intending to report emissions to the UNFCCC ETF Reporting Tool, if "Other emissions from MEMs" is selected in this worksheet in <u>Column |SRC|</u> 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. <u>Column |AT|</u>: input the activity type corresponding to the source selected.
- 3. <u>Column |AD|</u>: input AD (quantity of the activity type input in <u>Column |AT|</u> and following the units in <u>Column |U|</u>).
- 4. <u>Column |U|</u>: input unit of the AD.
- 5. <u>Column | Biogenic |</u> (CO₂ 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)

egory: Electronics Indu scategory: 2.E.5 - Other (pl eet: Other emissions is PFC-318 (c-C4F8)	ase specify)	F-Gases Manager)	User has used the Tier 3a method, so results for MEMS reported under "Other"				
Subdivision		Source		Activity Type	Activity Data	Activity Data Unit	Emission Factor (Gg/U)	Emissions (Gg)
				7545///				
s	۵V	SRC			AD AD			

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

1. <u>Column | P(MEMS) |:</u> input total production of electronic devices, as determined by the total surface area of electronic substrates used during the production of those devices, in m².

Example: AD entry for MEMS – Tier 1

Sector: Category: Subcategory: Sheet: Data	Industrial Processe Electronics Industri 2.E.5 - Other (plea FC Emissions from	ry ise spec		nanical systems					
Gas PFC-318	c-C4F8)	~	F-Gases Manager						
						Equation 6.1 (Upda	ted)		
	ubdivision		Annual production (m2 of substrate used a measured by the surfac area of substrate used during the production o electronic devices, including test substrates	e (annual mass square met if surface area class, kg	nission Factor of emissions per ers of substrate a for the product of gas i/m2)	c-C4F8 Emis: (kg)		CO2 Equivalent Conversion Factor (tonnes CO2 / tonne c- C4F8)	c-C4F8 Emissions (Gg CO2 equivalent)
	S	ΔŢ	P(MEMS)	7	EFi	Ei = P(MEMS)	* EFi	CO2eq	Ei * CO2eq / 1000000
* National			0.06	5	0.076 🗸		0.00494	9,540	0.00
*				Gas	Emission	Factor			
Total			0.06	c-C4F8		0.076	0.00494		0.00

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 <u>Table 6.6 (Updated</u>). 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 <u>Column |Subdivision|</u>, users input information row by row, as follows:

1. <u>Column |EF|</u>: input EF for each GHG, in Gg/unit. See figure above for worksheet **Other**. <u>Note that</u> 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 <u>Column |Subdivision|</u>, and each gas, input information, row by row, as follows:

- <u>Column | EFi |</u>: input EF for each GHG, in Gg/unit. <u>Note that</u> 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 CF4, c-C4F8 and SF6
- 2. <u>Column |CO₂eq|</u>: this column is automatically populated with the GWP of the gas in the drop-down menu Gas.

FC Emissions from manufacturing of Worksheet Sector: Industrial Processes and Category: Electronics Industry Subcategory: Subcategory: 2.E.5 - Other (please spe- Sheet: FC Emissions from manufa- Data FC Emissions from manufa- Data	Product Use		d storage or other re	duction		
Gas Sulphur Hexafluoride (SF6)	F-Gases Manager					
			Eq	uation 6.1 (Updated)		
Subdivision	Annual production (m2 of substrate used as measured by the surface area of substrate used during the production of electronic devices, inclu	square meters of surface area for th	nissions per f substrate he product	SF6 Emissions (kg)	CO2 Equivalent Conversion Factor (tonnes CO2 / tonne SF6)	SF6 Emissions (Gg CO2 equivalent)
S AV	P(MEMS) V	EFi		Ei = P(MEMS) * EFi	CO2eq	Ei * CO2eq / 1000000
Unspecified	100	- Contraction	1.86 🗸	1	86 23,500	4.37
*		Gas	Emission Factor			
Total		SF6	1.86		L	
	100				86	4.37

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:

 <u>Column |SRC|</u>: 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). <u>Note that</u> the drop-down menu includes a single choice of MEMS. This source includes <u>all</u> 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. <u>Column |A|</u>: collect and input information on the amount of CO₂ captured (with subsequent storage), in tonnes.
- 3. <u>Column |B|:</u> collect and input information on any other reduction of GHGs, in tonnes. <u>Column |B|</u> may include short-term CO₂ capture or reduction of other GHGs only in cases where the subsequent CO₂ emissions from use are included elsewhere in the GHG inventory.
- 4. <u>Column |Biogenic</u>|: (visible only when gas = CO₂) 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

Worksheet Sector: Ind Category: Be Subcategory: 2.8	from manufacturing of mic ustrial Processes and Prodi ctronics Industry 5 - Other (please specify) oture and storage or other r		Capture an	d storage or other reduction			
Gas PFC-318 (c-C4	F8)	→ F-Gases Man	ager				
Sut	division			Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
	S 47	SRC	ΔV	A	В		C / 1000
* Northern RamCo					25	25	0.025
* Total		MEMS Unspecified					
						25	0.025

2.F Product Uses as Substitutes for Ozone Depleting Substances

<u>Chapter 7</u> 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:

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

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 subapplications (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	\mathbf{SF}_{6}	NF ₃
			X	X	X	X

IPCC Equations

- ✓ <u>Tier 1</u>: <u>Equation 7.1 and 7.2A/B</u> (Refrigeration and Air Conditioning (RAC)), <u>Equation 7.17</u> (Fire Protection)
- ✓ <u>Tier 2a</u>: <u>Equations 7.10, 7.11, 7.12, 7.13</u> and <u>7.14</u> (RAC)
- ✓ <u>Tier 2b</u>: <u>Equation 7.9 (RAC)</u>

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).

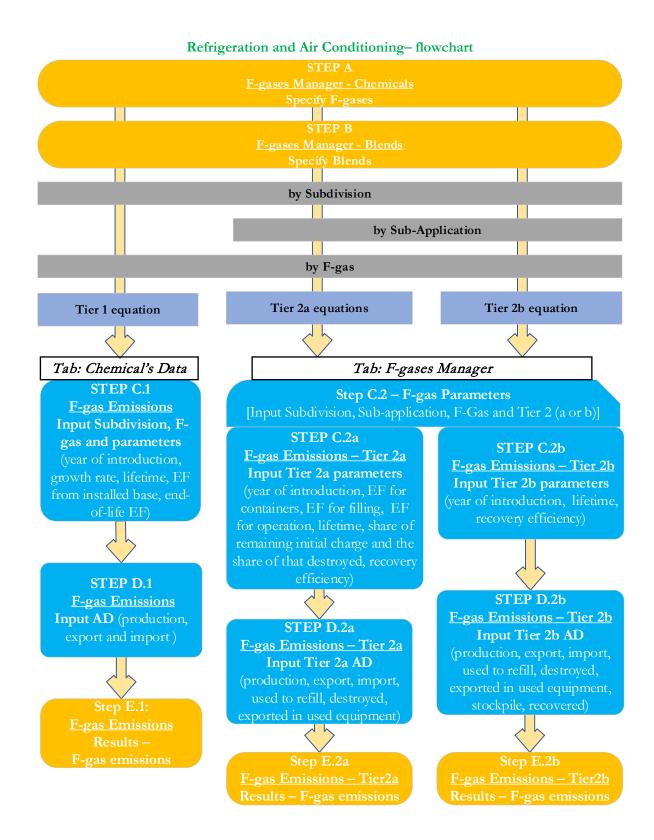
User's Work Flowchart

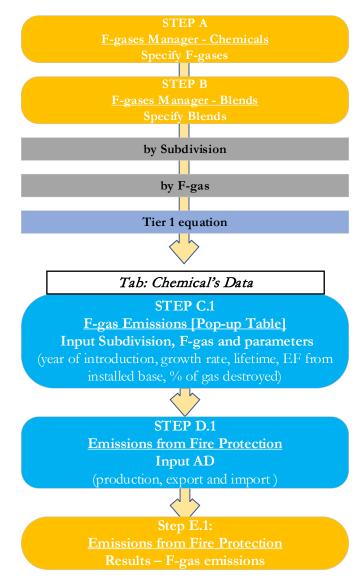
For Refrigeration and Air Conditioning, consistent with the key category analysis and the decision tree in Figure 7.6 of the 2006 IPCC Guidelines, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific¹ 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.





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.2b**). 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.

<u>Customizing the Software for Refrigeration and Air Conditioning and Fire Protection: Subdivision/sub-application/F-gases/blends</u>

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.

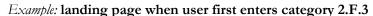
When the Tier 1 Equation is applied:

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. <u>Note that</u> 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: 1	landing p	age when	user first o	enters catego	orv 2.F.1.a	and 2.F.1.b
Livennepve.	and many p	age when	GOUL HIDE	chiero careg	01 y = 11 11 11 14	

2006 IPCC Categories 👻 👎	F-Gas Emissions F-Gas Parameters - Tier 2 F-Gas Emissions - Tier 2a F-Gas Emissions - Tier 2b	
2.E.5 - Other (please specify) - Product Uses as Substitutes for Ozon 2.F.1 - Refrigeration and Aric Conditionin - 2.F.1 - Refrigeration and Stationar - 2.F.1 - Mobile Air Conditioning 2.F.2 - Foam Blowing Agents	Worksheet Industrial Processes and Product Use 1 Category: Product Uses as Substitutes for Ozone Depleting Substances 1 Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning 1 Stheet: Emissions 1	990
2.F.2 - Foam blowing Agents 2.F.3 - Fire Protection		(%) NA
2.F.4 - Aerosols 2.F.5 - Solvents 2.F.6 - Other Applications (please speci	I. Total Chemical Agent Inputs (across the time series) (ΣD) NA Bankt) + ΣE + ΣF NA II. Total Chemical Agent in equipment in use (last year of the time series) (Bankt)) NA NA NA	
Other Product Manufacture and Use 2.G.1 - Electrical Equipment	III. Total Chemical Agent Emissions (across the time series) (ΣΕ) NA	
2.6.7. Decided exploring 2.6.1.a. Manufacture of Electrical 2.6.1.b. Use of Electrical Equipme 2.6.1.c. Disposal of Electrical Equipme 2.6.2.c. Disposal of Electrical Equipme 2.6.2.b. Another the electrical Equipme 2.6.2.b. Accelerators 2.6.2.c. Other (please specify) 2.6.3.b. N20 from Product Uses 2.6.3.b. Propellant for pressure an	IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (<u>CF</u>) NA	



	1 010		0				
2006 IPCC Categories 🗸 🗸	Emissions from Fire Protection						
2 E 5 - Other (please specify) - Product Uses as Substitutes for Ozon 2.F.1 - Refrigeration and Air Conditionin - 2.F.1.a - Refrigeration and Stationar - 2.F.1.b - Mobile Air Conditioning 2.F.2 - Foam Blowing Acents	Worksheet Sector: Industrial Processes and Product Use Category: Product Uses as Substitutes for Ozone Depleting Substances Subcategory: 2.F.3 - Fire Protection Sheet: Emissions						1990
2.F.3 - Fire Protection	Subdivision Unspecified V Gas	Chemical's Data	IY NA	GR (%) NA	d (yr) NA	EF (%) NA	X (%)
2.F.4 - Aerosols 2.F.5 - Solvents	I. Total Chemical Agent Inputs (across the time series) (∑D)		NA	$Bank(t) + \Sigma E + \Sigma F$	NA		
2.F.6 - Other Applications (please speci	II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t))		NA				
Other Product Manufacture and Use 2.G.1 - Electrical Equipment	III. Total Chemical Agent Emissions (across the time series) (ΣE)		NA				
- 2.G.1.a - Manufacture of Electrical	IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across	the time series) (∑F)	NA				
2.G.1.b - Use of Electrical Equipme 2.G.1.c - Disposal of Electrical Equi 2.G.2 - SF6 and PFCs from Other Prod - 2.G.2.a - Military Applications - 2.G.2.b - Accelerators							

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

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 Worksheet	F-Gas Emissions - Tier 2					
Violsnieet Industrial Processes and Product Use Category: Product Uses as Substitutes for Ozone Depleting Substant Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning Sheet: Emissions	ces					1990
Subdivision Unspecified V Gas	Chemical	s Data IY NA	GR (%) NA	d (years) NA	EF (%) NA X (%) NA	
I. Total Chemical Agent Inputs (across the time series) (ΣD)		NA	Bank(t) + ΣE + ΣF	NA		
II. Total Chemical Agent in equipment in use (last year of the time series) (Bank	(t))	NA	Ī.			
III. Total Chemical Agent Emissions (across the time series) (ΣE)		NA	ù		X	
IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at				×		
		Chemical's D	Data			
	Country/Territory	World				
	Category	2.F.1.a - Refrigeration an	d Stationary Air Condition	oning		
	Subdivision	Unspecified		× (+)		
	Gas			× +		
	Data Year of Introduction (IY)			2.F.1.a - Subdiv	vision — 🗆	×
	Growth Rate in New E				Subdivision	
	Assumed Equipment Li			Unspecifie	9/2	
	Emission Factor from in			Country-sp	ecific	×
	% of Gas Destroyed at			*		×
	a or cass Destroyed at	and of the (A)				
				Default 'Unspec	ified' subdivision cannot be deleted but can be ren	amed.
			Save		Save Undo	Close
			Save			

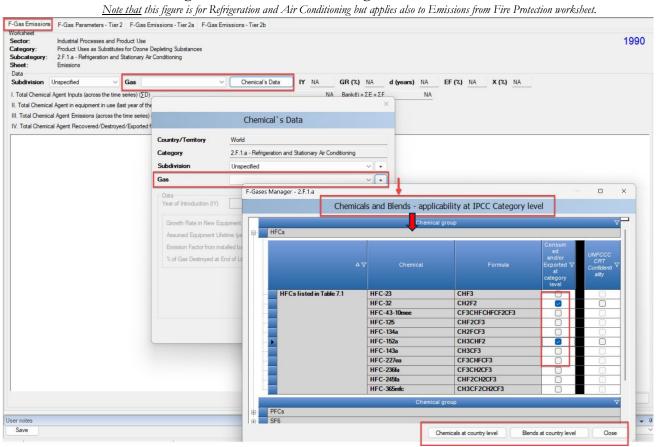
Identifying relevant F-gases /blends at the IPCC category level

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 Fgases (or blends thereof) at the national level, select **Chemicals at country level** or **Blends at country level** from the bottom of the screen.
- 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 this category 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, SF₆ or NF₃, 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



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 subapplications 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

Gas Emissions orksheet	s F-Gas Parameters - Tie					
ector:	Industrial Processes and	Product Use				199
ategory:	Product Uses as Substitu		lating Substances			199
			-			
ubcategory:	2.F.1.a - Refrigeration and		nationing			
neet:	F-Gas Parameters - Tier 2					
ata						
F-Gases Ma	inager					
			Subdivisio	n		
*						V 3 7
						_
s Emissions F-G	as Parameters - Tier 2 F-Gas Emiss	ions - Tier 2a F-Gas E	missions - Tier 2b			
sheet						
	strial Processes and Product Use					
	uct Uses as Substitutes for Ozone Deple I.a - Refrigeration and Stationary Air Con					
	I.a - Heringeration and Stationary Air Con is Parameters - Tier 2	aitioning				
3						
E-Gases Manager						
F-Gases Manager			9.42.4			
			Si	bdivision		
* National			Su	ıbdivision		
			Su	bdivision		
			Su	bdivision		Ļ
* National			Su	bdivision		•
National			Su	bdivision		•
* National * Unspecified				Ibdivision		•
Mational Unspecified	Parameters - Tier 2 F-Gas Emissions	- Tier 2a F-Gas Emissi		bdivision		
National Unspecified Emissions F-Gas heet		- Tier 2a F-Gas Emissi		ibdivision		
Mational Unspecified	ial Processes and Product Use			Ibdivision		1
National Unspecified Emissions F-Gas heet or: Industri pory: Produc		Substances		ibdivision		1
National Unspecified Emissions F-Gas heet r: Industr pory: Produc accopri: 2.F.1a	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting	Substances		ibdivision		1
National Unspecified Emissions F-Gas neet r: Industri proy: Produc ategory: 2 F.1 a r: F-Gas	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances		bdivision		1
National Unspecified Emissions F-Gas heet r: Industri proy: Produc ategory: 2 F.1 a F.Gas	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances		bdivision		1
National Unspecified Emissions F-Gas heet r: Industri proy: Produc ategory: 2 F.1 a F.Gas	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances				1
Mational Unspecified Emissions heet or: Industin gory: Production ategory: 2.F.1.a t: F.Gas f	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances	ons - Tier 2b			1
National Unspecified Emissions F-Gas heet or. Industr gory: Produc daegory: 2.F.1a t: F-Gas f Gases Manager	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances	ons - Tier 2b Subdivisi	on		1
National Unspecified Unspecified Unspecified Great Industr Gory: Produc Artaregory: 2.F.1a tt: FGas f -Gases Manager	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances	ons - Tier 2b	on		
National Unspecified Unspecified Emissions F-Gas heet or: Industr or: Industr or: Froduc ategory: 2.F.1a t: F-Gas f Gases Manager	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances	ons - Tier 2b Subdivisit Sub-appli	on	Bacayang di cancu of churan din ba	
National Unspecified Unspecified Emissions F-Gas heet or: Industr or: Industr or: Froduc ategory: 2.F.1a t: F-Gas f Gases Manager	tal Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition Parameters - Tier 2	Substances ing Lifetime of equipment	ons - Tier 2b Subdivisit Sub-appli	on	Recovery efficiency of charge (to be redaimed/recycled) remaining at end	v
National Unspecified Unspecified Emissions F-Gas heet or: Industr or: Industr or: Froduc ategory: 2.F.1a t: F-Gas f Gases Manager	ial Processes and Product Use t Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition	Substances	ons - Tier 2b Subdivisit Sub-appli	on	reclaimed/recycled) remaining at end of life in retired equipment	v
National Unspecified Emissions F-Gas heet or. Industr gory: Produc daegory: 2.F.1a t: F-Gas f Gases Manager	tal Processen and Product Use It Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition Parameters - Tier 2 Sub-application	Substances ing Lifetime of equipment (years)	ons - Tier 2b Subdivisi Sub-applin Emission factor for filing (production/manufacturing) of new equipment (% initial charge/yr)	on cation Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	reclaimed/recycled) remaining at end of life in retired equipment (%)	Share of initial charge remaining at the end of life (%)
National Unspecified Unspecified Emissions F-Gas heet or: Industr or: Industr or: Froduc ategory: 2.F.1a t: F-Gas f Gases Manager	tal Processes and Product Use It Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration	Substances ing Lifetime of equipment (years) 12 ≤ d ≤ 20	ons - Tier 2b Subdivisit Sub-appli Emission factor for filing (production/manufacturing) of new equipment (% initial chargevy) 02 < k < 1	on Emission factor for equipment operation (textsge/servicing) (% initia charge/yr) 0.1≤x≤05	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nrec,d < 70	Share of initial charge remaining at the end of life (%)
National Unspecified Emissions F-Gas heet or. Industr gory: Produc daegory: 2.F.1a t: F-Gas f Gases Manager	Ial Processes and Product Use It Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration Stand-alone Commercial Applications	Substances ing Lifetime of equipment (years) 12 ≤ d ≤ 20 10 ≤ d ≤ 15	ons - Tier 2b Subdivisir Emission factor for filing (production/manufacturing) of new equipment (% initial chargelyr) 02 c k < 1 05 c k < 3	cation Emission factor for equipment operation (texkspasservicing) (\$\overline{chargedyr}) (\$1 < x < 0.5 1 < x < 1.5	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nrec.d < 70 0 < nrec.d < 70	Share of initial charge remaining at the end of life (%) 0 0 < p < 80
National Unspecified Emissions F-Gas heet or. Industr gory: Produc daegory: 2.F.1a t: F-Gas f Gases Manager	tal Processes and Product Use It Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration	Substances ing Lifetime of equipment (years) 12 ≤ d ≤ 20	ons - Tier 2b Subdivisit Sub-appli Emission factor for filing (production/manufacturing) of new equipment (% initial chargevy) 02 < k < 1	on Emission factor for equipment operation (textsge/servicing) (% initia charge/yr) 0.1≤x≤05	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nrec,d < 70	Share of initial charge remaining at the end of life (%)
National Unspecified Emissions F-Gas heet or. Industr gory: Produc daegory: 2.F.1a t: F-Gas f Gases Manager	al Processes and Product Use It Uses as Substitutes for Ozone Depleting - Refrigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration Stand-alone Commercial Applications	Substances ing Lifetime of equipment (years) 12 ≤ d ≤ 20 10 ≤ d ≤ 15	ons - Tier 2b Subdivisir Emission factor for filing (production/manufacturing) of new equipment (% initial chargelyr) 02 c k < 1 05 c k < 3	cation Emission factor for equipment operation (texkspasservicing) (\$\overline{chargedyr}) (\$1 < x < 0.5 1 < x < 1.5	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nrec.d < 70 0 < nrec.d < 70	Share of initial charge remaining at the end of life (%) 0 0 < p < 80
National Unspecified Unspecified Emissions F-Gas heet or: Industr or: Industr or: Froduc ategory: 2.F.1a t: F-Gas f Gases Manager	Ial Processes and Product Use It Uses as Substitutes for Ozone Depieting - Refigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration Stand-alone Commercial Applications Medium & Large Commercial Refrigeration Transport Refrigeration Transport Refrigeration	Substances ing Lifetime of equipment (years) 12 ≤ d ≤ 20 10 ≤ d ≤ 15 7 ≤ d ≤ 15	ons - Tier 2b Subdivisit Emission factor for filing (production/manufacturing) of new equipment (% initial chargelyr) 0.2 c k c 1 0.5 c k c 3 0.5 c k c 3	n Emission factor for equipment operation (leakage@srvicing) (% initial chargelyr) 0.1 ≤ x ≤ 0.5 1 ≤ x ≤ 1.5 10 ≤ x ≤ 3.5	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nrec,d < 70 0 < nrec,d < 70 0 < nrec,d < 70	Share of initial charge remaining at the end of life (%) 0 0 50 < p < 100
National Unspecified Unspecified Emissions F-Gas heet or: Industr or: Industr or: Froduc ategory: 2.F.1a t: F-Gas f Gases Manager	al Processes and Product Use It Uses as Substrutes for Ozone Depleting - Refigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration Stand-alone Commercial Applications Medium & Large Commercial Refrigeration Transport Refrigeration Industrial Refrigeration including Food Processing and Cold Storge	Substances ing Lifetime of equipment (years) 12 cd c 20 10 cd c 15 7 cd c 15 6 cd c 9 15 cd c 30	ons - Tier 2b Subdivisit Sub-applin Emission factor for filling (production/manufacturing) of new equipment (% findla chargevr) 0.2 s k s 1 0.5 s k s 3 0.5 s k s 3 0.2 s k s 1 0.5 s k s 3	cation Emission factor for equipment operation (leakage/servicing) (% initial charge/yr) 0.1 ≤ x ≤ 0.5 1 ≤ x ≤ 1.5 10 ≤ x ≤ 2.5 15 ≤ x ≤ 50 7 ≤ x ≤ 2.5	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nrec.d < 70 0 < nrec.d < 70 0 < nrec.d < 70 0 < nrec.d < 90	Share of initial charge remaining at the end of life (%) Id 0 0< < p < 80
National Unspecified Unspecified Gas Green Green Green Gas Gases Manager	Ial Processes and Product Use It Uses as Substitutes for Ozone Depieting - Refigeration and Stationary Air Condition Parameters - Tier 2 Sub-application Domestic Refrigeration Stand-alone Commercial Applications Medium & Large Commercial Refrigeration Transport Refrigeration Transport Refrigeration	Substances ing Lifetime of equipment (years) 12 cd c20 10 cd c15 7 cd c15 6 cd c9	ons - Tier 2b Subdivisit Emission factor for filing (production/manufacturing) of new equipment (%, India chargeyr) 0.2 s k s 1 0.5 s k s 3 0.5 s k s 3 0.5 s k s 3 0.2 s k s 1	en cation Emission factor for equipment operation (leakage/servicing) (x) = (x = 0.5 1 ≤ x ≤ 0.5 1 5 ≤ x ≤ 50	reclaimed/recycled) remaining at end of life in retired equipment (%) 0 < nprec,d < 70 0 < nprec,d < 70 0 < nprec,d < 70 0 < nprec,d < 70	Share of initial charge remaining at the end of life (%) 0 0< < p < 80

Identifying relevant F-gases/blends at the IPCC category level

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:

- 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.
- 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>.

Note that: 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

r: Industrial Processes ory: Product Uses as Su stegory: 2.F.1.a - Refrigeration F-Gas Parameters - Gases Manager	bstitutes for Oz on and Stationa	one Depleting Substances			1
	F-Gases	Manager - 2.F.1.a			— X
Unspecified	-	Chemicals a	nd Blends - applicability	at IPCC Category level	
			Chemical group		
		HFCs			
		۵٦	7 Chemical	Formula	Consumed and/or Exported ⊽ at category level
		HFCs listed in Table 7.1	HFC-23	CHF3	
			HFC-32	CH2F2	
			HFC-43-10mee	CF3CHFCHFCF2CF3	
	-		HFC-125	CHF2CF3	
	in		HFC-134a	CH2FCF3	
		•	HFC-152a	CH3CHF2	
			HFC-143a	CH3CF3	
			HFC-227ea	CF3CHFCF3	
			HFC-236fa	CF3CH2CF3	
			HFC-245fa	CHF2CH2CF3	

3. For users intending to use the Software for reporting in the UNFCCC ETF Reporting Tool: If AD and/or emissions for a particular F-gas consumed in this category is considered confidential, the user may check the box UNFCCC CRT Confidentiality for that gas. For Tier 2, the designation of confidentiality occurs row by row, for each gas consumed in the subdivision/sub-application (see Annex I: Mapping between the IPCC Inventory Software and the UNFCCC ETF Reporting Tool).

<u>Note that:</u> if checked, "C" will be reported for AD and "TE" 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, SF₆ or NF₃, 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

ctor: tegory: bcatego eet:	Product Use		tes for Ozone I Stationary Air	Depleting Substanc Conditioning	es							19
ta E.Gassa	Manager											
i -uases	a manayer					Subdivision						
Uns	specified											
-						Sub-application						
	Domestic Refrige	ration										
										Recovery		
	Chemical	Tier	Year of Introducti on	Emission factor for containers management (%/yr)	Emission factor for filling (production/ma nufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servici ng) (% initial charge/yr)	Lifetime of equipme nt (years)	Share of initial charge remaining at the end of life (%)	Share of charge remaining at the end of life that is destroyed (%)	efficiency of charge (to be reclaimed/recyc led) remaining at end of life in retired equipment (%)	UNF CCC CRT Confi dentia lity	
	Chemical	Tier	Introducti	for containers management	for filling (production/ma nufacturing) of new equipment (% initial	for equipment operation (leakage/servici ng) (% initial	of equipme nt	charge remaining at the end of life	remaining at the end of life that is destroyed	charge (to be reclaimed/recyc led) remaining at end of life in retired equipment	CCC CRT Confi dentit lity	

EF/Parameters Input¹

The following sections in Chapter 7, Volume 3 of the 2006 IPCC Guidelines contain information on the choice of EF/parameters:

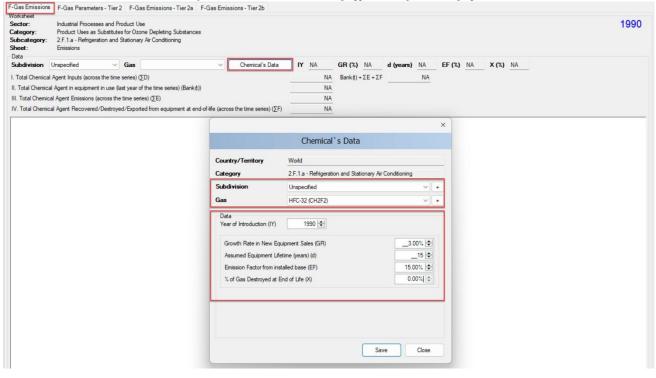
- ✓ <u>Section 7.5.2.2</u> contains information on the choice of EFs/parameters for RAC.
- ✓ <u>Section 7.6.2.2</u> contains information on the choice of EFs/parameters for Fire Protection.

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 <u>here</u> if additional F-gases or blends needs to be added to the drop-down menu).
- 3. <u>Window | Year of Introduction |</u>: input the year of introduction of the agent in the country for use in RAC (e.g., 1990).
- 4. <u>Window | Growth Rate in New Equipment Sales |</u>: input the growth rate in sales of new equipment, usually assumed linear across the period of assessment (e.g. 3%).
- 5. <u>Window | Assumed Equipment Lifetime |:</u> input the equipment lifetime number of years: <u>Note that:</u> the average lifetime for refrigeration and air conditioning equipment is 15 years. <u>Note that:</u> for fire protection, the average lifetime is 15 years.
- 6. <u>Window | Emission Factor from Installed Base |</u>: input the EF from installed base or bank, in percent. <u>Note that:</u> the average EF from installed base for refrigeration and air conditioning equipment is 15 % annually. <u>Note that:</u> for fire protection, the average EF from installed base is 4% annually.
- 7. <u>Window |% of Gas Destroyed at End-of-Life</u>]: input the agent destroyed at the end-of-life, percent. <u>Note that</u> the default assumption of 0% means no F-gas is destroyed at the end-of-life, thus all gases in retired equipment are emitted.

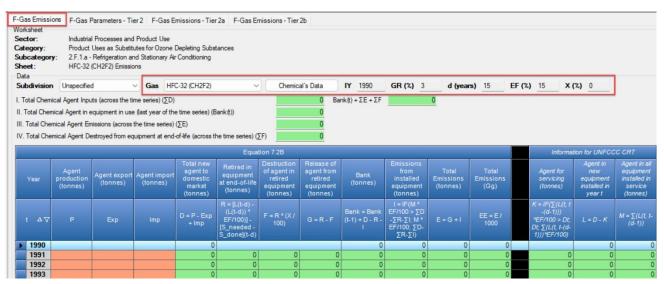
Example: entering EF/parameter information- Tier 1

<u>Note that</u> this figure is for Refrigeration and Air Conditioning but applies also to Emissions from Fire Protection worksheet. The IPCC default values for Fire Protection, 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

			H2CF3) Emissio	ns											_
Subdivision	Unspecifie	d N	Gas H	FC-365mfc (CH	3CF2CH2CF3	Chemi	ical's Data	IY 1990	GR (%)	3 d	(yr) 15	EF ((%) 4	X (%) 0	
Total Chem	ical Agent Inpi	uts (across the tir	me series) (∑D)				0 Ba	nk(t) + ΣE + ΣF		0					_
. Total Che	nical Agent in	equipment in use	a (last year of th	e time series) (E	Bank(t))		0								
I. Total Che	mical Agent Er	missions (across t	the time series)	(ΣE)			0								
Total Che	mical Agent D	estroved from ea	uipment at end	-of-life (across t	he time series) (ΣE)	0								
	-						-							tion for UNFCC	O OPT
					Equa	tion 7.17	-						morma		
	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 equipm installer servic (tonne
t ∆⊽	Ρ	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 > ΣD -ΣR-ΣI; M * EF/100; ΣD- ΣR-ΣI)	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 = Σ(L((d-1),
1990				0				0	0	0	0			0	
1991				0	0	0	0	0	0	0	0		0	0	
				0	0	0	0	0	0	0	0		0	0	
1992				U	U	U	0	U U	U	U	v				
and the second s				0		0	0	2.00 A	0				0	0	

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 <u>Table 7.9</u> 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. <u>Window | t (start) |</u>: input the year of introduction of refrigerant (F-gas/blend).
 - b. <u>Window |EFc|</u>: input the EF for containers management (percent per year).
 - c. <u>Window | EFk |:</u> input the EF for filling new equipment (percent of initial charge per year).
 - d. <u>Window |EFx|:</u> input the EF for equipment operation (percent of initial charge per year).
 - e. <u>Window |d|</u>: input the lifetime of equipment, years.
 - f. Window |p|: input the share of initial (full) charge remaining at end-of-life, percent. <u>Note that</u>: 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 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 <u>QA/QC check</u> in the AD section below).
 - g. <u>Window |D|</u>: input the share of charge remaining at the end of life that is destroyed, percent.
 - h. <u>Window $|\eta (\text{rec,d})|$ </u> input the recovery efficiency of charge to be reclaimed/recycled, percent. <u>Note that</u>: the sum of <u>Column |D| + <u>Column $|\eta (\text{rec,d})|$ </u> must be ≤ 100 because gas is either emitted, destroyed or reclaimed/recycled.</u>
- 5. <u>Tier 2b: for each sub-division, sub-application and each F-gas/blend, input the following information:</u>
 - a. <u>Column | t (start) |</u>: input the year of introduction of refrigerant (F-gas/blend).
 - b. <u>Column |d|</u>: input the lifetime of equipment, years.
 - c. <u>Column |D|</u>: input the share of charge remaining at the end of life that is destroyed, percent.
 - d. <u>Column $|\eta (\text{rec}, d)|$ </u> input the recovery efficiency of charge to be reclaimed/recycled, percent. <u>Note that:</u> the sum of <u>Column $|D| + Column |\eta (\text{rec}, d)|$ </u> 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

Sub-application Image: Commercial Refrigeration Image: Commercial Re	-Gas Emissions Vorksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Product Use Product Uses as Substitutes for Ozone Depleting Substances	1990
Image: Sub-application I	F-Gases Man	anager	
Sub-application Image: Commercial Refrigeration Image: Com			
Domestic Refrigeration Medium & Large Commercial AErigeration Residential and Commercial AC, including Heat Pumps Rest of Country Res	🖃 🕨 Tokyo		Z
Medium & Large Commercial AC, including Heat Pumps I Residential and Commercial AC, including Heat Pumps I Subdivision I Rest of Country I Omessic Refrigeration I Medium & Large Commercial AC, including Heat Pumps I Image: Country Image: Country Image		Sub-application	
Residential and Commercial AIC, including Heat Pumps I Subdivision I Rest of Country I Domestic Refrigeration I Medium & Large Commercial AIC, including Heat Pumps I Residential and Commercial AIC, including Heat Pumps I Transport Refrigeration I Transport Refrigeration I	Dom	mestic Refrigeration	
Subdivision Image: Subdivision Rest of Country Image: Sub-application Domestic Refrigeration Image: Sub-application Image: Residential and Commercial ACC, including Heat Pumps Image: Sub-application Image: Residential and Commercial ACC, including Heat Pumps Image: Sub-application Image: Transport Refrigeration Image: Sub-application	Med	adium & Large Commercial Refrigeration	
Rest of Country Image: Sub-application Image: Sub-application Image: Sub-application Image: Domestic Refrigeration Image: Sub-application Image: Sub-application Image: Sub-application Image: Residential and Commercial ACC, including Heat Pumps Image: Sub-application Image: Sub-application Image: Residential and Commercial ACC, including Heat Pumps Image: Sub-application Image: Sub-application Image: Transport Refrigeration Image: Sub-application Image: Sub-application Image: Sub-application	• Res	ssidential and Commercial A/C, including Heat Pumps	
Rest of Country Image: Sub-application Image: Sub-application Image: Sub-application Image: Domestic Refrigeration Image: Sub-application Image: Sub-application Image: Residential and Commercial AC, including Heat Pumps Image: Sub-application Image: Sub-application Image: Residential and Commercial AC, including Heat Pumps Image: Sub-application Image: Sub-application Image: Transport Refrigeration Image: Sub-application Image: Sub-application	*		
Sub-application Image: Control of the second seco		Subdivision	
Domestic Refrigeration I Medium & Large Commercial Refrigeration I Residential and Commercial AC, including Heat Pumps I Transport Refrigeration I	Rest of	f Country	
B Medium & Large Commercial Refrigeration Image: Commercial AIC, including Heat Pumps B Residential and Commercial AIC, including Heat Pumps Image: Commercial AIC, including Heat Pumps B Transport Refrigeration Image: Commercial AIC, including Heat Pumps		Sub-application	
B Residential and Commercial AIC, including Heat Pumps Image: Commercial AIC, including Heat Pumps Image: Transport Refrigeration Image: Commercial AIC, including Heat Pumps Image: Commercial AIC, including Heat Pumps	Dom	mestic Refrigeration	
Transport Refrigeration	Med	edium & Large Commercial Refrigeration	
	⊕ Res	ssidential and Commercial A/C, including Heat Pumps	
Industrial Refrigeration including Food Processing and Cold Storage	Tran	ansport Refrigeration	
	😥 Indu	dustrial Refrigeration including Food Processing and Cold Storage	

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.

<u>Note that</u>: 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.

F-Gas Emissions F-Gas Parameters - Tier 2 F-Gas Emissions - Tier 2a F-Gas Emissions - Tier 2t Worksheet Sector: Category: Subcategory: Industrial Processes and Product Use Product Uses as Substitutes for Ozone Depleting Substances 2.F.1.a - Refrigeration and Stationary Air Conditioning F-Gas Emissions - Emission Factor Approach - Tier 2a 1990 Sheet: Sub-application Domestic Refrigeration Gas HFC-152a (CH3CHF2) Subdivision Unspecified Intro Year 1990 EFc [%] 5 EFk [%] 0.1 p [%] 99.75 D [%] 20 EFx [%] 0.25 Lifetime (d) [yr] 15 n(rec.d) [%] 80 I. Total Chemical Agent Inputs (across the time series) ($\Sigma F + \Sigma H$) $\Sigma G + Bank(t) + \Sigma V + \Sigma Q + \Sigma S + \Sigma T$ 0 II. Total Chemical Agent in new equipment exported (across the time series) (5G) III. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) IV. Total Chemical Agent Emissions (across the time series) (ΣV) 0 V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) ($\Sigma Q + \Sigma S + \Sigma T$) 0 $N = \sum (M + 1, t))$ 1990 1991 1992 alculated alculated 1993 Calculated 1994 Calculated 1995 alculated

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:

- ✓ <u>Sections 7.5.2.3</u> contains information on the choice of AD for Refrigeration and Air Conditioning.
- ✓ <u>Sections 7.6.2.3</u> 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 <u>F-gas consumption</u> 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 redorange cells, by subdivision/gas, and for each year, as follows:

- 1. <u>Column |t|</u>: 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. <u>Column |P|</u>: input the amount of the respective chemical identified in **Gas** produced for consumption in the designated subdivision.
- 3. <u>Column |Exp|</u>: 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. <u>Column | Imp |</u>: input the amount of the respective chemical identified in **Gas** that was imported for consumption in the designated subdivision, in tonnes. <u>Note that</u>: data on production, export and import of the agent (F-gas/blends) should be entered for the reporting (inventory) year in <u>Column | t |</u> 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 |L| will be included in the JSON file for upload to the UNFCCC ETF Reporting Tool.
- 3. <u>Column | R |</u>: the Software tracks the amount of agent in retired equipment. <u>Note that:</u> 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.

Inform	ation for CRT				HIDDE	N CALCULATIO	N	
agent for servicing	agent in new equipment installed in year t	agent in all equipment installed in service	needed ag	ent across lifetime		actual a	gent used across tin	ne
(tonnes)	(tonnes)	(tonnes)	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	$\sum_{i=1}^{d-1} (S_done)$
NO	10,000.000	10,000.000	installed in year t-20	9,000.000	year t-20	NO	installed in year t-2	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-1	9 4,600.000
1,900.000	8,100.000	27,100.000	installed in year t-1	8 7,290.000	year t-18	1,900.000	installed in year t-1	8 3,340.000
2,710.000	7,290.000	34,390.000	installed in year t-1	6,561.000	year t-17	2,710.000	installed in year t-1	7 2,287.000
3,439.000	6,561.000	40,951.000	installed in year t-1	5,904.900	year t-16	3,439.000	installed in year t-1	6 1,412.200
4,095.100	5,604.900	46,555.900	installed in year t-1.	5 5,044.410	year t-15	4,095.100	installed in year t-1	5 660.490
0.000	0.000	46,555.900	installed in year t-1-	1 0.000	year t-14	0.000	installed in year t-1	4 0.000
0.000	0.000	46,555.900	installed in year t 13	3 0.000	year t-13	0.000	installed in year t-1	3 0.000
0.000	0.000	46,555.900	installed in year t-12	2 0.000	year t-12	0.000	installed in year t-1	2 0.000
4,655.590	5,344.410	51,900.310	installed in year t 1	4,809.969	year t 11	4,655.590	installed in year t 1	1 400.000
100.000	0.000	41,900.310	installed in year t-10	0.000	year t-10	100.000	installed in year t-1	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	3 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	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-0	5 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

$\label{eq:calculation} \textit{Example: Calculation of S-needed and S-done for source categories 2.F.1 and 2.F.3}$

to calculate actual servicing occurred in each year subsequent to the installation of the equipment installed in a year:

installed in year	1-20	1-19	1-18	1-17	1-16	1-15	1-14	1-13	1-12	1-11	1-10	1-9	1-8	1-7	1-6	1-5	1-4	1-3	1-2	1-1
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	10.00
t-19	1,000.000					-	_													
t-18	1,000.000	900.000																		
t-17	1,000.000	900.000	810.000							-								_		
ι-16	1,000.000	900.000	810.000	729.000									as: if am							
t-15	1,000.000	900.000	810.000	729.000	656.100								year is les							
t-14	0.000	0.000	0.000	0.000	0.000	0.000							cing. If th (S need)							
ι-13	0.000	0.000	0.000	0.000	0.000	0.000	0.000			is le	ss man is		agent ava				ine amou	Int OI		
t-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000					agentava		Servicing	<i>.</i>				
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				
t3									0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
										100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
ι-2											0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
t-2 t-1											0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

- 4. <u>Column |F|</u> is the amount of agent in the retired equipment destroyed in the year of retirement. <u>Note that</u> the % destroyed was added in **Chemical's Data** tab.
- 5. <u>Column |G| is the total amount of agent retired in the year, minus the amount destroyed.</u>
- 6. <u>Column |Bank|</u>: the *Software* back-calculates the development of the bank of the agent from the current reporting year to the year of its introduction. <u>Note that</u> 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. <u>Column |1|</u>: contains emissions from installed equipment in year t, in tonnes.
- 8. <u>Column |E|</u>: total emissions are calculated, in tonnes. <u>Note that</u> total emissions are calculated as emissions from installed equipment plus emissions from retired equipment.
- 9. <u>Column | EE |</u>: 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 $(\sum D)$
- II. Total chemical agent in equipment in use, last year of the time series (Bank(t))
- III. Total chemical agent emissions, across time (ΣE)
- IV. Total chemical agent recovered/destroyed/exported in equipment at end-of-life(ΣF)

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 HFC-143a (CH3CF3) Emissions Sheet: Subdivision Unspecified Gas HFC-143a (CH3CF3) Chemical's Data IY 1998 GR (%) 3 d (years) 15 EF (%) 15 X (%) 0 V 224,053.265215 I. Total Chemical Agent Inputs (across the time series) (∑D) 224.053.265215 $Bank(t) + \Sigma E + \Sigma F$ Demonstration of conservation of mass: 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 Total inputs = bank+emissions+recovery/destruction IV. Total Chemical Agent Destroyed from equipment at end-of-life (across the time series) (∑F) 0 Retired in equipment at end-of-life (tonnes) gent imp (tonnes) Bank (tonnes) Emission: (tonnes) Emissio (Gg) EE = E / 1000 t AV 31,632,230 5,582,1584 1,931,82866 37,214,389 7,224,2127 5,582,1584 5,58216 2009 224 212 5.292.38411 2010 7.440.93915 7,440.93915 33 212 194 5 860 97552 5,582.1584 39 073 170 5 860 9755 5 8609 1 858 78074 34,744,907 2011 7 664 16732 7.664.16732 6,131.45429 6,131.45429 6.1314 5.860.97552 1.803.19181 40.876.361 894.09234 7.894.0923 36,243,149 6.395.85 6.3958 6.131.45429 762.63806 42 638 999 2012 6.395.8 10.426.783 2013 8,130.91511 8,130,91511 4 436 08620 4 436 08626 33,947,282 5,990,69682 10.4267 5.613.01124 2.517.90387 39,937,978 32,655,613 8,374,84257 3,903.75591 5,762.7553 9,666.51121 9.6665 3,073.04384 38,418,368 2014 8,374.8425 3,903.7559 5,301.79872 3 455 26759 3 455 2675 32 152 468 5.673.96504 9.1292 5,153.0022 3,473.08565 37 826 433 2015 8,626.08784 8,626,08784 9,129.2326 5.130.7595 2016 8.884.87048 8.884.87048 3.078.1647 3.078.16477 32,265.298 5.693.87614 8,772,0409 8.7720 3.754.11098 37,959.174 9.151.41659 9,151,41659 2.761.86299 2,761,86299 32,856,623 5,798.22776 8,560,0907 8.5600 5.206.48856 3,944,92804 38,654,851 2017 2,497.36916 2018 9,425,95909 9 425 95909 2,497,36916 33 817 431 5 967 78209 8 465 15125 8 46515 5 357 51556 4 068 44353 39 785 213 6,187.36901 41,249,126 9,708.73786 9,708.73786 35.061.757 8.4644 5,565.95097 2019 0 2 277 0429 2,277.04298 8,464.4119 4,142.78689 2020 10,000 10.000 2.094.3941 2.094.39411 36 522 259 6.445.10454 8 539 4986 8.539 5 817 77005 4,182.22995 42,967.363 2021 10 300 10 300 1 943 90979 1 943 90979 38 146 596 6 731 75239 8 675 66218 8 6756 6 102 06164 4 197 93836 44 878 349 6.410.41562 4.198.58438 2022 10,609 1,820,9083 7.040.20328 8,861,11164 8.8611

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 redorange 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.

orksheet ector: ategory: ubcategor neet: ata	Product y: 2.F.1.b -	Processes and Uses as Substit Mobile Air Cond la (CH3CF3) Err	utes for Ozone litioning	Depleting Subs	tances										
ubdivision	n Unspecified	4	✓ Gas HFI	C-143a (CH3CF	:3) ~	Chemic	al`s Data	IY 1998	GR (%) 3	d (year	s) 15	EF (%) 15 X ((%) 0	
			me series) (∑D)					$ink(t) + \Sigma E + \Sigma F$	138,529.5232	76					
Total Chen	mical Agent in e	quipment in use	e (last year of the	e time series) (B	lank(t))	45,76	67.65362								
. Total Cher	mical Agent Em	nissions (across	the time series)	(ΣE)		92,761	1.869656								
/. Total Che	mical Agent De	stroyed from ec	uipment at end	of-life (across th	ne time series) (ΣF)	0								
			9		Equa	tion 7.2B							Informat	tion for UNFCC	C 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 ii equipm installe servic (tonne
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 > ΣD -ΣR-ΣI; M * EF/100; ΣD- ΣR-ΣI)	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 = Σ(L (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	3,242.8
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.
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.
2003	0	0	Contraction of the local sector in the local sector is a sector of the local sector is a sector is a sector of the local sector is a sector is a sector of the local sector is a sector of the	1,413.89386	0	0	0	and the ball of the ball	830.2709	830.2709	0.83027		727.27861	686.61526	
2004	0	0			0	0	0	U,LUT.UULLU	924.17686	924.17686	0.92418		830.2709	626.03978	
2005	0			1,500	0	0	0		1,010.55033	1,010.55033	1.01055		924.17686	575.82314	
2006	0	0		1,800	0	0	0		1,128.96778	1,128.96778	1.12897		1,010.55033	789.44967	7,526.4
2007	0	0		2,100 2,400	0	0	0	I I I I I I I I I I I I I I I I I I I	1,274.62262	1,274.62262	1.27462		1,128.96778	971.03222 1,125.37738	
2008	0			2,400	0	0	0	Contraction of the second of the	1,443,42922	1,443.42922	1.63191		1,274.62262	1,125.37738	10,879
2003	0		3.000	3.000	0	0	0		1.837.12761	1.837.12761	1.83713		1.631.91484	1.368.08516	12.247
2011	0	0		3,400	0	0	0	A REAL PROPERTY AND A REAL	2,071.55847	2,071.55847	2.07156		1,837.12761	1,562.87239	13,810
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
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
2014	0			4,600	912.28868	0	912.28868	1	2,640.49936	3,552.78803	3.55279		2,294.70513	2,305.29487	17,603
2015	0	0		5,000	807.47915	0	807.47915		2,873.30258	3,680.78173	3.68078		2,498.00304	2,501.99696	19,155
2016	0	0		6,000	719.35206	0	719.35206	A CONTRACTOR OF A CONTRACTOR O	3,234.40438	3,953.75645	3,95376		2,746.3581	3,253.6419	the second second second
2017	0	0	the second s	7,000	645.43388	0	645.43388		3,702.42864	4,347.86253	4.34786		3,120.50429	3,879.49571	24,682
2018	0	-		8,000	583.62297	0	583.62297		4,259.5209	4,843.14387	4.84314		3,599.43636	4,400.56364	28,396
2019	0	0		9,000	532.13382	0	532.13382	In the last of the ball and the	4,890.77269	5,422.90651	5.42291		4,165.61494	4,834.38506	32,605
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	37,22

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.

Gas Emissi /orksheet category: cubcategor iheet:	Industrial Product y: 2.F.1.b -	Parameters - Tie Processes and Uses as Substitt Mobile Air Cond Ia (CH3CF3) Em	Product Use utes for Ozone I litioning		2a F-Gas Er tances	nissions - Tier	2Ь								
and the second second	Unspecified	t v	Gas HF	C-143a (CH3CF	·3) ~	Chemica	al's Data	IY 1998	GR (%) 3	d (year	rs) 15 I	EF (%) 15	5 X (%) 0	
Total Chem	ical Agent Inpu	ts (across the tir	me series) (ΣD)			123.546	110824 Ba	nk(t) + ΣE + ΣF	123,546,1108	24					
		quipment in use			lank(t))	10000000000	.365611			-					
	-	issions (across					.745213								
	and the second second second				ne time series) ()	100000000000000000000000000000000000000	0								
v. rotal crie	micar Agent De	anoyeu nom eq	upment at enu-	or nic (dcross tr	ie unie selies) (U					_			
					Equa	tion 7.2B						1.00	Informat	ion for UNFCC	C 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)	s	gent for ervicing onnes)	Agent in new equipment installed in year t	Agent in equipme installed service (tonnes,
t ∆⊽				D = P - Exp + Imp	R = [L(t-d) - (L(t-d)) * EF/100)] - [S_needed - S_done](t-d)	F = R * (X / 100)		Bank = Bank (t-1) + D - R - I	I = IF(M * EF/100 > ΣD -ΣR-ΣI; M * EF/100; ΣD- ΣR-ΣI)		EE = E / 1000	*EF Dt; 2	IF(∑(L(t, t (d-1))) /100 > Dt; ∑(L(t, t-(d- *EF/100)	L = D - K	M = Σ(L(I (d-1))
2001	0	0	2,299.2502	2,299.2502	0	0	0	and the state of t	1,058.21138	1,058.21138	1.05821		839.20453	1,460.04566	7,054.74
2002	0	0		2,368.2277	0	0	0	and the second second second	1,254.71383	1,254.71383	1.25471		058.21138	1,310.01632	8,364.75
2003	0	0		2,439.27453	0	0	0		1,432.39794	1,432.39794	1.4324		254.71383	1,184.5607	9,549.3
2004	0	0	and the second second second second	2,512.45277	0	0	0	0,004.00020	1,594.40616	1,594.40616	1.59441		132.39794	1,080.05483	10,629.3
2005	0	0	In the Archite Charles of the Archite	2,587.82635	0	0	0	9,879.37541	1,743.41919	1,743,41919	1.74342		594.40616	993.42019	11,622.7
2006	0	0	Contractor in the local sector in the local se	2,665.46114 2,745.42498	0	0	0	10,663.111	1,881.72548	1,881.72548	1.88173		743.41919	922.04195 863.69949	12,544.8
2007	0	0		2,745.42498	0	0	0	12.091.286	2,011.28041	2,011.28041 2,133.75651	2.01128 2.13376		381.72548 011.28041	863.69949 816.50732	14,225.0
2008	0	0			0	0	0	and the second second second	2,133.75651	2,133.75651	2.13376		133,75651	778.86485	15.003.9
2005	0	0		3,000	0	0	0	13,390.323	2,362.9983	2,362.9983	2.363		250.58623	749.41377	15,753.3
2011	0	0		2.400	0	0	0	13.421.775	2.368.54855	2.368.54855	2.36855		,362.9983	37.0017	15,790.3
2012	0	0		1,800	0	0	0	12,853.226	2,368.54855	2,368.54855	2.36855	-	1,800	0	15,790.3
2013	0	0		1,200	1,788.51869	0	1,788.51869	10,211.780	2,052.92761	3,841.4463	3.84145		1,200	0	13,686.1
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	11,834.5
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	10,195.6
2016	0	0		2,000		0	1,022.03196	4,104.46286	1,413.7866	2,435.81856	2.43582	1.3	310.33717	689.66283	9,425.24
2017	0	0		4,000	855.66497	0	855.66497	5,614.10637	1,634.69153	2,490.3565	2.49036	1,2	217.28415	2,782.71585	10,897.9
2018	0	0		6,000	651.50839	0	651.50839		2,138.45631	2,789.96469	2.78996		457.00742	4,542.99258	14,256.3
2019	0			8,000	515.24494	0	515.24494		2,879.98087	3,395.22581	3.39523		976.44808	6,023.55192	19,199.8
2020	0	0	10,000	10,000	397.36808	0	397.36808		3,821.32266	4,218.69074	4.21869		730.96784	7,269.03216	25,475.

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. <u>Note that</u> if a subdivision/sub-application/F-gas / blend is not available for selection, the user should refer back to the description for Tier 2 in <u>Customizing the Software for Refrigeration and Air Conditioning: subdivision/sub-application/F-gases</u>
- 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)

			_		1	C					`			,	1	T				0				
Gas Emis	sions F-Ga	is Parameters -	Tier 2 F-G	as Emissions	-Tier 2a F-	-Gas Emission	s - Tier 2b																	
ksheet																								
ctor:		trial Processes a																						
egory:		ict Uses as Subs																						
bcatego		a - Refrigeration																						
eet:	F-Gas	Emissions - Emi	ission Factor	Approach - Tie	er 2a																			
ta	and the second sec																							
bdivisi	on Rest of C	Country	~	Sub-applica		ic Refrigeration		~		A (HFC-32/HFC														
ntro Ye	ar Rest of C	The second s		EFk [%] 1	Domesti	ic Refrigeration				A (HFC-32/HFC		nín	ec.d) [%] 70)										
	The second				Residen	& Large Comm	ercial Refrigeration	on Ing Heat Pumps		34a (CH2FCF3)														
iotal Che	emical Agent In	inputs (across the	e time series)	$(\Sigma F + \Sigma H)$	The arden	ibar and comme	add ave. Includ	ind friede i dinios		LU Y Daliki	() + ZV + ZQ +	25+21	0											
Total Ch	emical Agent i	in new equipment	nt exported (a	across the time	series) (∑G)				0															
Total C	nemical Agent	in equipment in	use (ast yea	r of the time se	ries) (Bank(t))				0															
	Sector Sector Sector	Emissions (acro	all all a second																					
									U															
Total Ch	emical Agent	Recovered/Des	stroyed/Expo	rted from equip	ment at end-or	f-life (across the	e time series) (∑0	$1 + \Sigma S + \Sigma T$	0															
												Equation 7.10	7.44											
	Amountin				Contrined	Contained	Domestic	Emitted by	Used to fill	Emitted	Contained	Contained	Emitted from				Recovered	-			Exported			
	the bank			Exported in		in factory-	Sales of new	containers	domestically	during filling		in new	equipment in				and				in	Amount in the bank		
		Manufactured Chemical in	in bulk in		charged	charged	& recovered	management				equipment	use in year t	Used to		equipment retired in		at end of life in		oyed in art		on December 31st	Total emissions in year t	
	January	veert								equipment in			including		(kg)	year t		veart		(g)		of year t	(kg)	
	1st of year	(kg)			equipment in year t	equipment i		transfer from bulk to small.	equipment in year t	yeart (kg)	country in year t	in year t (kg)	servicing (kg)			(kg)	from equipment				-life in vear t			(Gg)
					in yoar t	equipment	(//g/	Durk to smail,	yeart	(kg)	yeart	(Kg)	(kg)			P = M(t-d)	equipment				ycart			
																* (p/100) -	Q = P*(n			S = P *			V=1+K+N+	W=V/
	Bank(t-1)						H = C + D - E + Q(t-1)	I = H * (EFc / 100)		K = J * (EFk / 100)			d+1,t)) *		O = Sdone or specified	(Sneeded	Q = P*(ŋ (rec,d)/100)	R=P-Q		D/100 or		Bank(t) = Bank(t-1) + M + O - N - P	V=I+K+N+ R	W = V7 1000000
																- Sdone)(t-				specified				
1000									0							a)								
1990	0		-				0	0	0			0	0	Calart				-				(0	
1991	0		-	-		-	0	0	0	0	0	0	0	Calcul.	0	0	0		Calc	0	-	0	0	
1992	0		-	-			0	0	0	0	0	0	0	Calcul.	0	0	0		Calc	0		0	0	
1993	0						0	0	0	0	0	0	0	Calcul	0	0	0		Calc_	0		0	0	
1994	0		-	-	-	-	0	0	0	0	0	0		Calcul	0	0	0		Calc	0		0	0	
1995	0		-	-	-	-	0	0	0	0	0 0	0	0	Calcul	C	0	0		Calc_	0		0	0	
1996	0		2	2	-		0	0	0	0		0	0	Calcul_	0	0	0		Calc	0	2	0	0	
1997																								

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:

<u>Note that:</u> 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. <u>Column |C|</u>: input the amount of domestically manufactured F-gas/blend used in that subdivision/sub-application, in year t, kg.
- 2. <u>Column |D|:</u> input the amount imported in bulk in year t, kg.
- 3. <u>Column |E|</u>: input the amount exported in bulk in year t, kg. <u>Note that</u>: 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 <u>Ensuring mass conservation of gases</u>).
- 4. <u>Column |F|</u>: input the amount contained in factory-charged imported equipment in year t, kg.
- 5. <u>Column |G|:</u> input the amount contained in factory-charged exported new-equipment in year t, kg.
- 6. <u>Column |O|</u>: input the amount used to refill equipment in year t, kg. In <u>Column |O|</u> there is a dropdown 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 (<u>Column |H|</u>) minus any emissions from containers management during fillings of the domestic sales (<u>Column |I|</u>) 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 (<u>Column |J|</u>).
 - If domestic sales for that year (<u>Column |H|</u>) minus any emissions from containers management during fillings of the domestic sales (<u>Column |I|</u>) 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 (<u>Column |J|</u>).
 - b. *Specified* (white cell) users enter user-specific AD manually.
- 7. <u>Column |S|</u>: amount destroyed in year t, kg. In <u>Column |S|</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, <u>Column |P|</u> (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 <u>Column |D|</u> in the worksheet **F-Gas Parameters Tier 2**.
 - b. Specified (white cell) users enter country-specific AD manually. <u>Note that:</u> a warning will appear on <u>Column |S|</u> if the values in <u>Columns S +T +Q</u> are greater than the amount in <u>Column |P|</u>.
- 8. <u>Column |T|:</u> 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. <u>Column |Bank (t-1)|</u>: amount in the bank (i.e. the amount of refrigerant stored in products) on January 1st of year t, kg.

<u>Note that</u> this column is automatically calculated and is equal to the bank at the end of the previous year.

- 10. <u>Column |H|:</u> 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. <u>Column |1|</u>: emitted by containers management (during transfer from bulk to small, and as leftover if not recovered), kg.

<u>Note that</u> this cell is calculated as the total amount of domestic sales in year (t) multiplied by the EF for containers $|EF_c|$, as indicated in worksheet **F-Gas Parameters-Tier 2** (2% in this example).

12. <u>Column ||||:</u> amount used to fill domestically manufactured new equipment in year t, kg. <u>Note that</u> 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. <u>Column |K|:</u> emitted during filling of new equipment in year t, kg. <u>Note that</u> this cell is calculated as the amount in <u>Column |J|</u> multiplied by the EF for filling <u>|EFk|</u>, as indicated in worksheet **F-Gas Parameters-** Tier 2 (1% in this example).
- 14. <u>Column |L|:</u> amount contained in new equipment filled in country in year t, kg. <u>Note that this cell is calculated as the total amount used to fill new equipment minus emissions from filling of that equipment.</u>
- 15. <u>Column |M|: amount contained in new equipment in year t (i.e. amount added to the bank), kg.</u> <u>Note that</u> 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. <u>Column |N|:</u> amount emitted from equipment in use in year t, kg. <u>Note that</u> 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. <u>Note that</u> 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. <u>Column |Q|:</u> amount recovered and recycled/reclaimed from equipment retired in year t, kg. <u>Note that</u> this cell is calculated based on the agent in equipment reaching the end of its lifetime <u>Column |P|</u> and the percentage of that which is recycled/reclaimed <u> $|\eta$ (rec.d)|</u>, provided by the user in worksheet **F-Gas Parameters- Tier 2**, (70% in this example).
- 19. <u>Column |R|:</u> amount emitted at end of life in year t, kg. <u>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.</u>
- 20. <u>Column |Bank(t)|</u>: amount in the bank on December 31st of year t, kg. <u>Note that</u> 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. <u>Column |V|:</u> total emissions in year t, kg. <u>Note that</u> this cell is calculated as the sum of emissions from containers, equipment filling, equipment in use, and at end of life.
- 22. <u>Column |W|:</u> 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 $(\Sigma F + \Sigma H)$
- II. Total chemical agent in new equipment exported, across time $(\sum G)$
- III. Total chemical agent in equipment in use, (last year of the time series) (Bank(t))
- IV. Total chemical agent emissions, across time $(\sum V)$
- V. Total chemical agent recovered/destroyed/exported in equipment at the end of life $(\sum Q + \sum S + \sum T)$

In the case of Tier 2a, mass conservation has been ensured if:

$$\Sigma F + \Sigma H = \Sigma G + Bank(t) + \Sigma V + \Sigma Q + \Sigma S + \Sigma T$$

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.

Intro Year 1990	EFc [%]	2	EFk [%]	1	EFx [%]	1	Lifetime (d) [yr]	15 p	2] 99		0 [%] 0		n(rec.d) [%] 70)
I. Total Chemical Agent In	Inputs (across the	e time serie	s) (ΣF + ΣH)					45,025.21547	ΣG +	Bank(t) + 2	EV + ΣQ + 2	ES + ΣT	45,025.215477	
II. Total Chemical Agent	in new equipmer	nt exported	(across the time	e series) (∑G	i)			1,073						
III. Total Chemical Agent	t in equipment in	use (last ye	ear of the time s	eries) (Bank(t	(t))			10,056.705721						
IV. Total Chemical Agent	t Emissions (acro	ss the time	series) (∑V)					14,628.960779						
V. Total Chemical Agent	Recovered/Des	stroyed/Exp	oorted from equi	pment at end	d-of-life (acros	s the time se	eries) ($\Sigma Q + \Sigma S + \Sigma T$)	19,266.548977						
Intro Year 1990	EFc [%]	2	EFk [%]	1	EFx [%]	30	Lifetime (d) [yr]	15	p [%]	70	D [%]	0	η(rec.d) [%]	70
				1	EFx [%]	30	Lifetime (d) [yr]	15 26.			D [%] + ΣV + ΣC			_
Intro Year 1990 . Total Chemical Agent II I. Total Chemical Agent	Inputs (across th	e time serie	es) (ΣF + ΣH)			30	Lifetime (d) [yr]	26,						_
Total Chemical Agent I	Inputs (across th in new equipme	e time serie nt exported	es) ($\Sigma F + \Sigma H$) d (across the tin	ne series) (Σ((G)	30	Lifetime (d) [yr]	26,	5 <mark>66</mark> Σ					_
. Total Chemical Agent I I. Total Chemical Agent	Inputs (across th in new equipme t in equipment in	e time serie nt exported use (last y	es) ($\Sigma F + \Sigma H$) d (across the tin rear of the time	ne series) (Σ((G)	30	Lifetime (d) [yr]	26,	566 Σ()73 0					_

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. <u>Note that</u> if a subdivision/sub-application/F-gas / blend is not available for selection, the user should refer back to the description for Tier 2 in <u>Customizing the Software for Refrigeration and Air Conditioning: subdivision/sub-application/F-gases</u>.
- 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.

													11							
Gas Emissio	ons F-Gas Par	ameters - Ti	ier2 F-Ga	s Emissions - Tie	er 2a F-Gas En	nissions - Tier 2b														
rksheet					-															
ector:			d Product Use																	20
ategory:				e Depleting Sub	stances															
ubcategory				Air Conditioning																
heet:	F-Gas Emis	sions - Mass	Balance App	roach - Tier 2b																
Data	-				-			_	-											
Subdivision	-		~ S		Domestic Refriç				Gas HFC-23 (C											
Intro Year	Tokvo	Litetime to	25	nírec	Domestic Refrig	eration mmercial Application			HFC-23 (C											
					and the second second	mmercial Apolication	ns			(CH3CF3)		_								
. Total Chemi	cal Agent Inputs	(across the t	time series) (2	$G + \Sigma E - \Sigma Sto +$	Strom)				0 2	$\Sigma F + Bank(t) + \Sigma I$	Q + ΣN + ΣO + ΣF	P	0							
I. Total Chen	nical Agent in nev	v equipment	exported (acr	oss the time serie	es) (ΣF)				0											
II. Total Cher	nical Agent in eg	upment in us	se (last year o	f the time series)	(Bankt))				0											
	mical Agent Emis																			
									U											
/. Total Chen	nical Agent Reco	vered/Destri	oyed/Exporte	d from equipment	t at end-of-life (ac	ross the time series) (ΣN + ΣO	+ ΣP)	0											
	y										ation 7.9									
Year	Domestically Manufactured Chemical in	Imported in bulk in year t	Exported in bulk in year t	Contained in factory- charged Imported	Contained in factory- charged Exported new		To stockpile	From	Used in year t to fill new equipment not factory-		Total Charge in new- equipment in	Used in year t -d to fill new equipment not factory-	Used in year t -d to fill new equipment factory-	Original Total Charge in year t -d of Equipment	recyc	overed and led/reclaimed in equipment	Destr	oyed in year t (kg)	Exported in used equipment	
Year				factory- charged	factory- charged				to fill new equipment not	Used in year t to fill new equipment	Total Charge	-d to fill new equipment not	d to fill new equipment	Charge in year t	recyc		Destr			
Year t A	Manufactured Chemical in year t	in bulk in year t	in bulk in year t	factory- charged Imported equipment in	factory- charged Exported new -equipment in	of new chemical in year t			to fill new equipment not factory- charged	Used in year t to fill new equipment factory- charged	Total Charge in new- equipment in year t	-d to fill new equipment not factory- charged	d to fill new equipment factory- charged	Charge in year t -d of Equipment Retiring in year t (kg) M = K + L + E(t-	recyc	ted/reclaimed n equipment red in year t (kg) N = M * (n (rec,d)/100)	Destr	(kg) O = M * (D/100)	in used equipment in year t	in year t (kg) Q = G - Sto + Strom - J + M
t 🛆	Manufactured Chemical in year t (kg)	in bulk in year t (kg)	in bulk in year t (kg)	factory- charged Imported equipment in year t	factory- charged Exported new -equipment in year t	of new chemical in year t (kg)	stockpile (kg)	stockpile (kg)	to fill new equipment not factory- charged (kg)	Used in year t to fill new equipment factory- charged (kg)	Total Charge in new- equipment in yeart (kg) J = H + 1	-d to fill new equipment not factory- charged (kg) K = H(t-d)	-d to fill new equipment factory- charged (kg) L = I(t-d)	Charge in year t -d of Equipment Retiring in year t (kg)	recyc	ted/reclaimed n equipment red in year t (kg) N = M * (n	Destr	(kg) O = M *	in used equipment in year t (kg)	in year t (kg) Q = G - Sto +
t ∆ 1999	Manufactured Chemical in year t (kg)	in bulk in year t (kg)	in bulk in year t (kg)	factory- charged Imported equipment in year t	factory- charged Exported new -equipment in year t	of new chemical in year t (kg)	stockpile (kg)	stockpile (kg)	to fill new equipment not factory- charged (kg)	Used in year t to fill new equipment factory- charged (kg)	Total Charge in new- equipment in yeart (kg) J = H + 1	-d to fill new equipment not factory- charged (kg) K = H(t-d)	-d to fill new equipment factory- charged (kg) L = I(t-d)	Charge in year t -d of Equipment Retiring in year t (kg) M = K + L + E(t- d) + F(t-d)	recyc fron reti	ted/reclaimed n equipment red in year t (kg) N = M * (n (rec,d)/100) or specified		(kg) O = M * (D/100)	in used equipment in year t (kg)	in year t (kg) Q = G - Sto + Strom - J + M
t ∆ ▶ 1999 2000	Manufactured Chemical in year t (kg)	in bulk in year t (kg)	in bulk in year t (kg)	factory- charged Imported equipment in year t	factory- charged Exported new -equipment in year t	of new chemical in year t (kg)	stockpile (kg)	stockpile (kg)	to fill new equipment not factory- charged (kg)	Used in year t to fill new equipment factory- charged (kg)	Total Charge in new- equipment in year t (kg) J = H + 1 0 0	-d to fill new equipment not factory- charged (kg) K = H(t-d) 0	-d to fill new equipment factory- charged (kg) L = I(t-d)	Charge in year t -d of Equipment Retiring in year t (kg) M = K + L + E(t- d) + F(t-d)	recyc fron reti	ted/reclaimed n equipment red in year t (kg) N = M * (n (rec,d)/100) or specified	Calc.	(kg) O = M * (D/100)	in used equipment in year t (kg)	in year t (kg) Q = G - Sto + Strom - J + M
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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:

<u>Note that:</u> 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. <u>Column |B|</u>: input the amount of domestically manufactured F-gas/blend in year t, kg.
- 2. <u>Column |C|: input the amount imported in bulk in year t, kg.</u>
- 3. <u>Column |D|:</u> input the amount exported in bulk in year t, kg. <u>Note that</u> 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 <u>Ensuring mass conservation</u> 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 <u>Ensuring mass conservation of gases</u>).
- 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 |||</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.



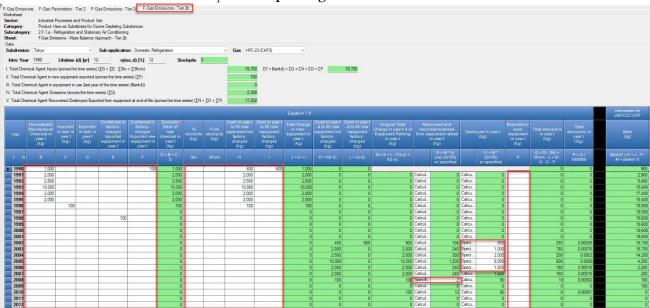
- 10. <u>Column |N|:</u> input the amount recovered and recycled/reclaimed from equipment retired in year t, kg. In <u>Column |N|</u> there is a drop-down menu for two options:
 - a. Calculated (green cell) the *Software* estimates the amount of gas recovered and recycled/reclaimed in year t. The *Software* 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, <u>Column | M|</u>, 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. <u>Note that</u> the amount destroyed plus any values entered in <u>Column |N|</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.
- 12. <u>Column |P|:</u> input the amount exported in used equipment in year t, kg. <u>Note that</u> the amount exported plus any values entered in <u>Column |N|</u> plus <u>Column |O|</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.

Once AD are input, the Software makes several calculations in green cells (these cannot be modified):

- 9. <u>Column |G|:</u> domestic sales of new chemical in year t, kg. <u>Note that</u> this cell is calculated as the total domestic manufactured F-gas/blend, plus bulk import minus bulk export.
- 10. <u>Column |||:</u> total charge in new equipment in year t, kg. <u>Note that</u> 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. <u>Column |K|:</u> amount used in the year t-d to fill new equipment not factory-charged, kg. <u>Note that</u> 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. <u>Column |L|:</u> amount used in the year t-d to fill new equipment factory-charged, kg. <u>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).</u>
- 13. <u>Column |M|:</u> the original total charge in year t-d of equipment retiring in year t, kg. <u>Note that</u> this cell is calculated as information entered in <u>Column |K|</u> plus <u>Column |L|</u> 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. <u>Column |Q|:</u> Total emissions in year t, kg. <u>Note that</u> 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. <u>Column |R|:</u> Total emissions in year t, Gg.
- 16. <u>Column |Bank_(t)|:</u> 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).

<u>Note that</u> 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

Ensuring mass conservation of gases in Tier 2b

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 (ΣF)
- 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 $(\Sigma N + \Sigma O + \Sigma P)$

In the case of Tier 2b, mass conservation has been ensured if:

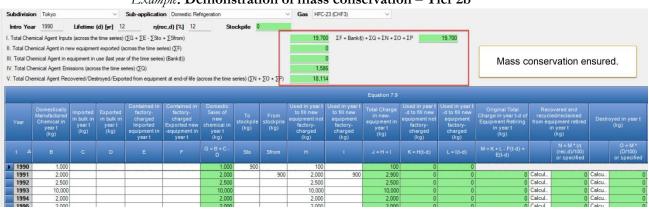
$$\sum G + \sum E + \sum S_{to} + \sum S_{from} = \sum F + Bank(t) + \sum Q + \sum N + \sum O + \sum P$$

If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading, 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 ∑N+∑O+∑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

. Total Che I. Total Ch /. Total Ch	mical Agent Input emical Agent in ne emical Agent in e emical Agent Emi	s (across the w equipmer quipment in ssions (acro	nt exported (a use (last year ss the time se	$(\Sigma G + \Sigma E - \Sigma Stoacross the time setr of the time serieseries) (\Sigma Q)$	ries) (∑F)		eckpile 0		19.70 2.89 17.22	0) + ΣQ + ΣN + ΣO	0+ΣP	20,124	beand	ecaus l usec	onservations on servations of the amiguitation	ount uipm	to stock ent in 19	pile 90 is
											Equation 7.9								
Year	Domestically Manufactured Chemical in year t (kg)	Imported in bulk in year t (kg)	Exported in bulk in year t (kg)	Contained in factory- charged Imported equipment in year t	Contained in factory- charged Exported new -equipment in year t	Domestic Sales of new chemical in year t (kg)	To stockpile (kg)	From stockpile (kg)	Used in year t to fill new equipment not factory- charged (kg)	Used in year t to fill new equipment factory- charged (kg)	Total Charge in new- equipment in year t (kg)	Used in year t -d to fill new equipment not factory- charged (kg)	Used in year t -d to fill new equipment factory- charged (kg)	Original Total Charge in year t-d of Equipment Retiring in year t (kg)	from eq	overed and ed/reclaimed uipment retired n year t (kg)	Destro	iyed in year t (kg)	Exported i used equipmen in year t (kg)
t 🔺	в	с	D	E	F	G = B + C - D	Sto	Sfrom	H	1	J = H + I	K = H(t-d)	L = I(t-d)	$\begin{split} M &= K + L - F(t\text{-}d) + \\ & E(t\text{-}d) \end{split}$		N = M * (η (rec,d)/100) or specified		O = M * (D/100) or specified	Р
1990	1,000					1,000	900		200		200	0	0						
1991	2,000					2,000		900	2,000	900	2,900	0	0		Calcul.		Calcu	0	
1992	2,500					2,500			2,500		2,500	0	0		Calcul.		Calcu_	0	
1993	10,000					10,000			10,000		10,000		0	-	Calcul.		Calcu	0	
1994	2.000					2.000			2.000		2.000	0	0	0	Calcul	0	Calcu.	0	

Results

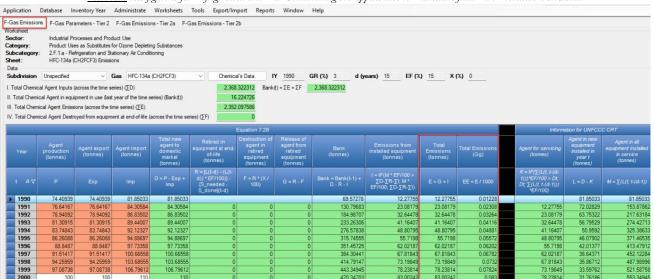
GHG emissions from Refrigeration and Air Conditioning are estimated one row for each year of the time series, in the following worksheets:

- ✓ F-Gas Emissions
- F-Gas Emissions Tier 2a
- \checkmark 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

-Gas Emissic /orksheet	ons F-Gas	Parameters - Tie	r 2 F-Gas	Emissions -	Tier 2a F-	Gas Emissio	ns - Tier 2b																	
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Subdivision	n Tokyo		V Su	b-applicat	tion Domest	tic Refrigeratio	on	~ (as R-410A (H	HFC-32/HFC-125 (5	50. V													
Intro Year	1990	EFc [%] 2	E	Rk [%] 1	E	Fx [%] 1	Lifetim	e (d) [yr] 15	P [4]	99 DI	2 0	ŋ(rec,d) [%]	70											
		puts (across the ti								ΣG + Banke) + ΣV														
		new equipment		1.2	1.1.000				Contraction of the local division of the loc	20 + 66 (4) + 2 V	+20+23+21	45,025,2154	<u>.</u>											
					10.00			-	1.073															
		n equipment in us			ies) (Bank(t))				056.705721															
	errical Agent E	Emissions (across	the time series	s) (ΣV)				14	628.960779															
	mical Agent R	Recovered/Destro	yed/Exported	from equipr	nent at end-of	f-life (across th	he time series) (∑Q +	ΣS + ΣΤ)	,266.548977															
	mical Agent R	Recovered/Destro	yed/Exported	from equipr	nent at end of	f-life (across th	he time series) (∑Q +	ΣS + ΣT) 19	,266.548977			Equation 7.10	. 7.14											
	Amount in	Domestically Manufacture		from equipr Exported in bulk in year t (kg)	Contained In factory- charged Imported equipment	Contained in factory- charged Exported new- equipment	Domestic Sales of new & recovered chemical (in bulk) in year t	Emitted by containers management (during transfer from bulk to small,	Used to fill domestically manufactured new equipment in year t	Emitted during filling of new equipment in year t (kg)	Contained in new equipment filled in country in year t	Equation 7.10 Contained in new equipment consumed in year t (kg)	- 7.14 Emitted from equipment in use in year t, including servicing (kg)	Used to r year (kg	rt r	In equipment retired in year in t (kg)	Recovered and ccycled/reclai red from equipment etired in year	Emitted at end of life in year t (kg)			Exported in equipment at end-of- life in year t (kg)	Amount in the bank on December 31st of year t (kg)	Total emissions in year t (kg)	Total emissions in year t (Gg)
V. Total Chen Year	Amount in the bank or January 1st of year t	Domestically Manufacture d Chemical in year t (kg) C	Imported in bulk in year 1 (kg) D	Exported in bulk in year t	Contained In factory- charged Imported equipment	Contained in factory- charged Exported new-	Domestic Sales of new & recovered chemical (in bulk) in year t (kg) H = C + D - E + Q(t-1)	Emitted by containers management (during transfer from	Used to fill domestically manufactured new equipment in year t d = H - 1 - 0	Emitted during filling of new equipment in year t (kg) K = J * (EFk / 100)	new equipment filled in country in year t L=J-K	Contained in new equipment consumed in year t (kg) M = L + F - G	$\label{eq:constraint} \begin{array}{c} \mbox{Emilted from} \\ \mbox{equipment in} \\ \mbox{use in year t} \\ \mbox{in cluding} \\ \mbox{servicing} \\ \mbox{(kg)} \\ \mbox{N} = \sum (M(t-d+1))^* \\ \mbox{(EFx / 100)} \end{array}$	year (kg S Sp	O = Sdone of	In equipment retired in year in t (kg) r P = M(t-d) *	and scycled/reclai med from equipment				equipment at end-of- life in year t	bank on December 31st of year t (kg) Bank(t) = Bank(t- 1) + M + O - N - P	emissions in year t (kg) V=I+K+N +R	emissions in year t (Gg) W = V / 1000000
V. Total Chen Year 1 △ 1990	Amount in the bank on January 1st of year t (kg) Bank(t-1)	Domestically Manufacture d Chemical in year t (kg) C D 2,000	Imported in bulk in year 1 (kg) D	Exported in bulk in year t	Contained in factory- charged imported equipment in year t F	Contained in factory- charged Exported new- equipment G	Domestic Sales of new & recovered chemical (in bulk) in year t (kg) H = C + D - E + Q(L-1) 3.000	Emitted by containers management (during transfer from bulk to small, l = H * (EFc / 100)	Used to fill domestically manufactured new equipment in year t J = H - I - O 2.940	Emitted during filling of new equipment in year t (kg) K = J * (EFk / 100) 28.4	new equipment filled in country in year t L = J - K 2.910.6	Contained in new equipment consumed in year t (kg) M = L + F - G	$\label{eq:constraint} \begin{array}{c} \mbox{Emitted from} \\ \mbox{equipment in} \\ \mbox{use in year t} \\ \mbox{in cluding} \\ \mbox{servicing} \\ \mbox{(kg)} \\ \mbox{N} = \sum (M(L \\ d + 1.t))^* \\ \mbox{(EFx / 100)} \\ \mbox{19.355} \end{array}$	yoai (kg Sp	O = O = O f or or occified	In equipment retired in year (kg) P = M(t-d) * (p/100) - (Sneeded -	and ccycled/reclai med from equipment etired in year	life in year t (Kg) R = P - Q - S - T		yed in year t (kg) S = P * D/100 or	equipment at end-of- life in year t	bank on December 31st of year t (kg) Bank(t) = Bank(t 1) + M + O - N - P 1.916.244	emissions in year t (kg) V - I + K + N + R 108.756	emissions in yeart (Gg) W = V / 1000000
V. Total Cher Year 1 △ 1990	Amount in the bank on January 1st (kg) Bank(L-1) C 1,916.244	Domestically Manufacture t d Chemcal in year t (kg) C 2000 2000	Imported In bulk in year 1 (kg) D 1,000 2,000	Exported in bulk in year t	Contained in factory- charged imported equipment in year t F 25 23	Contained in factory- charged Exported now- equipment G 1,000	Domestic Sales of new & recovered chemical (in bulk) in yeart (kg) H = C + D - E + Q(L1) 3000 2200	Emitted by containers management (during transfer from bulk to small, I = H * (EFc / 100) 60 44	Used to fill domestically manufactured new equipment in year t J = H - 1 - 0 2.940 2.136.644	Emitted during filling of new equipment in year t (kg) K = J * (EFk / 100) 29.4 21.36644	new equipment filled in country in year t L=J-K 2,910.6 2,115,27756	Contained in new equipment consumed in year t (kg) M = L + F - G 1,935.6 2,138.27756	Emitted from equipment in use in year t, including servicing (kg) N = Σ(M(L- d+1:))* (EFx / 100) 19.356 40.73878	yaan (kg S Sp Calc.	O = Sdone or becified	In equipment retired in year (kg) P = M(t-d) * (p/100) - (Sneeded -	and ccycled/reclai med from equipment etired in year	life in year t (Kg) R = P - Q - S - T	Calc_	yed in year t (kg) S = P * D/100 or	equipment at end-of- life in year t	bank on December 31st of yeart (kg) Bank(t) = Bank(t- 1) + M + O - N - P 1.916.244 4.033.13878	emissions in year t (kg) V = I + K + N + R 108.756 106.10522	emissions in year t (Gg) W = V / 1000000 0.00011 0.00011
V. Total Chen Year 1 △ 1990 1991 1992	Amount in the bank on January 1st of year t (kg) Bank(L-1) 0 1,916.244 4,033.138	Domestically Manufacture t d Chemical in year t (kg) C D 2,000 4 200 1,303	Imported In bulk in year 1 (kg) D 1,000 2,000 2,000	Exported in bulk in year t	Contained In factory- charged Imported equipment In year t F 25 23 100	Contained in factory- charged Exported new- equipment G 1,000	Domestic Sales of new & recovered chemical (in bulk) in year t (kg) H = C + D - E + Q(L-1) 3.000 2.200 3.303	Emitted by containers management (during transfer from bulk to small, I = H * (EFc / 100) 60 44 66.06	Used to fill domestically manufactured new equipment in year t J = H - I - O 2.940 2.136.644 3.196.20122	Emitted during filling of new equipment in year t (kg) K = J * (EFk / 100) 29.4 21.36644 31.96201	new equipment filled in country in year t L = J - K 2.910.6 2.115.27756 3.164.23921	Contained in new equipment consumed in year 1 (kg) M = L + F - G 1935.6 2,138.27756 3,264.23921	Emitted from equipment in use in year t, including servicing (kg) N = <u>2</u> (M(L d+1t))* (EFx / 100) 19.356 40,73878 73.38117	year (kg S Sp Calc. Calc.	O = Sdone or Decified 19.356 0.73878	In equipment retired in year (kg) P = M(t-d) * (p/100) - (Sneeded -	and ccycled/reclai med from equipment etired in year	life in year t (Kg) R = P - Q - S - T	Calc	yed in year t (kg) S = P * D/100 or	equipment at end-of- life in year t	bank on December 31st of year t (kg) Bank(t) = Bank(t 1) + M + O - N - P 1.916.244 4.033.13878 7.264.7356	emissions in yeart (kg) V - I + K + N + R 108.756 106.10522 171.40318	emissions in yeart (Gg) W = V / 1000000 0.00011 0.00011 0.00017
V. Total Ohen Veiar 1 4 1990 1991 1992 1993	Amount in the bank on January 1st of year t (kg) Bank(I-1) 0 1,916,244 4,033,138 7,264,7356	Domestically Manufacture t d Chemical in year t (kg) C 2,000 2,000 1,303 3 340	Imported in bulk in year 1 (kg) D 1.000 2.000 2.000 1.000	Exported in bulk in yeart (kg)	Contained in factory- charged imported equipment in year t F 25 23 100 200	Contained in factory- charged Exported new- equipment G 1,000	Domestic Sales of new & recovered chemical (in bulk) in year t (kg) H = C + D - E + C(L-1) 3,000 2,200 3,303 1,340	Emitted by containers management (during transfer from bulk to small, I = H * (EFc / 100) 60 44 66.06 26.8	Used to fill domestically manufactured new equipment in year t J = H - 1 - O 2.340 2.136.644 3.196.20122 1.239.81883	Emitted during filling of new equipment in year t (kg) K = J * (EFk / 100) 29.4 21.36644 31.96201 12.39819	new equipment filled in country in year t L = J - K 2,910.6 2,115,27756 3,164,23921 1,227,42064	Contained in new equipment consumed in year 1 (kg) M = L + F - G 1.935,6 2,138,27756 3,264,29221 1,427,42064	Emilted from equipment in use in year t, including servicing (tg) N = 2(M(L d+7.t))* (EFx / 100) 19.366 40.73878 73.38117 87.65537	Calc. 44 Calc. 71	O = Sdone or 0 = 0	In equipment retired in year (kg) P = M(t-d) * (p/100) - (Sneeded -	and ccycled/reclai med from equipment etired in year	life in year t (Kg) R = P - Q - S - T	Calc Calc Calc	yed in year t (kg) S = P * D/100 or	equipment at end-of- life in year t	bank on December 31st of year t (kg) Bank(t) = Bank(t 1) + M + O - N - P 1.916,244 4,033,13878 7,264,7366 8,677,88204	emissions in year t (kg) V - I + K + N + R 108.756 106.10522 171.40318 126.85356	emissions in year t (Gg) W = V/ 1000000 0.00011 0.00011 0.00017 0.00013
V. Total Cher Year 1 4 1990 1991 1992	Amount in the bank on January 1st of year t (kg) Bank(L-1) 0 1,916.244 4,033.138	Domestically Manufacture t d Chemical in year t (kg) C 0 2,000 1,303 5 340	Imported In bulk in year 1 (kg) D 1,000 2,000 2,000	Exported in bulk in year t	Contained In factory- charged Imported equipment In year t F 25 23 100	Contained in factory- charged Exported new- equipment G 1,000	Domestic Sales of new & recovered chemical (in bulk) in year t (kg) H = C + D - E + Q(L-1) 3.000 2.200 3.303	Emitted by containers management (during transfer from bulk to small, I = H * (EFc / 100) 60 44 66.06	Used to fill domestically manufactured new equipment in year t J = H - I - O 2.940 2.136.644 3.196.20122	Emited during filing of new equipment in year t (kg) K = J * (EFk./ 100) 229.4 21.36644 31.96201 12.33819 18.959	new equipment filled in country in year t L = J - K 2.910.6 2.115.27756 3.164.23921	Contained in new equipment consumed in year 1 (kg) M = L + F - G 1935.6 2,138.27756 3,264.29221 1,427.42064 1,846.541	Emitted from equipment in use in year t, including servicing (kg) N = <u>2</u> (M(L d+1t))* (EFx / 100) 19.356 40,73878 73.38117	Calc. 41 Calc. 77 Spe	O = Sdone or Decified 19.356 0.73878	In equipment retired in year (kg) P = M(t-d) * (p/100) - (Sneeded -	and ccycled/reclai med from equipment etired in year	life in year t (Kg) R = P - Q - S - T	Calc	yed in year t (kg) S = P * D/100 or	equipment at end-of- life in year t	bank on December 31st of year t (kg) Bank(t) = Bank(t 1) + M + O - N - P 1.916.244 4.033.13878 7.264.7356	emissions in year ((kg) V - I + K + N + R 108.756 106.10522 171.40318 126.85356 185.18378	emissions in yeart (Gg) W = V / 1000000 0.00011 0.00011 0.00017

Example: results: F-gas Emissions - Tier 2b

	s F-Gas Para	ameters - Tier 2	F-Gas Emissio	ns-Tier2a F	-Gas Emissions -	Tier 2b															
caheet																					
tor:		ocesses and Produ																			
gory:		es as Substitutes fo																			
category: et:		frigeration and Stat sions - Mass Balan																			
et:	F-Gas Emiss	sions - Mass Balan	ce Approach - I	ier 20																	
bdivision	Tokyo		Sub-anni	ication Domes	tic Refrigeration		× 6	as HFC-23 IC	HE3)	~											
ntro Year		Lifetime (d) [yr]		ŋ(rec.d) [%]	A DOWN	Stockpile 0		aa mezsie	rir Jy												
						жоскрие	_				-										
		(across the time se						19,700	EF + Bank(t) + ΣQ	+ΣΝ+ΣΟ+ΣΡ	19,71	30									
Total Chemi	cal Agent in new	v equipment export	ed (across the ti	me series) (∑F)				0													
Total Chem	cal Agent in equ	upment in use (ast	year of the time	series) (Bankt))				0													
Total Cherr	ical Agent Emiss	sions (across the tir	(DZ) (series					1,586													
	-																				
Total Chemi	cal Agent Hecon	vered/Destroyed/8	aported from ec	upment at end-o	t-ite (across the t	me senes) (2N + ;	20 + 2P)	18,114													
<u> </u>	200000			Contained in	Contained in	Domestic Sales			Used in year t	Used in year t	Total Charge	Used in year t	Used in year t								
	Domestically Manufactured					of new					In new-			Original Total Charge in year t-d of					Exported in used	Total emissions	
				charged Imported	charged Exported new		To stockpile (kg)		equipment not factory-	equipment factory-	equipment in	equipment not factory-	equipment factory-			claimed from efired in year t		ed in year t kg)			omiss
	year t			equipment in	-equipment in	year t			charged	charged	yeart	charged	charged	in year t		kq)			yeart		
	(kg)			year t	yeart	(kg)			(kg)	(kg)	(kg)	(kg)	(kg)	(kg)					(kg)		
																N = M * (n		O = M *			
														$\begin{split} \mathbf{M} &= \mathbf{K} + \mathbf{L} - \mathbf{F}(\mathbf{I} \text{-} \mathbf{d}) + \\ & \mathbf{E}(\mathbf{I} \text{-} \mathbf{d}) \end{split}$		(rec,d)/100)		(D/100)		Q = G - Sto + Sfrom - J + M - N - O - P	R = 1000
	B 1.000		D	E	F		Sto 900		H. 100		J = H + I		L = I(t-d)						P		
			D	E	F	G = B + C - D 1,000 2,000			100		100		L = I(t-d) 0	E(t-d)	Calculated	(rec,d)/100) or specified	0 Calculated	(D/100)	P		
1990	1,000		D	E	F	1,000			100	900	100		L = i(t-d) 0 0	E(t-d)	Calculated Calculated	(rec,d)/100) or specified	Calculated	(D/100)	P		
1990 1991	1,000		D	E	F	1,000			100	900	100	0	0 0 0	E(t-d)		(rec,d)/100) or specified		(D/100)	P		
1990 1991 1992	1,000 2.000 2.500		D	E	F	1,000 2,000 2,500 10,000 2,000			100 2,000 2,500 10,000 2,000	900	100 2,900 2,500 10,000 2,000	0 0 0	0 0 0	E(t-d)	Calculated	(rec,d)/100) or specified	Calculated	(D/100)	P		
1990 1991 1992 1993 1994 1995	1,000 2,000 2,500 10,000		D	E	F	1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2,900 2,500 10,000 2,000 2,000	0 0 0 0 0 0	0 0 0	E(t-d)	Calculated Calculated Calculated Calculated	(rec,d)/100) or specified	Calculated Calculated	(D/100)	P		
1990 1991 1992 1993 1994 1995 1996	1,000 2,000 2,500 10,000 2,000		D	E	F	1,000 2,000 2,500 10,000 2,000			100 2,000 2,500 10,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0	0 0 0	E(t-d)	Calculated Calculated Calculated Calculated Calculated	(rec,d)/100) or specified	0 Calculated 0 Calculated 0 Calculated 0 Calculated 0 Calculated 0 Calculated	(D/100)	P		
1990 1991 1992 1993 1994 1995 1996 1997	1,000 2,000 2,500 10,000 2,000		D			1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2,900 2,500 10,000 2,000 2,000	0 0 0 0 0 0	0 0 0	E(t-d)	Calculated Calculated Calculated Calculated Calculated Calculated	(rec,d)/100) or specified	Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(D/100)	P		
1990 1991 1992 1993 1994 1995 1996 1997 1998	1,000 2,000 2,500 10,000 2,000		D	E 100		1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0	0 0 0		Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec,d)/100) or specified	Calculated	(D/100)	P		
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999	1,000 2,000 2,500 10,000 2,000		D			1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0	0 0 0		Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec,d)/100) or specified	Calculated	(D/100)	P		
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000	1,000 2,000 2,500 10,000 2,000		D			1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec,d)/100) or specified	Calculated	(D/100)	P	Strom - J + M N - O - P 0 0 0 0 0 0 0 0 0 0 0 0 0	
1990 1991 1992 1993 1994 1995 1995 1995 1997 1998 1999 2000 2001	1,000 2,000 2,500 10,000 2,000		D			1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0		Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec.d)/100) of specified	Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(D/100) or specified 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	P		
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002	1,000 2,000 2,500 10,000 2,000		D			1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		E(t-d)	Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec.d)/100) or specified	Calculated C	(D/100) or specified 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	P	Stron J + M- N- O-P 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
1990 1991 1992 1993 1994 1995 1996 1995 1996 1997 1998 1999 2000 2001 2002 2003	1,000 2,000 2,500 10,000 2,000		D			1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		E(t-d)	Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec.d)/100) or specified	Calculated	(Dr) 00) or specified 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Ρ	Shori J + M- N - O - P 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004	1,000 2,000 2,500 10,000 2,000					1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		E(t-d)	Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec.d)/100) or specified	Celculated	(Chrico) or specified 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Ρ	Stron J + M- N- O-P 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2002	1,000 2,000 2,500 10,000 2,000					1,000 2,000 2,500 10,000 2,000 2,000			100 2,000 2,500 10,000 2,000 2,000	900	100 2.900 2.500 10,000 2.000 2.000 100	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		E(t-d)	Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated Calculated	(rec.d)/100) or specified	Calculated	(Chroo) or specified 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	P	Shori J + M- N - O - P 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	

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: re	sults: fire	protection	– all	tiers
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-missions from	n Fire Protectio	10												
Worksheet Sector: Category: Subcategory Sheet: Data	Industrial Product L r: 2.F.3 - Fin	Processes and	tes for Ozone D	epleting Substand	ces									
Subdivision	Unspecified	~	Gas HFC	C-23 (CHF3)	~ (Chemical's D	lata IY	1990 G	R (%) 10	d (yr) 15	EF (%)	4 X (%) 0		
I. Total Chemic	cal Agent Input	s (across the tin	ne series) (∑D)			17,512.1987	35 Bank(t) +	ΣΕ + ΣΕ 17.5	12.198735					
II. Total Chemi	nical Agent in ea	quipment in use	(last year of the	time series) (Bank	<(t))	10,109.8777	48							
III. Total Chem	mical Agent Emi	ssions (across t	he time series) (<u>Σ</u> Ε)		7,402.3209	87							
IV. Total Chen	mical Agent De	stroyed from equ	upment at end-o	f-life (across the t	ime series) (∑F)		0							
					Equa	ition 7.17					_	Inform	ation for UNFCC	C 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 ∆⊽			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 > ΣD- ΣR-ΣΙ; M * EF/100; ΣD- ΣR-ΣΙ)			$ \begin{array}{l} {\cal K} = IF(\sum(L(t, t-(d-1)))) * EF/100) \\ > Dt; Dt; \sum(L(t, t-(d-1)))) \\ * EF/100) \end{array} $	L = D - K	M = ∑(L(t, t-(c 1))
▶ 1990	12.82895	0		71.24061				68.39099		2.84962	0.00285		71.24061	71.2406
1991	14.11185	0		78.36467	0					5.87023	0.00587	2.84962	75.51505	146.7556
1992	15.52303	0	and the second	86.20114	0			International Activity of the second s		9.08346	0.00908		80.33092	227.0865
1993	17.07534	0		94.82126	0				12.51297	12.51297	0.01251	9.08346	85.73779	312.8243
1994 1995	18.78287 20.66116	0		104.30338 114.73372	0					16.18459 20.12656	0.01618		91.79041 98.54913	404.614
1995	20.66116	0	103.47982		0			The second s	and the second se	24.36978	0.02013	20.12656	98.54913	609.244
1997	25	0		Read and a second second second second	0					28.9481	0.02457	24.36978	114.45802	723.7024

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 <u>Table 7.4</u> 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.

<u>GHGs</u>

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
			Χ	X	Χ	Χ

IPCC Equations

- ✓ <u>Tier 1</u>: <u>Equation 7.7</u> (generic equation for both Closed Cell and Open Cell Foams), <u>Equation 7.8</u> (Open Cell Foams) at the application level
- \checkmark <u>Tier 2</u>: <u>Box 7.2</u> (sub-application level, both closed and open cell foams)
- ✓ <u>Tier 3</u>: 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

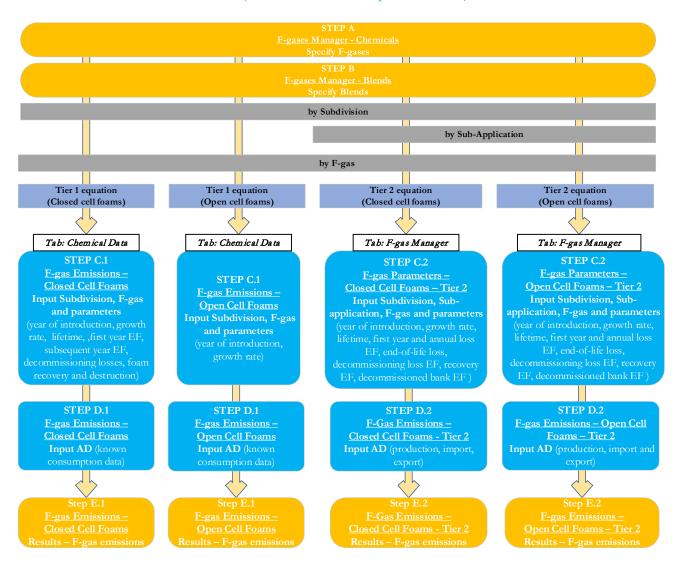
For Foam Blowing Agents, consistent with the key category analysis and the decision tree in <u>Figure 7.4</u> of the 2006 *IPCC Guidelines*, GHG estimates are calculated using a single methodological tier or by applying a combination of tiers according to the availability of AD and of user-specific⁴⁸ 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 <u>customize</u> the <u>Software</u> 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:

Closed Cell Foams

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.

Open Cell Foams

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

2006 IPCC Categories - 4 2.F.2 - Foam Blowing Agents	F-Gas Emissions - Open Cell Foams - Tier 2 F-Gas Emissions - Closed Cell Foams - F-Gas Emissions - Open Cell Foams - Tier 2 F-Gas Emissions - Closed Cell Foams - Tier 2	
2.F.3 - Fire Protection 2.F.4 - Aerosols 2.F.5 - Solvents 2.F.6 - Other Applications (pl 2.G - Other Product Manufacture 2.G.1 - Electrical Equipment	Worksheet Industrial Processes and Product Use Sector: Industrial Processes and Product Use Substatempt Category: Product Uses as Substatures for Conce Depleting Substances Substatempt S	1990
-2.G.1.a - Manufacture of -2.G.1.b - Use of Electrica	Uda Subdavision Umpeched ~ Gas ~ Chemical's Data IY GR (2) EFyl (2) EFal (2) d (yr) RD (2)	
2.G.1.c - Disposal of Ele	I. Total Chemical Agent Inputs (across the time series) (ΣA) NA Bank (\$) + ΣH + ΣF NA	
= 2.G.2 - SF6 and PFCs from	II. Total Chemical Agent in equipment in use (last year of the time series) (Bankt)) NA	
	III. Total Chemical Agent Emissions (across the time series) (Σ H) NA	
2.G.2.c - Other (please s	IV. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (2F) NA	

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 <u>above</u>.

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 Fgases /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 <u>above</u>, 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 <u>below.</u>).

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.

Note that the example is for closed cell foams, but also applies to open cells foams

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

F-Gas Emissi	ons - Open Cell	Foams - Tier 2												
F-Gas Emissi	ons - Closed Cel	Il Foams F-G	as Emissions -	Open Cell Foam	s F-Gas Para	ameters - Closed Ce	Il Foams - Tier 2	F-Gas Parar	meters - Open C	ell Foams - Tier 2	F-Gas Emission	s - Closed Cell F	oams - Tier 2	
Worksheet Sector: Category: Subcategory Sheet:	Product Us 2.F.2 - Foa	rocesses and Processes and Processes and Processes as Substitute m Blowing Agent ssions - Closed C	s for Ozone Dep s	oleting Substance	s									
Data Subdivision	1		V Sub-a	pplication			~	Gas		~				
Intro Year		Growth Rate (Product lifetin	ne (d) [vr]	EFfyl (*		EFal [%]	MPL [21	EFd [%]	EFrd [7		Fad [%]
III. Total Ch IV. Total Ch	emical Agent in e emical Agent En	equipment dispos nissions (across tl	ed (last year of ne time series) (- /)B(t))	s the time series) (\sum J	+ ΣDi)							
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 Decommission ing (tonnes)	Amount Recovered and Destroyed at decommissio ning	Emitted at decommissio ning (tonnes)	Decommission ed bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss from decommissio ned 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)	$\begin{array}{l} H = IF(\underline{\Sigma}(E(t{\text{-}}(d{\text{-}}1),t)^* \\ (EFal{\text{/}}100)) <= \\ CAremaining(t); \\ \underline{\Sigma}(E(t{\text{-}}(d{\text{-}}1),t)^* \\ (EFal{\text{/}}100)); \\ CAremaining(t)) \end{array}$	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

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 <u>above</u>, 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

F-Gas Emission	s - 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	
Sector: Category:	Industrial Processes and Product Use Product Uses as Substitutes for Ozone Depleting Substances					1990
Subcategory: Sheet:	2.F.2 - Foam Blowing Agents F-Gas Parameters - Closed Cell Foams - Tier 2					
Data						
F-Gases Mar	nager		<u></u>			
			Subdivision			
Nationa						
			Sub-application			
1 7 1	uded Polyethylene (PE)					X
Poly Poly One Pher Pher	urethane - Cont. Laminate / Boardstock urethane - Sirpe-in-Fipe Component Foam (OCF) nolic - Discontinuous Block nolic - Discontinuous Block nolic - Discontinuous Block					
Extr	uded Polvethylene (PE)					

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 <u>above</u>.

T . 1 . •		1 1 0	cell foams-Tier 2
Hyandla ontoring	H_MARAR AT CATAGO	TINTEL TOP OTOP	cell toome_ lier 7
$\Delta \lambda u / u / u$. Chicing	1-2asus al calc201		i uun nuanns— 1 iui 2

-Gas Emissions - /orksheet	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
ector: ategory: ubcategory:	2.F.2 - Foam Blowing	ostitutes for Ozone Depleting Substances				
F-Gases Mana	ger F	-Gases Manager - 2.F.2				- 0 ×
National			Chemicals and Bler	nds - applicability at IPCC Category	level	
				Chemical group		V
		HFCs				
		D PFCs				
		⊕ SF6				
		H NF3				
		Ethers and Halogenated Ethers	1			
		Other GHGs				
		Blends				
				Character	als at country level Blends at country lev	el Close

EF/parameters input

The following sections in Chapter 7, Volume 3 of the 2006 IPCC Guidelines contain information on the choice of EF/parameters:

- ✓ <u>Table 7.5</u> 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 popup 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 <u>customizing</u> <u>the *Software*</u> if an additional F-gas or blend needs to be added to the drop-down menu).
- 3. <u>Window | Year of Introduction |</u>: input the year of introduction of the agent in the country for use in foam blowing (closed cell) (e.g., 1990).
- 4. <u>Window |Growth Rate in consumption|</u>: input the growth rate in consumption, usually assumed linear across the period of assessment, in %.
- 5. <u>Window |First year loss Emission Factor|:</u> input the EF for the first-year loss in percent of the original charge (IPCC default =10% of the original charge/year.
- <u>Note that:</u> according to <u>Table 7.5</u>, the value could drop to 5% if significant recycling takes place during manufacturing.
 6. <u>Window | Annual loss Emission Factor |:</u> input the EF for annual loss in percent of the original charge (IPCC default = 4.5% of the original charge/year).
- 7. <u>Window | Product lifetime |:</u> input the lifetime of closed cell foams, in years (IPCC default =20 years).
- 8. <u>Window |Agent recovery and destruction|:</u> 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. <u>Window | Confidentiality |:</u> 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. <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, SF₆ or NF₃, as appropriate (for further information, see Annex I).

Example: entering EF	Fs, parameters information and	l confidentiality for closed	cell foams- Tier 1
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Worksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes ar	nd Product Use titutes for Ozone Depleting Substance Agents		Foams - Tier 2 F-Gas Parameters -			1990
Subdivision	Unspecified	✓ Gas	Chemical's Data	IY GR (%)	EFfyl (%) EFal (%)	d (yr) RD (%)	
				NA Bank(t) + ΣH + ΣF	NA		
	tal Chemical Agent in equipment in use (last otal Chemical Agent Emissions (across the ti atal Chemical Agent Bassured (Desteud		:))		×		
			nd-of-life (ac	Chemical`s Data			
			Country/Territory	World			
	tal Chemical Agent Recovered/Destroye		Category	2.F.2 - Foam Blowing Agents			
			Subdivision	Unspecified	~[+]		
			Gas	HFC-23 (CHF3)	~ +		
			Data Year of Introduction (I	Y) 1990 🜩			
			Growth Rate in cons	sumption (GR)	_3.00% 🗢		
			First year loss Emissi	ion Factor (EFfyl)	10.00% 🚖		
			Annual loss Emisisor		4.50% 🚖		
			Product lifetime (yea Agent recovery and		20 🜩		
			UNFCCC CRT Conf.	identiality			
					Save Close		

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

Vorksheet iector: Category: iubcategory: iheet:	Industrial Process Product Uses as 2.F.2 - Foam Blov	ses and Product Use Substitutes for Ozone Depleti	ng Substances	imeters - Closed Cell Foams						199
Data Subdivision	Unspecified	✓ Gas HFC-23 (0)		Chemical's Data	1990 GR (%) <u>3</u> EFfyl (%)) <u>10</u> EFal ((%) 4.5 di(yr)) 20 RD (%) 0	
	10 To	is the time series) ($\sum A$)			0 Bank(t)) + ΣΗ + ΣΕ	0			
		nt in use (last year of the time : across the time series) (ΣΗ)	series) (Bank(t))		0					
		······································	uipment at end-of-life (across	the time series) (ΣF)	0					
					Equation 7.7					
				Bank (at the end of the	<u>-</u>				15 555	
	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	year) (tonnes)	loss (tonnes)	Agent recovery and destruction (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	Agent at Decommissioning (tonnes)	
Year t ∆⊽				year)		destruction	Total Emissions		Decommissioning	
t ∆⊽ 1990	(tonnes)	(tonnes)	(tonnes) C = Σ(B(t-(d-1),t)) *	year) (tonnes) Bank(t) = A - B - C - I +	E = I - F	destruction (tonnes) F = I * RD/100	H = B + C + E	(Gg) EE = H / 1000 0	Decommissioning (lonnes) i = [A(t-d) - A(t-d) * EFFyV100 - A(t-d) * EFaV100 * d]	
t ∆⊽	(tonnes)	(tonnes)	(tonnes) C = Σ(B(t-(d-1),t)) *	year) (tonnes) Bank(t) = A - B - C - I +	loss (tonnes) E = I - F 0 0 0	destruction (tonnes) F = I * RD/100 0	iotal Emissions (tonnes)	(Gg) EE = H / 1000 0	Decommissioning (lonnes) i = [A(t-d) - A(t-d) * EFly/100 - A(t-d) * EFly/100 * d]	3 3 3

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 <u>customizing</u> <u>the *Software*</u> if an additional F-gas or blend needs to be added to the drop-down menu).

- 3. <u>Window | Year of Introduction |</u>: input the year of introduction of the agent in the country for use in foam blowing (open cells) (e.g., 1990).
- 4. <u>Window | Growth Rate in consumption |</u>: 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. <u>Note that:</u> if checked, "C" will be reported for AD and "TE" 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, SF₆ or NF₃, as appropriate (for further information, see Annex I).

Example: entering EFs, parameters information and confidentiality for open cell foams- Tier 1

	ns - Open Cell Foams - Tier 2 ns - Closed Cell Foams F-Gas I	Emissions - Open Cell Foams F	-Gas Parameters - Closed Cell F	Foams - Tier 2 F-Gas Parameters - Open	Cell Foams - Tier 2 F-	Gas Emissions - Cle	osed Cell Foams - T	ïer 2	
Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Produ Product Uses as Substitutes fo 2.F.2 - Foam Blowing Agents HFC-23 (CHF3) Emissions - Op	r Ozone Depleting Substances							1990
Subdivision	Unspecified V G	HFC-23 (CHF3)	Chemical's Data	IY 1990 GR (%) 0					
					×		(
			01	Chemical`s Data					
			Country/Territory	World	ť.				
	t ∆⊽		Category	2.F.2 - Foam Blowing Agents	1				2
1990 1991			Subdivision	Unspecified	V (+)		2	2	2
1992		1					2		
1993			Gas	HFC-23 (CHF3)	× +		2		
1994			Data						
1995 1996			Year of Introduction (IY)	1990 🗢			2		
1996									
1998			Growth Rate in consumpt	tion (GR)	_0.00% 🗢		3		<u> </u>
1999							3		
2000									
2001							(1		
2002							2		
2003									I
2004 2005									
2005							2		
2000			UNFCCC CRT Confidenti	iality			3		
2007							2		
2009							3		
2010				Save	Close		2		
2011				Jave	Close		2		
0040							_		

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

Gas Emissions orksheet	- Closed Cell Foams F-Ga	s Emissions - Open Cell Foams	F-Gas Parameters - Closed Cell Foams - T	Tier 2 F-Gas Parameters - Open Cell Foams - Tier 2	F-Gas Emissions - Closed Cell Foams - Tie	er 2	
ector: itegory: ibcategory: ieet: ata	2.F.2 - Foam Blowing Agents HFC-23 (CHF3) Emissions - 0	for Ozone Depleting Substances Open Cell Foams					19
ubdivision	Unspecified 🗸 🗸	Gas HFC-23 (CHF3)	Chemical's Data	1990 GR (%) 3			
				Equation 7.8			
			Consumption (tonnes)	Total Emissions (tonnes)			
8	t 🛆	7	8)	C = B			() <u> </u>
1990							2
1991							
1992							
1993							
1994							

When the Tier 2 method is applied

<u>Closed Cell Foams</u> <u>Open Cell Foams</u>

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. <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). <u>Note that for Closed Cell Foams: for gases for which there are default parameters in Tables 7.6 and 7.7</u>, 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. <u>Column | t (start) |</u>: input the year of introduction of F-gas/blend for [closed][open] cell foams.
- 3. <u>Window |G|</u>: input the growth rate in consumption, usually assumed linear across the period of assessment, in %.
- 4. <u>Column |d|</u>: input the product lifetime, years.

<u>Note that for Closed Cell Foams</u>: this column is automatically populated for HFC-134a, 152a, 245fa, 365mfc, and 227ea; the user may manually overwrite the default value.

<u>Note that for Open Cell Foams</u>: a product lifetime of 1 year is automatically populated because the default assumption is that all emissions occur in the year of manufacturing.

5. <u>Column | EFfyl</u>]: 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.

<u>Note that for Open Cell Foams</u>: an EFfyl of 100 is automatically populated because the default assumption is that all emissions occur in the year of manufacturing.

- 6. <u>Column | MPL |: input the EF for maximum potential end-of-life loss (% of initial charge).</u> <u>Note that</u>: 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. <u>Column | EFal</u>]: input the EF for annual loss (% of initial charge). <u>Note that for Closed Cell Foams</u>: this column is automatically populated for HFC-134a, 152a, 245fa, 365mfc, and 227ea; the user may manually overwrite the default value. <u>Note that for Open Cell Foams</u>: 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. <u>Column |EFd|:</u> input the EF for decommissioning losses (% of decommissioned amount less the amount recovered/destroyed).

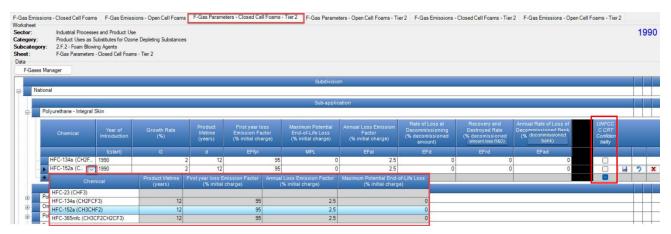
<u>Note that:</u> decommissioning losses are those at the end of service life that occur when the product/equipment is scrapped. This factor is applied to the total agent at decommissioning, less any agent that has been recovered/destroyed.

<u>Note that</u>: 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 <u>only where there is</u> <u>definite evidence</u> to support this and should normally attribute emissions to subsequent years based on a more appropriate release function.

- 9. <u>Column |EFrd|</u>: input the EF for recovery and destruction rate (% of decommissioned amount). <u>Note that</u>: 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. <u>Column | EFad |</u>: input the EF for losses from the decommissioned bank (% of the decommissioned bank).
- 11. <u>Column | Confidentiality |:</u> 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. <u>Note that</u>: if checked, "C" will be reported for AD and "TE" 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, SF₆ or NF₃, as appropriate (for further information, see Annex I).

Example: entering EFs, parameters information and confidentiality for closed cell foams- Tier 2

Note that 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

Gas Emissio orksheet	ons - Closed Ce	II Foams F-G	ias Emissions -	Open Cell Foam	s F-Gas Para	ameters - Closed	d Cell Foams - Tie	r 2 F-Gas P	arameters - Ope	n Cell Foams - Tie	r 2 F-Gas Emiss	ions - Closed Ce	ell Foams - Tier 2]
ector: ategory: ubcategory heet: lata	Product U 2.F.2 - Foa	Processes and Processes and Processes as Substitute am Blowing Agen ssions - Closed C	es for Ozone Dep ts	oleting Substance 2	s									
Subdivision	National		∨ Sub-a	pplication Poly	urethane - Integ	gral Skin	~	Gas HFC-	134a (CH2FCF3)	~				
Intro Year	1990	Growth Rate (%) 2	Product lifetim	ne (d) [yr] 12	Effy	4 [%] 95	EFal [%]	0 M P	L [%] 2.5	EFd [%] 0	EFre	d [%] 0	EFad [%
III. Total Che	emical Agent in	equipment dispo	A CONTROLLAR CONTROL	time series) (Bank the time series) (D ΣP)				0 0						
	and the second second	National Sectors	a contraction of the	om equipment at e	nd-of-life (across	s the time series)	(ΣJ + ΣDi)	0						
	and the second second	National Sectors	a contraction of the	om equipment at e	nd-of-life (across	s the time series)		0 30x 7.2						
V. Total Che	and the second second	National Sectors	a contraction of the	Annual domestic consumption (tonnes)	nd-of-life (across First year loss (tonnes)	Annual loss (tonnes)		0 Amount Recovered and Destroyed at decommissio ning	Emitted at decommissio ning (tonnes)	Decommission ed bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss from decommissio ned bank (tonnes)	Total emissions in year t (tonnes)	Total emissions yeart (Gg)
V. Total Che	Amount in Foams produced domestically	covered/Destroy Amount in Foams imported	ed/Exported fro Amount in Foams exported	Annual domestic consumption	First year loss	Annual loss	Agent at Decommissio ning	Amount Recovered and Destroyed at decommissio	decommissio ning	ed bank (at the end of the year)	of the year)	from decommissio ned bank		emission: year t
V. Total Che Year t A	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bj * (EFfyl/100)	Annual loss (tonnes) H = IF(Σ(E(t- (d-1),t)* (EFal/100)) c CAremaining (t); Σ(E(t-(d- 1),t)* (EFal/100)); CAremaining (t)) 0	E Agent at Decommissio ning (tonnes) I = MPL * E(t- d) = CAremaining (d+1)	Amount Recovered and Destroyed at decommissio ning J = *	decommissio ning (tonnes) K = (I-J) *	ed bank (at the end of the year) (tonnes) DB = I - J - K -	of the year) (tonnes) Bank = Bank(t-1)	from decommissio ned bank (tonnes) N = DB(t-1) *	in year t (tonnes) P = G + H + K	emission year t (Gg) Q = P / 1(
Y. Total Che Year	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bj * (EFfyl/100)	Annual loss (tonnes) $H = IF(\Sigma(E(t-(d-1),t)*(EFal/100))$ c CAremaining (t); $\Sigma(E(t-(d-1),t)*(EFal/100));$ (CAremaining (t)) 0 0	E Agent at Decommissio ning (tonnes) I = MPL * E(t- d) = CAremaining (d+1)	Amount Recovered and Destroyed at decommissio ning J = i * (EFrd/100)	decommissio ning (tonnes) K = (I-J) * (EF d/100)	ed bank (at the end of the year) (tonnes) DB = I - J - K -	of the year) (tonnes) Bank = Bank(t-1)	from decommissio ned bank (tonnes) N = DB(t-1) * (EFad/100)	in year t (tonnes) P = G + H + K + N 0 0	emission year (Gg) Q = P / 1

Example: grid ready for entry of AD for open cell foams - Tier 2

	ions - Open Cel Industrial Product U ry: 2.F.2 - Fo	I Foams - Tier Processes and Ises as Substitu am Blowing Ag	2 Product Use Ites for Ozone E	Depleting Substa		Parameters - Closed Cell F	Foams - Tier 2	F-Gas Param	eters - Open Ce	II Foams - Tier 2	F-Gas Emissio	ns - Closed Cell	Foams - Tier 2		
Subdivisio	n National		⊻ Sub	-application	Polyurethane - I	Flexible Foam	√ G	as HFC-365m	fc (CH3CF2CH2	(CF3) 🗸					
Intro Yea	ar 1990	Growth Rat	e (%) 0	Product I	ifetime (d) [y	r]1 EFfyl[%	.] 80	EFal [%] 5	MPL	[%] 0	EFd [%] 1	EFi	d [%] 2	EFad [%]	1
	hemical Agent E hemical Agent Re				at end-of-life (ad	cross the time series) ($\sum J + \sum$	EDi) 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 Decommissio ning (tonnes)	Amount Recovered and Destroyed at decommissio ning	Emitted at decommissio ning (tonnes)	Decommissio ned bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss from decommissio ned bank (tonnes)	Total emissions in year t (tonnes)	Total emissions in year t (Gg)	
	Bi A			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 = * (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		
1990					0	0					0		0	C	
1991					0			0					0	C)
					0	0	0	0	0	0	0	0	0	0	
1992															
					0								0	(

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 <u>F-gas consumption</u> 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. <u>Column |A|</u>: 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.

<u>Note that</u> 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.

<u>Note that</u>, unlike many categories in IPPU, AD entry worksheets for source category 2.F.2 (along with 2.F.1 and 2.F.3) are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

Once known AD are input, the *Software* makes several calculations based on the factors added in the Chemical's Data tab:

2. <u>Column |B|</u>: calculates emissions in the first year, in tonnes. <u>Note that</u> this cell is calculated based on the total consumption in that year and the first-year loss EF entered in the tab **Chemical's Data** tab.

- 3. <u>Column |C|</u>: calculates annual emissions from 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₍₁₎|</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 |1|</u>) multiplied by the foam recovery and destruction factor entered in the **Chemical's Data** tab.

- <u>Column |H|</u>: calculates total emissions, in tonnes. <u>Note that this cell is calculated as the sum of emissions in the first year, plus annual emissions from the bank, plus emissions from decommissioning.</u>
- 8. <u>Column |EE|</u>: calculates total emissions, in Gg.
- 9. <u>Column |1|</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 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.</u>

Green cells are estimated by the *Software* and cannot be modified. Cell calculations are provided below the column header.

	ns - Closed Cell Foar	ms F-Gas Emissions -	Open Cell Foams F-Gas Par	ameters - Closed Cell Foams	s - Tier 2 F-Gas I	Parameters - Open Cell	Foams - Tier 2 F-G	as Emissions - Close	d Cell Fo	oams - Tier 2
orksheet ector: ategory: ubcategory: heet:	Product Uses as 2.F.2 - Foam Blow	ses and Product Use Substitutes for Ozone Dep wing Agents Emissions - Closed Cell Foa	-							
)ata S ubdivision	Unspecified	Gas HFC-2	3 (CHF3)	Chemical's Data	r 1990 GR ((%) 3 EFfyl (%) 10 EFal	(%) 4.5 d	(yr) 20	RD (%) 0
Total Chemica	al Agent Inputs (acros	ss the time series) (ΣA)		7,657.76022	27 Bank(t) + ΣH +	ΣF 7,657.760227			-	
I. Total Chemic	cal Agent in equipmer	nt in use (last year of the tir	ne series) (Bank(t))	2,467.15989	98	-				
		(across the time series) (Σ		5,190,60032	28					
			" nt at end-of-life (across the time s		0					
					Equation 7.7					
					Equation 7.7					
Year	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Bank (at the end of the year) (tonnes)		Agent recovery and destruction (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)		Agent at Decommissioning (tonnes)
Year t ∆⊽	(tonnes)			year)	Decommissioning	destruction				Decommissioning (tonnes) I = [A(t-d) - A(t-d)]
t ∆⊽ ▶ 1990	(tonnes) A 100	(tonnes) B = A * (EFfyl/100)	(tonnes) C = Σ(A(t-(d-1),t))* (EFal/100) 0 4.5	year) (tonnes) Bank(t) = A - B - C - I + Bank(t-1) 85.5	Decommissioning loss (tonnes) E = I - F	destruction (tonnes) F = I * RD/100	(tonnes) H = B + C + E 14.5	(Gg) EE = H / 1000 0.0145		Decommissioning (tonnes) I = [A(t-d) - A(t-d) ' EFfyV100 - A(t-d) '
t ∆⊽ ▶ 1990 1991	(tonnes) A 100 125	(tonnes) B = A * (EFfyl/100) 12	$(tonnes) \\ C = \sum_{i} (A(t-(d-1),t)) * \\ (EFal/100) \\ i \\ 5 \\ 10.125 \\ i \\ 10.125 $	year) (tonnes) Bank(t) = A - B - C - I + Bank(t-1) 85.5 187.875	Decommissioning loss (tonnes) E = I - F	destruction (tonnes) F = I * RD/100	(tonnes) H = B + C + E 14.5 22.625	(Gg) EE = H / 1000 0.0145 0.02263		Decommissioning (tonnes) I = [A(t-d) - A(t-d) EFfyV100 - A(t-d)
t △ ⊽ 1990 1991 1992	(tonnes) A 100 125 128.75	(tonnes) B = A * (EFfyl/100) 12 12.8	$(tonnes) \\ C = \sum (A(t-(d-1),t)) * \\ (EFal/100) \\ 4.5 \\ 5 \\ 10.125 \\ 5 \\ 15.91875 \\ 15.$	year) (tonnes) Bank(t) = A - B - C - I + Bank(t-1) 85.5 187.875 287.83125	Decommissioning loss (tonnes) E = I - F 0 0	destruction (tonnes) F = I * RD/100 0	(tonnes) H = B + C + E 14.5 22.625 28.79375	(Gg) EE = H / 1000 0.0145 0.02263 0.02879		Decommissioning (tonnes) I = [A(t-d) - A(t-d) EFfyV100 - A(t-d)
t △マ 1990 1991 1992 1993	(tonnes) A 100 125 128.75 132.6125	(tonnes) B = A * (EFfyl/100) 12 128 13.2612	(tonnes) C = Σ(A(t-(d-1),t)) * (EFal/100) 5 10.125 5 10.125 5 21.88631	year) (tonnes) Bank(t) = A - B - C - I + Bank(t-1) 85.5 187.875 287.8315 385.29619	Decommissioning loss (tonnes) E = I - F 0 0 0	destruction (tonnes) F = I * RD/100 0 0 0	(tonnes) H = B + C + E 14.5 22.625 28.79375 35.14756	(Gg) EE = H / 1000 0.0145 0.02263 0.02879 0.03515		Decommissioning (tonnes) I = [A(t-d) - A(t-d) EFfyV100 - A(t-d)
t △ ♥ 1990 1991 1992 1993 1994	(tonnes) A 100 125 128.75 132.6125 136.59088	(tonnes) B = A * (EFfyl/100) 12.8 13.2615 13.2615	(tonnes) C = <u>\((4(-(d-1),i))^*</u> (EFal/100) 0 4.5 5 10.125 5 10.125 5 21.88631 9 28.0329	year) (tonnes) Bank(t) = A - B - C - I + Bank(t-1) 285,5 187,875 287,83125 385,29619 480,19507	Decommissioning loss (tonnes) E = I - F 0 0 0 0 0 0	destruction (tonnes) F = I * RD/100 0 0 0 0 0 0	(tonnes) H = B + C + E 14.5 22.625 28.79376 35.14756 41.69199	(Gg) EE = H / 1000 0.0145 0.02263 0.02879 0.03515 0.04169		Decommissioning (tonnes) I = [A(t-d) - A(t-d) EFfyV100 - A(t-d)
t △▽ 1990 1991 1992 1993	(tonnes) A 100 125 128.75 132.6125	(tonnes) B = A * (EFfyl/100) 12 128 13.2612	(tonnes) C = ∑(A(L-(d-1),1)) * (EFal/100) 0 45 5 10.125 5 21.88631 9 22.0329 6 34.36389	year) (tonnes) Bank(t) = A - B - C - I + Bank(t-1) 85.5 187.875 287.8315 385.29619	Decommissioning loss (tonnes) E = I - F 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	destruction (tonnes) F = I * RD/100 0 0 0	(tonnes) H = B + C + E 14.5 22.625 28.79375 35.14756	(Gg) EE = H / 1000 0.0145 0.02263 0.02879 0.03515		Decommissioning (tonnes) I = [A(t-d) - A(t-d) EFfyV100 - A(t-d)

Example: AD input - closed 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 redorange 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 (ΣA)
- II. Total chemical agent in equipment in use, last year of the time series (Bank(t))
- III. Total chemical agent emissions, across time (ΣH)
- IV. Total chemical agent recovered/destroyed (ΣF)

For Tier 1, mass conservation has been ensured if:

$$\sum A = Bank(t) + \sum H + \sum F$$

If mass has been conserved, all cells are green. An orange colour signals that the amount of chemical input is smaller than the amount of chemical stored in the system and the subsequent emissions, while a red colour means that the chemical input is greater than the amount stored in the system and the subsequent emissions. If the check results in orange or red shading 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

	is closed cerri dans	F-Gas Emissions - Open	Cell Foams F-Gas Parame	eters - Closed Cell Foams - Tier 2	F-Gas Parameters -	Open Cell Foams - Tier 2	F-Gas Emissions	- Closed Cell Foams - Hel	r2 P-Gas Emissions - Open Cell Poams - He
orksheet ector: ategory: ubcategory: heet: Data	2.F.2 - Foam Blowing	stitutes for Ozone Depleting	Substances						
Subdivision	Unspecified	Gas HFC-23 (CH	F3) ~ (Chemical's Data IY 1990	GR (%) 3	EFfyl (%) 50	EFal (%) 10	d (yr) 5 F	RD (%) 20
. Total Chemica	al Agent Inputs (across the	e time series) (∑A)		10	0 Bank(t) + ΣH + Σ	F 100			
I. Total Chemic	cal Agent in equipment in u	use (last year of the time ser	ies) (Bank(t))		0		Mass con	servation ensured	
II. Total Chemic	cal Agent Emissions (acro	ss the time series) (∑H)		10	00		101033 001	iservation ensured	
V. Total Chemic	ical Agent Recovered/De	stroyed/Exported from equip	oment at end-of-life (across the	time series) (∑F)	0				
IV. Total Chemi	ical Agent Recovered/De	stroyed/Exported from equip	oment at end-of-life (across the	time series) (∑F)	Equation 7.7				
IV. Total Chemic Year		stroyed/Exported from equip Emissions in first year (tonnes)	Annual loss (tonnes)	time series) (ΣF) Bank (at the end of the year) (tonnes)	Equation 7.7 Decommissioning loss (tonnes)	Agent recovery and destruction (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	Agent at Decommissioning (tonnes)
	Consumption (tonnes)	Emissions in first year	Annual loss	Bank (at the end of the year)	Decommissioning	destruction			(tonnes)
Year t △⊽ 1990	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes) C = Σ(B(t-(d-1),t)) * (EFa/100) 1(Bank (al the end of the year) (tonnes) Bank(t) = A - B - C - I + Bank(t- 1) 4(Decommissioning loss (tonnes) E = I - F	destruction (tonnes)	(tonnes)	(Gg) EE = H / 1000 0.06	(tonnes) I = [A(t-d) - A(t-d) * EFfyV100 - A(t-d) *
Year t △⊽ 1990 1991	Consumption (tonnes)	Emissions in first year (tonnes) B = A * (EFfyl/100)	Annual loss (tonnes) C = <u>Σ(B(t-(d-1),i)</u>)* (EFal/100) 1(Bank (at the end of the year) (tonnes) Bank(t) = A - B - C - I + Bank(t- 1) 4(0) 3(3)	Decommissioning loss (tonnes) E = I - F	destruction (tonnes)	(tonnes) H = B + C + E 60 10	(Gg) EE = H / 1000 0.06 0.01	(tonnes) I = [A(t-d) - A(t-d) * EFfyV100 - A(t-d) *
Year t △マ 1990 1991 1992	Consumption (tonnes) A 100 0 0	Emissions in first year (tonnes) B = A * (EFfyl/100)	Annual loss (tonnes) C = <u>2(B(t-(d-1),t))</u> * (EFal/100) 11 11 11	Bank (at the end of the year) (tonnes) Bank(t) = A - B - C - I + Bank(t- 1) 4(0 3(0) 2 2	Decommissioning loss (tonnes) E = I - F 0 0 0 0 0 0 0	destruction (tonnes)	(tonnes) H = B + C + E 60 10 10	(Gg) EE = H / 1000 0.06 0.01 0.01	(tonnes) I = [A(t-d) - A(t-d) * EFfyV100 - A(t-d) *
Year t △⊽ 1990 1991	Consumption (tonnes)	Emissions in first year (tonnes) B = A * (EFfyl/100)	Annual loss (tonnes) C = <u>Σ(B(t-(d-1),i)</u>)* (EFal/100) 1(Bank (at the end of the year) (tonnes) Bank(t) = A - B - C - I + Bank(t- 1) - 4(0	Decommissioning loss (tonnes) E = I - F 0 0 0 0 0 0 0	destruction (tonnes)	(tonnes) H = B + C + E 60 10	(Gg) EE = H / 1000 0.06 0.01	(tonnes) I = [A(t-d) - A(t-d) * EFfyV100 - A(t-d) *

Example: Mass not conserved over time – Tier 1

Gas Emission orksheet ector: ategory: ubcategory:	Industrial Processe	s and Product Use ubstitutes for Ozone Depleting		ers - Closed Cell Foams - Tier 2 F-Gas Para	neters - Upen Cell Fo	ams-lier2 F-GasE	missions - Closed Cell	Foams - Her 2 F-Ga	s Emissions - Upen Cell Foams -
heet: lata	HFC-23 (CHF3) Em	issions - Closed Cell Foams							
ubdivision	Unspecified	V Gas HFC-23 (CHF	-3) ~ Ch	emical's Data IY 1990 GR (%)	3 EFfyl (%)	50 EFal (%)	10 d (yr)	6 RD (%) 2	20
I. Total Chemics II. Total Chemic	cal Agent Emissions (ad	n use ≬ ast year of the time serie cross the time series) (ΣH)	es) (Bank‡)) ment at end-of-life (across the ti	100 Bank(t) + 0 110 me series) (ΣF. 0	ΣΗ + ΣΕ	los	lass not conserve sees over the cou (60 tonnes) plus tonnes) are gre consumption	urse of the lifetim initial losses (50 ater than initial	
				Equat	on 7.7		consumption	(Too tonnes)	
	Consumption (tonnes)	Emissions in first year (tonnes)	Annual loss (tonnes)	Bank (at the end of the year) (tonnes)	Decommissioning loss (tonnes)	Agent recovery and destruction (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	Agent at Decommissioning (tonnes)
t ∆⊽	A	B = A * (EFfyl/100)	C = ∑(B(t-(d-1),t)) * (EFal/100)	Bank(t) = A - B - C - I + Bank(t-1)	E=I-F	F = I * RD/100	H = B + C + E	EE = H / 1000	l = [A(t-d) - A(t-d) + EFfyl/100 - A(t-d) + EFal/100 * d]
1990	100	50	10				60		
1991	0	0	10	30		0	10	0.01	
1992	0	0	10	20		0	10		
1993	0	0	10	10	0	0	10		
1004		0	10	0	0	0	10	0.01	
1994 1995	0	0	10	0	0	0	10	0.01	

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. <u>Column |B|</u>: 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.

<u>Note that</u> unlike the Tier 2 worksbeets, 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.

<u>Note that</u>, unlike many categories in IPPU, AD entry worksheets for source category 2.F.2 (along with 2.F.1 and 2.F.3) are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

Once known AD are input, the *Software* calculates total emissions in <u>Column |C|</u> as equal to the consumption in <u>Column |B|</u>, in tonnes, consistent with Equation 7.8 in the 2006 IPCC Guidelines.



F-Gas Emissions Norksheet	s - Closed Cell Foams	F-Gas Emissions - Open C	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 En	missions - Open C	Cell Foams - Tier 2	
Sector: Category: Subcategory: Sheet: Data	2.F.2 - Foam Blowing	ostitutes for Ozone Depleting S	lubstances				1990
Subdivision	Unspecified	Gas HFC-23 (CHF3)	3) V Chemical's Data IY 1990 GR (%) 3	1			
			Equat	ion 7.8			
			Consumption (tonnes)	Total Emissions (tonnes)			
	t	۵V	8	C = 8			
1990			100	100	3		
1991			98.33333	98.33333	3		
1992			96.66667	96.66667	3		
1993			95	95	3		
1994			93.33333	93.33333	3		
1995			91.66667	91.66667	2		
1996			90	90	3		
1997			78.33333	78.33333	3		
1998			66.66667	66.66667	3		
1999			55	55	3		
2000			43.33333	43.33333	3		
2001			31.66667	31.66667	3		
2002			20	20	3		
2003			10	10	3		
2004 2005			0	0	3		

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.

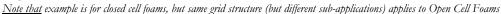
When the Tier 2 method is applied

<u>Closed Cell Foams</u> <u>Open Cell Foams</u>

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 <u>EF/parameters</u> 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. <u>Note that</u> if a subdivision/sub-application/F-gas / blend is not available for selection, refer back to the description for Tier 2 in <u>Customizing the Software</u> 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)



	ions - Open Cell											10.115	T: 0	
	ions - Closed Ce	Il Foams F-G	ias Emissions -	Open Cell Foams	F-Gas Paran	neters - Closed Cel	II Foams - Tier 2	F-Gas Paramet	ers - Open Cell F	Foams - Tier 2 F-0	aas Emissions - Clos	sed Cell Foams -	Tier 2	
orksheet	last start f	Processes and Pr												
ector: ategory:				leting Substance										
ibcategor		am Blowing Agen		lieung Substance	5									
neet:		ssions - Closed C		2										
ata	1 000 211													
ubdivision	n National		Sub-ar	plication Poly	urethane - Integra	al Skin	✓ Ga:	s HFC-134a (C						
dearrierer	National		• • • • • •		urethane - Integra			1110 1040 (0		~				
Intro Year	r Territories		2	Product lit Poly	urethane - Continu	uous Panel	EFa	al (<mark>HFC-134a (C</mark> HFC-152a (C	H2FCF3) H3CHE2)	5 EF	d [%] 0	EFrd [%] 0	EFad [%]	0
I Total Che	emical Agent Inpu	ts (across the tim	and the second se	One	Component Foan	n (OCF)) + DB(t) + ΣP + 2	Σ.J + ΣDi	0			
					urethane - Injecte	(XPS)		O Dank(c	,	Lu . Zu.				
				time series) (Extr.		(U						
III. Total Ch	nemical Agent in e	equipment dispos	sed (last year of t	the time series) (D	B(t))			0						
IV Total Ch	hemical Agent En	nissions (across t	he time series) ((P)				0						
···· ·································														
	-				nduofulfe (across t	the time series (∇I)	+ 5Di)	0						
	-				nd-of-life (across t	he time series) (∑J ·	+ ∑Di)	0						
	-				nd-of-life (across t	'he time series) (ΣJ ·		0 3ox 7.2						
	-	covered/Destroy	ved/Exported fro	m equipment at e	nd-of-life (across t	he time series) (ΣJ -	E	Amount	Territoria et			Annual loss		7-44
V. Total Ch	emical Agent Re Amount in Foams	covered/Destroy	ved/Exported fro	m equipment at en			E Agent at	Amount Recovered	Emitted at	Decommissioned	Bank (at the end		Total emissions	
	Amount in Foams produced	covered/Destroy	ved/Exported fro	m equipment at e	nd-of-life (across t First year loss (tonnes)	he time series) (ΣJ- Annual loss (tonnes)	E	Amount Recovered	Emitted at decommissio ning		of the year)	from decommission	in year t	
V. Total Ch	Amount in Foams produced domestically	covered/Destroy Amount in Foams	ved/Exported fro Amount in Foams	Annual domestic	First year loss	Annual loss	E Agent at Decommissionin	Amount Recovered and Destroyed at decommissio		bank (at the end		from decommission ed bank		
V. Total Ch	Amount in Foams produced	covered/Destroy Amount in Foams imported	ed/Exported fro Amount in Foams exported	Annual domestic consumption	First year loss	Annual loss	E Agent at Decommissionin g	Amount Recovered and Destroyed at	decommissio ning	bank (at the end of the year)	of the year)	from decommission	in year t	year t
V. Total Ch	Amount in Foams produced domestically	covered/Destroy Amount in Foams imported	ed/Exported fro Amount in Foams exported	Annual domestic consumption	First year loss	Annual loss (tonnes) Η = IF(Σ(E(t-(d-	E Agent at Decommissionin g (tonnes)	Amount Recovered and Destroyed at decommissio	decommissio ning	bank (at the end of the year)	of the year)	from decommission ed bank	in year t	emission year t
V. Total Ch	Amount in Foams produced domestically	covered/Destroy Amount in Foams imported	ed/Exported fro Amount in Foams exported	Annual domestic consumption (tonnes)	First year loss (tonnes)	Annual loss (tonnes) Η = IF(Σ(E(t-(d- 1),t) * (EFal/100))	E Agent at Decommissionin g (tonnes)	Amount Recovered and Destroyed at decommissio ning	decommissio ning (tonnes)	bank (at the end of the year) (tonnes)	of the year) (tonnes)	from decommission ed bank (tonnes)	in year t (tonnes)	emission year t
V. Total Ch	Amount in Foams produced domestically (tonnes)	covered/Destroy Amount in Foams imported	ed/Exported fro Amount in Foams exported	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi *	Annual loss (tonnes) H = IF(Σ (E(t.(d- 1),t) * (EFal/100)) <= CAremining	E Agent at Decommissionin g (tonnes)	Amount Recovered and Destroyed at decommissio ning J = 1 *	decommissio ning (tonnes) K = (I-J) *	bank (at the end of the year) (tonnes) DB = I - J - K - N	of the year) (tonnes) Bank = Bank(t-1)	from decommission ed bank (tonnes) N = DB(t-1) *	in year t (tonnes) P = G + H + K +	emission yeart (Gg)
V. Total Ch 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) H = IF(Σ(E(t-(d- 1),t) * (EFal/100)) <= CAremanino) (t) Σ(E(t-(d-1),t)	E Agent at Decommissionin g (tonnes) I = MPL * E(t-d)	Amount Recovered and Destroyed at decommissio ning	decommissio ning (tonnes)	bank (at the end of the year) (tonnes)	of the year) (tonnes)	from decommission ed bank (tonnes)	in year t (tonnes)	emission yeart (Gg)
V. Total Ch Year	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi *	Annual loss (tonnes) H = IF(Σ (E(t.(d- 1),t) * (EFal/100)) <= CAremining	E Agent at Decommissionin g (tonnes) I = MPL * E(t-d) = CAremaining (d+1)	Amount Recovered and Destroyed at decommissio ning J = 1 *	decommissio ning (tonnes) K = (I-J) *	bank (at the end of the year) (tonnes) DB = I - J - K - N	of the year) (tonnes) Bank = Bank(t-1)	from decommission ed bank (tonnes) N = DB(t-1) *	in year t (tonnes) P = G + H + K +	emission yeart (Gg)
V. Total Ch Year	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi *	Annual loss (tonnes) H = IF(Σ (E(t-(d- 1),t) * (EFal/100)) \leftarrow CAremaining (t); Σ (E(t-(d-1),t) \in (EFal/100));	E Agent at Decommissionin g (tonnes) I = MPL * E(t-d) = CAremaining (d+1)	Amount Recovered and Destroyed at decommissio ning J = 1 *	decommissio ning (tonnes) K = (I-J) *	bank (at the end of the year) (tonnes) DB = I - J - K - N	of the year) (tonnes) Bank = Bank(t-1)	from decommission ed bank (tonnes) N = DB(t-1) * (EFad/100)	in year t (tonnes) P = G + H + K +	emission year t (Gg) Q = P / 10
V. Total Ch Year t ∆	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi * (EFfyl/100)	Annual loss (lonnes) H = IF(∑(E(t-(d- 1),t) * (EFai/100); c = CAremaining (t) ∑(E(t-(d-1),t) * (EFai/100); CAremaining(t)) 0	E Agent at Decommissionin (tonnes) I = MPL * E(t-d) = CAremaining (d+1)	Amount Recovered and Destroyed at decommissio ning J = * (EFrd/100)	decommissio ning (tonnes) K = (I-J) * (EFd/100)	bank (at the end of the year) (tonnes) DB = I - J - K - N + DB(t-1)	of the year) (tonnes) Bank = Bank(t-1) + E - G - H - I	from decommission ed bank (tonnes) N = DB(t-1) * (EFad/100)	in year t (tonnes) P = G + H + K + N	emission yeart (Gg) Q = P / 10
V. Total Ch Year t ∆ 1990 1991	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi * (EFfy1/100) 0	$\begin{array}{l} \mbox{Annual loss} \\ (\mbox{tonnes}) \\ \mbox{H} = \mbox{if}(\Sigma(e(t-d_1),t) * (EFa/1/00)) \\ <= CAremaining (t) \\ (t) : \Sigma(e(t-(d-1),t) * (EFa/1/00)) \\ CAremaining (t)) \\ \mbox{0} \\ \mbox{0} \end{array}$	E Agent at Decommissionin g (tonnes) I = MPL * E(t-d) = CAremaining (d+1) 0	Amount Recovered and Destroyed at decommissio ning J = 1 * (EFrd/100)	decommissio ning (tonnes) K = (I-J) * (EF d/100)	bank (at the end of the year) (tonnes) DB = I - J - K - N + DB(t-1)	of the year) (tonnes) Bank = Bank(t-1) + E - G - H - I	from decommission ed bank (tonnes) N = DB(t-1) * (EFad/100)	in year t (tonnes) P = G + H + K + N 0 0	emission yeart (Gg) Q = P / 10
V. Total Ch Year t A	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi * (EFfyl/100) 0 0	Annual loss (tonnes) H = IF(Σ(E(t-(d- 3),t),* (EFaI/100)) << CAYemaining (t) Σ(E(t-(d-1))); CAremaining(t)) 0 0 0 0 0 0 0	E Agent at Decommissionin (tonnes) i = MPL * E(t-d) = CAremaining (d+1) 0 0 0	Amount Recovered and Destroyed at decommissio ning J = 1 * (EFrd/100)	decommissio ning (tonnes) K = (I-J) * (EF d/100) 0 0	bank (at the end of the year) (tonnes) DB = I - J - K - N + DB(t-1) 0 0	of the year) (tonnes) Bank = Bank(t-1) + E - G - H - I 0 0	from decommission ed bank (tonnes) N = DB(t-1) * (EFad/100)	in year t (tonnes) P = G + H + K + N	emission: year t (Gg) Q = P / 10
V. Total Ch Year t A 1990 1991 1992	Amount in Foams produced domestically (tonnes)	Amount in Foams imported (tonnes)	Amount in Foams exported (tonnes)	Annual domestic consumption (tonnes) E = Bi + Ci -	First year loss (tonnes) G = Bi * (EFfyl/100) 0 0 0 0	Annual loss (tonnes) H = IF(∑(E(-(d- 1),t) * (EFal/100)) << CAremaining (t) ∑(E(+(d-1),t) * (EFal/100)); CAremaining(t) 0 0 0 0 0 0 0 0 0 0	E Agent at Decommissionin (tonnes)	Amount Recovered and Destroyed at decommissio ning J = 1 * (EFrd/100) 0 0 0	decommissio ning (tonnes) K = (I-J) * (EF d/100) 0 0 0 0	bank (at the end of the year) (tonnes) DB = I - J - K - N + DB(t-1) 0 0 0	of the year) (tonnes) Bank = Bank(t-1) + E - G - H - 1 0 0 0	from decommission ed bank (tonnes) N = DB(t-1) * (EFad/100) 0 0 0	in year t (lonnes) P = G + H + K + N 0 0 0	emissions year t (Gg) Q = P / 10

AD are entered for each subdivision/sub-application/ F gas/blend, and for each year (based on the year of introduction of the foam blowing agent) in worksheet **F-Gas Emissions – Closed Cell Foams - Tier 2** and/or worksheet **F-Gas Emissions – Open Cell Foams - Tier 2**, as follows:

<u>Note that</u>, unlike many categories in IPPU, AD entry worksheets for source category 2.F.2 (along with 2.F.1 and 2.F.3) are for the entire time series in the open worksheet. AD for all years can be accessed when opening any year.

- <u>Column |Bi|</u>: input the amount of F gases/blends produced domestically, in tonnes. <u>Note:</u> 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. <u>Column |Ci|</u>: input the amount of F-gas/blend imported in open cell foams, in tonnes. <u>Note:</u> 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. <u>Column |Di|:</u> input the amount of F-gas/blend exported in open cell foams, in tonnes. <u>Note:</u> 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. <u>Column | E |:</u> total amount of F-gas/blend consumed domestically in year t, in tonnes. <u>Note that</u> this cell is calculated as the sum of production (<u>Column | Bi |</u>) plus imports (<u>Column | Ci |</u>) minus exports (<u>Column | Di |</u>).
- 5. <u>Column |G|:</u> amount of F-gas/blend lost (emitted) in the first year during manufacture or installation, in tonnes.

<u>Note that</u> 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. <u>Column |H|:</u> amount of F-gases/blends emitted annually from the bank of foams, in tonnes. <u>Note that</u> 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. <u>Column |1|</u>: amount of F-gas/blend remaining at decommissioning in year t, in tonnes. <u>Note that</u> 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. <u>Column |||:</u> amount of F-gas/blend recovered and destroyed, in tonnes. <u>Note that</u> this cell is calculated by multiplying the amount for decommissioning in <u>Column |I|</u> 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**.
- <u>Column |K|:</u> amount of F-gas/blend emitted at decommissioning in year t, in tonnes. <u>Note that this cell is calculated by multiplying the amount for decommissioning in Column |I|</u>, 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. <u>Column |DB|</u>: decommissioned bank is the quantity of F gas/blend that remains in foams after decommissioning, and will continue to emit, in tonnes. <u>Note that</u> 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. <u>Column | Bank_(t) |:</u> the bank at the end of the year t, in tonnes. <u>Calculated as</u> 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. <u>Column |N|:</u> annual loss from decommissioned bank, in tonnes. <u>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.</u>
- 13. <u>Column | P|:</u> total emissions in year t, in tonnes . <u>Calculated as the sum of first year and annual losses, as well as losses during decommissioning and from the decommissioned bank.</u>
- 14. <u>Column |Q|:</u> total emissions in year t, in Gg.



Example: **AD** input for closed and open cell foams- Tier 2 <u>Note that</u> although example applies to closed cell foams, the data entry grid for open cell foams is exactly the same

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) ($\Sigma Bank_{(t)}$)
- 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.

+ F-Gas Emissions - Open Cell Foams - Tier 2 F-Gas Emissions - Open Cell Foams - Tier 2 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 - Closed Cell Foams Worksheet Industrial Processes and Product Use Product Uses as Substitutes for Ozone Depleting Substance 2.F.2 - Foam Blowing Agents F-Gas Emissions - Closed Cell Foams - Tier 2 Sector: Category Subcate Sheet: Data Subdivision National Sub-application Polyurethane - Integral Skin Gas HEC-152a (CH3CHE2) EFal [%] 0.5 Intro Year 1990 Growth Rate (%) 2 100 Product lifetime (d) [yr] 10 EFd [%] 60 EFrd [%] 50 EFad [%] 0 EFfyl [%] 10 MPL [%] I. Total Chemical Agent Inputs (across the time series) ($\Sigma Bi + \Sigma Ci$) Bank(t) + DB(t) + ΣP + ΣJ + ΣDi II. Total Chemical Agent in equipment in use (last year of the time series) (Bank (t)) Problem with mass III. Total Chemical Agent in equipment disposed (last year of the time series) (DB(t)) conservation IV. Total Chemical Agent Emissions (across the time series) (SP) V Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) ($\Sigma_1 + \Sigma_2$ Emitted at rst year loss G = Bi * (EFfyl/100) K = (I-J) * 1990 384,6446 1991 1992 902 3375 920.3843 104.04 106.1208 1993 1.061.20 938.792 106.1208 2.000 1994 082 4321 1 082 43210 108 24322 5 41210 968 7767 13 65538

Example: mass conservation not realized- Tier 2 closed cell foams

Example: mass conservation confirmed- Tier 2 closed cell foams

Total Che Total Che Total Che	mical Agent Inputs emical Agent in eq emical Agent in e emical Agent Emi	quipment in use quipment dispos ssions (across ti	ne series) (ΣBi + Σ (last year of the ti sed (last year of th he time series) (Σ	me series) (Bank(t)) ne time series) (DB(t P)))	EFfyl [%] 1	51,994.367 15,893.625 5,366.780 15,317.005 15,416.95	7186 Bank(t) + 5133 3612 3911 5153	MPL [%] DB(t) + ΣP + Σ	12	a [%] 60 367186		onservat	
-				-			Bo	x 7.2 Amount		-				
	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 Decommission ing (tonnes)	Recovered and Destroyed at decommissio ning	Emitted at decommissio ning (tonnes)	Decommission ed bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss d from decommissio ned bank (tonnes)	Total emissions in year t (tonnes)	Total emissions yeart (Gg)
t∆	Bi		Di	E = Bi + Ci - Di	G = Bi * (EFfyl/100)	$\begin{array}{l} H = IF(\sum(E(t{-}(d{-}1),t) * (EFal/100))) \\ <= CAremaining \\ (t); \sum(E(t{-}(d{-}1),t) * \\ (EFal/100)); \\ CAremaining(t)) \end{array}$	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	l) N = DB(t-1) * (EFad/100)	P = G + H + K + N	
1990	1,000		0	1,000	100	5					8	95	105	0.1
1991	1,020		0	1,020		10.1	0	0	0	0	1,802		112.1	0.1
1992	1,040.4		0	1,040.4	104.04	10.1	0	0	0	0	2,729.1	1941 - Contra 1947 - Contra	114.14	
1993	1,061.208		2,000	-938.792	106.1208	10.1	0	0	0	0	1,674.147		116.2208	0.11
1994	1,082.43216		0	1,082.43216	108.24322	15.51216	0	0	0	0	2,632.823	98 0	123.75538	0.12

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

ias Emissions - κsneet ctor: tegory: bcategory:	2.F.2 - Foam Blowin	F-Gas Emissions - Open s and Product Use ubstitutes for Ozone Depleting ng Agents	Substances	aters - Closed Cell Foams - Tier	2 F-Gas Paramet	ers - Open Cell Foams -	Tier 2 F-Gas Emiss	ions - Closed Cell Foam	s - Tier 2
eet: ta	HFC-134a (CH2FC	F3) Emissions - Closed Cell Foa	ams						
bdivision Ur	Inspecified	 Gas HFC-134a (0 	CH2FCF3) V (Chemical's Data IY 1990	GR (%) 0	EFfyl (%) 10	EFal (%) 4.5	5 d (yr) 20	RD (%) 0
otal Chemical A	Agent Inputs (across	the time series) (∑A)		66,750 Ba	ank(t) + ΣH + ΣF	66,750			
Total Chemical	Agent in equipment	in use (last year of the time ser	ies) (Bank(t))	17,100					
		cross the time series) (∑H)		49.650					
			nd-of-life (across the time serie						
	r Agent Necovereu/	Destroyed from equipment at e	and-or-line (across the time serie	s)(ZI)					
			n		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 Decommissionin (tonnes)
t ∆⊽	A	B = A * (EFfyl/100)	$C = \sum (A(t-(d-1),t)) * (EFal/100)$	Bank(t) = A - B - C - I + Bank (t-1)	E=I-F	F = I * RD/100	H = B + C + E	EE = H / 1000	l = [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	Ĵ.
1992	1,500	150	202.5	3,645	0			0.3525	
1993	1,500	150	270	4,725	0			0.42	
1994	1,500	150	337.5	5,737.5	0			0.4875	
1995	1,500	150	405	6,682.5	0			0.555	
1996	1,550	155	474.75		0			0.62975	
1997	1,600	160	546.75	8,496	0			0.70675	
1998	1,650	165	621	9,360	0			0.786	
1999	1,700	170	697.5	10,192.5	0			0.8675	
2000	1,750	175	776.25	10,991.25	0			0.95125	
2001 2002	1,800	180	857.25	11,754	0	-		1.03725	
	1,850	185	940.5	12,478.5	0	1	12 22 23 25 25 20 20 10 20 20 20 20 20 20 20 20 20 20 20 20 20	1.1255	
	1 000								
2002 2003 2004	1,900 1,950	190 195	1,026	13,162.5	0			1.30875	4

Example: results: F-gas emissions – open cell foams- Tier 2

orksheet	ons - Open Cell F	oams - Tier 2												
ctor: tegory: bcategory eet: ata	Product Us y: 2.F.2 - Foar	ocesses and Pro es as Substitutes n Blowing Agents sions - Open Cell	for Ozone Dep	leting Substances	8									
	National		V Sub-ap	plication Poly	urethane - Flexible	Foam	√ Gas	s HFC-134a (C	H2FCF3)	~				
ntro Year	1990	Growth Rate (2) 0	Product lifeti	me (d) [yr] 1	EFfvl (7.] 100 E	Fal [%] 0	MPL [%	1 0 E	Fd [%] 0	EFrd [%] 0	EFad [3	0 [3
Total Che	mical Agent Input	e (acrose the time	e eeries) (SBi +	500				765.5 Bankit) + DB(t) + ΣP + Σ		765.5	7		
	emical Agent in ed			T . (1)	A))		-	12 Dalik (t,	/·····································		100.0			
							-	414						
	emical Agent in e		and sold states are		B(t))									
	emical Agent Em			and the second second			anna li	339.5						
Total Che	emical Agent Rec	overed/Destroye	ed/Exported from	m equipment at er	nd-of-life (across t	he time series) (∑J +	· ΣDi)	0						
							B	lox 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 Decommissionin g (tonnes)	Amount Recovered and Destroyed at decommissio ning	Emitted at decommissio ning (tonnes)	Decommissioned bank (at the end of the year) (tonnes)	Bank (at the end of the year) (tonnes)	Annual loss from decommissior ed bank (tonnes)	Total emissions in year t (tonnes)	Total emissions yeart (Gg)
	Bi	Ci		E = Bi + Ci - Di	G = Bi * (EFfyl/100)	$H = IF(\sum(E(t-(d-1),t) * (EFal/100)))$ <= CAremaining (t): $\sum(E(t-(d-1),t))$	I = MPL * E(t-d) = CAremaining	J = * (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	
						*(EFal/100)); CAremaining(t))								
1990	100	10	0			*(EFal/100)); CAremaining(t)) 0					10		100	
1990 1991	102	10	0	112	102	*(EFal/100)); CAremaining(t)) 0 0	10				10		102	0.1
1990 1991 1992	102 50	10 10	0	112 60	102 50	*(EFal/100)); CAremaining(t)) 0 0 0	10 10	0	0	20	10 10	0	102 50	0.1
1990 1991 1992 1993	102 50 25	10 10 12	0	112 60 37	102 50 25	* (EFal/100)); CAremaining(t)) 0 0 0 0	10 10 10	0	0	20 30	10 10 12	0	102 50 25	0.1 0. 0.0
1990 1991 1992 1993 1994	102 50 25 20.83333	10 10 12 12	0 0 0 0	112 60 37 32.83333	102 50 25 20.83333	*(EFal/100)); CAremaining(t)) 0 0 0 0 0 0 0 0	10 10 10 10 12	0 0 0	0 0 0	20 30 42	10 10 12 12	0	102 50 25 20.83333	0.1 0. 0.0 0.020
1990 1991 1992 1993 1994 1995	102 50 25 20.83333 16.66667	10 10 12 12 12 12	0 0 0 0 0	112 60 37 32.83333 28.66667	102 50 25 20.83333 16.66667	*(EFal/100)); CAremaining(t)) 0 0 0 0 0 0 0 0 0 0 0 0	10 10 10 12 12	0 0 0 0	0 0 0	20 30 42 54	10 10 12 12 12 12	0	102 50 25 20.83333 16.66667	0.1 0. 0.020 0.020 0.016
1990 1991 1992 1993 1994 1995 1996	102 50 25 20.83333 16.66667 12.5	10 10 12 12 12 12 12	0 0 0 0 0 0	112 60 37 32.83333 28.66667 24.5	102 50 25 20.83333 16.66667 12.5	*(EFal/100)); CAremaining(t)) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	10 10 10 12 12 12 12	0 0 0 0 0	0 0 0 0	20 30 42 54 66	10 10 12 12 12 12 12	0 0 0 0	102 50 20.83333 16.66667 12.5	0.1 0.0 0.020 0.016 0.01
1990 1991 1992 1993 1994 1995 1996 1997	102 50 25 20.83333 16.66667 12.5 8.33333	10 10 12 12 12 12 12 12 12	0 0 0 0 0 0 0 0	112 60 37 32.83333 28.66667 24.5 20.33333	102 50 20.83333 16.66667 12.5 8.33333	*(EFal/100)); CAremaining(t)) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	10 10 10 12 12 12 12 12	0 0 0 0 0 0	0 0 0 0 0	20 30 42 54 66 78	10 10 12 12 12 12 12 12 12	0 0 0 0 0	102 50 225 20.83333 16.66667 12.5 8.33333	0.1 0.0 0.020 0.016 0.01 0.008
1990 1991 1992 1993 1994 1995 1996 1997 1998	102 50 25 20.83333 16.66667 12.5	10 10 12 12 12 12 12 12 12 12 12	0 0 0 0 0 0	112 60 37 32.83333 28.66667 24.5 20.33333 16.16667	102 50 22.83333 16.66667 12.5 8.33333 4.16667	*(EFal/100)); CAremaining(t)) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	10 10 10 12 12 12 12 12 12 12	0 0 0 0 0 0 0 0	0 0 0 0 0 0	20 30 42 54 66 78 90	10 10 12 12 12 12 12 12 12 12	0 0 0 0 0 0	102 50 225 20.83333 16.66667 12.5 8.33333 4.16667	0.1 0.1 0.00 0.020 0.016 0.01 0.008 0.004
1990 1991 1992 1993 1994 1995 1996 1997	102 50 25 20.83333 16.66667 12.5 8.33333 4.16667	10 10 12 12 12 12 12 12 12	0 0 0 0 0 0 0 0 0	112 60 37 32.83333 28.66667 24.5 20.33333 16.16667 12	102 50 225 20.83333 16.66667 12.5 8.33333 4.16667 0	*(EFal/100)); CAremaining(t)) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	10 10 10 12 12 12 12 12 12 12 12	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	20 30 42 54 66 78 90	10 10 12 12 12 12 12 12 12	0 0 0 0 0 0 0	102 50 225 20.83333 16.66667 12.5 8.33333	0.1 0.0 0.020 0.016 0.016 0.018

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.

<u>Section 7.7</u> 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
			Χ	Χ	X	X

IPCC Equations

- ✓ <u>Tier 1</u>⁴⁹: <u>Equation 7.6</u> (Aerosols), <u>Equation 7.5</u> (Solvents), and <u>Equation 7.18</u> (Other Applications- Emissive)
- ✓ <u>Tier 2</u>: (*Aerosols and Solvents only*) Same as Tier 1 Equation, although at the sub-application level, and userspecific EFs, if available. A lifetime longer than two years can be considered.
- ✓ <u>Tier 3</u>: 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:

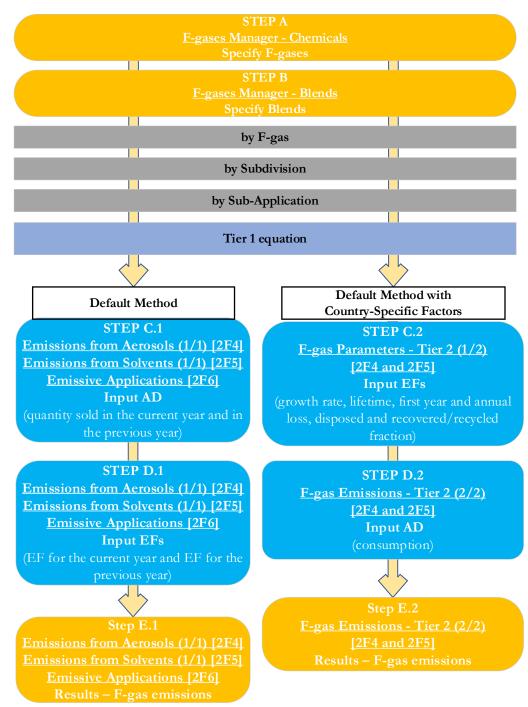
- ✓ F-gases Manager: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ Emissions from Aerosols (1/1) or Emissions from Solvents (1/1) or Emissive Applications contains for each F-gas, subdivision and sub-application (if applicable), information on the quantity 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-specific⁵⁰ 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 <u>section below on customizing the *Software*</u> 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 subapplications 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).

<u>Customizing the Software for Aerosols, Solvents and Other Applications- Emissive: subdivision/sub-application/F-gases/blends</u>

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)

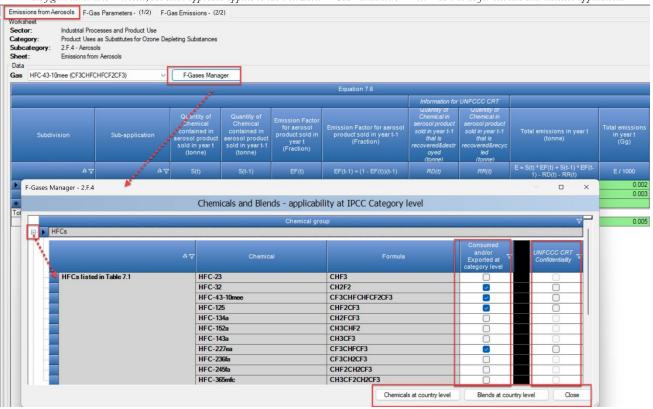
Figure illustrates solvents, but the same applies to the same named worked for Aerosols (2.F.4)

Emissions from Worksheet Sector: Category: Subcategory: Sheet: Data	Industrial Proc Product Uses	cesses and Product Use as Substitutes for Ozone D ts	-Gas Emissions - (2/2) Depleting Substances							1990
Subdivision		✓ Sub	application		✓ Gas		~			
Lifetime (d) (уг)	Growth Rate (%)	EFfyl (%)	EFal (%)	D (%)	R (%)		ntry not possible until u		
I. Total Chemic	al Agent Inputs (a	cross the time series) (ΣC)			Bank(t)	+ ΣI + ΣRD + ΣRR)		ases at the category losses at the category losses		
II. Total Chemi	cal Agent in equip	ment in use (last year of the	e time series) (Bank(t))		<u> </u>					
	and the second second	ns (across the time series)								
IV. Total Chem	ical Agent Recov	ered/Destroyed from equip	ment at end-of-life (across the time se	ries) (Σ RD + Σ RR)						
Year	Consumpti on (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 A	с	D = C * (EFfyl/100)	$\begin{array}{l} E = \sum (iF(C(t-(d-1),t) * \\ (EFal/100) <= CAremaining(t); \\ C(t-(d-1),t) * (EFal/100); \\ CAremaining(t))) \end{array}$	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	

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

- 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 <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 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, SF₆ or NF₃, 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. <u>Column |Subdivision|</u> compile each calculation worksheet 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.
- 2. <u>Column |Sub-application|</u>: 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. <u>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. Users should not change the category name of metered dose inhalers, as this may impact the import of data into that tool.</u>

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)

		oleting Substances							
as HFC-43-10mee (CF3CHF	CHFCF2CF3) V	F-Gases Mana	ger						
					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 I-1 (Fraction)	Chemical in Solvent product sold in year t-1 that is recovered&destr oyed (tonne)	Chemical in Solvent product sold in year t-1 that is recovered&recyc led (tonne)	Total emissions in year t (tonne)	Total emissio in year t (Gg)
۵Ţ	△ 7			EF(t)	EF(t-1) = (1 - EF(t))(t-1)		RR(t)	E = S(t) * EF(t) + S(t-1) * EF(t-1) - RD(t) - RR(t)	
Ø Northern	Precision Cleaning 🗸 🗸	125	30	0.5	0.5	0	0	77.5	0.0
Southern	Unspecified Precision Cleaning	125	45	0.5	0.5	0	0	85	0.
rotal	Electronics Cleaning Metal Cleaning Deposition Application	250	75					162.5	0.1

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:

- 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.

<u>Note that</u>, 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

ssions from Aerosols F-Gas Parameters · (1/2) F-Gas Emissions - (2/2)	
ctor: Industrial Processes and Product Use regory: Product Uses as Substitutes for Ozone Depleting Substances bocategory: 2.7.4 - Arensola eet: F-Gas Parameters - Tier 2 ta	1990
a F-Gases Manager	
Subdivision	
National	
Sub-application	
Metered Dose Inhalers (MDIs)	
Wetered Dose Inhalers (MDIs)	
Personal Care Products	
Household Products	
Other General Products	

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:

- \checkmark Section 7.3.2.2 contains information on the choice of EF for aerosols.
- \checkmark Section 7.2.2.2 contains information on the choice of EF for solvents.
- ✓ <u>Section 7.7.2.2</u> 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:

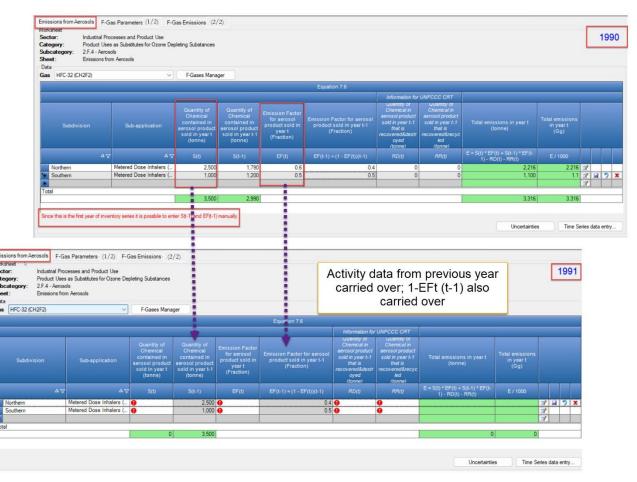
1. <u>Column $|EF_{(t)}|$ </u>: input the EF for loss in the current year, fraction.

<u>Note that</u> 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 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. <u>Column $|EF_{(t-1)}|$:</u> input one minus the EF for loss in the previous year, fraction. <u>Note that</u>, 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. <u>Window | 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).
- 2. <u>Window | Growth Rate |</u>: input the growth rate in sales of product, usually assumed linear across the period of assessment, in % (no IPCC default).
- 3. <u>Window |Lifetime|</u>: input the lifetime of product, in years. <u>Note that:</u> 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. <u>Window | EFfyl |</u>: input the fraction of chemical emitted from product in the year of initial use. <u>Note that</u>: 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. <u>Window |EFal|</u>: input the fraction of chemical emitted annually. <u>Note that:</u> 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. <u>Window |D|</u>: input the fraction of chemical that is destroyed at disposal (%) <u>Note that</u>: the default assumption is that no chemical is destroyed at disposal. The user must ensure that <u>Column |D|</u> plus <u>Column |R|</u> is $\leq 100\%$. If the sum of these columns is greater than 100%, an alert with an exclamation point will appear in <u>Column |Chemical|</u> (see image below).
- 7. <u>Window | R |</u>: input the fraction of chemical that is recovered/recycled at disposal (%) <u>Note that</u>: the default assumption is that no chemical is destroyed at disposal. The user must ensure that <u>Column | D |</u> plus <u>Column | R |</u> is $\leq 100\%$. If the sum of these columns is greater than 100%, an alert with an exclamation point will appear in <u>Column | Chemical |</u> (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

ctor: Industrial Processes and Product U	lse					
tegory: Product Uses as Substitutes for Ozi bcategory: 2.F.5 - Solvents	one Depleting Substances					
eet: F-Gas Parameters - Tier 2						
ata						
F-Gases Manager						
			Subdivision			
National						
			Sub-applicat			
Metal Cleaning			Sub-applicat	ion		
Metal Cleaning		, ,				
Chemical	Growth Rate (%)	Product lifetime (years)	First year loss Emission Factor (%)	Annual loss factor (%)	Fraction of chemical disposed that is destroyed (%)	Fraction of chemical disposed recovered/recycled (%)
	G	d	EFfyl	EFal	D	R
			50	10	100	
→ 🥴 HFC-365mfc (CH3CF2 🗸	3	5	50	10	100	

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.
- \checkmark 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 <u>important notes to avoid double counting of</u> <u>F-gas consumption</u> 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 <u>Column |Subdivision</u> and each sub-application in <u>Column |Sub-application|</u>, 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. <u>Column $|S_{(t)}|$:</u> input the quantity of the specific F-gas/blend contained in products sold in the current year, in tonnes.
- <u>Column |S_(t-1)|:</u> input the quantity of the specific F-gas/blend contained in products sold in the previous year, in tonnes.
 <u>Note that direct entry is only required in the first year of the inventory time series.</u> When the user creates the next inventory year (using the previous year)
- as the basis, which is the recommended approach⁵¹), the quantity of F-gases/blends will be automatically transferred to this column, in a gray cell.
 3. <u>Column | RD_(t) |:</u> input the quantity of the specific F-gas/blend contained in products sold in the previous year, that are recovered and destroyed, in tonnes. <u>Note that the default assumption is that recovery for destruction does not occur.</u>
- 4. <u>Column |RR_(t)|:</u> input the quantity of the specific F-gas/blend contained in products sold in the previous year, that are recovered and recycled, in tonnes. <u>Note that the default assumption is that recovery for recycling does not occur.</u>

An illustration of the AD input and carry over of the value S(t) to the subsequent year inventory is illustrated above in Figure <u>Example</u>: **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 <u>TFI website</u>. 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** <u>above</u> 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:

<u>Note that</u>, 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.

 <u>Column |C|:</u> input the amount of chemical agent consumed, in tonnes. <u>Note:</u> 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. <u>Column |D|:</u> calculates the amount of chemical agent lost (emitted) in the first year, in tonnes. <u>Note that</u> 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. <u>Column |E|:</u> calculates the amount of chemical agent emitted annually from the bank of chemical in aerosols/solvents, in tonnes. <u>Note that</u> 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. <u>Column |H|:</u> calculates the amount of chemical agent remaining in the product at decommissioning, in tonnes.

<u>Note that</u> 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. <u>Column |RD|:</u> calculates the amount of chemical agent recovered and destroyed, in tonnes. <u>Note that</u> 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. <u>Column |RR|:</u> calculates the amount of chemical agent recovered/recycled, in tonnes. <u>Note that</u> 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. <u>Column | Bank_(t) |</u>: calculates the bank at the end of the year t, in tonnes. <u>Note that</u> 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. <u>Column |||:</u> calculates total emissions in year t, tonnes. <u>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.</u>
- 9. <u>Column |J|:</u> 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

/orksheet Sector: Category: Subcategory Sheet: Data	Industrial F Product U r: 2.F.5 - Sol		F-Gas Emissions - (2/2 se one Depleting Substances		·					
Subdivision	Western	~	Sub-application Precision	Cleaning		✓ Gas HFC	-43-10mee (CF3CHFCHF			
Lifetime (d)	(yr) 3	Growth Rate (%)	0 EFfyl (%) 50		EFal (%) 20	D (%) 1	0 R (%)	0		
Tatal Chami	and Annual Insuit					500 Bank(t) + ΣI + ΣRD + ΣRR)	500		
		s (across the time series)	The second secon			ouu banki	()+21+2RD+2RR)	000		
	and the second second		of the time series) (Bank(t))			0				
III. Total Chen	mical Agent Emis	ssions (across the time s	nies) (∑l)			495				
IV. Total Cher	mical Agent Rec	overed/Destroyed from	equipment at end-of-life (across	the time ser	ries) ($\Sigma RD + \Sigma RR$)	5				
IV. Total Cher	mical Agent Rec	overed/Destroyed from	equipment at end-of-life (across	the time ser	ries) (ΣRD + ΣRR)	5				
IV. Total Cher Year	Consumpti	Emissions in first (tonnes)		the time ser	nies) (ΣRD + ΣRR) Solvent at Decommissioning (tonnes)	5 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)
1	Consumpti on	Emissions in first	ear Annual loss (tonnes) $E = \sum_{i} (IF(C(t-(d-1)), C(t-(d-1))))$,t) * ning(t); 100);	Solvent at Decommissioning	Destruction	Recycling	year)		
Year	Consumpti on (tonnes) C	Emissions in first (tonnes)	ear Annual loss (tonnes) (E= $\Sigma(IF(C(L(d-1)))$ (EFal/D0) $\approx CAremai(C(L(-1))) * (EFal/T0)$,t) * ning(t); 100);	Solvent at Decommissioning (tonnes) H = C(t-d) - C(t-d)* (EFfyl/100) - C(t-d)*	Destruction (tonnes)	Recycling (tonnes)	year) (tonnes) Bank(t) = C - D - E - H +	(tonnes)	in year t (Gg) J = I / 1000
Year t 4 1990 1991	Consumpti on (tonnes) C 2	D = C * (EFtyl/10	ear Annual loss (tonnes) (E=∑(IF(C(t-(d-1)) (C(t-(d-1))) <(E=At/10)) <= CAremai (C(t-(d-1))) *(E=At/1)) (CAremaining(t)) 100 50	.t) * ining(t); 100);)) 40	Solvent at Decommissioning (tonnes) H = C(t-d) - C(t-d)* (EFfyl/100) - C(t-d)* (EFal/100)*(d-1)	Destruction (tonnes) RD = H * (D/100)	Recycling (tonnes) RR = H * (R/100)	year) (tonnes) Bank(t) = C - D - E - H + Bank(t-1) 100 110	(tonnes) I = D + E + H - RD - RR 100 90	in year t (Gg) J = I / 1000 0.1 0.09
Year t & 1990 1991 1992	Consumpti on (tonnes) C 2	 Emissions in first ; (tonnes) D = C * (EFfyl/10 0 	ear Annual loss (tonnes) (EFal/100) <= CAremain (CFal/100) <= CAremaining(t) C(1-(d-1),) * (EFal/7 CAremaining(t))	.t) * ining(t); 100);)) 40 60	Solvent at Decommissioning (tonnes) H = C(t-d) - C(t-d)* (EFby/100) - C(t-d)* (EFal/100)*(d-1) 0 0	Destruction (tonnes) RD = H * (D/100)	Recycling (tonnes) RR = H * (R/100)	year) (tonnes) Bank(t) = C - D - E - H + Bank(t-1) 110 110	(tonnes) I = D + E + H - RD - RR 100 90 160	in year t (Gg) J = I / 1000 0.11 0.09 0.16
Year t 4 1990 1991 1992 1993	Consumpti on (tonnes) C 2	 Emissions in first (tonnes) D = C * (EFtyl/10 0 0 0 	ear Annual loss (tonnes) (EFal/100) $\leq CAremain(EFal/100) \leq CAremaining(t)1005000$	(t) * (ning(t); (t00);))) 40 60 60	Solvent at Decommissioning (tonnes) H = C(1-d) - C(1-d)* (EFsyl100) - C(1-d)* (EFsµl100) - (C1-d)* (EFal/100)*(d-1) 0 0 2 2	Destruction (tonnes) RD = H * (D/100) 0 0 0 2	Recycling (tonnes) RR = H * (R/100) 0 0 0 0 0	year) (tonnes) Bank(t) = C - D - E - H + Bank(t-1) 110 110 150 700	(tonnes) I = D + E + H - RD - RR 100 90 160 78	in year t (Gg) J = 1 / 1000 0.1 0.09 0.16 0.078
Year t & 1990 1991 1992	Consumpti on (tonnes) C 2	D = C * (EFly//10	ear Annual loss (tonnes) $E = \chi(F(C(t,(d-1), (EFal/100) \sim CAremai(C(t,(d-1), t) * (EFal/100) (CAremaining(t))10050100$.t) * ining(t); 100);)) 40 60	Solvent at Decommissioning (tonnes) H = C(t-d) - C(t-d)* (EFby/100) - C(t-d)* (EFal/100)*(d-1) 0 0	Destruction (tonnes) RD = H * (D/100) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Recycling (tonnes) RR = H * (R/100) 0 0	year) (tonnes) Bank(t) = C - D - E - H + Bank(t-1) 110 110	(tonnes) I = D + E + H - RD - RR 100 90 160 78	in year t (Gg) J = 1 / 1000 0.11 0.09 0.16 0.078 0.049

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 $(\sum C)$
- II. Total chemical agent in equipment in use (last year of the time series) (Bank_(t))
- III. Total chemical agent emissions, across time (ΣI)
- IV. Total chemical agent recovered/destroyed/exported ($\sum RD + \sum RR$)

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 <u>Column |C|</u> 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

orksheet	Aerosols F-Ga	as Parameters - (1/2)	F-Gas Emissions - (2/2)						
ector: ategory: abcategory neet:	Product Uses		Depleting Substances						
ata Subdivision	National	v Sit	-application Metered Dose Inhale	ens (MDIs)	✓ Gas HFC-	227ea (CF3CHFCF3)	~		
Lifetime (d)		Growth Rate (%) 0	EFfyl (%) 50	EFal (%) 1	D (%) 25			Mass conserved - no	
								* (D) + (R) <100 FYL (50%) + lifetime * AL (5	
		cross the time series) (Σ C)			1,376 Bank(t)) + ΣI + ΣRD + ΣRR)	1,376		(170) -100
		ment in use (last year of th			0				
I. Total Cher	nical Agent Emissio	ons (across the time series)	(ΣI)		1,027.872				
/ Total Cher	nical Agent Recov	ered/Destroyed from equir	oment at end-of-life (across the time se	eries) (ΣRD + ΣRR)	348,128				
	-								
	Consumpti on (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 emissi in year t (Gg)
t 🛆	с	D = C * (EFfyl/100)	$E = \sum (IF(C(t-(d-1),t) * (EFal/100) <= CAremaining(t); C(t-(d-1),t) * (EFal/100); CAremaining(t)))$	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 / 100
1990	150	75						75 75	
	225	112.5	1.5	0				186 114	0.
1991								.25 116.75	0.11
1992	226	113	3.75	0					
1992 1993	230	115	6.01	0	0	0	404	.24 121.01	0.12
1992 1993 1994	230 245	115 122.5	6.01 8.31	0	0	0	404 518	.24 121.01 .43 130.81	0.12
1992 1993 1994 1995	230 245 300	115 122.5 150	6.01 8.31 9.26	0 0 69	0 0 17.25	0 0 20.7	404 518 590	.24 121.01 .43 130.81 .17 190.31	0.12 0.13 0.19
1992 1993 1994 1995 1996	230 245 300 0	115 122.5 150 0	6.01 8.31 9.26 10.01	0 0 69 103.5	0 0 17.25 25.875	0 0 20.7 31.05	404 518 590 476	.24 121.01 .43 130.81 .17 190.31 .66 56.585	0.12 0.13 0.19 0.05
1992 1993 1994 1995 1996 1997	230 245 300 0 0	115 122.5 150 0 0	6.01 8.31 9.26 10.01 7.75	0 0 69 103.5 103.96	0 0 17.25 25.875 25.99	0 0 20.7 31.05 31.188	404 518 590 476 364	.24 121.01 .43 130.81 .17 190.31 .66 56.585 .95 54.532	0.12 0.13 0.19 0.05 0.05
1992 1993 1994 1995 1996 1997 1998	230 245 300 0 0 0	115 122.5 150 0 0 0	6.01 8.31 9.26 10.01 7.75 5.45	0 0 69 103.5 103.96 105.8	0 0 17.25 25.875 25.99 26.45	0 0 20.7 31.05 31.188 31.74	404 518 590 476 364 25	.24 121.01 43 130.81 17 190.31 66 5685 95 54.532 3.7 53.06	0.12 0.13 0.19 0.05 0.05 0.05
1992 1993 1994 1995 1996 1997 1998 1999	230 245 300 0 0 0 0 0	115 122.5 150 0 0 0 0 0 0	6.01 8.31 9.26 10.01 7.75 5.45 3	0 69 103.5 103.96 105.8 112.7	0 0 17.25 25.875 25.99 26.45 28.175	0 20.7 31.05 31.188 31.74 33.81	404 518 590 476 364 25	24 121.01 43 130.81 17 190.31 66 56.585 95 54.532 37 53.06 38 53.715	0.12 0.13 0.19 0.05 0.05 0.05 0.05
1992 1993 1994 1995 1996 1997 1998	230 245 300 0 0 0	115 122 5 150 0 0 0 0 0 0 0	6.01 8.31 9.26 10.01 7.75 5.45 3 0	0 0 69 103.5 103.96 105.8	0 0 17.25 25.875 25.99 26.45 28.175 34.5	0 20.7 31.05 31.188 31.74 33.81 41.4	404 518 590 476 364 25	.24 121.01 43 130.81 17 190.31 66 5685 95 54.532 3.7 53.06	0.1: 0.1: 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)
- \checkmark 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

		oleting Substances									19	90
as HFC-43-10mee (CF3CHF0	CHFCF2CF3) ~	F-Gases Mana	ger									
					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)	Chemical in Solvent product sold in year t-1 that is recovered&destr oyed (tonne)	Chemical in Solvent product sold in year t-1 that is recovered&recyc led (tonne)	Total emissions in year t (tonne)	Total emissions in year t (Gg)			
				EF(t)	EF(t-1) = (1 - EF(t))(t-1)		RR(t)	E = S(t) * EF(t) + S(t-1) * EF(t- 1) - RD(t) - RR(t)				
Northern	Precision Cleaning	125	30	0.5	0.5	0	0	77.5	0.0775	3	17	ĩ
Southern	Unspecified	125	45	0.5	0.5	0	0	85	0.085	3		ĺ
otal		250	75					162.5	0.1625			_

$\label{eq:example:results: F-Gas emissions-default method with refining assumptions$

ector: tegory: bcategory: eet: ata	Product Uses	ons - Tier 2								1
ubdivision	National	✓ Sut	-application Metered Dose Inhal			227ea (CF3CHFCF3)	~			
fetime (d)	(yr) 5	Growth Rate (%) 0	EFfyl (%) 50	EFal (%) 1	D (%) 25	i R (%)	30			
Total Chemi Total Chem	cal Agent in equip ical Agent Emissio	cross the time series) (ΣC) ment in use (last year of th ins (across the time series) ered/Destroyed from equip	e time series) (Bank(t))	eries) (ΣRD + ΣRR)	1,376 Bank (t 0 1,027.872 348.128)+ΣI+ΣRD+ΣRR)	1,376			
Year	Consumpti on (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 △	с	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)* (EFtyl/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		3
1991	225	112.5	1.5				186	114		and the second s
1992	226	113		0			295.25	116.75		
1993	230	115	6.01	0		0	404.24	121.01		
1994 1995	245 300	122.5	8.31	0	-	0	518.43	130.81 190.31		
1996	0	0		103.5		31.05	476.66	56.585		
1997	0	0		103.96		31,188	364.95	54.532	24/25/21/2018	
1998	0	0		105.8		31.74	253.7	53.06		2
1999	0	0				33.81	138	53.715		
2000	0					41.4	0	62.1	0.0621	
	0	0	0	0	0	0	0	0	0	3
2001	0	0	0	0	0	0	0	0	0	2
2001 2002		0	0				0			3
2002 2003	0				0	0	0	0		
2002 2003 2004	0	0								
2002 2003 2004 2005	0	0	0	0			0	0		
2002 2003 2004 2005 2006	0 0 0	0 0 0	0	0	0	0	0	0	0	2
2002 2003 2004 2005	0	0	0 0 0	0 0 0	0	0		0	0	3

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, <u>Section 7.7</u> 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 <u>Section 7.7.1</u> 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.

<u>GHGs</u>

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

- ✓ <u>Tier 1 Equation 7.19</u> (contained applications), at application level
- \checkmark <u>Tier 2</u>: Same equation as Tier 1, although at the sub-application level
- ✓ <u>Tier 3</u>: 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

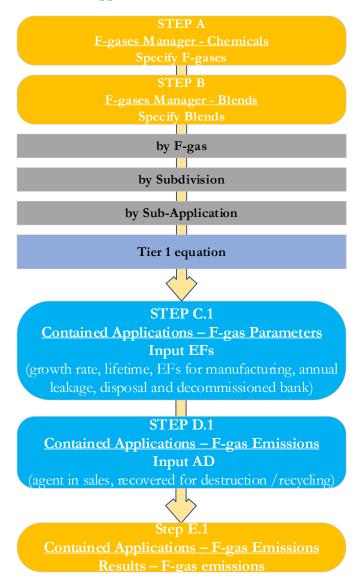
GHG emissions from the Other Applications source category (contained only) are estimated using the following worksheets:

- ✓ 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-specific⁵² 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.

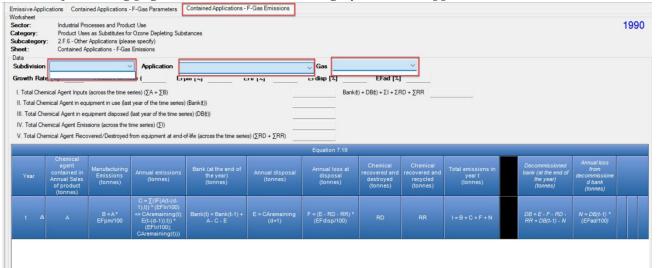
Step D.1, in worksheet **Contained Applications – F-Gas Emissions**, users input the amount of annual sales of chemical and the amount recovered for recycling/destruction.

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 <u>above</u>. 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 <u>above</u> 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. <u>Window |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).
- 2. <u>Window | Growth Rate |</u>: input the growth rate in consumption, usually assumed linear across the period of assessment, in % (no IPCC default).
- 3. <u>Window |Lifetime|</u>: input the lifetime of product, in years. <u>Note that</u>: 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. <u>Window |EF_{pm}|</u>: input the EF for manufacturing, based on a percentage of the sales of the chemical in other applications- contained (no IPCC default).
- 5. <u>Window |EF_{lr}|:</u> 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. <u>Window |EF_{disp}|:</u> input the EF for disposal, based on a percentage of the chemical disposed in that year (no IPCC default)
- 7. <u>Window $|EF_{ad}|$ </u>: 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. <u>Window |UNFCCC confidentiality|:</u> 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

ssive Applications Contained Applications	plications - F-Gas Parameters	Contained Applicati	ons - F-Gas Emissions					
egory: Industrial Processe Product Uses as S category: 2.F.6 - Other Applic	and Product Use Ibstitutes for Ozone Depleting Sub- ations (please specify) ons - F-Gas Parameters	stances						199
			5	Subdivision				
Northern								
				Application				
National								 _
Chemical	Growth Rate (%)	Lifetime (years)	Manufacturing EF (%)	Leakage Rate EF (%)	Disposal Rate EF (%)	Rate of Loss at Decommissioning (% decomissioned amount)	UNFCCC CRT Confidenti ality	
	G	d	EFpm	EFIr	EFdisp	EFad		
HFC-23 (CHF3)	1	10	10	2.5	100	0		2
1								
				Application				
*								
			5	Subdivision				

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 <u>important notes to avoid double counting of</u> <u>F-gas consumption</u> 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:

- <u>Column |A|:</u> input the amount of annual sales of F-gas for other contained applications, in tonnes. <u>Note that</u>: 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. <u>Column |RD|</u>: 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. <u>Column |RR|</u>: 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. <u>Column |B|:</u> calculates the amount of chemical agent lost (emitted) during manufacturing, in tonnes. <u>Calculated by</u> 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.**
- <u>Column |C|</u>: calculates the amount of chemical agent emitted annually from the bank of chemical in contained applications, in tonnes.
 <u>Calculated by</u> 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. <u>Column | Bank_(t) |:</u> calculates the bank at the end of the year t, in tonnes. <u>Calculated as</u> 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. <u>Column |E|:</u> calculates the amount of F-gases in contained equipment at the end-of-life, in tonnes. <u>Calculated by</u> 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. <u>Column |F|:</u> calculates the emissions during disposal, in tonnes. <u>Calculated as</u> 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. <u>Column |DB|:</u> 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. <u>Column |P|</u>: 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.

			1	Example: A E) input – c	containe	d appli	cations			
	cations Contain	ned Applications -	F-Gas Parameters	Contained Applications - I	F-Gas Emissions						
rksheet											
ector:		cesses and Produc									
ategory: ubcategory:		Applications (pleas	Ozone Depleting Subs	lances							
neet:		oplications - F-Gas									
Data											
Subdivision	Northern	~	Application Na	tional		✓ Gas HFC-3	23 (CHF3)	~			
Growth Rate	e (%) 1	Product lifetin	ne (10 EFp	m [%] 10 E	Fir [%] 2.5	EFdisp [%] 8	0 EFad	[%] 0			
I. Total Chem	nical Agent Inputs	(across the time se	eries) (∑A + ∑B)			1,468.5 Ba	ank(t) + DB(t) + ΣI	+ ΣRD + ΣRR	1,468.5		
II. Total Cher	nical Agent in equ	ipment in use (last	year of the time series)	(Bank(t))		0		_			
III. Total Che	mical Agent in eq	uipment disposed (last year of the time seri	es) (DB(t))		175.25					
		sions (across the ti			-	1,168.25					
		en el el terre de la composition de la		f-life (across the time series		1,100.25					
v. rotal Cher	mical Agent Reco	vereu/ Destroyed fi	rom equipment at end-o	The lacross the time series	s) (2nD + 2RR)						
	Chemical					Equation 7.19					
	agent	Manufacturing		Bank (at the end of		Annual loss at			Total emissions in	Decommissioned	Annual los from
	contained in Annual Sales		Annual emissions (tonnes)	the year)	Annual disposal (tonnes)	disposal	recovered and destroyed	recovered and recycled	year t	bank (at the end of the year)	decommissi
	of product	(tonnes)		(tonnes)		(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)	d bank (tonnes)
	(tonnes)										(tonnes)
			$C = \sum (IF(A(t-(d-1),t)) * (EF(t-1),t))$								
t ∆			<= CAremaining(t);	Bank(t) = Bank(t-1) +		F = (E - RD - RR) *			I=B+C+F+N	DB = E - F - RD -	
		EFpm/100	E(t-(d-1)),t)) * (EFIr/100);			(EFdisp/100)				RR + DB(t-1) - N	(EFad/100
			CAremaining(t)))								
1990	100			97.5		i			12.5		
1991	200	20	7.5	290	0				27.5	0	
1992 1993	300 335	30 33.5	15	575	0				45	0	
1993	400	33.5	23.375 33.375	886.625 1.253.25	0		-		56.875	0	
1994	400		33.375	1,253.25	0					0	
1996	0		33.375	1,186.5	0					0	
1997	0		33.375	1,153.125	0					0	
1998	0	0	33.375	1,119.75	0	0	0	0	33.375	0	
1999	0		33.375	1,086.375	0			0	33.375	0	
2000	0		30.875	980.5	75				90.875	15	
2001	0	1.0	25.875	804.625	150	N	15		133.875	42	
2002	0		18.375	561.25	225		10	-	190.375	85	
2003	0		10	300	251.25 300			0		115.25	1
2004	0		0	0	300					175.25	
2005	0		0	0	0			0	0	175.25	
2000	0	0	0		0					175.25	

the AD input - contained applications

Ensuring mass conservation of gases in contained applications

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 ($\Sigma A + \Sigma B$)
- II. Total chemical agent in equipment in use (last year of the time series) (Bank_(t))
- Total chemical agent in equipment disposed (last year of the time series) (DB_(t)) III.
- IV. Total chemical agent emissions, across time (ΣI)
- V. Total chemical agent recovered/destroyed/exported ($\Sigma RD + \Sigma RR$)

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:

- \checkmark 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%. \checkmark
- \checkmark A user currently cannot enter a negative value in <u>Column |A|</u> although it is possible that in a given year exports could be greater than imports, causing negative consumption.

Emissive Applications Worksheet Contained Applications - F-Gas Parameters Contained Applications - F-Gas Emissions Sector: Industrial Processes and Product Use Mass not conserved - there is recovery for Product Uses as Substitutes for Ozone Depleting Substances 2.F.6 - Other Applications (please specify) Category destruction reported in 1997 but no emissions at disposal (in fact, adding a value in column RD Sheet: Contained Applications - F-Gas Emissions leads to negative emissions in Column F, which Data is not valid). Note Subdivision Northern Application National Gas HFC-23 (CHF3) Growth Rate (%) 1 Product lifetime (10 EFpm [%] 10 ERr [%] 10 EFdisp [%] 80 EFad [%] I. Total Chemical Agent Inputs (across the time series) ($\Sigma A + \Sigma B$) $\mathsf{Bank}(\mathfrak{k}) + \mathsf{DB}(\mathfrak{k}) + \Sigma \mathsf{I} + \Sigma \mathsf{RD} + \Sigma \mathsf{RR}$ 1,488.5 468 5 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 the time series) (∑I) V. Total Chemical Agent Recovered/Destroyed from equipment at end-of-life (across the time series) (SRD + SRF year t 1990 1991 200 1992 1993 741. 1994 400 1.00 1995 874. 1996 133 5 74 1997 100

Example: mass conservation not realized – contained applications

Example: mass conservation confirmed – contained applications

orksheet ategory: ubcategory: neet: ata	Product Uses : 2.F.6 - Other	cesses and Produc as Substitutes for Applications (pleas oplications - F-Gas	Ozone Depleting Subs ie specify)	tances					HOWEVER 2001. The that must	conservation is co R, note the negativ ere is an error in R t be addressed, as r is greater than the	e emissions in D and/or RR s the sum of
ubdivision	Northern	~	Application Na	ational		Gas HFC-	23 (CHF3)	~		disposal.	
rowth Rate	e (%) 1	Product lifetin	ne (10 EFp	m [%] 10 E	Fir [%] 2.5	EFdisp [%] 8	0 EFad	[7] 0		r.	
I. Total Chem	nical Agent Inputs	(across the time se	nies) ($\Sigma A + \Sigma B$)			1,468.5 B	ank(t) + DB(t) + ΣI	+ ΣRD + ΣRR	1,468.5		
II. Total Cher	mical Agent in equ	ipment in use (last	year of the time series)	(Bank(t))		0					
III. Total Che	emical Agent in equ	uipment disposed (last year of the time ser	ies) (DB(t))		135.25					
		sions (across the tir				1,008.25					
	entersente de construer			f-life (across the time series	a) (ΣRD + ΣRR)	325					
	and a second				//2/10 / 2/11	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)	n bank (at the e the year) (tonnes)	nd of decommissi
t A	A	B = A* EFpm/100	$\begin{array}{l} C = \sum (IF(A(t-(d-1),t))^* (EFIr/100) \\ <= CAremaining(t); \\ E(t-(d-1)),t))^* \\ (EFIr/100); \\ CAremaining(t))) \end{array}$	Bank(t) = Bank(t-1) + A - C - E	E = CAremaining (d+1)	F = (E - RD - RR) * (EFdisp/100)	RD	RR		DB = E - F - I RR + DB(t-1)	
1990	100	10	2.5	97.5					12.		
1991	200	20	7.5		0				27.	.5	0
1992	300	30	15		0					45	0
1993	335	33.5	23.375		0				56.87		0
1994	400	40	33.375		0				73.37		0
1995 1996	0	0	33.375 33.375		0				33.37	10-11	0
1997	0		33.375	2017-02-01	0	-			33.37	0+4	0
1998	0		33.375		0				33.37		0
1999	0		33.375		0				33.37	(h-1)	0
2000	0	0	30.875	980.5	75	60	0	0	90.87	75	15
2001	0	0	25.875	804.625	150	-52	15	200	-26.12	25	2
2002	0		18.375		225				190.37		45
2003	0		10		251.25	1125 /	100		13	631	75.25
2004	0		0		300				24		135.25
2005	0		0		0		-			1	135.25
	0	0	0	0	0	0	0	0		0	35.25

Results

Recall that discussion of the results for worksheet **Emissive Applications** is included in section <u>2.F.4 (Aerosols)</u>, <u>2.F.5 (Solvents) and 2.F.6: (Other Applications - Emissive)</u>.

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

missive Appli lorksheet	cations Contain			Contained Applications - F							
ector: ategory: ubcategory heet: Data	Product Uses : 2.F.6 - Other	cesses and Produces as Substitutes for Applications (pleas oplications - F-Gas	Ozone Depleting Subs se specify)	stances							
Subdivision	Northern	~	Application N	ational		Gas HFC-	23 (CHF3)	~			
Growth Rate	e (%) 1	Product lifetin	ne (10 EF	om [%] 10 El	Fir [%] 2.5	EFdisp [%] 8	0 EFad	[%] 0			
I. Total Chem	nical Agent Inputs	(across the time se	eries) (ΣA + ΣB)		-	1.468.5 B	ank(t) + DB(t) + ΣI	+ΣRD + ΣRR	1,468.5		
II. Total Cher	mical Agent in equ	ipment in use (last	year of the time series)	(Bank(t))		0					
III. Total Che	emical Agent in eq	uipment disposed (last year of the time ser	ies) (DBtt))		135.25					
		sions (across the ti				1.008.25					
	entrene de desente			of-life (across the time series	s) (ΣRD + ΣRR)	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 decommission d bank (tonnes)
t ∆	A	B = A* EFpm/100	C = ∑(IF(A(t-(d- 1),t)) * (EFIr/100) <= CAremaining(t); E(t-(d-1)),t)) * (EFIr/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			0					0	
1992	300	30			0		0			0	
1993 1994	335 400	33.5 40	23.375		0					0	
1994	400	40			0					0	
1996	0				0			C	and the second se	0	
1997	0				0					0	
1998	0				0				and the second se	0	
1999	0				0					0	
2000	0				75	27.5			and the second	15	1
2001	0				150				-26.125	2	
2002	0				225					45	
2003	0				251.25		100			75.25	
2004	0				300					135.25	
2005	0					~				135.25	
2000	0				0					135.25	

2.G Other Product Manufacture and Use (2.G)

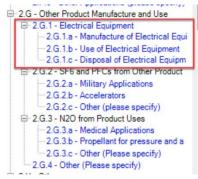
2.G.1 Electrical Equipment

i)

Most of the SF₆ used in electrical equipment is used in gas insulated switchgear and substations and in gas circuit breakers, though some SF₆ 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:

- Emissions during manufacturing and installation of electrical
 - equipment (2.G.1.a)
- ii) <u>Emissions from use of electrical equipment (2.G.1.b)</u>
- iii) <u>Emissions from disposal (2.G.1.c)</u>



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 <u>2.G.1 – Tier 3 Utility Level Mass Balance Approach</u> 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.

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.

<u>GHGs</u>

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):

- ✓ <u>Tier 1: Equation 8.1</u>
- ✓ <u>Tier 2:</u> Same equation as Tier 1 Note that: <u>Equation 8.2</u> in a Tier 2 Equation, but is calculated under category 2.G.1.c.
- ✓ <u>Tier 3: Equations 8.3, 8.4a</u> (pure mass balance for manufacturing), <u>8.4b</u> (hybrid mass balance and EF approach for manufacturing), <u>8.5a</u> (pure mass balance for installation), <u>8.5b</u> (hybrid mass balance and EF approach for installation) and <u>Equation 8.8</u> (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.

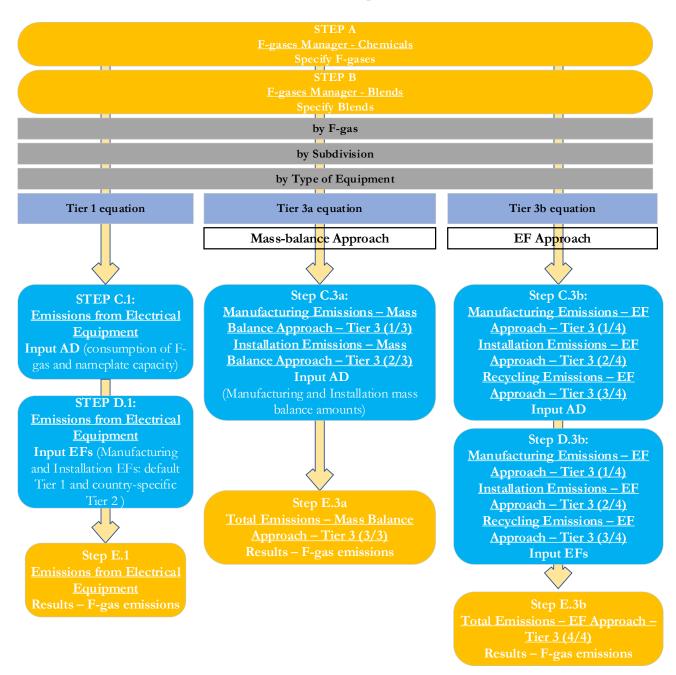
User's Work Flowchart

For Manufacture of Electrical Equipment, consistent with the key category analysis and the decision tree in <u>Figure</u> <u>8.1</u> 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-specific⁵³ 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.

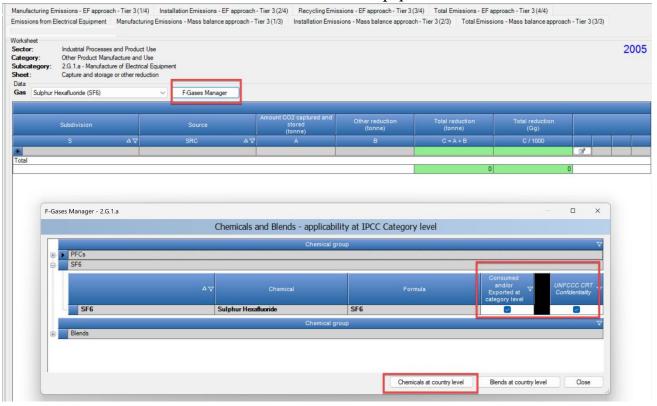
As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category **Manufacture of Electrical Equipment**.

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 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 <u>above</u>.

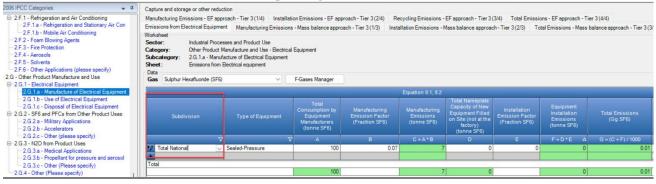
For users intending to use data entered in the Software for reporting in the UNFCCC ETF Reporting Tool: If emissions for this category are considered confidential, the user may check the box UNFCCC CRT Confidentiality. If checked, "IE" will be reported for emissions in the JSON file generated for the 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 CO₂ equivalents.

Example: populating the F-gases manager and designating confidentiality for category: manufacture of electrical equipment

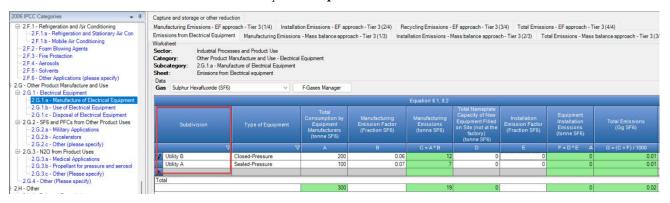


Second, for all Tiers and all worksheets, input of AD for the manufacture and installation of electrical equipment requires the user to enter information on the subdivisions in the country. Users compile the calculation worksheets either with a single row of data for the entire category, with its univocal name/code entered in <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



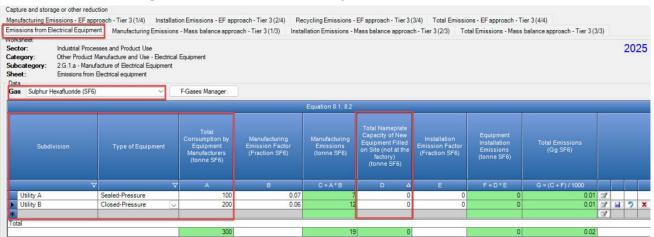
When the Tier 1 Equation is applied:

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



When the Tier 3 Equations are applied:

Tier 3(a) Mass-balance:

To estimate <u>emissions from manufacturing</u>, for each subdivision in <u>Column |Subdivision|</u> (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. <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> 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 <u>Column |B|</u> from the previous year) or "specified" (directly entered), in tonnes.
- 3. <u>Column |B|:</u> input the amount of F-gas stored in containers at equipment manufacturers?? at the end of the year, in tonnes.
- 4. <u>Column |C|:</u> input the amount of F-gas purchased by equipment manufacturers from chemical producers or distributors in bulk, in tonnes.
- 5. <u>Column |D|:</u> input the amount of F-gas returned by equipment users or distributors to equipment manufacturers with or inside of equipment, in tonnes.
- 6. <u>Column |E|</u>: input the amount of F-gas returned to site of equipment manufacturers after off-site recycling of equipment, in tonnes.
- 7. <u>Column |F|:</u> input F-gas from the equipment manufacturers that is contained in new equipment delivered to customers, in tonnes.
- 8. <u>Column |G|:</u> input F-gas from the equipment manufacturers delivered to equipment users in containers, in tonnes.
- 9. <u>Column |H|:</u> input the amount of F-gas from the equipment manufacturers returned to suppliers, in tonnes.
- 10. <u>Column |1|:</u> input the amount of F-gas from the equipment manufacturers sent off-site for recycling, in tonnes.
- 11. <u>Column |J|</u>: input the amount of F-gas destroyed by the equipment manufacturers, in tonnes.

Example: AD input for manufacturing emissions – Tier 3 mass-balance

ssions from Electric ksheet	al Equipment Manufac	cturing Emissio	ns - Mass balar	nce approach - T	Tier 3 (1/3)	Installation Emi	ssions - Mass	balance approa	ch - Tier 3 (2/3)) Total Emis	sions - Mass ba	lance approac	h - Tier 3 (3/3)		
egory: Othe ocategory: 2.G. set: Emis	istrial Processes and Prod er Product Manufacture ar 1.a - Manufacture of Elec ssions from Electrical Equi	nd Use - Electric trical Equipment	t cturing Emission		e approach - Ti	er 3 (1/3)									200
s PFC-14 (CF4)			F-Gases Man	lager											
					_		Equation 8.4A								
		Decreas	e in Chemical	Inventory	Acqu	isitions of Che	mical		Disbu	rsements of Cl	nemical				
Subdivision	Type of Equipment	containers at of the	I stored in the beginning e year t nnes)	Chemical stored in containers at the end of the year t (tonnes)	Chemical purchased from producers or distributors in bulk (tonnes)	returned by equipment users or distributors with or inside of equipment (tonnes)		Chemical contained in new equipment delivered to customers (tonnes)	Chemical delivered to equipment users in containers (tonnes)	Chemical returned to suppliers (tonnes)	Chemical sent off-site for recycling (tonnes)	Chemical destroyed (tonnes)	Emissions (tonnes)	Emissions (Gg)	
			A	в		D		F		н	1		K = A - B + C + D + E - F - G - H - I - J	K/1000	
Unspecified	200	Specified	1,000	100	50	20	0	25	20	0	0	0	925	0.93	3 🖬 🤊
										-					3

To estimate <u>emissions from installation</u>, for each subdivision in <u>Column |Subdivision|</u> (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. <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 amount of F-gas used to fill new equipment onsite, in tonnes.
- 3. <u>Column |B|</u>: input the total nameplate capacity of new equipment that is installed and filled onsite, in tonnes.

nissions from Electrical Equipment Manufactur	ing Emissions - Mass balance approach - Tie	3 (1/3) Installation Emissions -	Mass balance approach - Tier 3	(2/3) Total Emissions - Mass	balance approach - Tier 3 (3/3)			
orksheet setor: Industrial Processes and Product stegory: Other Product Manufacture and I ubcategory: 2.G.1.a - Manufacture of Electrica teet: Emissions from Electrical Equipme ata	Jse - Electrical Equipment	ach - Tier 3 (2/3)					20	07
as Sulphur Hexafluoride (SF6)	✓ F-Gases Manager							
		Equation	- 0.54					
		Equation	n 6.5A			 		_
Subdivision	Type of Equipment	Chemical used to fill equipment (tonnes)	Total Nameplate capacity of New Equipment (tonnes)	Emissions (tonnes)	Emissions (Gg)			
Subdivision	Type of Equipment	Chemical used to fill equipment	Total Nameplate capacity of New Equipment					

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 <u>emissions from manufacturing</u>, for each subdivision in <u>Column |Subdivision|</u> (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. <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 nameplate capacity of newly manufactured equipment, in tonnes.

Example: AD input manufacturing emissions - EF approach - Tier 3b

Manufacturing Er	ectrical Equipment Manufactu hissions - EF approach - Tier 3 (1	ring Emissions - Mass balance approach - Tier 3 /4) Installation Emissions - EF approach - Tier		Mass balance approach - Tier 3 (- EF approach - Tier 3 (3/4) To		s balance approach - Tier 3 (3/3) Tier 3 (4/4)
Worksheet Sector: Category: Subcategory: Sheet: Data		Use - Electrical Equipment cal Equipment nent - Manufacturing Emissions - EF approach - Tier	3 (1/4)			
Gas Sulphur H	exafluoride (SF6)	F-Gases Manager	Equation	8.4B		
	Subdivision	Type of Equipment	Total Nameplate capacity of equipment undergoing the process (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
* Unspecified	$\Delta \nabla$	Sealed-Pressure	A 1,000	B	C = A * B	C / 1000
*			1,000	ř		
Total					(0

Then, if there is newly manufactured equipment filled onsite (not by the manufacturer), <u>emissions from</u> <u>installation</u> can be estimated for each subdivision in <u>Column |Subdivision|</u> (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. <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 nameplate capacity of newly manufactured equipment that is not filled in the factory, but onsite, in tonnes.

<u>Note that</u>: 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.

Emissions from E	lectrical Equipment Manufactu	ring Emissions - Mass balance approach - Tier 3	(1/3) Installation Emissions -	Mass balance approach - Tier 3 (2/	3) Total Emissions - Mas	s balance approach - Tier 3 (3/3)
Manufacturing En	nissions - 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 Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Product Other Product Manufacture and 2.G.1.a - Manufacture of Electric Emissions from Electrical Equipm	Use - Electrical Equipment	2/4)			
Gas Sulphur H	exafluoride (SF6)	✓ F-Gases Manager				
			Equation	1 8.5B		
	Subdivision	Type of Equipment	Total Nameplate capacity of new equipment filled onsite (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
	Δ7	- 	A	В		C / 1000
* Unspecified		Gas-Insulated Transformers	2,000	0		
Total		1				

Example: AD input for installation emissions – EF approach – Tier 3

Then, if the manufacturer undertakes <u>recycling of gas</u>, these emissions can be estimated for each subdivision in <u>Column |Subdivision|</u> (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. <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 quantity of chemical fed into the recycling process by manufacturers, in tonnes.

masions nom cleculoar couplinent manulacium	ng Emissions - Mass balance approach - Tier 3 ((1/3) Installation Emissions - M	lass balance approach - Tier 3 (2	3) Total Emissions - Mass	balance approach - Tier 3 (
lata	Use Ise - Bectrical Equipment Equipment nt - Recycling Emissions - EF approach - Tier 3 (3/		EF approach - Tier 3 (3/4) Tota	I Emissions - EF approach - T	ïer 3 (4/4)
as PFC-14 (CF4)	F-Gases Manager	Equation	8.8		
Subdivision	Type of Equipment	Quantity of chemical fed into recycling process (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
	~	A	в	C = A * B	C / 1000
ΔA					

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 (<u>Table 8.2</u>)
- ii) Closed-pressure electrical equipment (Table 8.3)
- iii) Gas-insulated transformers (Table 8.4)

<u>Note that</u>: 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 <u>Column |Subdivision|</u>, and each gas, EF data are input in worksheet **Emissions from Electrical Equipment**, row by row as follows:

- 1. <u>Column |B|</u>: Input an appropriate default EF for manufacturing as contained in <u>Tables 8.2-8.4</u>, or input manually a country-specific EF (as a fraction of total consumption of the gas by equipment manufacturers).
- <u>Column |E|</u>: 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). <u>Note that</u> a separate default EF is not available for installation in <u>Tables 8.2-8.4</u>, as installation emissions are assumed to be included in the manufacturing or use EFs.

$\mathit{Example:}\,\mathbf{EF}$ input for manufacturing and installation emissions

ategory: Other Product Ma aubcategory: 2.G.1.a - Manufa				g Emissions - EF appro			oproach - Tier 3 (4/4) ons - Mass balance app	roach - Tier 3 (3/3)	
Gas Sulphur Hexafluoride (SF6)	~ F.(ases 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)	
۵ ک	ΔΥ			C = A * B			F = D * E	G = (C + F) / 1000	
Unspecified	Closed-Pressure	250	0.085	21.25	0	0	0	0.02	
	Sealed-Pressure	100	0.29	29	0	0	0	0.03	
*									2
fotal						-			
		350		50.25	0		0	0.05	2

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 <u>Column |Subdivision|</u>, and each gas, in <u>Column |B|</u> 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)

Manufacturing Emissions - EF approad Worksheet Sector: Industrial Processes Category: Other Product Manu Subcategory: 2.G.1.a - Manufactu		approach - Tier 3 (2/4) Recycling	Emissions - Mass balance app Emissions - EF approach - Ti			
Gas Sulphur Hexafluoride (SF6)	✓ F-Gases Manager		Equation 8.4B			
Subdivision	Type of Equipment	Process	Total Nameplate capacity of equipment undergoing the process (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
	ΔΥ		A		C = A * B	C / 1000
Unspecified	Closed-Pressure	200	1,000	5	5,000	5
*			Ļ			
Total					5.000	5

Example: EF input for installation emissions – EF approach – Tier 3 (2/4)

missions from Electrical Equipment Manufacturi	ing Emissions - Mass balance approach - Tier 3 (1/3) Installation Emissions - N	lass balance approach - Tier 3 (2/3) Total Emissions - Mass bala	ince approach - Tier 3 (3/3
1anufacturing Emissions - EF approach - Tier 3 (1/4 /orksheet	() Installation Emissions - EF approach - Tier	3 (2/4) Recycling Emissions -	EF approach - Tier 3 (3/4) Total	Emissions - EF approach - Tier 3	(4/4)
Data	lse - Electrical Equipment al Equipment nt - Installation Emissions - EF approach - Tier 3 (2	/4)			
as Sulphur Hexafluoride (SF6)	✓ F-Gases Manager	Equation	8.58		
Subdivision	Type of Equipment	Total Nameplate capacity of new equipment filled onsite (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
	AV	A	В	C = A * B	C / 1000
۵7					
∆ ⊽ Unspecified	Gas-Insulated Transformers	2,000	0.09	180	0.
		2,000	0.09	180	0.

Example: EF input for recycling emissions – EF approach – Tier 3 (3/4)

	nissions - EF approach - Tier 3 (1/4	 Installation Emissions - EF approach - Tier 	r 3 (2/4) Recycling Emissions	- EF approach - Tier 3 (3/4) Tot	al Emissions - EF approach - Tier 3	1(4/4)
lorksheet ector: ategory: ubcategory: heet: Data	Industrial Processes and Product Other Product Manufacture and U 2.G.1.a - Manufacture of Electrica Emissions from Electrical Equipme	Use - Electrical Equipment	3/4)			
ias Sulphur H	lexafluoride (SF6)	✓ F-Gases Manager				
		1	Equatio	n 8.8		
	Subdivision	Type of Equipment	Quantity of chemical fed into recycling process (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
	Δγ	- -	Ă	В	C = A * B	C / 1000
Unspecified	1	Sealed-Pressure	200	0.1	20	0.0
*						
Total						
TOIDI					20	0.

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

issions from Electrical Equipme	nt Manufacturing Emissions - Ma	ass balance approach	- Tier 3 (1/3) Installation	Emissions - Mass bala	ance approach - Tier 3	(2/3) Total Emissio	ns - Mass balance appr	oach - Tier 3 (3/3)
tegory: Other Product M bcategory: 2.G.1.a - Manuf	sses and Product Use Manufacture and Use - Electrical Equi acture of Electrical Equipment Electrical equipment	ipment ases Manager						
		accomanagor		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)
	V 47		В		D	E		G = (C + F) / 1000
National	Closed-Pressure	12,000	0.29	3,480	500	0	0	
	Gas-Insulated Transformers	54,000	0.29	15,660	3,200	0.1	320	1
	Sealed-Pressure	2,000	0.29	580	700	0.2	140	
	Gas-Insulated Transformers	3,500	0.22	752.5	870	0.01	8.7	
Tokyo City								
Tokyo City tal								

Example: results of Tier 3(a) emissions – mass-balance

nissions from Electrical Equipment Manufacturi	ing Emissions - Mass balance approach - Tier 3 (1/	8) Installation Emissions - Mass bala	ance approach - Tier 3 (2/3) Total En	nissions - Mass balance approach - Tier 3	3 (3/3)
orksheet ctor: Industrial Processes and Product ategory: Other Product Manufacture and L ubcategory: 2.6.1 a - Manufacture of Electrica heet: Emissions from Electrical Equipme ata	Ise - Electrical Equipment	(3/3)			200
as Sulphur Hexafluoride (SF6)	F-Gases Manager				
Subdivision	Type of Equipment	Manufacturing Emissions (tonnes)	Installation Emissions (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)
Subdivision					
• 2			(tonnes) B	(tonnes)	(Gg)
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	(tonnes) A	(tonnes) B	(tonnes) C = A + B	(Gg)

# Example: results of Tier 3(b) emissions – EF approach

ssions from Electrical Equipment Manu	racturing Emissions - Mass balance approa		nissions - Mass balance approact			
ufacturing Emissions - EF approach - Tier ksheet	r 3 (1/4) Installation Emissions - EF appr	roach - Tier 3 (2/4) Recycling E	missions - EF approach - Tier 3 (3	3/4) Total Emissions - EF approx	ach - Tier 3 (4/4)	
category: 2.G.1.a - Manufacture of Ele	and Use - Electrical Equipment	er 3 (4/4)				20
Sulphur Hexafluoride (SF6)	F-Gases Manager	Manufacturing Emissions	Installation Emissions	Recycling Emissions	Total Emissions	Total Emissions
Subhur Hexafluonde (SF6)	Type of Equipment	Manufacturing Emissions (tonnes)	Installation Emissions (tonnes)	Recycling Emissions (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)
Sulphur Hexafluonde (SF6) Subdivision	Type of Equipment	(tonnes) A			(tonnes) D = A + B + C	
Subhur Hexafluonde (SF6)	Type of Equipment		(tonnes)	(tonnes) C	(tonnes)	(Gg)

# 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 SF₆ 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 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.

# <u>GHGs</u>

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):

- ✓ <u>Tier 1: Equation 8.1</u>
- ✓ <u>Tier 2:</u> Same equation as Tier 1 Note that: <u>Equation 8.2</u> in a Tier 2 Equation, but is calculated under category 2.G.1.c.
- ✓ <u>Tier 3: Equations 8.3, 8.6a</u> (pure mass balance), <u>8.6b</u> (hybrid mass balance and EF approach) and <u>8.11</u> (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:

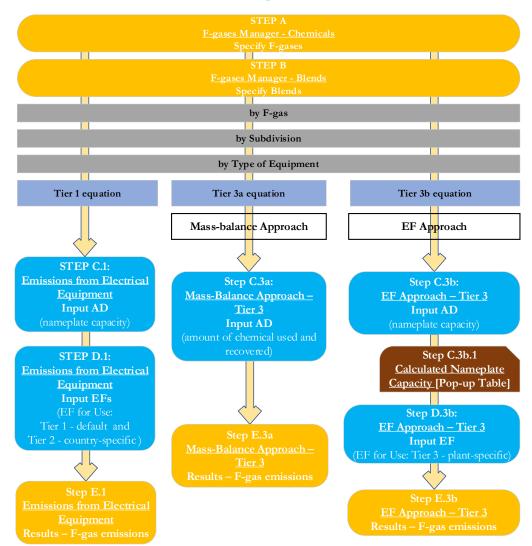
- ✓ F-gases Manager: contains data on F-gases used (including imported) and/or produced and exported in country.
- ✓ Emissions from Electrical Equipment: contains for each F-gas, subdivision and each type of equipment information on the total nameplate capacity of installed equipment and the EF from 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 <u>closed pressure</u> 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 <u>Figure 8.1</u> 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-specific⁵⁴ 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

<u>Section 8.2.2.3</u> 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**.

<u>Note that</u> 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 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 <u>above</u>.

<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 CO₂ 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 <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 (national)

Example: multiple subdivisions: emissions from use of electrical equipment - Tier 1/2 AD input

2006 IPCC Categories 🛛 👻 🕂	Emissions from Electrical Equipment Mass bala	ance approach - Tier 3 EF approach - Tier 3					
Other Product Manufacture and Use     Other Product Manufacture and Use     Other Product Manufacture and Use	Worksheet Sector: Industrial Processes and Produ Category: Other Product Manufacture and Subcategory: 2.G.1.b - Use of Electrical Equip Sheet: Emissions from Electrical equip Data Gas Subhur Hexafluoride (SF6)	I Use - Electrical Equipment oment					
2.G.2.a - Military Applications	Gas Suprior Hexalitoride (SF6)	<ul> <li>Picases manager</li> </ul>					
2.G.2.b - Accelerators	Equation 6.1						
2.G.2.c - Other (please specify)     G.3 - N2O from Product Uses     -2.G.3.a - Medical Applications     -2.G.3.b - Propellant for pressure an     -2.G.3.c - Other (Please specify)	Subdivision	Type of Equipment	Total Nameplate Capacity of Installed Equipment (tonne SF6)	Use Emission Factor (Fraction SF6)	Equipment Use Emissions (tonne SF6)	Total Emissions (Gg SF6)	
6.4 - Other (Please specify)	ΔV	۵ <u>.</u>				D = C / 1000	
ther	National	Closed-Pressure	3,000	0.007	21		
1 - Pulp and Paper Industry		Gas-Insulated Transformers	2,000	0.007	14		
2 - Food and Beverages Industry		Sealed-Pressure	2,000	0.007	14		
3 - Other (please specify) are, Forestry, and Other Land Use restock	Kanagawa	Gas-Insulated Transformers	1.200	0.007 🗸	8.4		

# 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, to estimate GHG emissions from use of electrical equipment, 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 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 <u>Column |Subdivision|</u> (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. <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 amount of F-gas used to recharge closed pressure equipment at servicing, in tonnes.
- 3. <u>Column |B|</u>: 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

Emissions from Electrical Equipment Mass balance Worksheet	ce approach - Tier 3 EF approach - Tier 3				
Sector: Industrial Processes and Product Category: Other Product Manufacture and U Subcategory: 2.G.1.b - Use of Electrical Equipm	Jse - Electrical Equipment				
	quipment - Mass balance approach - Tier 3				
Gas Sulphur Hexafluoride (SF6)	F-Gases Manager				
		Equation	1 8.6A		
Subdivision	Type of Equipment	Chemical used to recharge closed pressure equipment at servicing (tonnes)	Chemical recovered from closed pressure equipment at servicing (tonnes)	Emissions (tonnes)	Emissions (Gg)
۵7 م	7	A	В	C = A - B	C / 1000
Company EXELO	Closed-Pressure	2,000	200	1,800	1.8
*					
Total				1,800	1.8

# 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 <u>Column |Subdivision|</u> (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. <u>Column |A|</u>: input the total nameplate capacity of installed equipment, in tonnes. In <u>Column |A|</u> 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. <u>Column |Intro Year</u>]: input the year of introduction of that type of equipment in that subdivision.

<u>Note that</u> 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. <u>Column |Growth Rate|:</u>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.

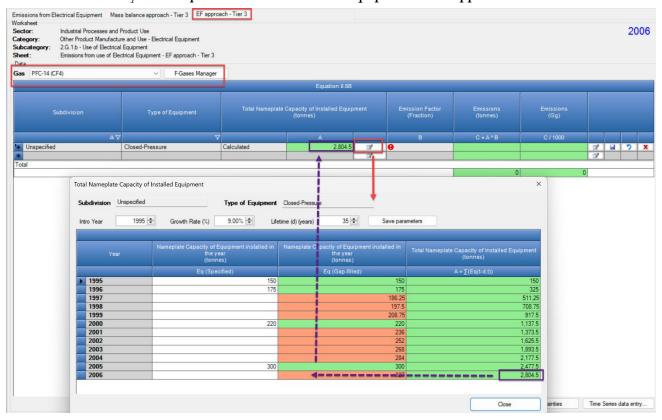
Note that: in the absence of country-specific information, an IPCC default factor of 9% may be used.

iii. <u>Column |Lifetime (d)|:</u> 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. <u>Column | Eq (specified) |:</u> input the nameplate capacity of equipment installed for each <u>known</u> 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. <u>Note that:</u> enter only data for known years in <u>Column | Eq (specified) |</u>. 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 <u>Column | Eq (specified) |</u>, 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 <u>Column | A|</u>.



#### 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  $SF_6$  (<u>Table 8.2</u>)
- ii) Closed-pressure electrical equipment (<u>Table 8.3</u>)
- iii) Gas-insulated transformers (<u>Table 8.4</u>)

<u>Note that</u>: 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 <u>Column |Subdivision|</u>, and each gas, EF data are input in worksheet **Emissions from Electrical Equipment,** row by row as follows:

1. <u>Column |B|</u>: Select the appropriate EF from the drop-down menu or from <u>Tables 8.2-8.4</u>, 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

ctor: Industrial Processes and Produ tegory: Other Product Manufacture and bcategory: 2.G.1.b - Use of Electrical Equip eet: Emissions from Electrical equip ta	d Use - Electrical Equipment pment				
as Sulphur Hexafluoride (SF6)	✓ F-Gases Manager				
		Equati	on 8.1, 8.2		
Subdivision	Type of Equipment	Total Nameplate Capacity of Installed Equipment (tonne SF6)	Use Emission Factor (Fraction SF6)	Equipment Use Emissions (tonne SF6)	Total Emissions (Gg SF6)
۵7		A	в	C = A * B	D = C / 1000
∆ ⊽ Kanagawa prefecture	Z Gas-Insulated Transformers	A 1.200	B 0.007	C = A * B 8.4	D = C / 1000
Kanagawa prefecture	Gas-Insulated Transformers	1,200	0.007	8.4	
Kanagawa prefecture	Gas-Insulated Transformers Closed-Pressure	1,200 10,000 50,000	0.007	8.4 270 350	

# 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 <u>Column</u> <u>Subdivision</u>, in <u>Column</u> <u>B</u> 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

ubcategory: 2.G.1.b - Use of Electrical	re and Use - Electrical Equipment	3				
as Sulphur Hexafluoride (SF6)	✓ F-Gases Manag	er				
			Equation 8.6B			
Subdivision	Type of Equipment	Total Nameplat	te Capacity of Installed Equipment (tonnes)	Emission Factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
Δγ		V	A	в	C = A * B	C / 1000
Company 2G2	Sealed-Pressure	Specified	1,000	0.01	5	

### **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

# <u>GHGs</u>

The Software includes the following GHGs for the Disposal of Electrical Equipment source category:

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
			Χ	Χ	Χ	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):

- ✓ <u>Tier 1: Equation 8.1</u>
- $\checkmark \quad \underline{\text{Tier 2: Equation 8.2}}$
- ✓ <u>Tier 3: Equations 8.3, 8.7a</u> (pure mass balance) <u>8.7b</u> (hybrid mass balance and EF approach), <u>8.8</u> (emissions from recycling), <u>8.9</u> (emissions from destruction) and <u>8.11</u> (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). <u>Note that</u> 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 closedpressure 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.

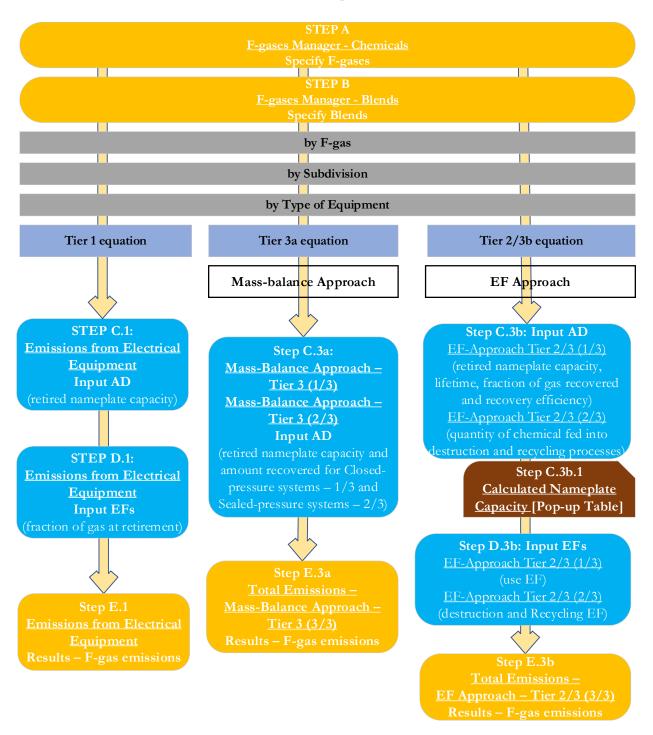
### User's Work Flowchart

For Disposal of Electrical Equipment, consistent with the key category analysis and the decision tree in <u>Figure 8.1</u> 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-specific⁵⁵ 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

<u>Section 8.2.2.3</u> 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.

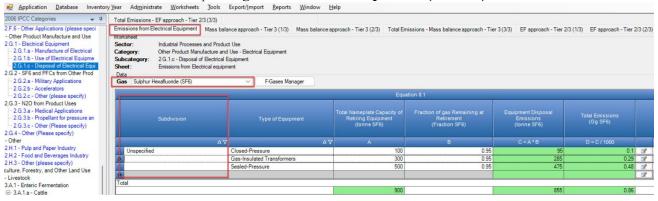
As a **starting step**, users must ensure that the **F-Gases Manager** has been populated for all F-gases to be reported for the source category **Disposal of Electrical Equipment**.

<u>Note that</u> 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 <u>above</u>. 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 CO₂ 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 <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 (national)



### Example: disposal of electrical equipment - Tier 1 AD input (multiple subdivisions)

<u>1 1</u>	1 1				/	
GIPCC Categories • 4 Total Emissions - EF approach - Tier 2/3 (3/3)	Capture and storage or other reduction					
Other Applications (please speci Emissions from Electrical Equipment Mass	balance approach - Tier 3 (1/3) Mass balance a	pproach - Tier 3 (2/3) Total E	missions - Mass balance approach - Tie	r 3 (3/3) EF approach - Tier 2	/3 (1/3) EF approach - Tier	2/3
er Product Manufacture and Use Worksheet						
- Electrical Equipment Sector: Industrial Processes and Pro	iduct Use					
G.1.a - Manufacture of Electrical Category: Other Product Manufacture	and Use - Electrical Equipment					
G.1.b - Use of Electrical Equipme Subcategory: 2.G.1.c - Disposal of Electric	al Equipment					
G.1.c - Disposal of Electrical Equi Sheet : Emissions from Electrical eq	upment					
- SF6 and PFCs from Other Prod Data						
G.2.a - Military Applications Gas Sulphur Hexafluoride (SF6)	V F-Gases Manager					
G.2.b - Accelerators						_
G.2.c - Other (please specify)		Equ	ation 8.1			
- N2O from Product Uses						
G.3.a - Medical Applications		Total Nameplate Capacity of	Fraction of gas Remaining at	Equipment Disposal		
G.3.b - Propellant for pressure an Subdivision	Type of Equipment	Retiring Equipment	Retirement	Emissions	Total Emissions	
G.3.c - Other (Please specify)		(tonne SF6)	(Fraction SF6)	(tonne SF6)	(Gg SF6)	
Other (Please specify)						
	Δ <u>Δ</u>	A	в	C=A*B	D = C / 1000	T
Pulp and Paper Industry Unspecified	Closed-Pressure	100	0.95	95	0.1	T
Food and Beverages Industry	Gas-Insulated Transformers	300	0.95	285	0.29	9
Other (please specify)	Sealed-Pressure	500	0.95	475	0.48	в
Forestry, and Other Land Use Tokyo City		1,000				+
STOCK	Sealed-Pressure	1,000	·			+
Enteric Fermentation	Closed-Pressure			<u> </u>		-
A.1.a - Cattle	Gas-Insulated Transformers	1.000		000	0.00	
-3 A 1 a i - Dairy Cows	Lesson and the second sec	1,900		855	0.86	81 - L

### 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, to estimate GHG emissions from disposal of electrical equipment, 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 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 <u>closed-pressure electrical equipment</u>, for each subdivision in <u>Column</u> <u>|Subdivision|</u> (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. <u>Column |Type of equipment|</u>: this worksheet is for closed-pressure equipment only, thus select Closed-Pressure from the drop-down menu.
- 2. <u>Column |A|</u>: input the total nameplate capacity of retired closed-pressure equipment, in tonnes. In <u>Column |A|</u> 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. <u>Column |Intro Year</u>]: input the year of introduction of that type of equipment in that subdivision.

<u>Note that</u> 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. <u>Column |Growth Rate|:</u>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. <u>Column | Lifetime (d) |: input the lifetime of installed equipment, in years.</u> <u>Note that</u>: the 2006 IPCC Guidelines do not provide a "default" but note a range of more than 30 to 40 years.
- iv. <u>Column |Eq (specified)|:</u> input the nameplate capacity of equipment installed for each <u>known</u> 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.

<u>Note that:</u> enter only data for known years in <u>Column | Eq (specified) |</u>. 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.

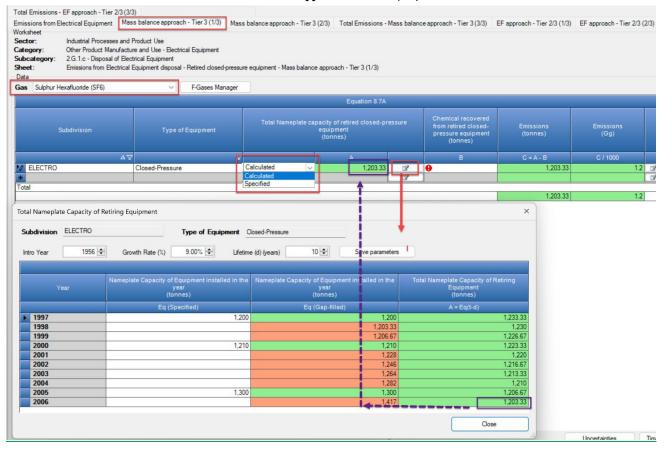
Do not enter 0 for unknown years, as the Software will include the 0 as a real number in the calculation for the interpolation/extrapolation. Enter 0 when that is the appropriate value to ensure that the bank of installed equipment does not extrapolate backwards or forwards into perpetuity; it is important 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 <u>Column |Eq (specified)|</u>, 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 <u>Column |A|</u>.

3. <u>Column |B|:</u> 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 <u>sealed-pressure electrical equipment</u>, for each subdivision in <u>Column</u> <u>|Subdivision|</u> and each chemical agent, data are input in worksheet **Mass Balance Approach – Tier 3 (2/3)**, row by row, as follows:

- 1. <u>Column |Type of equipment|</u>: 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. <u>Column |A|</u>: input the total nameplate capacity of retired sealed-pressure equipment, in tonnes. In <u>Column |A|</u> 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 sealedpressure electrical equipment for the given subdivision, based on information entered by the user in the pop-up table.
    - i. <u>Column |Intro Year</u>]: input the year of introduction of that type of equipment in that subdivision.

<u>Note that</u> 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. <u>Column |Growth Rate|:</u>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. <u>Column |Lifetime (d)|:</u> 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.
   <u>Note that:</u> enter only data for known years in <u>Column |Eq (specified)|</u>. 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. 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 <u>Column |Eq (specified)|</u>, 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 <u>Column |A|</u>.

- 3. <u>Column |B|:</u> input amount of F-gas recovered from sealed pressure equipment at retirement, in tonnes.
- 4. <u>Column |Use emissions calculated w/EF approach|:</u> 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.

<u>Note that</u>: 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. <u>Column | U_{EF} |:</u> input the annual EF for use of this equipment, fraction of the total nameplate capacity of the retired equipment. <u>Note that</u> the EF for use should be consistent with the Use EF in <u>Column | B |</u> for that subdivision/type of equipment in worksheet **EF** approach – Tier 3 of category 2.G.1.b.
- b. <u>Column |d|:</u> 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 <u>Column |A|</u> the same lifetime shall be input here.
- c. <u>Column |U|</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

ssions from El sheet tor: egory: icategory: icategory: icet: a	Industrial P Other Prod 2.G.1.c - D	Processes duct Manuf Disposal of	and Product Use acture and Use - Electrical Equipm	Electrical Equipm					ns - Mass baland	ce approach -`	Tier 3 (3/3) EF ap	proach - Tier 2/3 (	(1/3) EF approx	19
PFC-14 (C	(F4)			✓ F-Gase	s Manager									
							Equ Chemical	ation 8.2						
Subdivis	sion	Туре	of Equipment		late capacity of re pressure systems (tonnes)		recovered from retired sealed- pressure systems (tonnes)	Use emissions calculated with EF approach?	Use EF (Fraction)	Lifetime of equipment (years)	Lifetime Use Emissions from Sealed Equipment (tonnes)	Emissions (tonnes)	Emissions (Gg)	
	$\nabla$		V		A		В	Δ	Uef	d	U = A * Uef * d	C = A - U - B	C / 1000	
Unspecified		Sealed-I	ressure	Calculated	77.21835		9		0.005	35	13.51321	63.70514	0.06371	
Total Name	eplate Capa	acity of Re	tiring Equipme	nt								63.70514 ×	0.06371	
	ion Unspec		tiring Equipmen Growth Rat	Туре	of Equipment	Sealed-F me (d) (ye		i 🗘 Save	e parameters				0.06371	
Subdivisi	ion Unspec	cified	Growth Rat	Туре	% 🔹 Lifetir	me (d) (ye	ears) 35 elate Capacity of E y	Save Squipment installe ear nnes)		E	e Capacity of Retirie juipment tonnes)	×	0.06371	
Subdivisi	ion Unspec	cified	Growth Rat	r Type e (%) 9.00 pacity of Equipm the year	% 🔹 Lifetir ient installed in	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe	ed in the To	E0 (	quipment	×	0.06371	
Subdivisi	ion Unspec	cified	Growth Rat	e (%) 9.00 pacity of Equipm the year (tonnes)	% 🔹 Lifetir ient installed in	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe ear nnes) ap-filled)		E0 (	quipment tonnes)	×	0.06371	
Subdivisi Intro Year 1987 ▶ 1988 1989	Year	cified	Growth Rat	e (%) 9.00 pacity of Equipm the year (tonnes)	2 Difetir	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe ear nnes) ap-filled) 93	ed in the To 900 33.33333 66.66667	E0 (	quipment tonnes)	×	0.06371	
Subdivision Intro Year 1987 1988 1989 1990	Year	cified	Growth Rat	e (%) 9.00 pacity of Equipm the year (tonnes)	% 🔹 Lifetir ient installed in	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe ear nnes) ap-filled) 93	ed in the To 900 33.33333 66.66667 1,000	E0 (	quipment tonnes) = Eq(t-d)	ng	0.06371	
Subdivisi Intro Year 1987 1988 1989 1990 1991	ion Unspec	cified	Growth Rat	e (%) 9.00 pacity of Equipm the year (tonnes)	2 Difetir	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe ear innes) up-filled) 90	900 33.3333 66.6667 1.000 1.188.1	E0 (	juipment tonnes) = Eq(t-d) 	N9	0.06371	
Subdivisi Intro Year 1987 > 1988 1989 1990 1991 1992 1993	Year	cified	Growth Rat	e (%) 9.00 pacity of Equipm the year (tonnes)	2 Difetir	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe ear nnes) ap-filled) 90	900 33.3333 66.6667 1.000 1.188.1 .295.029	E0 (	juipment tonnes) = Eq(t-d) 54. 59. 64.	Ng 70342 262673 99314	0.06371	
Subdivisi Intro Year 1987 1988 1989 1990 1991	Year	cified	Growth Rat	e (%) 9.00 pacity of Equipm the year (tonnes)	2 Difetir	me (d) (ye	ears) 35 plate Capacity of E y (tor	Equipment installe ear nnes) pp-filled) 99 99 91 1,41	900 33.3333 66.6667 1.000 1.188.1	E0 (	uipment tonnes) = Eq(t-d) 	N9	0.06371	

# 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 <u>Column |Subdivision|</u> and each chemical agent, data are input in worksheet **EF Approach – Tier 2/3 (1/3)**, row by row, as follows:

- 1. <u>Column |Type of equipment|</u>: 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. <u>Column |A|:</u> input the total nameplate capacity of retired equipment, in tonnes. In <u>Column |A|</u> 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. <u>Column |Intro Year</u>]: input the year of introduction of that type of equipment in that subdivision.
  - ii. <u>Column |Growth Rate|:</u>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.

Column |Lifetime (d)|: input the lifetime of installed equipment in that subdivision, in ···· vears.

Note that: the 2006 IPCC Guidelines do not provide a "default" but a range of more than 30 to 40 years.

iv. <u>Column | Eq (specified) |:</u> 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 <u>Column | Eq (specified) |</u>, 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 <u>Column |A|</u> (see figure above for worksheet Mass balance approach-Tier 3 (1/3).

Column |C|: input the lifetime of installed equipment in that subdivision, in years. If the user selects 3. Calculated in Column |A| the lifetime is automatically populated based on the information entered in the pop-up table of <u>Column |A|</u>, 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.

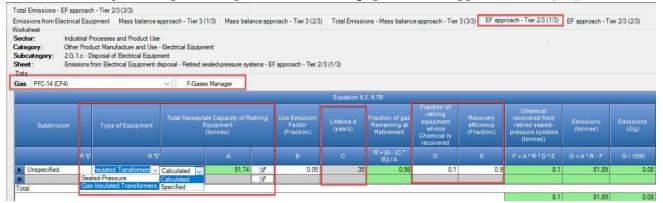
- <u>Column |D|</u>: input the fraction of retiring equipment whose chemical is recovered. 5.
- <u>Column |E|</u>: input the recovery efficiency of the chemical recovered, fraction.

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. <u>Column |A|:</u> input the quantity of chemical fed into the destruction process, in tonnes.
- 2. <u>Column |C|:</u> 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)

	Mass balance approach - Tier 3 (1/3)	Mass balance approach	h - Tier 3 (2/3) Total Er	nissions - Mass balance	approach - Tier 3 (3/3)	EF approach - Tier 2/3 (1/3)	F approach - Tier 2/3 (2/
ubcategory: 2.G.1.c - Disposal of	acture and Use - Electrical Equipment		er 2/3 (2/3)				
			Equation	n 8.2, 8.8, 8.9			-
Subdivision	Type of Equipment	Quantity of Chemical fed into destruction process (tonnes)	Destruction emission factor (Fraction)	Quantity of chemical fed into recycling process (tonnes)	Recycling emission factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
7 ۵	7	A	В	С	D	E = A * B + C * D	E / 1000
Unspecified	Sealed-Pressure	0.44	0.9	0.44	0.9	0.79	0
*							

### 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  $SF_6$  (<u>Table 8.2</u>)
- ii) Closed-pressure electrical equipment (<u>Table 8.3</u>)
- iii) Gas-insulated transformers (Table 8.4)

<u>Note that</u>: 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 <u>Column |Subdivision|</u>, and each gas, EF data are input in worksheet **Emissions from Electrical Equipment,** row by row as follows:

1. <u>Column |B|</u>: Select the appropriate EF from the drop-down menu or from <u>Tables 8.2-8.4</u>, or input manually a country-specific EF (as a fraction of gas remaining at retirement).

orksheet ector: Industrial Processes and Prod ategory: Other Product Manufacture a ubcategory: 2.G.1.c. Disposal of Electrica heet: Emissions from Electrical equi	nd Use - Electrical Equipment Equipment	pproach - Tier 3 (2/3) Total Em	issions - Mass balance ap	proach - Tie	r 3 (3/3) EF approach - Tier 2	2/3 (1/3) EF approach -	Tier 2/3	3 (2/3)
ata Gas Sulphur Hexafluoride (SF6)	F-Gases Manager	Equa	tion 8.1					
Subdivision	Type of Equipment	Total Nameplate Capacity of Retiring Equipment (tonne SF6)	Fraction of gas Remai Retirement (Fraction SF6)		Equipment Disposal Emissions (tonne SF6)	Total Emissions (Gg SF6)		
۵	Δ.Δ.	7 A	в		C = A * B	D = C / 1000		
Unspecified	Closed-Pressure Gas-Insulated Transformers	100 300		0.95 0.95 🗸	95 285		0.1	3
			Region	Erection o	of charge remaining at retireme	ot	F	Remark
	Sealed-Pressure	Type of Equipment Gas-Insulated Transformers	Japan	Tracaon c		.95 Not Reported		

### 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 <u>important note regarding sealed pressure systems</u> under Activity Data Input.

### EF/Hybrid approach (Tier 2 and Tier 3)

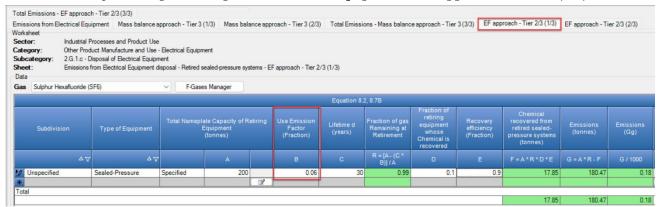
The Tier 2 and Tier 3 methods require the user to input facility-specific EFs for disposal for each gas and each subdivision in <u>Column |Subdivision|</u> in worksheet **EF Approach – Tier 2/3 (1/3),** row by row, as follows:

1. <u>Column |B|:</u> 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 <u>Column |Subdivision|</u> input information, row by row, as follows:

- 1. <u>Column |B|: input the destruction EF, as a fraction.</u>
- 2. <u>Column |D|:</u> 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)

	1 I T 0/10		T 3/200 T		1 7 0/0/01	FF 1 T 2/2 (1/2)	EF approach - Tier 2/3 (2
missions from Electrical Equipment	Aass balance approach - 1 ier 3 (1/3)	Mass balance approact	h - Tier 3 (2/3) Total En	nissions - Mass balance a	approach - Lier 3 (3/3)	EF approach - Tier 2/3 (1/3)	EP approach - Her 2/3 (.
industrial Processes a           Category:         Other Product Manufa           Subcategory:         2.G.1.c - Disposal of E	acture and Use - Electrical Equipment	ilissions - EF approach - Tie	er 2/3 (2/3)				
Gas Sulphur Hexafluoride (SF6)	✓ F-Gases Mar	nager					
			Equation	n 8.2, 8.8, 8.9			
Subdivision	Type of Equipment	Quantity of Chemical fed into destruction process	Destruction emission factor (Fraction)	Quantity of chemical fed into recycling process	Recycling emission factor (Fraction)	Emissions (tonnes)	Emissions (Gg)
		(tonnes)		(tonnes)			
Δ.Υ		(tonnes) A	B	(tonnes) C	D	E = A * B + C * D	E / 1000
∆ ⊽ * Unspecified	Sealed-Pressure				D 0.11	E=A*B+C*D 2.79	
		A		с			

# **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**

✓ <u>Tier 3: Equation 8.10</u>

### 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**.

<u>Note that</u> 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 <u>above</u>.

<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 CO₂ equivalents.

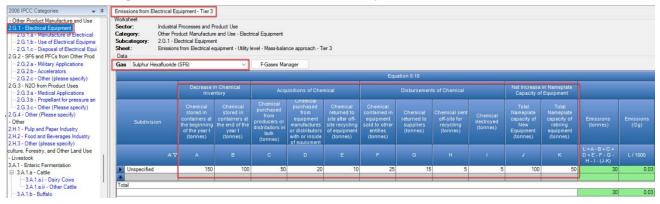
The procedure for populating the F-gases Manager is the same as for category 2.G.1.a Manufacture of Electrical Equipment (refer to Populating the F-gases manager and designating confidentiality for category: Manufacture of Electrical Equipment).

**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 <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> [subdivision] for each subdivision.

Then, for each subdivision in <u>Column |Subdivision|</u> and each chemical agent, data are input in worksheet **Emissions from Electrical Equipment – Tier 3,** row by row, as follows:

- 1. <u>Column |A|</u>: amount of F-gas (e.g., SF₆) stored in containers at the beginning of the year, in tonnes.
- 2. <u>Column |B|</u>: amount of F-gas stored in containers at the end of the year, in tonnes.
- 3. <u>Column |C|:</u> amount of F-gas purchased from chemical producers or distributors in bulk, in tonnes.
- 4. <u>Column |D|:</u> amount of F-gas purchased from equipment manufacturers or distributors with or inside of equipment, in tonnes.
- 5. <u>Column |E|</u>: amount of F-gas returned to site after off-site recycling, in tonnes.
- 6. <u>Column |F|</u>: amount of F-gas contained in equipment that is sold to other entities, in tonnes.
- 7. <u>Column |G|:</u> amount of F-gas returned to suppliers, in tonnes.
- 8. <u>Column |H|:</u> amount of F-gas sent off-site for recycling, in tonnes.
- 9. Column |1|: amount of F-gas destroyed, in tonnes.
- 10. <u>Column |H|</u>: total nameplate capacity of new equipment, in tonnes.
- 11. <u>Column |K|:</u> 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 SF₆ and PFCs from Other Product Uses

This category includes use of SF₆ and PFCs in all products, except those already includes elsewhere. The *2006 IPCC Guidelines* include the following activities under source category 2.G.2:

- ✓ <u>2.G.2.a Military applications</u>
- ✓ <u>2.G.2 b Accelerators</u>
- ✓ 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 <u>category 2.G.1</u>) and aluminium production (covered in <u>category 2.C.3</u>) and semiconductors (covered in <u>category 2.E</u>).

# 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).

### <u>GHGs</u>

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**

- $\checkmark \quad \underline{\text{Tier 1}: \text{Equation 8.12}}$
- ✓ <u>Tier 2</u>: <u>Equation 8.13</u>
- ✓ <u>Tier 3</u>: 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:

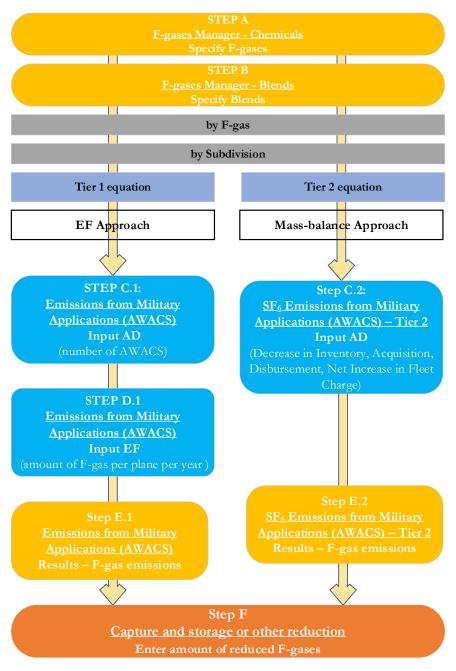
- ✓ F-gases Manager: contains data on F-gases used (including imported) and/or produced and exported in the country.
- Emissions from Military Applications (AWACS): contains for each gas information on the number of AWACS and an EF. The worksheet calculates the associated SF₆ and PFCs emissions for Tier 1.
- SF₆ Emissions from Military Applications (AWACS) Tier 2: contains mass-balance information on the amount of SF₆: decrease in inventory, acquisitions, disbursements and net increase in AWACS charge. The worksheet calculates the associated SF₆ 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 <u>Figure 8.2</u> 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-specific⁵⁶ 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 SF₆ Emissions from Military Applications (AWACS) – Tier 2, users collect and input in the *Software* information on the net decrease in the SF₆: inventory in the year, acquisitions of SF₆, disbursements of SF₆ 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 <u>important notes to avoid double counting of</u> <u>F-gas consumption</u> 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.

<u>Note that</u> 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 <u>above</u>.

<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 CO₂ 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 <u>2.F.1 Refrigeration and Air Conditioning</u>.

**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 <u>Column |S| [e.g. "country name" or "Unspecified" as selected from the drop-</u>

down menu] or where subnational aggregations are input, provide the univocal name/code into  $\underline{\text{Column } |S|}$  for each subdivision.

ssions from Milit kaheet	ary Application	is (AWACS)	F6 Emissions fr	om Military Appli	cations (AIMACS	) - Tier 2 Capt	ure and storage of	or other reduction	on										
stor: li egory: C scategory: 2	Other Product N 2.G.2.a - Military SF6 Emissions f	sses and Product Manufacture and I Applications rom Military Applic	Jse - SF6 and PF		oduct Uses														20
		10			-					Equation 8.1	13			5					
		Decn	ease in SF6 Inve	entory		Acquisitio				Dis	bursements o			Netl	icrease in AWA	CS Fleet Charg	e		
	Name of the system		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)		Acquisitions of SF6 (tonnes)	SF8 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)
	۵V	A				E	F	G = D + E + F		t	J	к	L=H+I+J+ K		N	0	P = M * (N - O)	Q = (C + G - L - P)	
Rest of Japan		1,700						95		10		10	30	0.013	þ	5	-0.07	1,715.07	1
	A1	100	20	80	10	10		20		10				0.013	0		-0.07	90.07	0.0

# Example: multiple subdivisions

# When the Tier 1 Equation is applied

For each subdivision in <u>Column |Subdivision|</u>, and each gas, data are input in worksheet **Emissions from Military Applications (AWACS)** row by row, as follows:

1. <u>Column |A|</u>: enter the number of AWACS in the fleet

### *Example:* military applications – AD for Tier 1

missions from Military Applicati	ons (AWA	SF6 Emis	sions from Military Applications (AWACS) - Tier	r 2 Capture and storage or other reduction	
ategory:         Other Product           ubcategory:         2.G.2.a - Milita           heet:         Emissions from	t Manufac ary Applic		S and PFCs from Other Product Uses		
Data Gas Sulphur Hexafluoride (SFI	6)	0	F-Gases Manager		
Sas Suprior Hexandonde (SP	~		i dadee manager		
	-			Equation 8.12	
National AWACS Fleet (number of AWACS)			Emission Factor (kg SF6 / plane)	Equation 8.12 Emissions (kg SF6)	Emissions (Gg SF6)
National AWACS Fleet			Emission Factor	Emissions	
National AWACS Fleet (number of AWACS)	20 😧		Emission Factor (kg SF6 / plane)	Emissions (kg SF6)	(Gg SF6)
National AWACS Fleet (number of AWACS)		Default Value	Emission Factor (kg SF6 / plane) B	Emissions (kg SF6)	(Gg SF6)

### When the Tier 2 Equation is applied

For each subdivision in <u>Column |Subdivision|</u>,  $SF_6$  data are input in worksheet  $SF_6$  Emissions from Military Applications (AWACS)- Tier 2, row by row, as follows:

1. <u>Column | Name of the System |</u>: input name of the military system where  $SF_6$  is used.

### Decrease in SF₆ Inventory

- 2. <u>Column |A|</u>: input amount of SF₆ stored in containers at the beginning of the year, tonnes.
- 3. <u>Column |B|:</u> input amount of SF₆ stored in containers at the end of the year, tonnes.

### Acquisitions of SF₆

- 4. <u>Column |D|: input amount of SF₆ purchased from chemical producers or distributors in bulk, tonnes.</u>
- 5. <u>Column |E|</u>: input amount of SF₆ purchased from AWACS manufacturers or distributors with or inside of new planes, tonnes.
- 6. <u>Column |F|:</u> input amount of SF₆ returned to site after off-site recycling, tonnes.

### Disbursements of SF₆

- 7. <u>Column |H|</u>: input SF₆ contained in AWACS that are transferred to other entities, tonnes.
- 8. <u>Column |I|</u>: input amount of SF₆ returned to suppliers, tonnes.
- 9. <u>Column |J|</u>: input amount of SF₆ sent off-site for recycling, tonnes.
- 10. Column |K|: input amount of SF₆ destroyed, tonnes.

# Net increase in AWACS Fleet Charge

- 11. Column |M|: input amount of SF₆ charged into each AWACS system, in tonnes (default charge is 0.013t)
- 12. <u>Column |N|</u>: input number of new AWACS units.
- 13. <u>Column |O|:</u> input number of retiring AWACS units.

#### *Example:* military applications – AD for Tier 2 SF6 Emissions from Military Applications (AWACS) - Tier 2 Emissions from Military Applications (AWACS) 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 2.G.2.a - Military Applications Subcategory: Sheet: SF6 Emissions from Military Applications (AWACS) - Tier 2 Data F-Gases Manager Decrease in SF6 Inventory Acquisitions of SF6 SF6 purchased from AWACS SF6 stored in containers at purchased from chemica SF6 stored in SF6 returned Name of the system manufacturers or distributors the beginning SF6 Inventory -site recycling year (tonnes) distributors in bulk of new planes (tonnes) $\Delta \nabla$ $\Delta \nabla$ C = A - B 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 Disbursements of SF6 Net Increase in AWACS Fleet Charge contained in AWACS that Net Increase in AWACS Fleet Charge Retiring AWACS The charge of the system (tonnes) New AWACS (Number of units) SF6 SF6 returned Emissions (tonnes) are transferred to to suppliers (tonnes) destroyed (tonnes) of SF6 (tonnes) recycling (tonnes) umber units) other entities (tonnes) Q / 1000 -0.07 1,715.07 1.72 10 0.013 0 10 10 30 0 5 0 10 0 0 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 <u>Table 8.7</u>.

### When the Tier 1 Equation is applied

For each subdivision in <u>Column |Subdivision|</u>, and each gas, data are input in worksheet **Emissions from Military Applications (AWACS),** row by row, as follows:

 <u>Column |B|</u>: select from the drop-down menu the default Tier 1 SF₆ EF of 740 kg/plane or enter manually a country-specific EF the F-gas. <u>Note that</u> the user shall the relevant gas in the "Gas" bar at the top, to enter data for each F-gas one by one

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**

SF₆ 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) (SF₆ and PFCs)
- $\checkmark$  Emissions from Military Applications (AWACS) Tier 2 (SF₆ only)

Total SF₆ 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. <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).
- 5. <u>Column |A|</u>: not applicable for this category.
- 6. <u>Column |B|:</u> collect and input information on any other long-term reduction of F-gas emissions, in tonnes. <u>Note that</u>: any destruction estimated in the Tier 2 worksheet should not be included in <u>Column |B|</u>. 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 SF₆ 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

ctor:	Industrial Processes and Pro	oduct Use						
tegory:	Other Product Manufacture	and Use						
bcategory:	2.G.2.a - Military Applications	ns						
eet:	Capture and storage or other	er reduction						
ta								
S PEC-14 (C	CE4)	- F-	Gases Manager					
as PFC-14 (C	CF4)	~ F4	Gases Manager					
as PFC-14 (C	CF4)	F4	Gases Manager					
as PFC-14 (C	CF4)		Gases Manager	1	Amount CO2 captured and	Other advatian	Tabl aduation	Total as dualing
as PFC-14 (C	CF4) Subdivision	F	Sases Manager		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
IS PFC-14 (C					stored			
as PFC-14 (C	Subdivision		Source SRC	۵V	stored (tonne)	(tonne)	(tonne)	(Gg)

# 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.

# <u>GHGs</u>

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**

- ✓ <u>Tier 1</u>: <u>Equation 8.14</u> (university and research) and <u>Equation 8.18</u> (industrial and medical particle accelerators)
- $\checkmark \quad \underline{\text{Tier 2: }} \underline{\text{Equation 8.15}} \text{ (all accelerators)}$
- ✓ <u>Tier 3: Equation 8.16</u> and <u>Equation 8.17</u> (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:

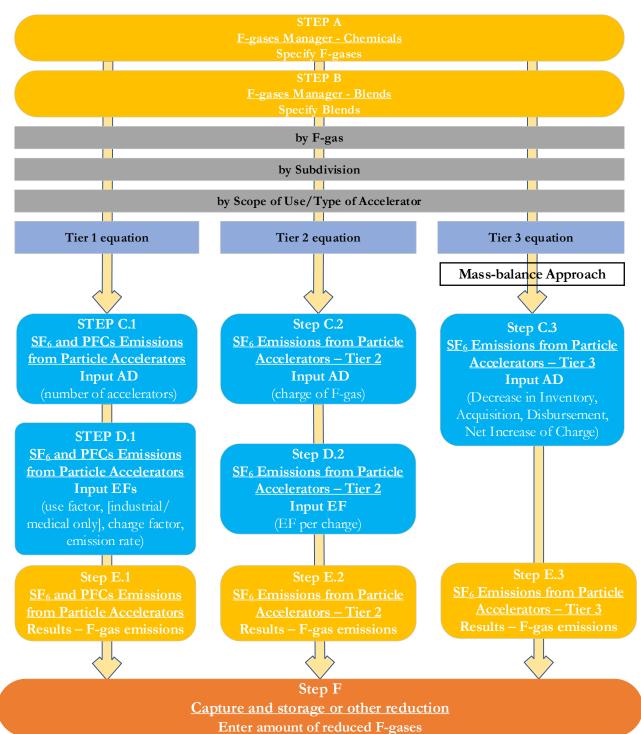
- ✓ F-gases Manager: contains data on F-gases used (including imported) and/or produced and exported in the country.
- ➢ SF₆ and PFCs Emissions from Particle Accelerators: contains for each subdivision, each F- gas and type of accelerator, information on the number of accelerators and default EFs (use factor, charge factor and EF). The worksheet calculates the associated F-gas emissions for Tier 1.
- SF₆ 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 SF₆ emissions for Tier 2.
- SF₆ Emissions from Particle Accelerators Tier 3: contains mass-balance information on the amount of SF₆: decrease in inventory, acquisitions, disbursements and net increase in accelerator charge. The worksheet calculates the associated SF₆ 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 <u>Figure 8.3</u> (research accelerators) and <u>Figure 8.4</u> (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-specific⁵⁷ 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.





Tier 2 methodological approach can be implemented either applying different region-specific EFs or applying to both regions the countryspecific 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 SF₆ 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 SF₆ 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 SF₆: inventory in the year, acquisitions of SF₆, disbursements of SF₆ 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

<u>Section 8.3.2.1</u> 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). <u>Section 8.3.2.3</u> provides generic information on the choice of AD for all Use of SF₆ 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 <u>F-gas consumption</u> 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 **SF₆ 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 <u>above</u>.

<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 CO₂ equivalents.

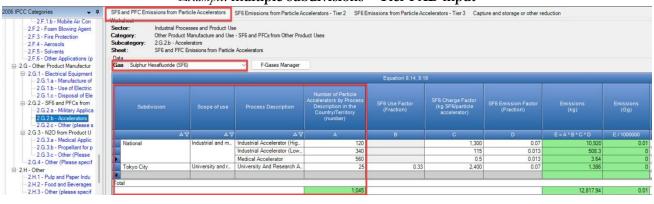
For a Figure illustrating Populating the F-gases manager and designating confidentiality for Accelerators, the user may refer to the illustration in category <u>2.F.1 Refrigeration and Air Conditioning</u>.

**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 <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> [subdivision] for each subdivision.

# When Tier 1 Equations are applied

For each subdivision in <u>Column |Subdivision|</u> and each gas, data are input in worksheet  $SF_6$  and PFCs Emissions from Particle Accelerators row by row, as follows:

- 1. <u>Column | Scope of Use|</u>: select from the drop-down menu: *university and research* or *industrial and medical*.
- 2. <u>Column |Process Description|</u>: 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. <u>Column |A|</u>: 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 <u>Column |Subdivision|</u>, data are input in worksheet  $SF_6$  Emissions from Particle Accelerators – Tier 2 row by row, as follows:

- 1. <u>Column | Scope of Use |</u>: select from the drop-down menu: *university and research* or *industrial and medical*.
- 2. <u>Column |Process Description|</u>: 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. <u>Column |A|</u>: input the sum of the individual accelerator charge for the accelerators in that subdivision/scope of use/process description, in kg charge.

orksheet ector: ategory: ubcategory: neet: ata	Other Product Manufacture 2.G.2.b - Accelerators	I Processes and Product Use oduct Manufacture and Use - SF6 and PFCs from Other Product Uses - Accelerators ssions from Particle Accelerators - Tier 2								
F-Gases Manager										
				Equation 8.15						
	Subdivision	Scope of use	Process Description	Σ Individual Accelerator Charges	SF6 Emission Factor (kg/kg of SF6 charge or fraction)	SF6 Emissions (kg)	SF6 Emissions (Gg)			
	Subdivision			(kg of charge)	naciony					
	Subdivision	۵7	۵ <b>۷</b>	(kg of charge) A	в	C = A * B	C / 1000000			
National		스 꼬 University and research	∆ ⊽ University And Research Accelerator			C = A * B 81.6				

### *Example:* accelerators – Tier 2 AD input

When Tier 3 Equations are applied

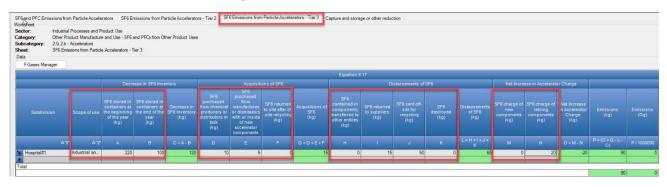
For each subdivision in <u>Column |Subdivision|</u> data are input in worksheet  $SF_6$  Emissions from Particle Accelerators – Tier 2 row by row

- 1. <u>Column | Scope of Use |</u>: select from the drop-down menu: *university and research* or *industrial and medical*.
- 2. <u>Columns |A| |K|</u>: the Decrease in SF₆ inventory, Acquisitions of SF₆, and Disbursements of SF₆ are filled in with user-specific information, in kg, in the same manner as for <u>Tier 2 military applications</u>.

### Net increase in Accelerator Charge

- 3. <u>Column |M|</u>: input the amount of SF₆ which is charged to new accelerator components, kg.
- 4. <u>Column |N|</u>: input amount of SF₆ which is charged to retiring accelerator components, kg.

### Example: Accelerators – Tier 3 AD input



# **Emission Factor Input**

Section <u>8.3.2.1</u> in Chapter 8 Volume 3 of the 2006 IPCC Guidelines provides some default EFs in the explanation to equations, while section <u>8.3.2.2</u> provides generic information on the choice of EF for all Use of SF₆ and PFCs in Other Products.

In addition, specific default factors are provided in <u>Table 8.9</u> (average  $SF_6$  charge in particle accelerators, by process description, for Tier 1) and <u>Table 8.10</u> (Tier 2 EFs for industrial and medical accelerators).

### When Tier 1 Equations are applied

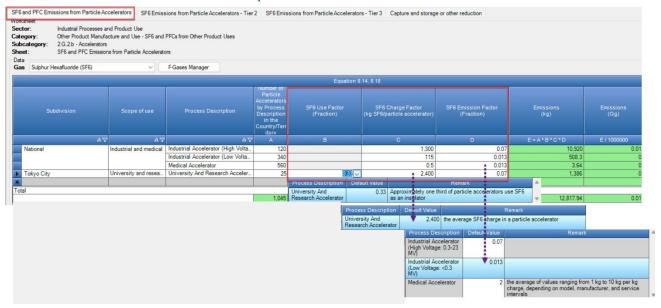
For each subdivision in <u>Column |Subdivision|</u>, gas, scope of use, and process description, data are input in worksheet  $SF_6$  and PFCs Emissions from Particle Accelerators, row by row, as follows:

1. <u>Column |B|:</u> (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 SF₆ only) or manually input a user-specific fraction.

<u>Note that</u> the user shall the relevant gas in the "Gas" bar at the top, to enter data for each F-gas one by one

in <u>Table 8.10</u>.

- 2. <u>Column |C|</u> 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. <u>Note that</u> the IPCC default SF₆ charge for university and research accelerators is 2400 kg SF₆ per accelerator, while default values for industrial/medical accelerators may be found in <u>Table 8.9</u>.
- 3. <u>Column |D|</u> 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. <u>Note that</u> the IPCC default SF₆ EF for university and research accelerators is 0.7, while default values for industrial/medical accelerators may be found



### Example: accelerators – Tier 1 EFs

## When the Tier 2 Equation is applied

For each subdivision in <u>Column |Subdivision|</u>, 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. <u>Column |B|</u>: the default SF₆ EF will be automatically populated in this column based on the processdescription selected. The user many enter manually a country-specific SF₆ EF.

### Example: accelerators – Tier 2 EFs

F6 and PFC Emissions from Particle Accelerato orksheet ector: Industrial Processes and Produ ategory: Other Product Manufacture an ubcategory: 2,G,2.b - Accelerators heet: SF6 Emissions from Particle Ac	ict Use d Use - SF6 and PFCs from Other P		article Accelerators - Tier 3 Ca	pture and storage or other reductio	n	
Data						
F-Gases Manager			Equation 8.15			
			Equation 6.15			
Subdivision		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)
Δ	V Δ	7 ۵	7 A	В	C = A * B	C / 1000000
National	University and research	University And Research Accelerator	1,200 0.07		81.6	
Unspecified	Industrial and medical	ndustrial Accelerator (Low Voltage: <0.3 MV) 🥪	1,500	1,500 * 0.01		
* Total		Process Description (kg/kg of SF6 charge		Remark		
		Industrial Accelerator (High Voltage: 0.3-23 MV)	0.07		101.1	
		Industrial Accelerator (Low Voltage: <0.3 MV)	0.013			
		Medical Accelerator	2 the average of v charge, dependi intervals	alues ranging from 1 kg to 10 kg pe ng on model, manufacturer, and se	er kg rvice	

### 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: SF₆ and PFCs Emissions from Particle Accelerators
- Tier 2: SF₆ Emissions from Particle Accelerators Tier 2
- Tier 3: SF₆ 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. <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).
- 5. <u>Column |A|</u>: not applicable for this category.
- 6. <u>Column |B|: collect and input information on any other long-term reduction of F-gas emissions, in tonnes.</u> <u>Note that</u>: any destruction estimated in the Tier 3 worksheet should not be included in <u>Column |B|</u>.

### Example: capture and storage or other reduction

SF6 and PFC Emi	issions from Particle Accelerators SF	6 Emissions from Particle Accelerators - Tier 2	SF	6 Emissions from Particle Accelerato	rs - Tier 3	Capture and storage or	other reduction	
Worksheet								
Sector:	Industrial Processes and Product Use							
Category:	Other Product Manufacture and Use							
Subcategory:	2.G.2.b - Accelerators							
Sheet:	Capture and storage or other reduction							
Data								
	lexafluoride (SF6)	✓ F-Gases Manager						
		,		,				
	Subdivision			Amount CO2 captured and stored (tonne)		ther reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
	S AV	SRC	Δγ					C / 1000
* Hospital#1		stream2				2	2	0
*								
Total								
							2	0

# 2.G.2.c Other (please specify)

# **Information**

Section 8.3.2.1 in the 2006 IPCC Guidelines provide guidance with specific equations for:

- ✓ Adiabatic uses,
- ✓ Sound-proof glazing,
- ✓ Other uses of SF₆ 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.

# <u>GHGs</u>

The Software includes the following GHGs for Other (SF6 and PFCs from Other Product Uses)

CO ₂	$CH_4$	$N_2O$	HFCs	PFCs	SF ₆	NF ₃
	-		<b>X</b> (waterproofing only)	<b>X</b> (all, except sound- proof glazing)	X (all)	

# **IPCC Equations**

- ✓ <u>Tier 1: Equation 8.19</u> (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)
- ✓ <u>Tier 2</u>: No Tier 2 Equations provided
- ✓ <u>Tier 3</u>: 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.

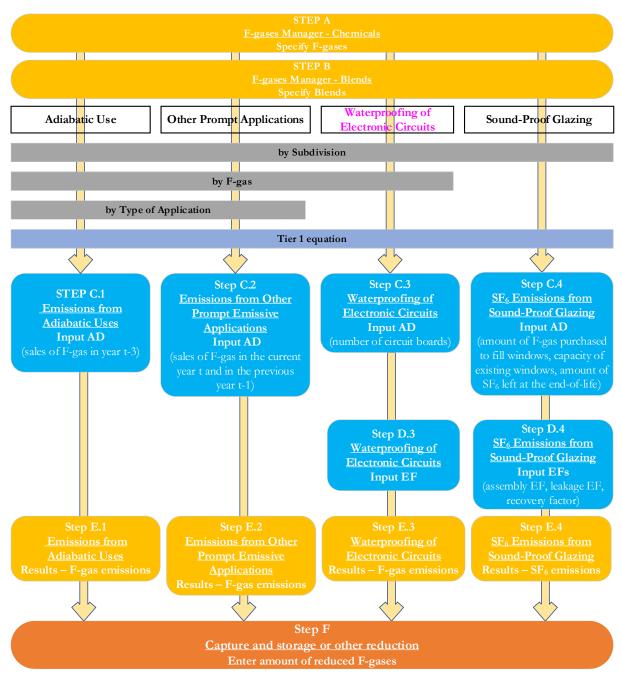
# Software Worksheets

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.
- ✓ SF₆ Emissions from Sound-Proof Glazing: contains for each subdivision, information on the amount of SF₆ emissions from assembly, use and disposal. The worksheet calculates the associated SF₆ 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 (SF₆ 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 SF₆ 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 SF₆ 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 SF₆ 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 <u>F-gas consumption</u> 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 SF₆ Emissions from Sound-Proof Glazing, which is only SF₆ 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.

<u>Note that</u> 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 <u>above</u>.

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 CO₂ equivalents.

For a Figure illustrating **Populating the F-gases manager and designating confidentiality for Other (SF₆ and <b>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 SF₆ and PFCs from Other Products 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 <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 Tier 1 Equations are applied

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

- 1. <u>Column | Type of Application |</u>: manually specify the type of adiabatic use.
- 2. <u>Column |A|</u>: 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

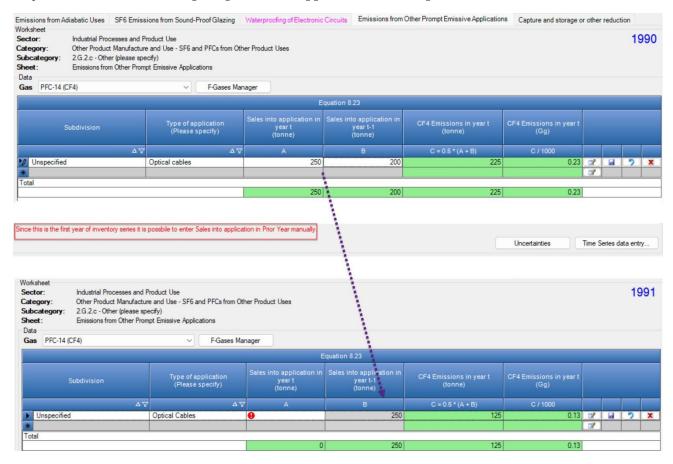
Emissions from A	Adiabatic Uses SF6 Emissions fi	rom Sound-Proof Glazing Waterproofin	g of Electronic Circuits Emissi	ons from Other Prompt Emissive A	Applications Capture and stor	age or o	ther reduct	tion	
Worksheet Sector: Category: Subcategory: Sheet: Data	Industrial Processes and Product Other Product Manufacture and 2.G.2.c - Other (please specify) Emissions from Adiabatic Uses	: Use Use - SF6 and PFCs from Other Product Us	es					19	91
Gas PFC-14	(CF4)	✓ F-Gases Manager							
			Equation 8.19						
	Subdivision	Type of application (Please specify)	Sales into application in year t-3 (tonne)	CF4 Emissions in year t (tonne)	CF4 Emissions in year t (Gg)				
	۵۲	7 A 7	A	B = A	B / 1000				
😽 Unspecifie	d	General uses	2,500	2.500	2.5	3		2	×
*		,				2			
Total									
			2.500	2.500	2.5				

<u>Then</u>, for each subdivision in <u>Column |Subdivision|</u>, and each gas, data are input in worksheet **Emissions from Other Prompt Emissive Applications** row by row, as follows:

- 1. <u>Column | Type of Application |</u>: input any other type of application of SF₆ and/or PFCs in the country (e.g. user of tracers in leak detection, in optical cables).
- 2. <u>Column |A|</u>: input the tonnes of sales of the chemical for this type of application in current year, in tonnes. <u>Note that</u>: as always it is important to save after entering the data. This ensures that the value is available for automatic population of <u>Column |B|</u> for the next year. Data should be entered from the first inventory year in the time series, forward, to ensure proper calculations.
- 3. <u>Column |B|</u>: 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 <u>Column |B|</u>. For all other years, this

value is automatically populated using the value entered in <u>Column |A|</u> 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



<u>Then</u>, for each subdivision in <u>Column |Subdivision|</u>, and each gas (note that for this category ALL gases must be entered, HFC-23, CF₄ and C₂F₆), data are input in worksheet <u>Waterproofing of Electronic Circuits</u> row by row, as follows:

1. <u>Column |n|</u>: input the number of circuit boards manufactured *(see image under EF input)*.

Then, for each subdivision in <u>Column |Subdivision|</u> data are input in worksheet  $SF_6$  Emissions from Sound-**Proof Glazing** row by row, as follows:

- 1. <u>Column |A|:</u> input the amount of SF₆ purchased to fill windows assembled in year t, in tonnes.
- 2. Column |D|: input the capacity (amount of SF₆) of existing windows in year t, in tonnes. <u>Note that</u> the total installed capacity reflects the total amount of SF₆ in existing windows, including domestically manufactured and imported, and excluding exports, and considering the lifetime of windows. <u>In a future release</u> in <u>Column |D|</u> 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 SF₆ remaining in windows at the end-of-lifetime in year t, in tonnes. <u>Note that</u>: 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. <u>In a future release</u>, 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 SF₆ EFs from Sound-proof Glazing are found in <u>Equations 8.20 and 8.21</u>. Section <u>8.3.2.2</u> provides generic information on the choice of EF for all Use of SF₆ and PFCs in Other Products.

EFs for Waterproofing of Electronic Circuits may be found in Table 8.11 (New) of the 2019 Refinement.

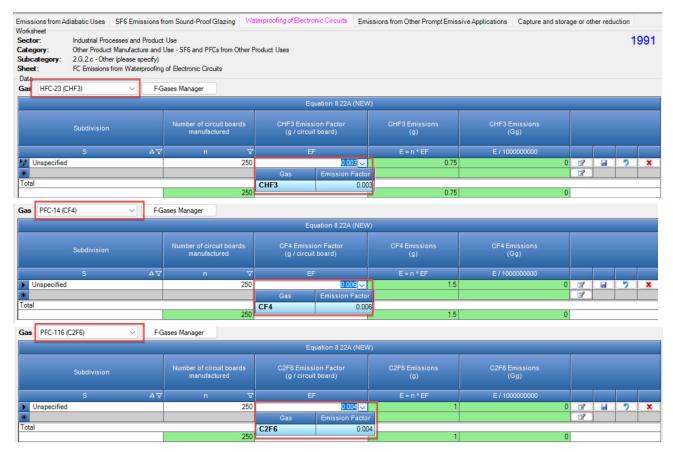
### When Tier 1 Equations are applied

<u>F</u>or each subdivision in <u>Column |Subdivision|</u>, and each gas (note that for this category ALL gases must be entered, HFC-23, CF₄ and  $C_2F_6$ ), data are input in worksheet <u>Waterproofing of Electronic Circuits</u> row by row, as follows:

1. <u>Column |EF|</u>: select from the drop-down menu the EF for the relevant gas or manually input a user-specific value, in grams/circuit board.

<u>Important:</u> 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



<u>Then</u>, for each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet **Emissions from Sound-proof Glazing**, row by row, as follows:

- 1. <u>Column |B|</u>: select from the drop-down menu or manually input a user-specific EF for assembly, fraction. <u>Note that</u>: the IPCC default EF is 0.33.
- 2. <u>Column |E|</u>: select from the drop-down menu or manually input a user-specific EF for leakage, fraction. <u>Note that</u>: the IPCC default EF is 0.01.

3. <u>Column |H|</u>: select from the drop-down menu or manually input a user-specific recovery factor, fraction. <u>Note that:</u> the IPCC default EF is 0.

Category: Other Pro Subcategory: 2.G.2.c -	Processes and Pro duct Manufacture Other (please spec sions from Sound-P	and Use - SF6 and PF fy)	Cs from Other Prod	duct Uses							
F-Gases Manager											
					Equation	8.20 - 8.22					
Subdivision	SF6 Purchased to Fill Windows Assembled in Inventory Year (SF6 tonne)	Assembly Emission Factor (Fraction)	Assembly Emissions (tonne SF6)	Capacity of Existing Windows in Inventory Year (tonne SF6)	Leakage Emission Factor (Fraction)	Leakage Emissions (tonne SF6)	Amount Left in Windows at End of Lifetime (Disposed of in Inventory Year)	Recovery Factor (Fraction)	Disposal Emissions (tonne SF6)	Emissions in year t (tonne SF6)	Emissions i yeart (Gg SF6)
		В	C = A * B				G				J / 1000
Δ 7	A										

#### 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
- ✓ SF₆ 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 SF₆ 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 SF₆ and PFC emissions.* 

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

- 1. <u>Column |CH|</u>: 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. <u>Note that</u>, 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. <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).
- 3. <u>Column | A |</u>: not applicable for this category.
- 4. <u>Column |B|:</u> collect and input information on any other long-term reduction of F-gas emissions, in tonnes.

PFC-14 (CF4)     FGases Manager       Subdivision     Type of other product use     Source     Amount CO2 captured and stored (tonne)     Other reduction (tonne)     Total reduction (tonne)     Total reduction (conne)       S     A T     CH     A T     SRC     A T     A     B     C=A+B     C/1000     1       Unspecified     Doted reduction     ID Bream 2     100     100     100     1     7	_		
Subdivision         Type of other product use         Source         Storrå (tonne)         Other reduction (tonne)         Total reduction (Gg)           S         Δ V         CH         Δ V         SRC         Δ V         A         B         C = A + B         C / 1000			_
100 100 100 01 -2			
Adabatic uses Soundarco V index	a 🤊	d	a

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

#### 2.G.3 N₂O 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.

#### <u>GHGs</u>

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 N₂O from product uses):

CO ₂	CH ₄	$N_2O$	HFCs	PFCs	SF ₆	NF ₃
		X				

#### **IPCC Equations**

- $\checkmark$  <u>Tier 1</u>: <u>Equation 8.24</u>
- ✓ <u>Tier 2</u>: No Tier 2 Equations provided
- ✓ <u>Tier 3</u>: 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

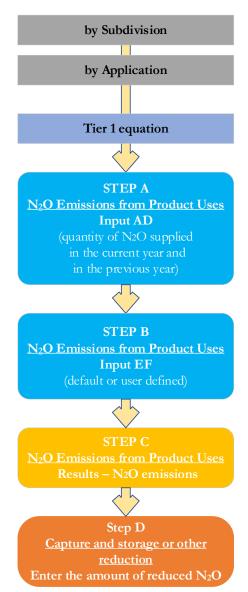
N₂O emissions from categories 2.G.3.a (medical applications), 2.G.3.b (Propellant for pressure and aerosol products) and 2.G.3.c (Other N₂O from product uses) are estimated using the following worksheets:

- N₂O Emissions from Product Use: contains for each subdivision and each type of application information on quantity of N₂O supplied in the current and the previous year and N₂O EF. The worksheet calculates the associated N₂O emissions.
- $\triangleright$  Capture and storage or other reduction contains information on reduction of N₂O, 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 N₂O 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:



#### N₂O 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  $N_2O$  Emissions from Product Use for each source category, users collect and input in the *Software* information on the amount of on quantity of  $N_2O$  supplied in the current year and the previous year.

Step B, in worksheet  $N_2O$  Emissions from Product Use, for each source category, users input the relevant  $N_2O$  EF.

Step C, in worksheet  $N_2O$  Emissions from Product Use for each source category, the *Software* calculates the associated  $N_2O$  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 N₂O 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 N₂O from Product Uses source category.

Input of AD for N₂O 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 dropdown menu] or where subnational aggregations are input, provide the univocal name/code into Column |Subdivision| for each subdivision



Example: multiple subdivisions

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet  $N_2O$  Emissions from Product Use, row by row, as follows:

- 1. <u>Column | Type of Application |</u>: input the type of application (e.g., medical, propellant, other specific).
- 2. <u>Column | A |</u>: input the quantity of N₂O supplied in the current year, in tonnes.
- 3. <u>Column |B|:</u> input the quantity of N₂O supplied in the previous year in tonnes. The user may either specify or calculate this value (see figure below).
  - Specified. In the first year of the inventory time series, the user must select specify and directly enter a. a value in <u>Column | B|</u>. For all other years of the time series, the user may choose to directly specify the value, or calculate the value as described below.
  - *Calculated:* The value is automatically populated using the value entered in <u>Column |A|</u> in year t-1. b. 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 N₂O for use in medical applications, use as propellants in aerosol products and others uses.

For each subdivision in <u>Column |Subdivision|</u>, data are input in worksheet  $N_2O$  Emissions from Product Use, row by row, as follows:

1. <u>Column |C|</u>: 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 N₂O 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

tegory: Other Pr bcategory: 2.G.3.a	Processes and Product Us oduct Manufacture and Use Medical Applications ssions from Product Uses		om Product Us	e							l	199
						Equation 8.24						
Subdivision	Type of applica (Please speci	tion y)	N2O Quan supplied in y (tonne)	/ear t		ipplied in yeart - 1 nne)	Emission Factor (Fraction)	N2O Emissions in year t (tonne)	N2O Emissions in year t (Gg)			
	ΔV	ΔV	A	ĺ		В	С	D = (0.5 * A + 0.5 * B) * C	D / 1000			
Northern	Medical Application	s		200	Specified	100	1	15		2		2
Southern	Medical Application	S	1	500	Specified	250	1	37	5 0.38	"with the second		
										2		
			· · · · ·	- 1		1						
		-,		700		350		52	5 0.53		-	
orksheet ector: Industri ategory: Other P ubcategory: 2.G.3.a heet: N20 Er	Il Processes and Product Us oduct Manufacture and Use Medical Applications issions from Product Uses	-	om Product Us	N		350		52	5 0.53		[	99
ategory: Other P ubcategory: 2.G.3.a	oduct Manufacture and Use - Medical Applications	-	om Product Us	N				52	5  0.53		[	99
orksheet ector: Industri ategory: Other P ubcategory: 2.G.3.a heet: N20 Er	oduct Manufacture and Use - Medical Applications	-	om Product Us	N		350 Equation 8.24		52	5 0.53		E	99
orksheet ector: Industri ategory: Other P ubcategory: 2.G.3.a neet: N20 Er	oduct Manufacture and Use - Medical Applications	tion	om Product Us N2O Quan supplied in y (tonne)	ie Itity year t			Emission Factor (Fraction)	52 N2O Emissions in year t (tonne)	5 0.53 N2O Emissions in year t (Gg)		[	99
rksheet Industri Itegory: Other P Ibicategory: 2.G.3.a Neet: N2O Er ata	oduct Manufacture and Use - Medical Applications issions from Product Uses Type of applici	tion	N2O Quan supplied in y	ie Itity year t		Equation 8.24		N2O Emissions in year t	N2O Emissions in year t			99
rksheet ctor: Industri tegory: Other P bcategory: 2.G.3.a eet: N2O Er sta Subdivision	oduct Manufacture and Use · Medical Applications issions from Product Uses Type of applicat (Please speci 쇼 '文' Medical Application	tion fy) A ⊽ s	N2O Quan supplied in y (tonne)	tity year t	(to Calculated	Equation 8.24 upplied in year t - 1 ne) B 200	(Fraction) C	N2O Emissions in year t (tonne) D = (0.5 * A + 0.5 * B) * C 212.5	N2O Emissions in year t (Gg) D / 1000 0.21			
inkaheet ector: Industri tegory: Other P abcategory: 2.G.3.a seet: N2O Er ata Subdivision	oduct Manufacture and Use • Medical Applications issions from Product Uses Type of applic (Please speci $\Delta \nabla$	tion fy) A ⊽ s	N2O Quan supplied in y (tonne)	tity year t	(tō	Equation 8.24 pplied in year t - 1 Ane) B	(Fraction)	N2O Emissions in year t (tonne) D = (0.5 * A + 0.5 * B) * C	N2O Emissions in year t (Gg) D / 1000 0.21			99

#### **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. <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>: not applicable for this category.
- 3. <u>Column |B|: collect and input information on any other long-term reduction of N₂O emissions, in tonnes.</u>

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

tegory: Other bcategory: 2.G.3	trial Processes and P Product Manufacture .c - Other (Please spe are and storage or oth	e and Use ecify)								19	9.
ias NITROUS OX		~									
NITROUS UX											-
Subdivis		Source		Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)	1			
			e ∆⊽	and stored (tonne)				1			
Subdivis	sion	Source		and stored (tonne)	(tonne)	(tonne)	(Gg)	0.1	?	2	,

#### 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.

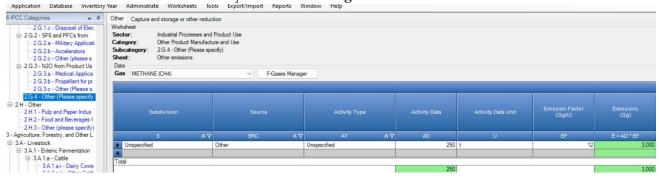
#### <u>GHGs</u>

Emissions from the Other (Other Product Manufacture and Use) source category include the following GHGs:

CO ₂	CH ₄	N ₂ O	HFCs	PFCs	$\mathbf{SF}_{6}$	NF ₃
X	Χ	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**

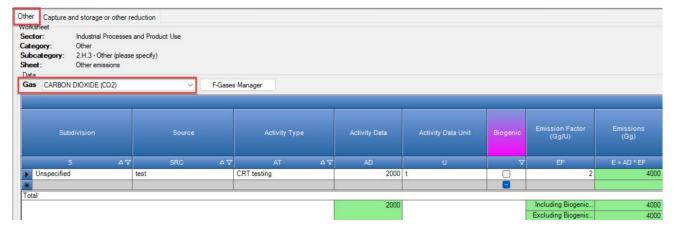
Emissions from the Other (IPPU) source category include the following GHGs:

CO ₂	CH ₄	$N_2O$	HFCs	PFCs	SF ₆	NF ₃
X	Χ	Χ	Χ	Χ	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 <u>volume 1, chapter 8</u> 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 <u>UNFCCC ETF Reporting Tool</u>. 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 <u>UNFCCC Interoperability – CRT Export Quick Start Guide</u>.

#### 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 <u>IPCC Inventory Software -UNFCCC Interoperability – CRT Export</u> <u>Quick Start Guide</u>. The result of the generated tables is presented below for the IPPU sector.

#### Example: generating visualized CRT for the IPPU sector

ble2(I) Table2(I).A-H    Table2(II)    Table2(II).B-Hs1    Table2(II).B-Hs2	esh vi ji	Export +	Worksheet Data CO2 Equivalents UNFCCC CRT	(1990)	05						
ABLE 2(1).A-H SECTORAL BACKGROUND DATA F nissions of CO2, CH4 and N20 (Sheet 1 of 1) GREENHOUSE GAS SOURCE AND SINK CATEGORIES		USTRIAL P		PRODUCT		EMISSION FACT	ORS (1)		EMISSIONS (2)		
		Prod	uction/Consumption quanti	ly i	CO2	CH4	N2O	C02	CH4	N2O	CO2 fossil
		Descri	ption (5)	(kt)	(01)	(0/0)	(1/1)	(80)	(kt)	(kt)	(kt)
2.A. Mineral industry								5.007 80330364	24,999,998	4,999,999	-0.2
2.A.1. Cement production	Clinke	r production. Carb	onates consumed	3.024	0.50192143		1	1.4158104	24,000.000	4,000.000	-0.1
2.A.2. Lime production		roduced, Carbona		5.5	0.79218502			4.35401762			-0.1
2.A.3. Glass production		production. Carbona		0.5	0.97942			0.48771			-0.1
2.A.4. Other process uses of carbonates	Gidss	production, Carbo		0.5	0.37342		-	5.001.54576562	24 999 998	4 999 999	-0.
2A4a Ceramics	Carbo	nates consumed		0.25	0.52197			0.1274925	24,000.000	4,000.000	-0.
2 A 4 b. Other uses of soda ash		nates consumed		0.266	0.47732			0.11996712			-0.
2 A.4.c. Non-metallurgical magnesium production		nates consumed		0.6	0.52197			0.191182			-0.
2 A 4 d. Other (please specify)	Carbon	nates consumed		0.0	0.52157			5.001.107124	24,999,998	4,999,999	-0.
Other process uses of carbonates [IPCC Software 2.A.4.d. 2.A.5]	Carbo	nates consumed	10	3.5	1 428 895178	7 142 857142	1.428.571428	5.001.107124	24,999,998	4,999,999	-0.
2.B. Chemical industry	Carbo	riates consumed	3	3.5	1,420.030110	7,142.007142	1,420.071420	9,106.34547397	10.74049447	1,509.090114	-1.233
2.B.1. Ammonia production (7)		nia production		0.25 C	2 23681333	NE	6.000	0.55819233 C	10.74045447 NE	1,509.050114 1,500 C	-0.00101
2.B.2. Nitric acid production (7)		acid production		200 C	2.23001333	NE	0.009	0.55615233 C	INE	0.499 C	-0.00101
2.B.2. Nitric acid production 2.B.3. Adipic acid production		acid production		1.2 C	2.500		0.009	3.000 C		0.04398 C	
2.B.3. Adipic acid production 2.B.4. Caprolactam, glyoxal and glyoxylic acid production	Adipic	acid production		1.20	2,500		0.3	275 C		0.548134 C	
2.8.4. Caprolactam, giyoxai and giyoxylic acid production 2.8.4.a. Caprolactam	and Count	lactam production		150 C	0.66666667		0.009	100 C		0.19375 C	
2.B.4.b. Givoxal		al production		0.75 C	133.333333333		0.003	100 C	2	0.072 C	
2.B.4.D. Giyoxai 2.B.4.C. Giyoxylic acid		al production vlic acid productio		60.08 C	1.24833555		0.02	75 C		0.282384 C	
2.B.4.C. Gryoxylic acid 2.B.5. Carbide production	GIYOX)	ylic acid productio	n	60.08 C	1.24833000		0.02	2.20485792 C	0.00423 C	0.282384 C	-0.0
2.B.5. Carbide production 2.B.5.a. Silicon carbide				0.000.0	0.50000400	0.00459627	4	1.15405567 C	0.00423 C		-0.00
2.5.5.a. Silicon carbide 2.8.5.b. Calcium carbide		e production		0.322 C	3.59023499	0.00459627			0.00148 C		
		e production		0.4 C	2.64700563	0.006875	1	1.05080225 C 2.89596 C	0.002/5 C		-0.00
2.B.6. Titanium dioxide production		um dioxide product used. Soda ash pr		2 C 0.556 C	0.31246043		1				-0.00
2.B.7. Soda ash production	Irona	used, boda ash pr	oduction	0.556 C	0.31246043			0.123728 C	4,73826447		-0.0
2.B.8. Petrochemical and carbon black production				0.005 74 0	0.00470000	0.00000400		5,818.20673238			
2.B.8.a. Methanol	Methan	nol production, Fu		2,005.71 C	0.00473002	0.00230198		8.47705	2.61710041		-1
	oxidation, n of the	Parties shou chapter 4 ("In box to provide details are ner	Id provide a detailed descrip dustrial processes and produ references to relevant secti aded to explain the contents	ct use" (CRT sector 2 ons of the NID, if any a of this table.	)) of the NID. Use t additional informati	uct use sector in this documentation on and/or further	C". Note th (Chemical ii (Electronics of the input	ent the note above, user at totals calculated in ora ndustry), 2.C (Metal indu industry, 2.G (Other pro of "C".	inge cells at the level stry), 2.D (Non-energy duct manufacture and	of category 2.A (Miner products from fuels a use), 2.H (Other) will	al industry), 2.8 and solvent use not change bec
truction or transformation). Arounts of CO2 captured or emission recovery, oxidation, destruction or transformati er gases. CO2 captured should be reported only when estimated using a higher-tier er vulation. Quantities of CO2 captured for later use and short-term storage should not be	issions	This document level for this b	tation box will be automatica ackground table.	lly populated with any	documentation ad	ded at the categor	of the input Orange ce UNFCCC re	industry, 2.G (Other pro of "C". porting tool. No action by hts\IPCC\IPCC software	information (i.e. are t y the user is required.	alank) will be calculate	ed automa

**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 "CO₂ 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 CO₂ capture reported in the worksheet **Capture and storage or other reduction**.

The following recurrent key instructions in the mapping are:

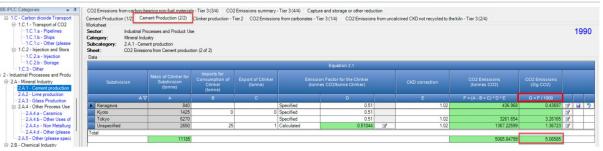
- ✓ The sign **"SUM"** indicates a summatory of information (numerical or alphabetical) contained across the column/row to which applies.
- ✓ The sign "-SUM" indicates that the result of the summatory is to be reported as a negative value.
- ✓ The sign "AND" indicates an additional element for mapping 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

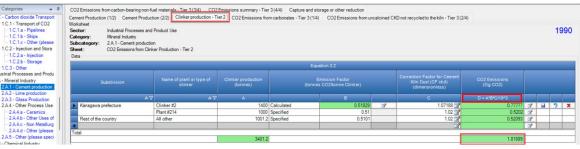
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO ₂
2.A. Mineral industry	SUM (H11:H14)
2.A.1. Cement production	IPCC 2.A.1 <cement (2="" 2)="" production=""> SUM of values in column G PLUS IPCC 2.A.1 <clinker -="" 2="" production="" tier=""> SUM of values in column D PLUS IPCC 2.A.1 <co2 Emissions summary - Tier 3 (4/4)&gt; SUM of values in column E /1,000 MINUS IPCC 2.A.1 <capture and="" or="" other="" reduction="" storage=""> SUM of values in column C / 1,000.</capture></co2 </clinker></cement>

#### UNFCCC CRT

#### **IPCC** Inventory Software



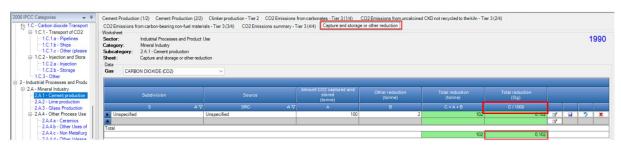
#### PLUS



PLUS

Ce (1/2) Ce (2/2) s - Tier 3 (1/4) CO2 the kiln - Tier 3 (2/4) - Carbon dioxide Transport 1.C.1 - Transport of CO2 CO2 En Tier 3 (3/4) 1990 Industrial P 2.A.1 - Ce CO2 Emis C.2.b and Pr 1319.13 527.652 est of the co 2198.8 20 3.68

#### 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</u> <u>AD for the Tier 1 method (and Tier 2 when the method relies on the same AD, as is the case for</u> <u>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.

Scenario	How AD are aggrega	ted in visualized CRT	
<b>#1:</b> User applies	GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	
all Tier 1 and/or		Production/Consumption quant	ity
Tier 2 methods		Description (5)	(kt)
The 2 methods	2.A. Mineral industry		
	2.A.1. Cement production	Clinker production	1.95
<b>#2:</b> User applies	GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	
all Tier 3 methods		Production/Consumption quant	ty
an menous		Description (5)	(kt)
	2.A. Mineral industry		
	2.A.1. Cement production	Carbonates consumed	1

#### *Example*: Aggregating AD: cement production example

#3: User applies	GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	
combination of		Production/Consumption quant	ity
		Description (5)	(kt)
Tier $1/2$ and $3$	2.A. Mineral industry		
methods	2.A.1. Cement production	Clinker production, Carbonates consumed	1.95

- ✓ To transfer complete and meaningful AD, the pale green cells are editable and should be updated to ensure 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).

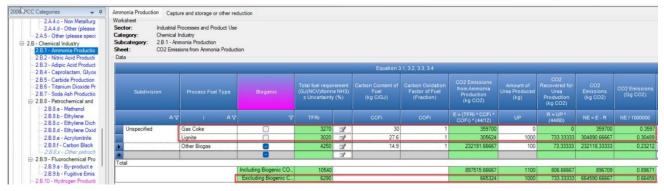
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA			IMPLIE
	Production/Consumption	quantity		CO2
	Description (5)	(	(kt)	(t/t)
2.A. Mineral industry				
2.A.1. Cement production	Clinker production, Carbonates consumed		0.95	
2.A.2. Lime production	Lime produced	2	Edit	
2.A.3. Glass production 0	Glass production	2	Notation Key	<b>7</b> .
2.A.4. Other process uses of carbonates			Refresh value	
2.A.4.a. Ceramics	Carbonates consumed	0		
2.A.4.b. Other uses of soda ash	Carbonates consumed		JSON Export	>
Summary Description User comment Official comme	Strike out (i.e. c one of the type	es of		
Summary Description User comment Official comme Clinker production, Carbonates consumed	one of the type	es of only user		
	ent one of the type AD, retaining that which the wants to trans	es of only user		
Clinker production, Carbonates consumed	ent one of the type AD, retaining that which the wants to trans	es of only user sfer		
Clinker production, Carbonates consumed	ent one of the type AD, retaining that which the wants to trans	es of only user sfer CTIVITY DATA		(kt)
Clinker production, Carbonates consumed	ent one of the type AD, retaining that which the wants to trans	es of only user sfer CTIVITY DATA		(kt)

#### Example: updating AD when multiple Tiers are used

#### 2. Calculation of CO₂ 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:* CO₂ emissions mapped to the CRT is the total, excluding biogenic CO₂. Any capture of biogenic CO₂ would be included as a reduction from CO₂ 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 GgCO₂ eq (e.g. either unspecified mix of HFCs, or unspecified mix of HFCs and PFCs, depending on the category).

	-						<u> </u>						-						~						• •											
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	HFC-23	HFC-32	IIFC-41	HFC-43-10mee	IIFC-125	HFC-134	HFC-134a	HFC-143	HPC-143a	HFC-152	HFC-152a		HFC-22/ea IIFC-236cb	HFC-236ea	IIFC-236fa	HFC-245ca	IIFC-245fa	HFC-365mfc	Т	Unspecified mix of IIFCs ⁽¹⁾	Total IIFCs	CF4	C2Fe	C ₃ F ₁	C4Fin	e-C4Fs	C ₅ F ₁₂	CaFie	C ₁₀ F ₁₈	e-C ₃ F ₆	Unspecified mix of PFCs ⁽¹⁾	Total PFCs		of HFCs and PFCs ⁽³⁾	SF ₆	NF3
										(1)									•	O2 equivale	ents (kt) (2)					(1)		-			CO2	equivalents	s (kt) (2)	2	(t)	(t)
2. Total actual emissions of halocarbons (by chemical), SF ₆ and NF ₃																																				
2.B. Chemical industry												_					6				-															
2.B.9. Fluorochemical production									Sn	ecific	HE	C.								ecified												Unsp	ecifie	ed mix	of	
2.B.9.a. By-product emissions									op	ecini								mi	x of	HFCs												Unsp HFC	s an	d PFC	s	
2.B.9.b. Fugitive emissions						-						_									-												-		-	
2.B.10. Other																																				

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.

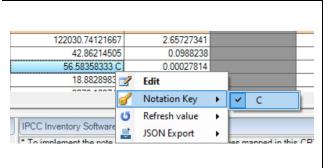
There are two different ways of handling confidentiality in the *Software*; one or non-F-gases (i.e. in CRT 2(I)A-H) and another way for F-gases (CRT 2(II)B-Hs1 and CRT 2(II)B-Hs2).

#### Designating AD and emissions confidential in CRT 2(I)A-H

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 CO₂, CH₄ and N₂O 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			IMPLIED	EMISSION FA		
	Production/Consumption quant	lity		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				695.08179
2.B. Chemical industry				Emissio		127783.73955497
2.B.1. Ammonia production (7)	Ammonia production	0.3		transfer, i		0.61994233
2.B.2. Nitric acid production	Nitric acid production	211.103 C	confidential			
2.B.3. Adipic acid production	Adipic acid production	2.402		emiss	ions	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				7
2.B.5. Carbide production						2.26095793
2.B.5.a. Silicon carbide	Carbide production	0.2				1.1540556
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		2		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 (
2.B.8.a. Methanol	Methanol production, Fuel consumed	2005.81		Cells \		122030.74121667
2.B.8.b. Ethylene	Ethylene production, Fuel consumed	2.444	-	transfer a	as "C"	42.8621450
2.B.8.c. Ethylene dichloride and vinyl chloride monomer	Ethylene dichloride and vinyl monomer productio	2.5527 C	-			56.58358333 0

The user cannot change the following rows to "C" in the visualization tables (references to "row" refers to the row in the mapping tables appended to this guidebook).

- ✓ Row 10 -category 2.A. Mineral industry
- ✓ Row 20- category 2.B. Chemical industry
- ✓ Row 50- category 2.C. Metal industry
- ✓ Row 69- category 2.D. Non-energy products from fuels and solvent use
- ✓ Row 80- category 2.E. Electronics industry
- ✓ Row 87- category 2.G. Other product manufacture and use
- ✓ Row 97- category 2.H. Other

#### Designating AD and emissions confidential in 2(II)B-Hs1 and 2(II)B-Hs2

The structure of UNFCCC reporting tables for F-gases is different than that for non-F gases in table 2(I)A-H. Specifically, there are no aggregations of emissions (or AD) in these tables. This necessitates a different approach for allowing the user to designate F-gases as confidential.

Designation of a gas as confidential is made by the user, category by category, generally (but not always) at the point where the user indicates which F-gases/blend are relevant for the category (i.e. in the F-gases Manager at the category level).

To access the category level F-gases Manager the user shall:

- ✓ select <u>F-Gases Manager</u> to open the IPCC category level manager (for some Tier 1 worksheets, the F-Gases Manager is accessible through the <u>Chemical's Data</u> tab.
- $\checkmark$  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 tCO₂ eq.

BLE 2(II).B-H SECTORAL BACKGROUND	DATA FOR INDU	ISTRIAL PROCESSI	S AND PRODUCT	IOF							
rces of fluonnated substances (Sneet 2 of 2)			-3 AND FRODUCT	JSE							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		ACTIVITY DATA Amount			IMPLIED EMISSION FACTORS (1)	-	EMISSIONS (2)				
	Filled into new manufactured produc	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		
SF6	<b>a</b>	IE	22 IE	IE	842.24090909	IE	IE	185.293	IE		
2.G.2.b. Accelerators											
	2	IE 0.144			2,320,721.29886	IE		3,348.33669	IE		
	3	IE 198.93	32 IE	IE	16.7569732	IE	IE	33.335183	IE		
2.G.2.c. Soundproof windows											
	3	2	IE NE	33	NE	NE	0.66	NE	NE		
2.G.2.d. Adiabatic properties: shoes and tyres											
	3	NE	IE NE	NO		NO	NO	NE	NO		
	1	IE	1 IE	IE	200	IE	IE	2	IE		
2.G.2.e. Other											
2.G.2.e.i. Waterproofing electronic circuits											
	3		IE NE					NE	NE		
	2		IE NE	NE		NE		NE	NE		
	3	NE	IE 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]											
	2	IE	4 NA	IE		NA	IE	26,520	NA		
	3	NO	IE NA	NO	NE	NA	NO	NE	NA		
2.G.4. Other (please specify)											
Other product manufacture and use [IPCC Software 2.G.4]											
	2	IE 1		IE		IE		51,181,250,000	IE		
	2		IE NO	NO	NE	NO		NE	NO		
	3	NO	IE NO	NO	NE	NO	NO	NE	NO		
H. Other (please specify)											
2.H.3. Other (please specify)											
Other industrial processes and product use [IPCC Software]											
	3	IE 2,0			56,928,688,277.5	IE		1,138,573,765,550	IE		
	2	IE 2,0		IE		IE		5,992,000	IE		
NF3	3	IE 2.0	20 IE	IE	999.500	IE	18	19,990,000	IE		

#### Example: F-gases designated as confidential reported, together, under 2.H, stocks

#### 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 CO₂ 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 <u>UNFCCC Interoperability-CRT Export Quick Start Guide</u> 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).

CRT Table	CRT category (ies)	Parameter/G as	Automa tic mappin g	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	CH4 and N2O (emissions and recovery)	NA	This category is from IPCC <i>Software</i> 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 4. Automatic Reporting of Notation Keys in the IPPU Sector of the CRT

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 <b>F-gas Emissions</b> ), 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 <i>Software</i> 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	С	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.					