Industrial Processes and Product Use (IPPU)

From the IPCC Guidelines to the IPCC Inventory Software

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INTERGOVERNMENTAL PANEL ON climate change

WMO

UN environment programme

Outline

- General and cross-cutting issues
  - *2019 Refinement* Categories and Biogenic component in IPPU
  - Fuel Manager
  - F-gases Manager and F-blends Manager *[will be presented separately]*

- 2.A.1 Cement Production
  - IPCC Guidelines – Tier 1, 2 and 3 – CO_2
  - The worksheets in the IPCC Inventory Software
  - Dummy data exercise – Tier 1, 2 and 3 and Capture – CO_2

- 2.C.1 Iron and Steel Production
  - IPCC Guidelines – Iron and Steel Production – Tier 1 and 2/3 for CO_2
  - IPCC Guidelines – Coke Production – Tiers and Reporting
  - The worksheets in the IPCC Inventory Software
  - Dummy data exercise – Iron and Steel Production – Tier 1 and 2/3 for CO_2
  - Dummy data exercise – Coke Production – Tier 1 for CO_2 and CH_4

- 2.B.8 Petrochemical and Carbon Black
  - Demonstration of data input for 2.B.8.b Ethylene Production

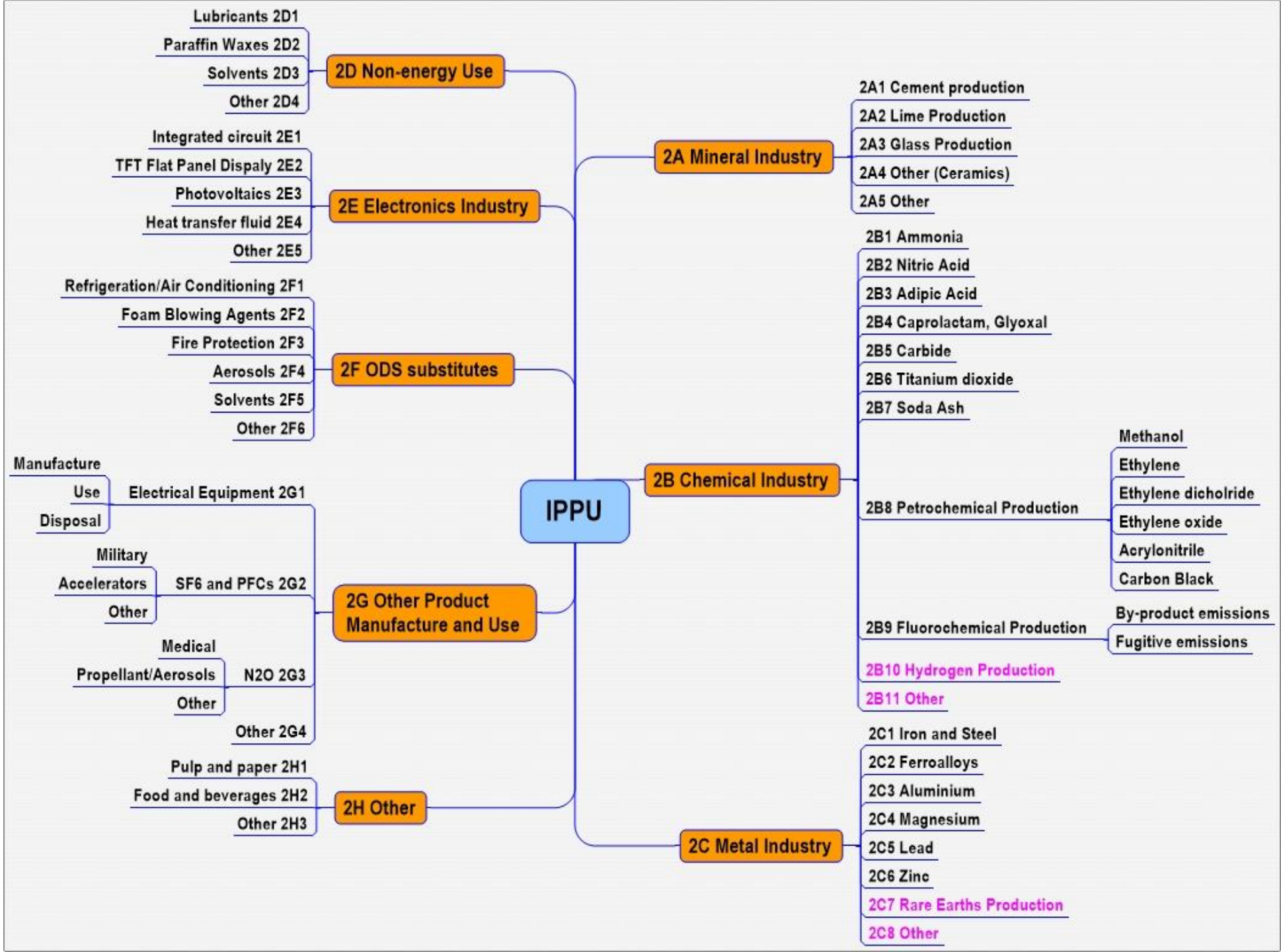
Outline (Cont.)

- 2.F.1 Refrigeration and Air Conditioning
  - F-gases/ blends and the F-gases Manager
  - Refrigeration and Air Conditioning – Tier 1
  - Refrigeration and Air Conditioning – Tier 2

Introduction

- The IPCC Inventory Software implements the *2006 IPCC Guidelines*
- There are elements of the *2019 Refinement* to meet the UNFCCC reporting requirements

IPPU


IPPU
2A Mineral Industry
2A1 Cement production
2A2 Lime Production
2A3 Glass Production
2A4 Other (Ceramics)
2A5 Other
2B Chemical Industry
2B1 Ammonia
2B2 Nitric Acid
2B3 Adipic Acid
2B4 Caprolactam, Glyoxal
2B5 Carbide
2B6 Titanium dioxide
2B7 Soda Ash
2B8 Petrochemical Production
Methanol
Ethylene
Ethylene dicholride
Ethylene oxide
Acrylonitrile
Carbon Black
2B9 Fluorochemical Production
By-product emissions
Fugitive emissions
2B10 Hydrogen Production
2B11 Other
2C Metal Industry
2C1 Iron and Steel
2C2 Ferroalloys
2C3 Aluminium
2C4 Magnesium
2C5 Lead
2C6 Zinc
2C7 Rare Earths Production
2C8 Other
2D Non-energy Use
Lubricants 2D1
Paraffin Waxes 2D2
Solvents 2D3
Other 2D4
2E Electronics Industry
Integrated circuit 2E1
TFT Flat Panel Dispaly 2E2
Photovoltaics 2E3
Heat transfer fluid 2E4
Other 2E5
2F ODS substitutes
Refrigeration/Air Conditioning 2F1
Foam Blowing Agents 2F2
Fire Protection 2F3
Aerosols 2F4
Solvents 2F5
Other 2F6
2G Other Product Manufacture and Use
Electrical Equipment 2G1
Manufacture
Use
Disposal
SF6 and PFCs 2G2
Military
Accelerators
Other
N2O 2G3
Medical
Propellant/Aerosols
Other
Other 2G4
2H Other
Pulp and paper 2H1
Food and beverages 2H2
Other 2H3

IPPU

- 2019 Refinement Categories
- Biogenic Component in IPPU

2019 Refinement categories

- To meet the UNFCCC reporting requirements, two new categories from the 2019 Refinement were introduced in the IPCC Inventory Software and they moved the numbering of categories in Chemical and Metal Industries (2.B and 2.C)

2006 IPCC	2019 IPCC	UNFCCC
2.B.10 Other	2.B.10 Hydrogen Production	2.B.10.a. Hydrogen production
	2.B.11 Other	2.B.10.b. Other
2.C.7 Other	2.C.7 Rare Earths Production	2.C.7.a. Rare earths production
	2.C.8 Other	2.C.7.b. Other

Biogenic

- **Biogenic component is not included in the national total. There are few instances in the IPPU sector, where the biogenic/biomass input can be used.**

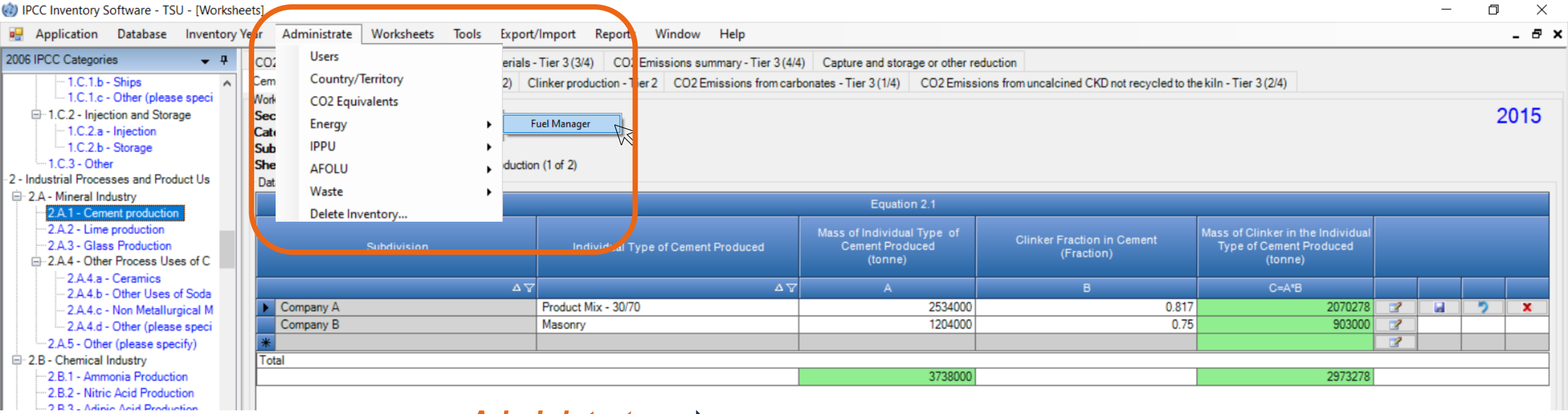
- **The following categories contain Biogenic input:**
  - 2.B.1 Ammonia Production
  - 2.B.5 Carbide Production
  - 2.B.6 Titanium Dioxide Production
  - 2.B.8 Petrochemical and Carbon Black Production
  - 2.B.10 Hydrogen Production
  - 2.C.1 Iron and Steel Production
  - 2.C.2 Ferroalloys Production
  - 2.C.5 Lead Production
  - 2.C.6 Zinc Production
  - 2.H.3 Other

Cross-cutting issues – IPPU/Energy

Fuel Manager

Fuel Manager (1)

- Some IPPU worksheets (e.g., Iron and Steel Production) use data from the Fuel Manager, which contains default and country specific data on fuels – NCV and Carbon Content
- Energy experts are supposed to populate Fuel Manager, but IPPU experts may need to check and correct or input a specific fuel information



Administrate ➡

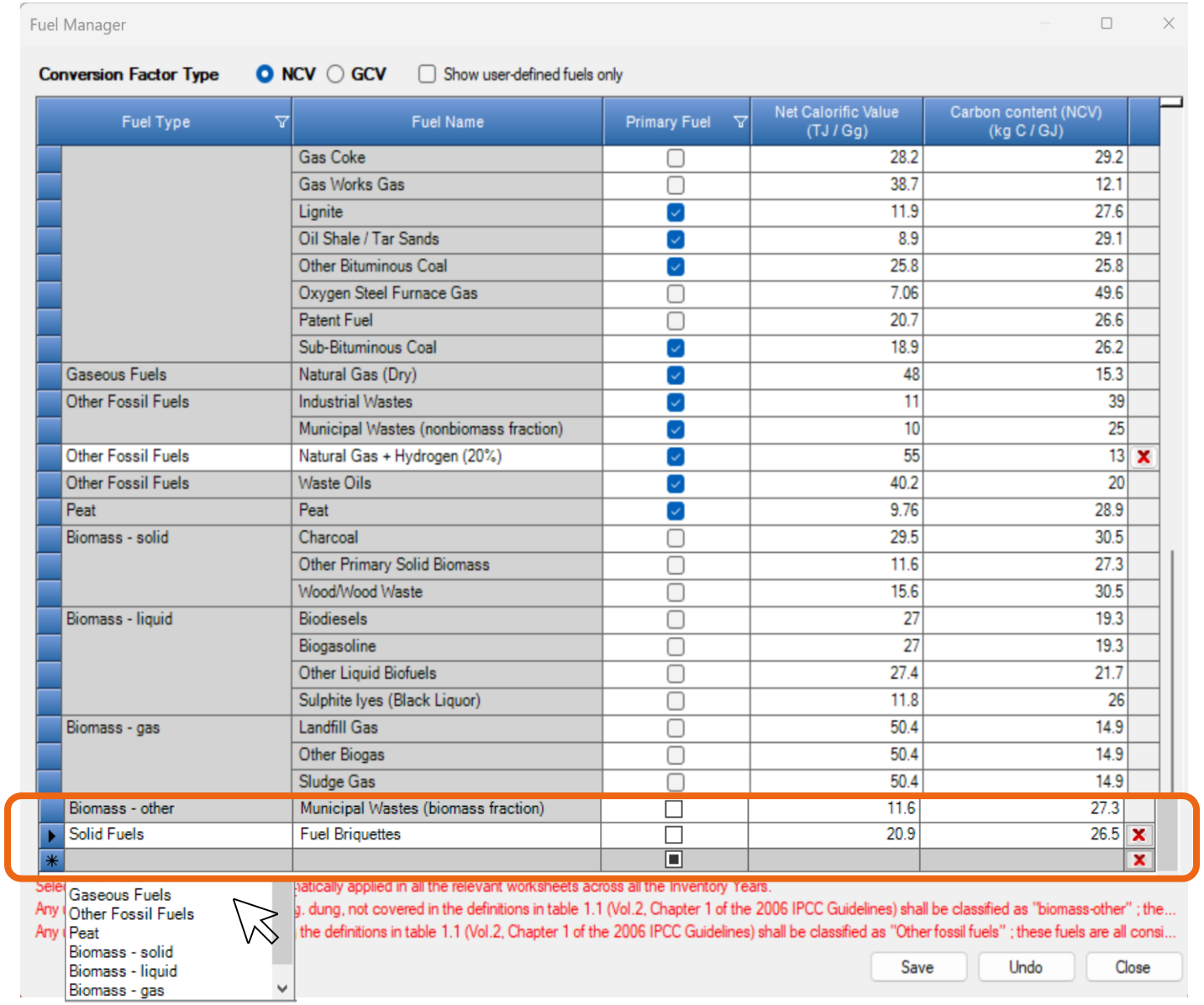
Energy ➡

Fuel Manager

Fuel Manager (2)

- The Fuel Manager contains data on carbon content and calorific value for each fuel.
- All IPCC default fuels are listed in. In addition, users can enter user-specific fuels together with relevant data required by the Fuel Manager (carbon content and calorific value).

Default IPCC fuels (embedded - in grey) and Country-specific fuels (manual input - in white)



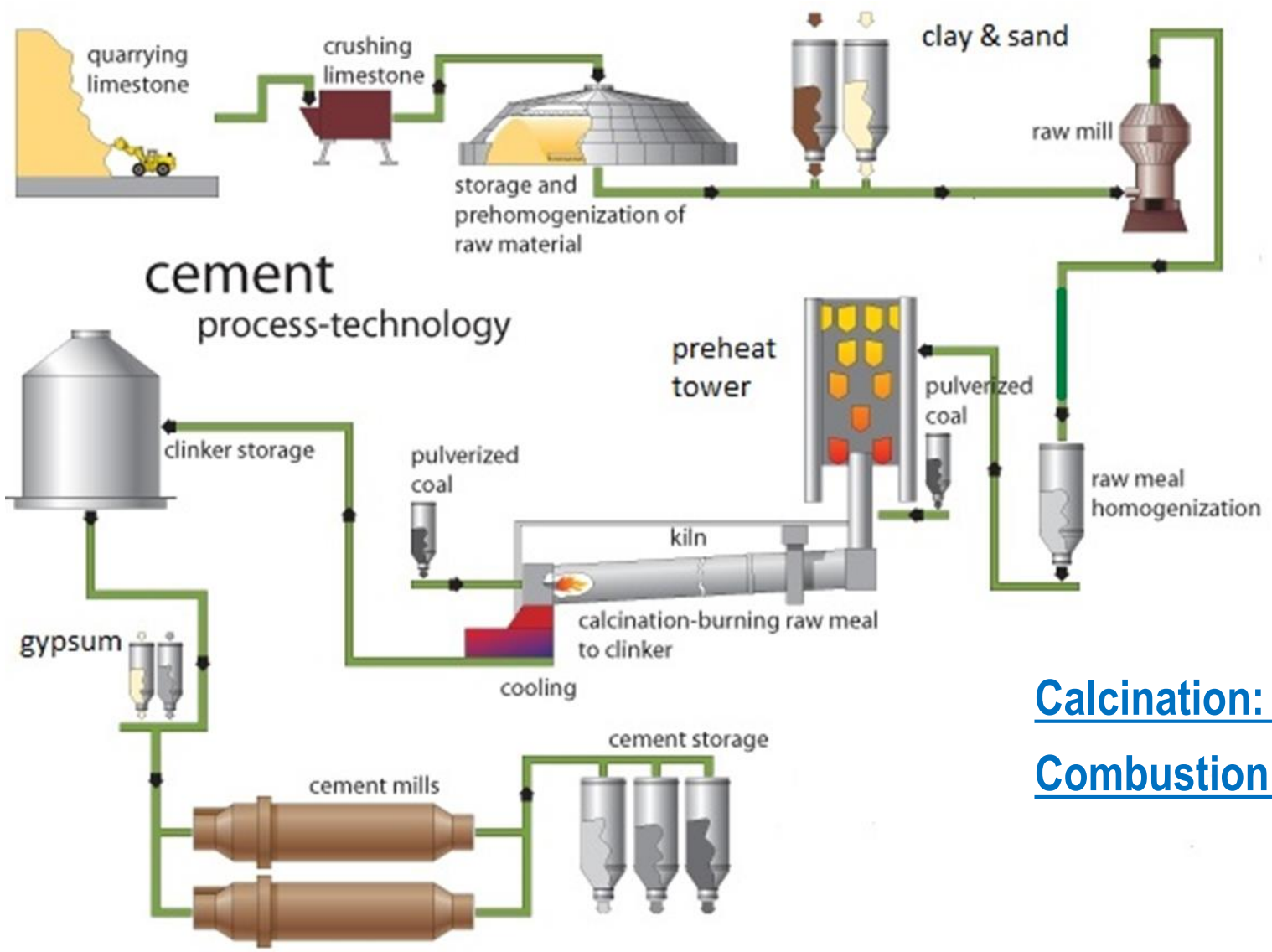
Examples of Data Input

- Cement Production (2.A.1)
- Iron and Steel (2.C.1)
- Petrochemical (2.B.8)
- Refrigeration and Air Conditioning (2.F.1)

Examples of Data Input

Cement Production (2.A.1)

2.A.1: Cement Production



Calcination: $CaCO_3 + (Heat) = CaO + CO_2$ (IPPU)

Combustion: $Coal/Gas + O_2 = CO_2 + (Heat)$ (Energy)

Image: adapted from DCMAC: http://www.dscrusher.com/solutions/production-line/sand-cement-cogeneration-production-line.html *(as of March 1 , 2015)*

2.A.1 Cement Production - Tiers

- ***2006 IPCC Guidelines* provide three Tiers for Cement Production**
  - **Tier 1** *(based on cement production data)*
  - **Tier 2** *(based on clinker production data)*
  - **Tier 3** *(based on carbonates input data)*

2.A.1 Cement Production

Tier 1

Tier 1

TIER 1 METHOD: ESTIMATING CLINKER PRODUCTION THROUGH USE OF CEMENT PRODUCTION DATA

As noted above, calculating CO_2 emissions directly from cement production (i.e., using a fixed cement-based emission factor) is not consistent with *good practice*. Instead, in the absence of data on carbonate inputs or national clinker production data, cement production data may be used to estimate clinker production by taking into account the amounts and types of cement produced and their clinker contents and including a correction for clinker imports and exports. Accounting for imports and exports of clinker is an important factor in the estimation of emissions from this source. Emissions from the production of imported clinker should not be included in national emissions estimates as these emissions were produced and accounted for in another country. Similarly, emissions from clinker that is ultimately exported should be factored into national estimates of the country where the clinker is produced. An emission factor for clinker is then applied and the CO_2 emissions are calculated according to Equation 2.1.

EQUATION 2.1
TIER 1: EMISSIONS BASED ON CEMENT PRODUCTION

$$CO_2\ Emissions = \left[\sum_i (M_{ci} \bullet C_{cli}) - Im + Ex\right] \bullet EF_{clc}$$

Where:

CO_2 Emissions = emissions of CO_2 from cement production, tonnes

M_{ci} = weight (mass) of cement produced[3] of type *i*, tonnes

C_{cli} = clinker fraction of cement of type *i*, fraction

Im = imports for consumption of clinker, tonnes

Ex = exports of clinker, tonnes

EF_{clc} = emission factor for clinker in the particular cement, tonnes CO_2/tonne clinker
The default clinker emission factor (EF_{clc}) is corrected for CKD.

Cement Production – Tier 1

$$CO_2 \text{ Emissions} = \left[\sum \left(M_{cement,i} \times C_{clinker\ fraction,i} \right) - Im + Ex \right] \times EF_{Clinker}$$

- $M_{cement,i}$: AD – Cement type i
- $C_{clinker\ fraction,i}$: Clinker Fraction in Cement type i
- Im, Ex: AD – Import/Export of Clinker
- $EF_{Clinker}$: Clinker EF

Tier 1 Defaults

- ✓ If cement production cannot be disaggregated by cement type, it is suspected that significant amounts of blended and/or masonry cements are being produced, and it is acceptable within *good practice* to assume an overall clinker fraction of 75%
- ✓ If cement production is known to be essentially all portland cement, then it is *good practice* to use a default value of 95% clinker

Default EF_{Clc} = 0.52
tonnes CO_2/tonne clinker
(corrected for cement kiln dust (CKD))

Tier 1 Emission Factor

- **In Tier 1, it is good practice to assume the following:**
  - default CaO content for clinker is 65% *(1 tonne of clinker contains 0.65 tonne CaO)*
  - $CaCO_3$ is 56.03 percent CaO and 43.97 percent CO_2 by weight (stoichiometry)
  - 2% correction factor for cement kiln dust (CKD) not recycled into the kiln

- **The amount of $CaCO_3$ needed to yield 0.65 tonne CaO is:**

  $CaCO_3$ = 0.65 / 0.5603 = **1.1601** tonne

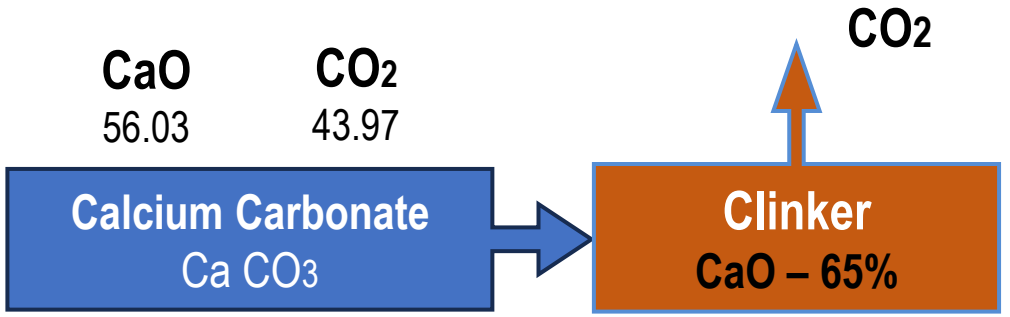
- **The amount of CO_2 released by calcining this $CaCO_3$ is:**

  CO_2 = 1.1601 x 0.4397 = **0.5101** tonne

- Assuming a correction addition of 2 % CKD, **the default EF is:**

  EFcl = 0.5101 x 1.02 = **0.52** tonne CO_2 / tonne clinker

1.1601 tonne $CaCO_3$ = 1 tonne of Clinker (with 0.5101 tonne of CO_2)



$CaCO_3 = CaO \cdot CO_2$

Ca 40 + C 12 + O 16x3
= 100.0869

1.1601 tonne $CaCO_3$ = 1 tonne of Clinker (with 0.65 tonne CaO)

✓ *Now let's see how it is realized in the Software*

Cement Production – Tier 1

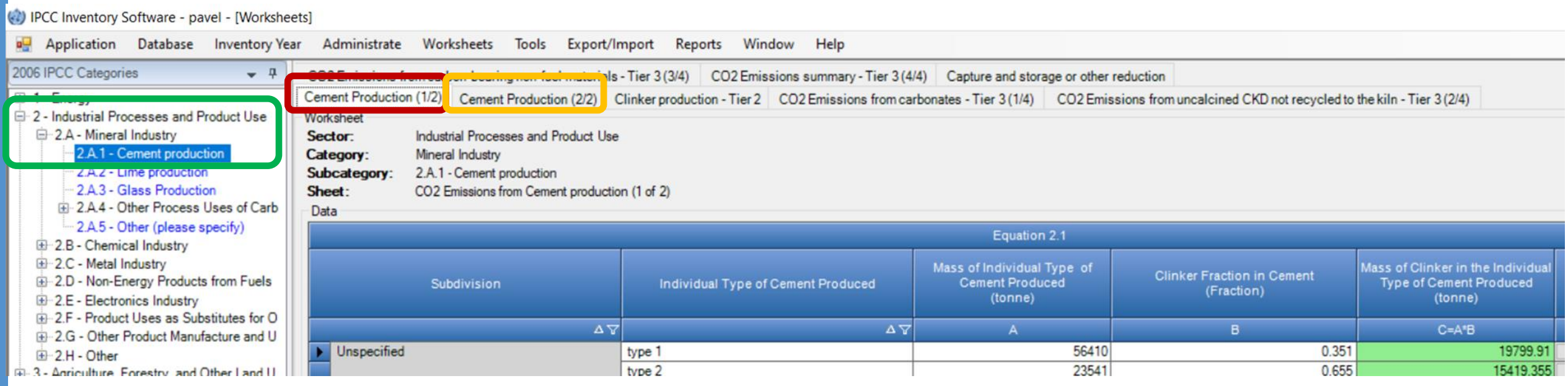
The Software breaks the Equation 2.1 into two worksheets:

i. Cement Production (1/2)

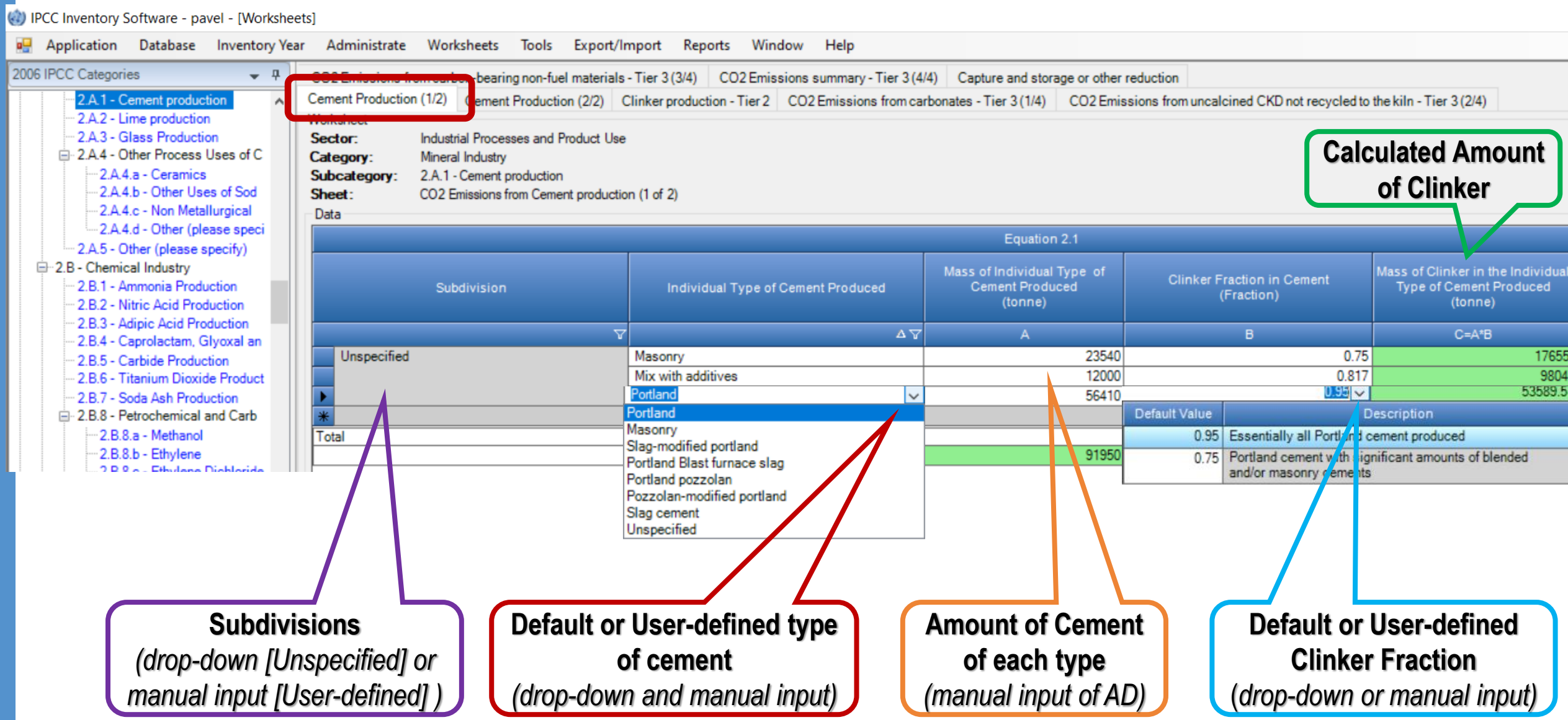
ii. Cement Production (2/2)

$$CO_2 \text{ Emissions} = \left[\sum \left(M_{cement,i} \times C_{clinker\ fraction,i} \right) - Im + Ex \right] \times EF_{Clinker}$$

Cement Production (1/2) **Cement Production (2/2)**



Cement Production – Tier 1 (1/2)



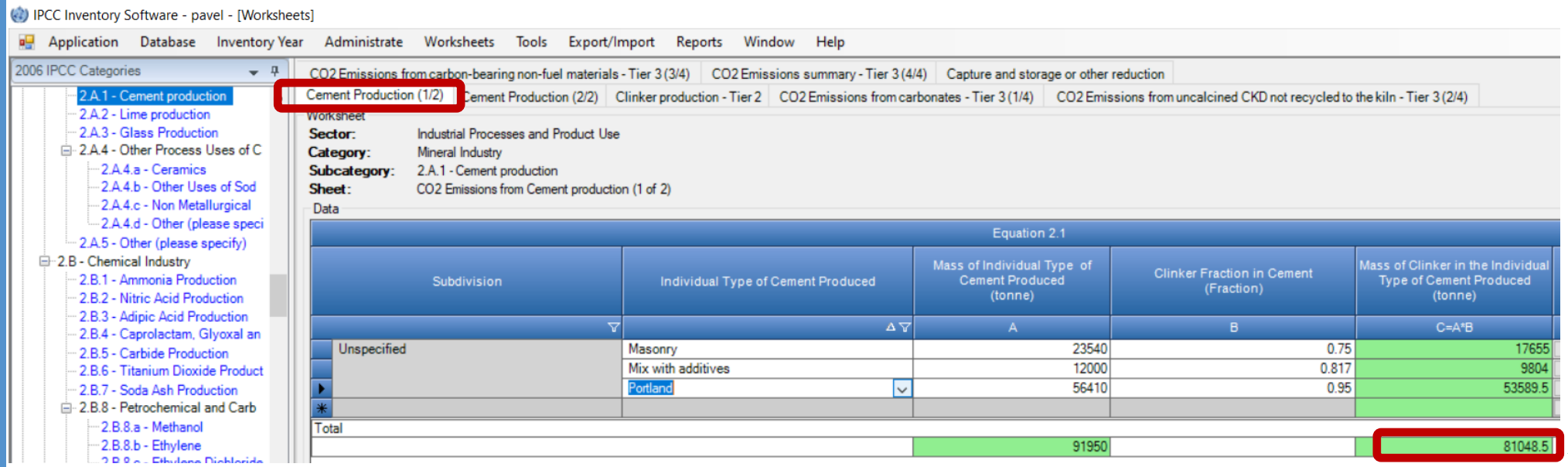
Subdivisions
(drop-down [Unspecified] or manual input [User-defined])

Default or User-defined type of cement
(drop-down and manual input)

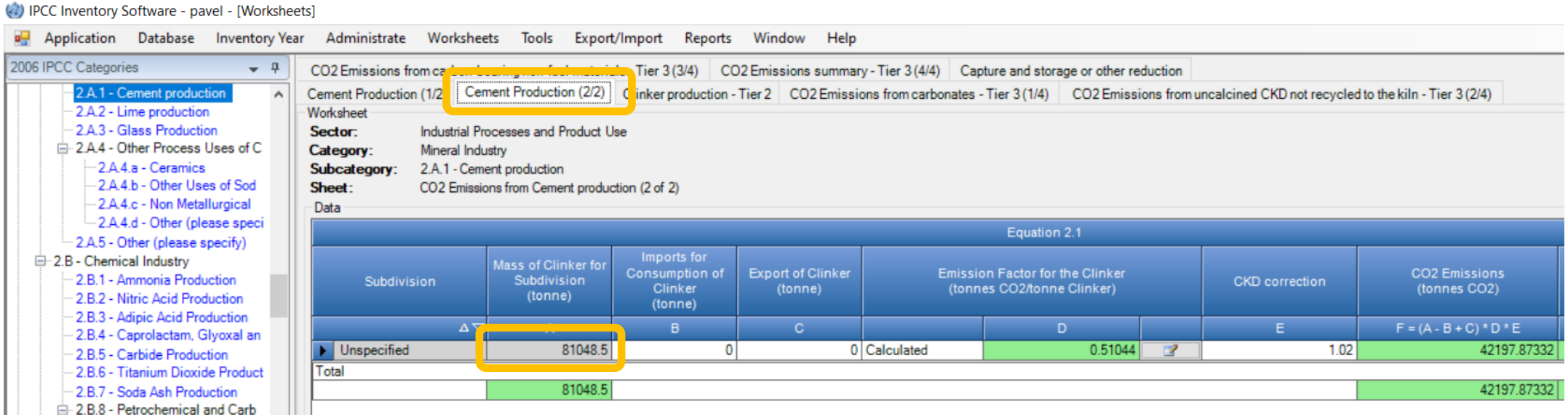
Amount of Cement of each type
(manual input of AD)

Default or User-defined Clinker Fraction
(drop-down or manual input)

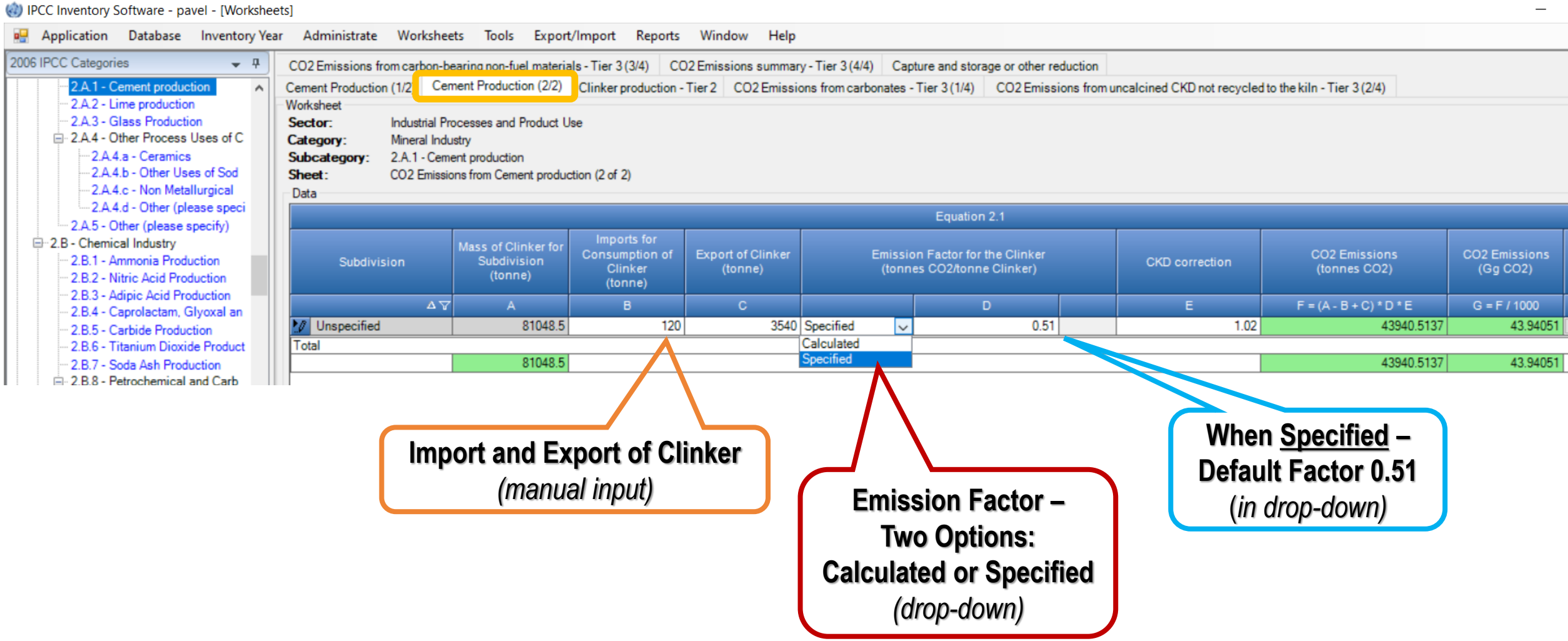
Cement Production – Tier 1



Calculated Amount of Clinker
(Will automatically be transferred into the second worksheet)



Cement Production – Tier 1 (2/2)

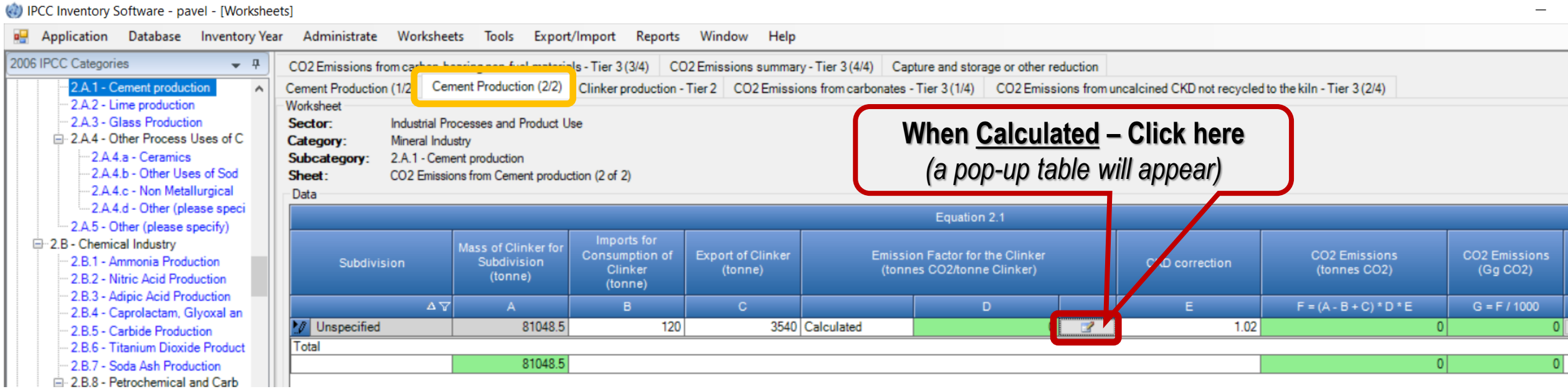


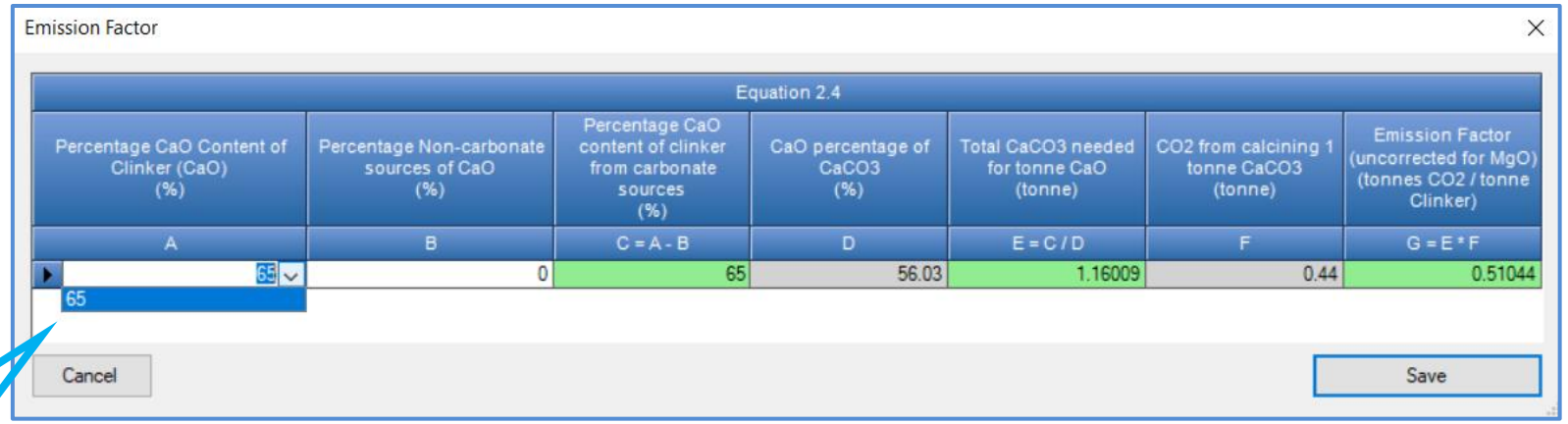
Import and Export of Clinker
(manual input)

Emission Factor – Two Options: Calculated or Specified
(drop-down)

When <u>Specified</u> – Default Factor 0.51
(in drop-down)

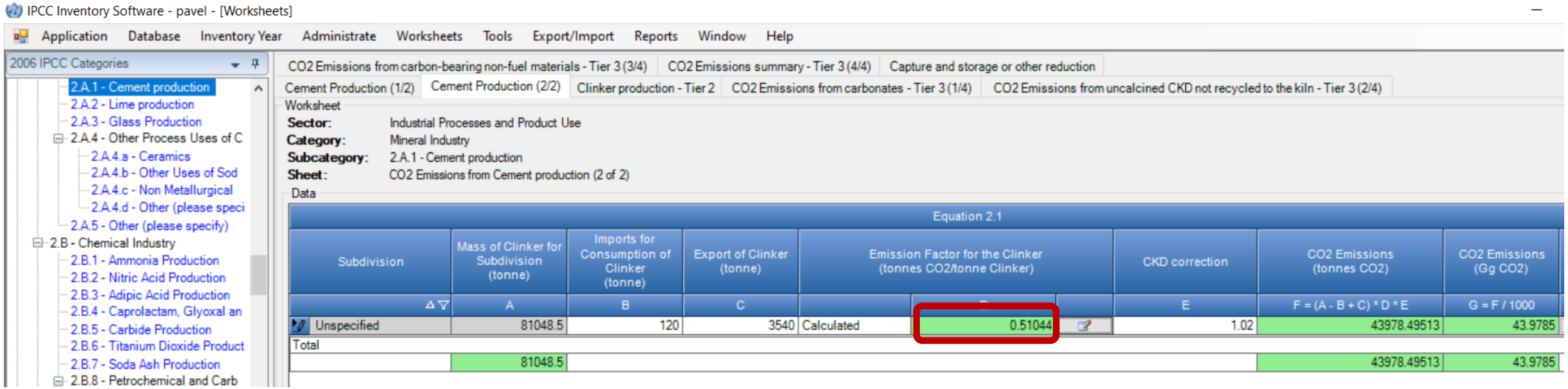
Cement Production – Tier 1 (2/2)

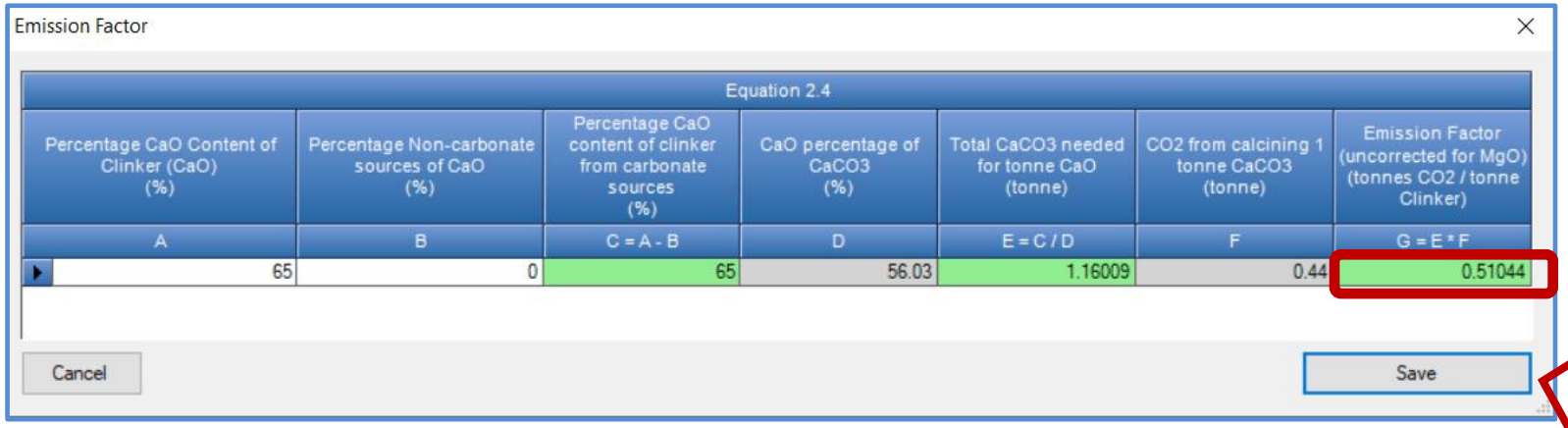




Default Factor 65% for CaO in Clinker
(drop-down)

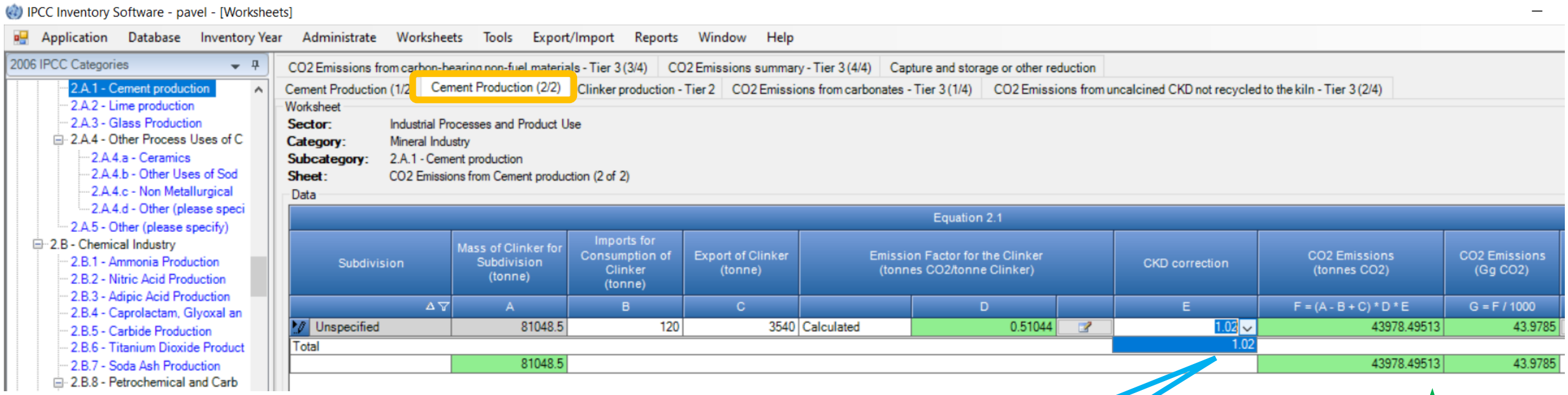
Cement Production – Tier 1 (2/2)





Click Save *(the calculated EF will automatically be transferred into the main worksheet)*

Cement Production – Tier 1 (2/2)



Default Factor for CKD – 1.02 or 2%
(in drop-down)

Calculated Amount of CO_2 Emissions
(in tonnes and Gg)

2.A.1 Cement Production

Tier 2

Tier 2 – Clinker AD

TIER 2 METHOD: USE OF CLINKER PRODUCTION DATA

If detailed and complete data (including weights and composition) for carbonate(s) consumed in clinker production are not available (Tier 3), or if a rigorous Tier 3 approach is otherwise deemed impractical, it is *good practice* to use aggregated plant or national clinker production data and data on the CaO content in clinker, expressed as an emission factor in the following Equation 2.2:

EQUATION 2.2
TIER 2: EMISSIONS BASED ON CLINKER PRODUCTION DATA

$$CO_2\ Emissions = M_{cl} \bullet EF_{cl} \bullet CF_{ckd}$$

Where:

CO_2 Emissions = emissions of CO_2 from cement production, tonnes

M_{cl} = weight (mass) of clinker produced, tonnes

EF_{cl} = emission factor for clinker, tonnes CO_2/tonne clinker (See discussion under Section 2.2.1.2, Choice of Emission Factors, for Tiers 1 and 2 below.) This clinker emission factor (EF_{cl}) is not corrected for CKD.

CF_{ckd} = emissions correction factor for CKD, dimensionless (see Equation 2.5)

Tier 2 – Specific EF for Clinker

TIER 2 METHOD

Emission factor for clinker (EF_{cl})

In the Tier 2 method, if sufficient country-specific data on CaO content of clinker and inputs of non-carbonate CaO sources are available, it is *good practice* to estimate a country-specific CO_2 emission factor for clinker. As noted above, the derivation of an emission factor for clinker requires that the CaO content of the clinker be known, as well as the fraction of CaO that was derived from a carbonate source (generally $CaCO_3$). The CaO content of clinker is generally within the range of 60 to 67 percent. At a given plant the CaO content will remain stable to within 1 to 2 percent. The basic default emission factor, as recommended under Tier 1, assumes that the clinker is 65 percent CaO and that this is 100 percent derived from $CaCO_3$ and that 100 percent calcination is achieved in the kiln.

The base (i.e., uncorrected for CKD) 0.51 emission factor in Equation 2.4 assumes a 65 percent CaO content in clinker. A similar calculation would yield emission factors for different CaO contents, if these contents are known. For example, for a clinker with 60 percent CaO all derived from $CaCO_3$ the EF_{cl} (not including a correction for CKD) is 0.47, and for 67 percent CaO the EF_{cl} is 0.53.

If it is known that a plant is deriving a significant fraction of CaO from a non-carbonate source (such as steel slag or fly ash), then this component of CaO should first be subtracted. For example, if 4 percent of the CaO in a 65 percent CaO clinker is from slag, then the CaO from carbonate is 61 percent and the calculation for this yields an EF_{cl} of 0.48.

The default emission factor does not include a correction for MgO. For every 1 percent of MgO derived from carbonate the emission factor is an additional 0.011 tonne CO_2/tonne clinker (i.e., $EF_{cl} = 0.510 + 0.011 = 0.52$ tonne CO_2/tonne clinker). Because MgO also may come from a non-carbonate source and because the MgO is deliberately kept low in portland cement, the true MgO from carbonate is likely to be very small. Given the fact that the assumption of a 100 percent carbonate source for the CaO already yields an overestimation of emissions (there is likely to be at least some contribution of CaO from non-carbonate sources) and the fact that some of the MgO is also likely to be from a non-carbonate source, a correction for MgO is not required for a Tier 2 calculation. For uncertainties associated with these assumptions please refer to Table 2.3.

Tier 2 – Specific Correction Factor for CKD

The CKD correction factor (CF_{ckd}) for use in Equation 2.2 can be derived as:

EQUATION 2.5
CORRECTION FACTOR FOR CKD NOT RECYCLED TO THE KILN

$$CF_{ckd} = 1 + (M_d / M_{cl}) \bullet C_d \bullet F_d \bullet (EF_c / EF_{cl})$$

Where:

CF_{ckd} = emissions correction factor for CKD, dimensionless

M_d = weight of CKD not recycled to the kiln, tonnes[a]

M_{cl} = weight of clinker produced, tonnes

C_d = fraction of original carbonate in the CKD (i.e., before calcination), fraction[b]

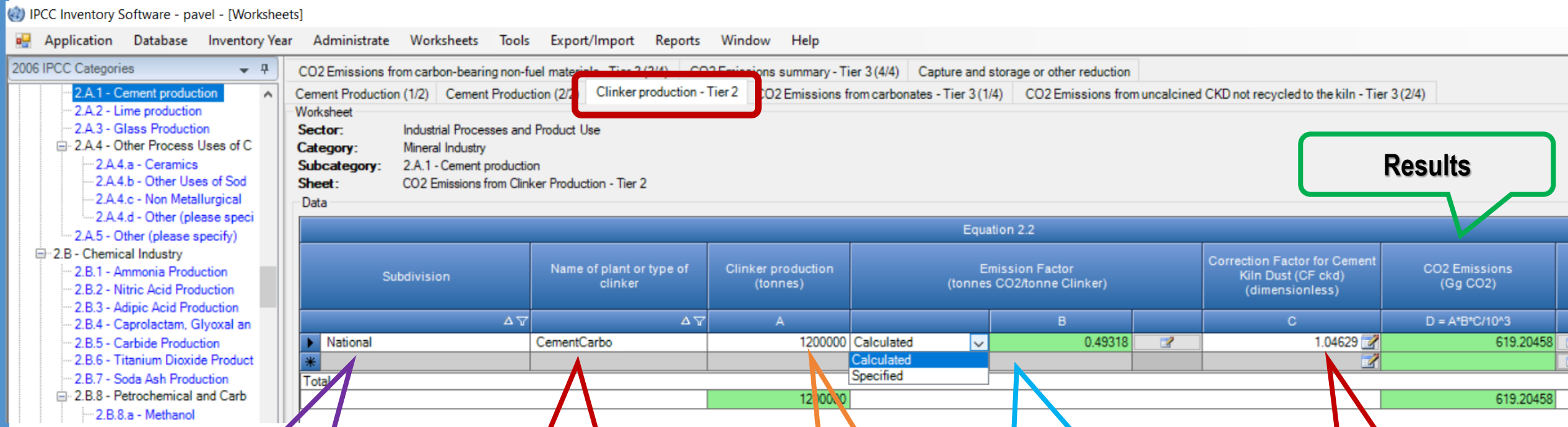
F_d = fraction calcination of the original carbonate in the CKD, fraction[b]

EF_c = emission factor for the carbonate (Table 2.1), tonnes CO_2/tonne carbonate

EF_{cl} = emission factor for clinker uncorrected for CKD (i.e., 0.51 tonnes CO_2/tonne clinker), tonnes CO_2/tonne clinker

✓ ...in the Software

Cement Production – Tier 2



Subdivisions
(drop-down [Unspecified] or manual input [User-defined])

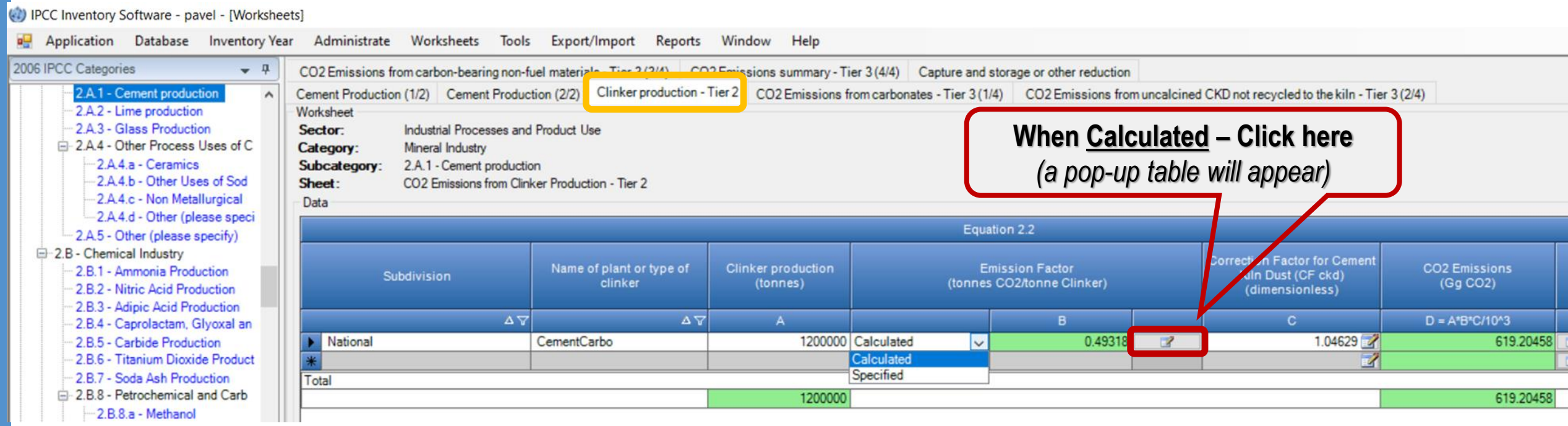
User-defined type of clinker or name of a plant
(manual input)

Amount of Clinker produced
(manual input of AD)

Emission Factor – Two Options: Calculated or Specified
(when Specified - manual input; when Calculated – a pop-up table)

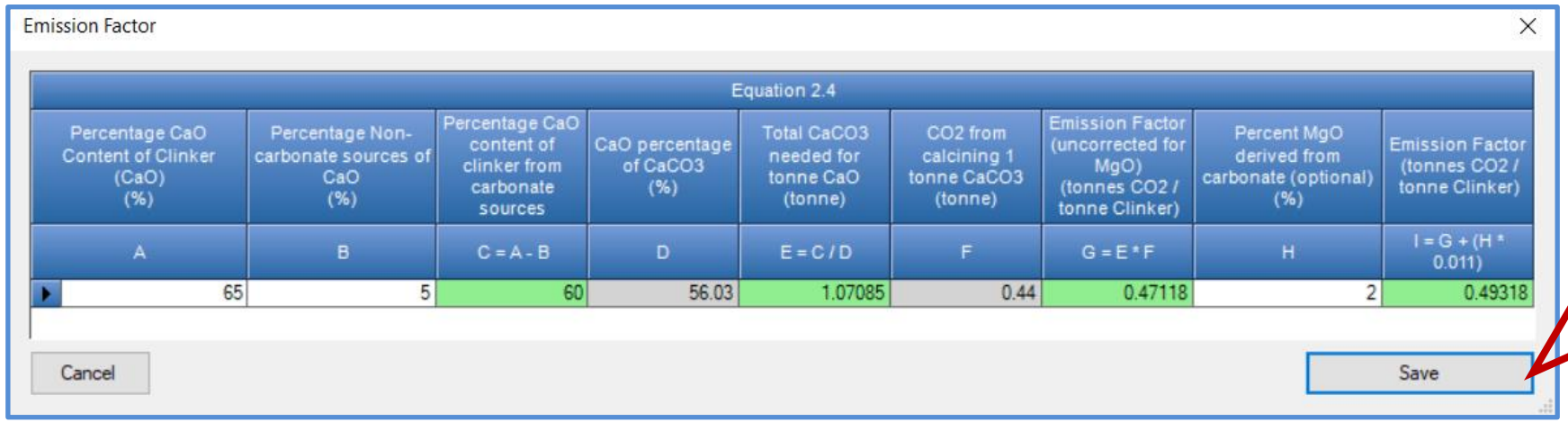
CKD Correction Factor
(manual input or calculated – a pop-up table)

Tier 2 – Calculated EF for clinker



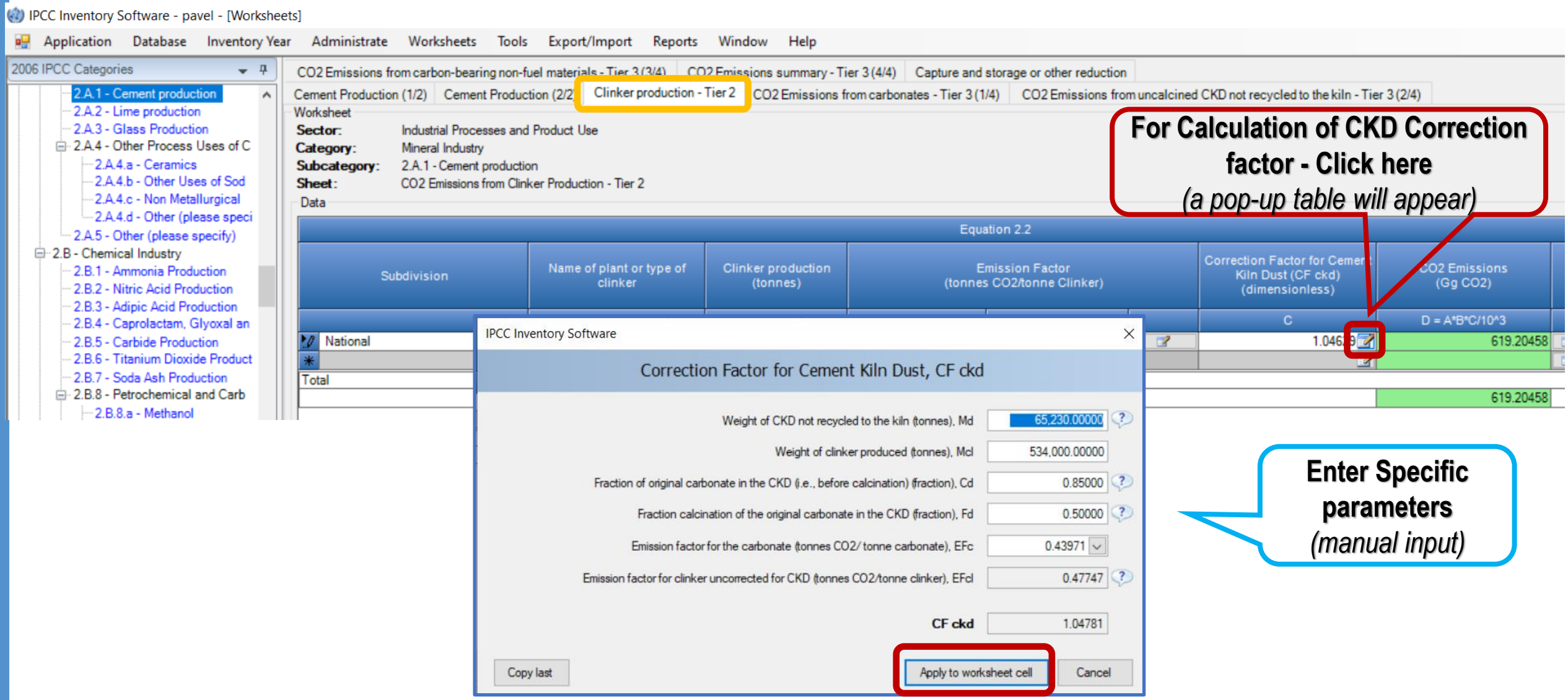
When <u>Calculated</u> – Click here
(a pop-up table will appear)

Enter Specific parameters *(manual input)*



Click Save *(calculated EF will automatically be transferred into the main worksheet)*

Tier 2 – Calculated Correction Factor for CKD



2.A.1 Cement Production

Tier 3

Tier 3 – Carbonates Input

EQUATION 2.3

TIER 3: EMISSIONS BASED ON CARBONATE RAW MATERIAL INPUTS TO THE KILN

$$CO_2\ Emissions = \sum_i (EF_i \bullet M_i \bullet F_i) - M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d + \sum_k (M_k \bullet X_k \bullet EF_k)$$

- $\sum_i (EF_i \bullet M_i \bullet F_i)$: Emissions from carbonates
- $M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d$: Emissions from uncalcined CKD not recycled to the kiln
- $\sum_k (M_k \bullet X_k \bullet EF_k)$: Emissions from carbon-bearing non-fuel materials

Where:

CO_2 Emissions = emissions of CO_2 from cement production, tonnes

EF_i = emission factor for the particular carbonate *i*, tonnes CO_2/tonne carbonate (see Table 2.1)

M_i = weight or mass of carbonate *i* consumed in the kiln, tonnes

F_i = fraction calcination achieved for carbonate *i*, fraction[a]

M_d = weight or mass of CKD not recycled to the kiln (= 'lost' CKD), tonnes

C_d = weight fraction of original carbonate in the CKD not recycled to the kiln, fraction[b]

F_d = fraction calcination achieved for CKD not recycled to kiln, fraction[a]

EF_d = emission factor for the uncalcined carbonate in CKD not recycled to the kiln, tonnes CO_2/tonne carbonate[b]

M_k = weight or mass of organic or other carbon-bearing nonfuel raw material *k*, tonnes[c]

X_k = fraction of total organic or other carbon in specific nonfuel raw material *k*, fraction[c]

EF_k = emission factor for kerogen (or other carbon)-bearing nonfuel raw material *k*, tonnes CO_2/tonne carbonate[c]

Cement Production – Tier 3

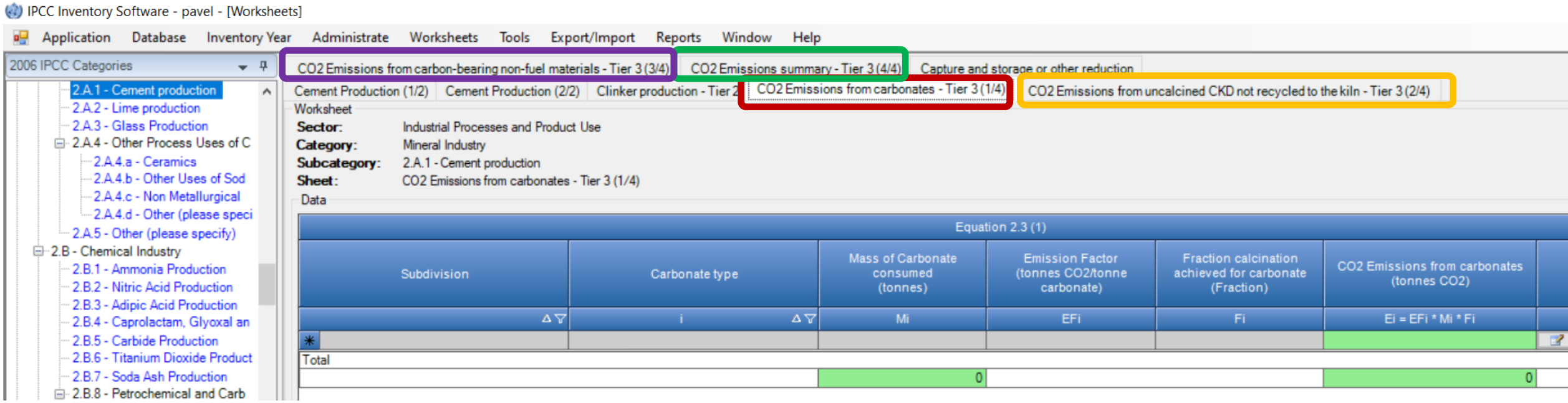
The Software breaks the Equation 2.3 into four worksheets:

i) Emissions from Carbonates
ii) Emissions from uncalcined CKD not recycled into the kiln
iii) Emissions from carbon-bearing materials
iv) CO_2 Emissions Summary (Total)

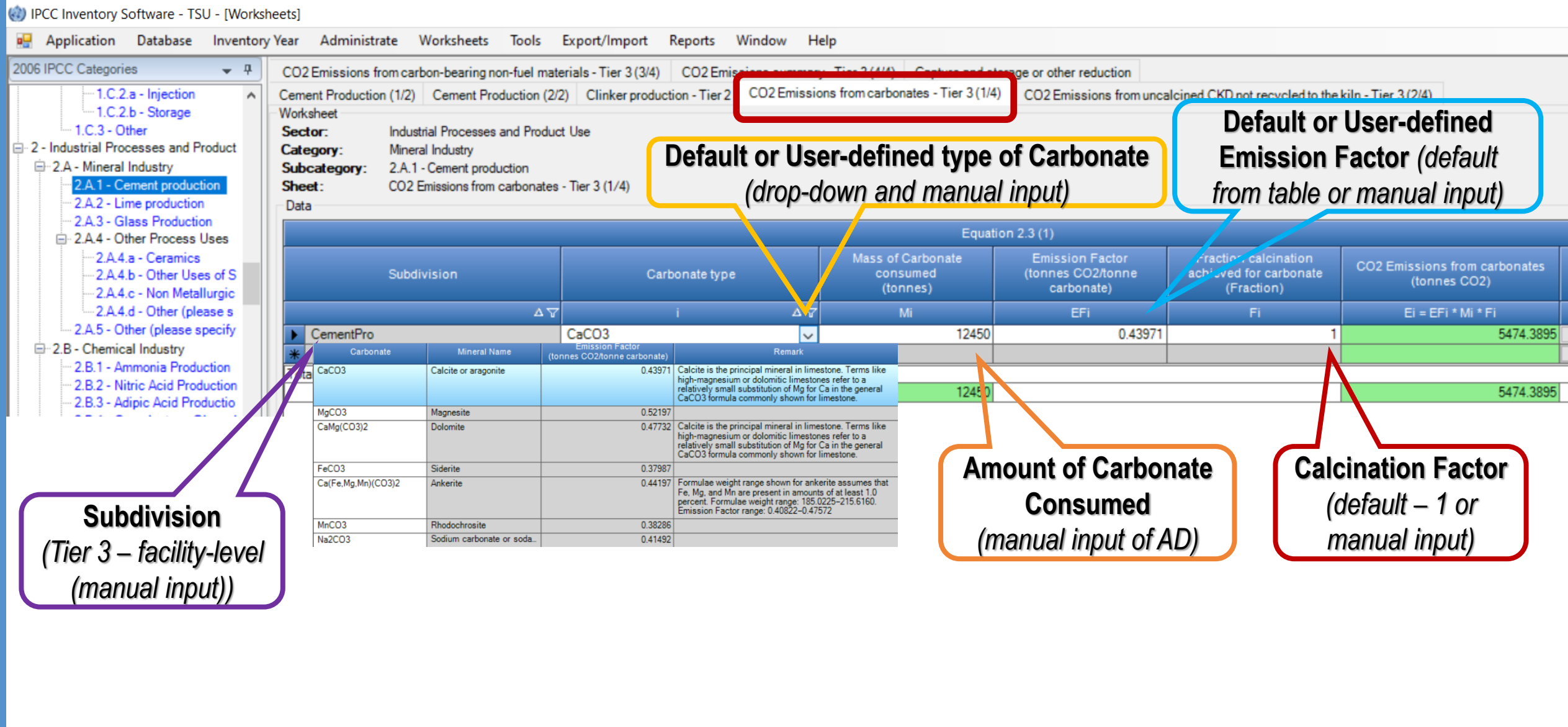
EQUATION 2.3
TIER 3: EMISSIONS BASED ON CARBONATE RAW MATERIAL INPUTS TO THE KILN

$$CO_2\ Emissions = \sum_i (EF_i \bullet M_i \bullet F_i) - M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d + \sum_k (M_k \bullet X_k \bullet EF_k)$$

- $\sum_i (EF_i \bullet M_i \bullet F_i)$: Emissions from carbonates
- $M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d$: Emissions from uncalcined CKD not recycled to the kiln
- $\sum_k (M_k \bullet X_k \bullet EF_k)$: Emissions from carbon-bearing non-fuel materials



Cement Production – Tier 3 (1/4)



Default or User-defined type of Carbonate *(drop-down and manual input)*

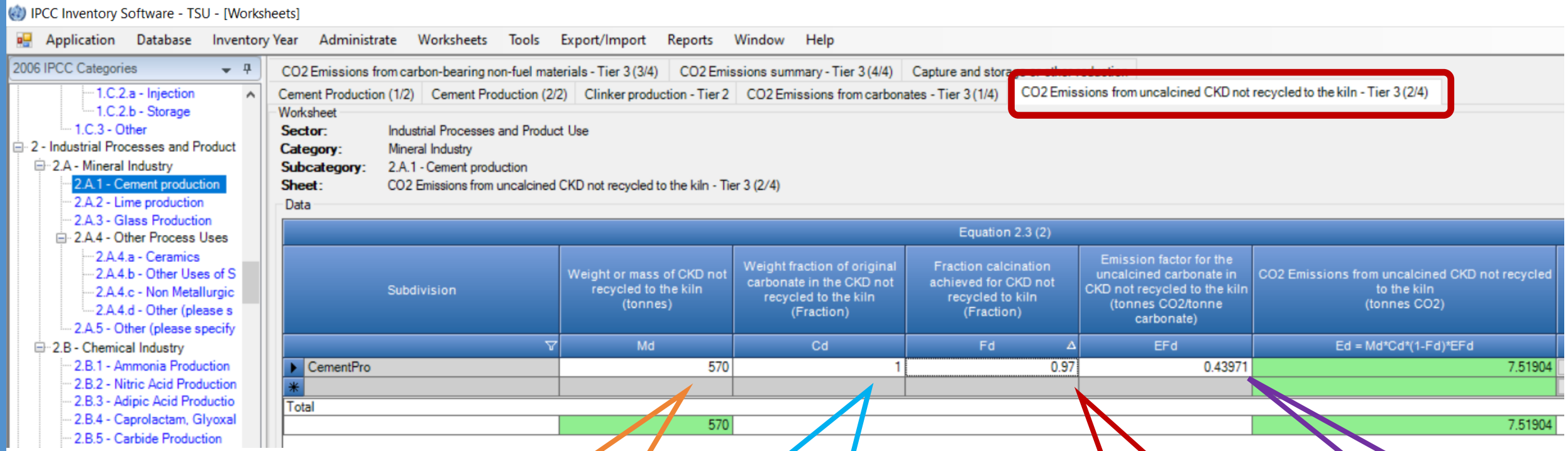
Default or User-defined Emission Factor *(default from table or manual input)*

Subdivision *(Tier 3 – facility-level (manual input))*

Amount of Carbonate Consumed *(manual input of AD)*

Calcination Factor *(default – 1 or manual input)*

Cement Production – Tier 3 (2/4)



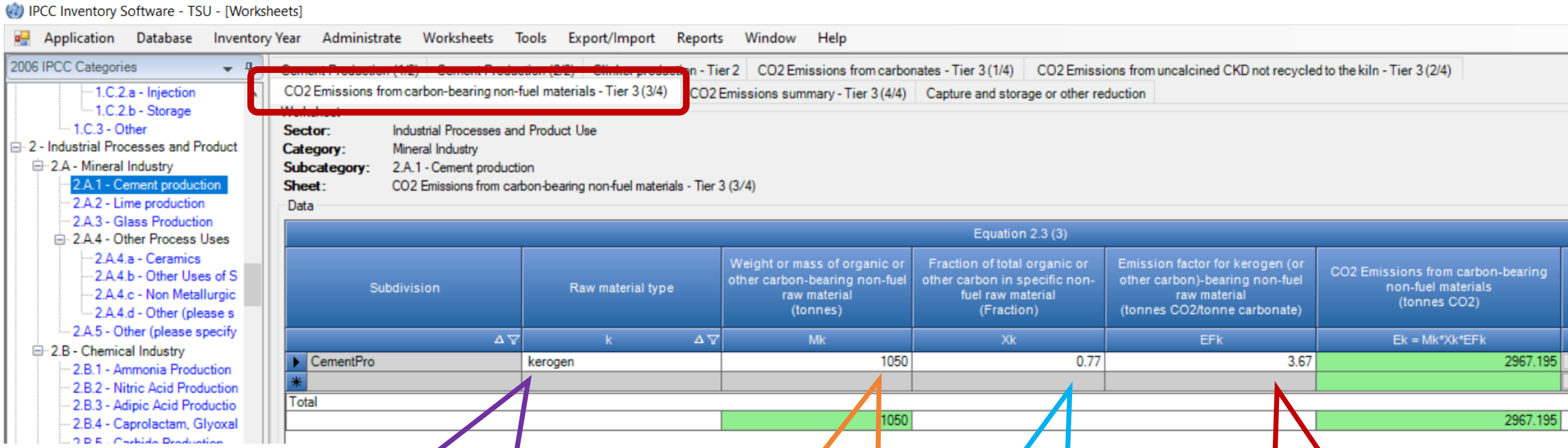
Amount of CKD not recycled to kiln *(manual input of AD)*

Default or User-defined Carbonate Fraction in CKD *(default – 1 or manual input)*

Calcination Factor *(default – 1 or manual input)*

Carbonate EF *(default or manual input)*

Cement Production – Tier 3 (3/4)



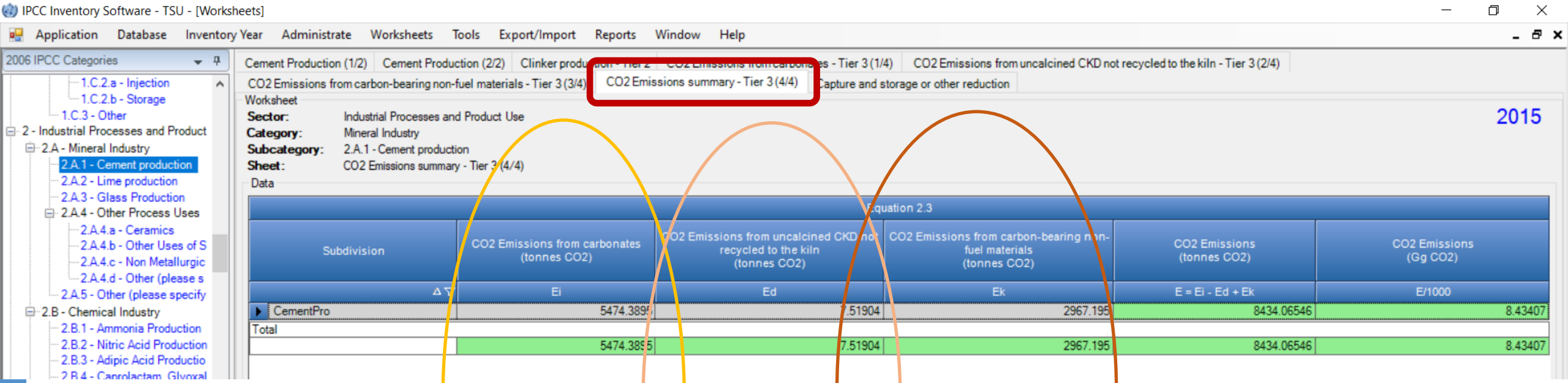
Name of raw material (non-fuel carbon-bearing material) *(manual input)*

Amount of raw material *(manual input of AD)*

User-defined Carbon Fraction *(manual input)*

User-defined Emission Factor *(manual input)*

Cement Production – Tier 3 (4/4)



EQUATION 2.3

TIER 3: EMISSIONS BASED ON CARBONATE RAW MATERIAL INPUTS TO THE KILN

$$CO_2\ Emissions = \sum_i (EF_i \bullet M_i \bullet F_i) - M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d + \sum_k (M_k \bullet X_k \bullet EF_k)$$

Emissions from carbonates

Emissions from uncalcined CKD not recycled to the kiln

Emissions from carbon-bearing non-fuel materials

2.A.1 Cement Production

CO_2 Capture

2A1 Cement Production

- Should CO_2 capture technology be installed and used at a plant, it is *good practice* to deduct the CO_2 captured in a higher tier emissions calculation.
- The default assumption is that there is no CO_2 capture and storage (CCS) taking place.
- Any methodology taking into account CO_2 capture should consider that CO_2 emissions captured in the process may be both combustion and process-related. In cases where combustion and process emissions are to be reported separately, e.g. for cement production, inventory compilers should ensure that the same quantities of CO_2 are not double counted. In these cases, the total amount of CO_2 captured should preferably be reported in the corresponding energy combustion and IPPU source categories in proportion to the amounts of CO_2 generated in these source categories.

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4 | Capture and storage or other reduction | Cement Production (1/2) | Cement Production (2/2) | Clinker production

Worksheet

Sector: Industrial Processes and Product Use
Category: Mineral Industry
Subcategory: 2.A.1 - Cement production
Sheet: Capture and storage or other reduction

Data

Gas CARBON DIOXIDE (CO2)

Subdivision	Source	Amount CO2 captured and stored (tonne)	Other reduction (tonne)	Total reduction (tonne)	Total reduction (Gg)
S	SRC	A	B	C = A + B	C / 1000
Unspecified	Unspecified	200000	25000	225000	225
Total				225000	225

✓ *Now let's do Exercises with Dummy data*

2.A.1 Cement Production

Tier 1

Dummy Data – Tier 1

- There are two cement production companies in Country X (Company A and Company B).
  - Company A produced 2,534 kt of cement in 2015 and 3,112 kt in 2022.
    - ✓ Cement is a product mix, so called '30/70' *(30% portland cement and 70% blended cement) and 20% additives*
  - Company B produced 1,204kt of cement in 2015 and 4,205 kt in 2022.
    - ✓ Detailed information on cement type was not reported, but it is supposed that significant amounts of blended and/or masonry cements were produced in addition to portland cement *(i.e. blended/masonry was much).*
  - Company B exported 45 kt of clinker in 2015 and 67 kt in 2022 (there is no import)

Dummy Data – Tier 1

- **Estimate CO_2 emissions from cement production in Country X in 2015 and 2022.**
- As regards clinker fraction to be used in the calculation, see Table 2.2 from the *2006 IPCC Guidelines*

TABLE 2.2
CLINKER FRACTION OF BLENDED CEMENT 'RECIPES' AND OVERALL PRODUCT MIXES (BASED ON U.S. STANDARDS ASTM C-150 AND C-595; U.S. DATA MAY BE ILLUSTRATIVE FOR OTHER COUNTRIES)

Cement Name	Symbol	Recipe	% Clinker	Notes
Portland	'PC'	100% PC	95 - 97	Some U.S. states allow inclusion of 3% GGBFS.
			90 - 92	Latest standards allow inclusion of ≤ 5% ground limestone.
Masonry	'MC'	2/3 PC	64	varies considerably
Slag-modified portland	I(SM)	slag < 25%	>70 - 93	
Portland BF Slag	IS	slag 25-70%	28 - 70	
Portland pozzolan	IP and P	pozz 15-40%	28 - 79/81	base is PC and/or IS
Pozzolan-modified portland	I(PM)	pozz <15%	28 - 93/95	base is PC and/or IS
Slag cement	S	slag 70+%	<28/29	can use CaO instead of clinker

PERCENT CLINKER IN THE PRODUCT MIX

	Percent Additives (Pozzolan + Slag) in the Blended Cement*					
Product Mix (PC/blend)**	**0%**	**10%**	**20%**	**30%**	**40%**	**75%**
100/0	95 - 97	0	0	0	0	0
0/100	0	85.5	76	66.5	57	23.8
15/85	14.2	86.9	78.9	70.8	62.7	26.4
25/75	23.8	87.9	80.8	73.6	66.5	41.6
30/70	28.5	88.35	81.7	75.1	68.4	45.2
40/60	38	89.3	83.6	77.9	72.2	52.3
50/50	47.5	90.3	85.5	80.8 ***	76	59.4
60/40	57	91.2	87.4	83.6	79.8	66.5
70/30	66.5	92.2	89.3	86.5	83.6	73.6
75/25	71.1	92.6	90.1	87.8	85.4	77.1
85/15	80.8	93.6	92.2	90.7	89.3	84.3

2.A.1 Cement Production

Tier 2

2.A.1 Tier 2 – Clinker AD

- Company CementCarbo reports data based on clinker production. It produced 534 kt of clinker in 2015 and 612 kt in 2022.
- For estimation of CO_2 EF from clinker, use the default CaO content in clinker – 65%.
- For the data concerning the correction factor for cement kiln dust (CKD), see the table below (plant-specific data).

Parameter	2015	2022
Weight of CKD not recycled to the kiln (Md), tonne	65,230.0	74,940.0
Weight of clinker produced (Mcl), tonne	534,000.0	612000.0
Fraction of original carbonate in the CKD before calcination (Cd), fraction	1	1
Fraction calcination of the original carbonate in the CKD (Fd), fraction	1	1
Emission factor for the carbonate (EFc), tonne CO_2/ tonne carbonate	0.43971	0.43971
Emission factor for clinker uncorrected for CKD (EFcl), tonne CO_2/ tonne clinker	0.51044	0.51044

2.A.1 Cement Production

Tier 3

2.A.1 Tier 3 – Carbonates Input

- **Company CementPro reports data based on the amount of carbonates consumed in cement production process:**
  - i. **Carbonates used:** amount of limestone (calcite - $CaCO_3$) used – 12,45 kt in 2015 and 10.05 kt in 2022, calcination fraction achieved is assumed to be 100%
  - ii. **Correction for uncalcined CKD:** the amount of CKD not recycled to the kiln – 0.57 kt in 2015 and 0.51 kt in 2022, the weight fraction of original carbonate in the CKD not recycled to the kiln is assumed to be 100%, the calcination fraction is 0.99, the EF for Calcite is 0.43971 tonne CO_2/ tonne carbonate.
  - iii. **Additional carbon-bearing non-fuel materials – Kerogen:** the amount of kerogen used – 1,05 kt in 2015 and 0.5 kt in 2022, carbon content – 77%, the EF – 3.67 tonne CO_2/ tonne of carbon.

2.A.1 Cement Production

CO_2 Capture

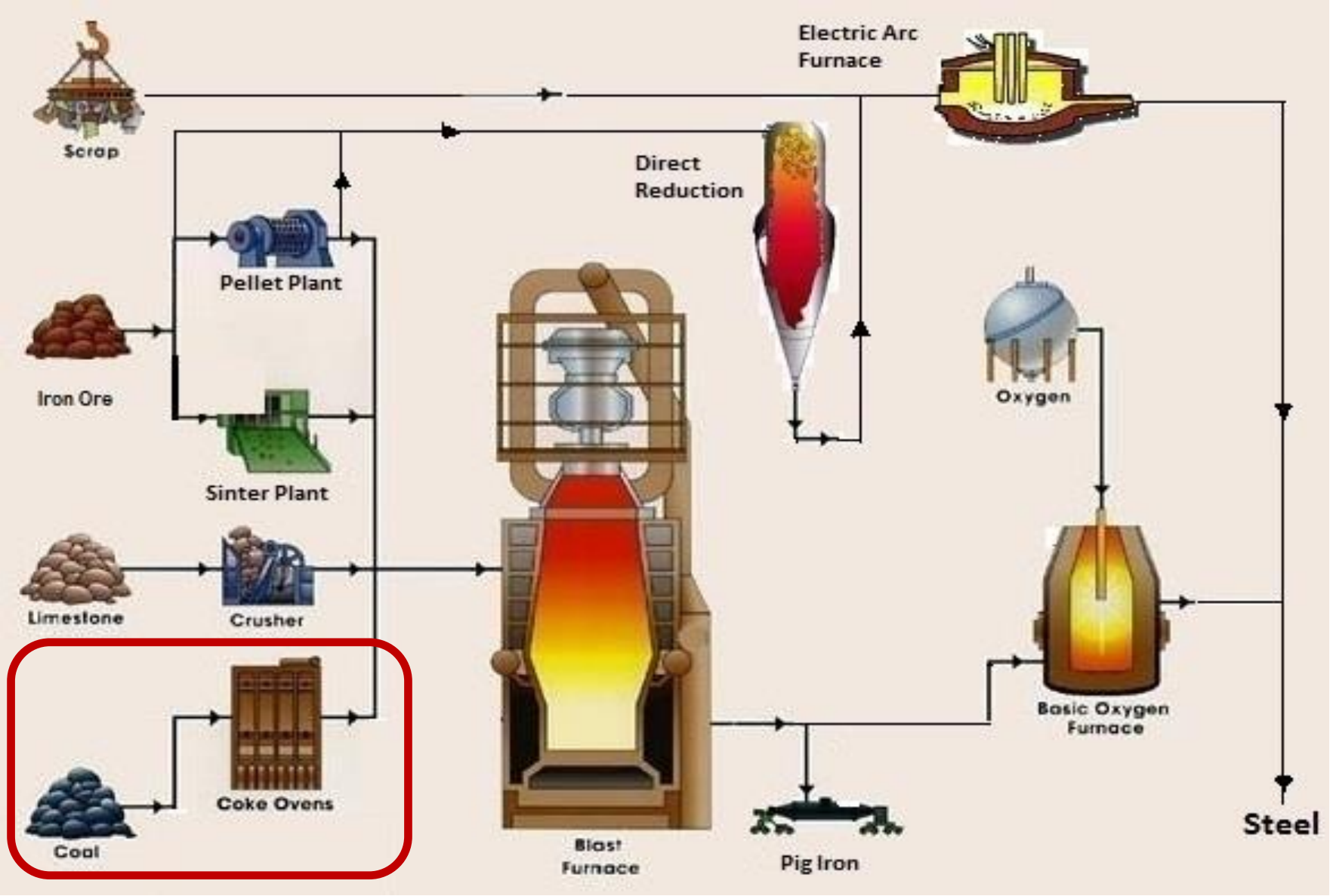
2A1 – CO_2 Capture

- Company X captured at the cement plant 200kt of CO_2 for the subsequent geological storage and 25kt of CO_2 for use (for re-conversion to carbonates, for production of methanol, etc.) in 2015. For 2022, the amounts are the same.

Examples of Data Input

Iron and Steel (2.C.1)

2C1: Iron and Steel Production



Coke Production

(on-site and off-site):

Coal + (*Heat*) = Coke + CO_2

(to be reported in Energy)

Iron and Steel Production

(coke as reductant and as fuel)

+ Iron Ore = Iron + CO_2 *(Reduction)*

Coke

+ Oxygen = CO_2 + (*Heat*) *(Combustion)*

(to be reported in IPPU)

Image: adapted from MetalPass http://www.metalpass.com/metaldoc/paper.aspx?docID=251 *(as of March 1 , 2015)*

2.C.1 Iron and Steel Production - Tiers

- ***2006 IPCC Guidelines* provide three Tiers for CO_2**
  - **Tier 1** *(EF approach)*
  - **Tier 2** *(mass-balance approach using specific carbon content data)*
  - **Tier 3** *(mass-balance approach with plant-specific data)*
- ***2006 IPCC Guidelines* provide two Tiers for CH_4**
  - **Tier 1** *(default EFs)*
  - **Tier 3** *(plant-specific data)*

1.A.1.c Coke Production - Tiers

- 2006 IPCC Guidelines: Tier 1 – AD x EF
- 2019 Refinement: Tier 1a – AD x EF

  Tier 1b – simplified carbon balance of carbon content of coking coal minus coke

- Tier 2 method for estimating CO_2 emissions is a mass-balance approach based on carbon content of all input and output materials. Tier 3 uses plant specific data.
- Tier 2 method is not applicable to estimating CH_4 emissions (it is a mass-balance for all Carbon and subsequent CO_2)

N.B. Emissions from Coke Production should be reported in Energy Sector (in category 1.A.1.c Manufacture of Solid Fuels (not 2.C.1 !!!))

- ✓ ***When preparing the JSON file for interoperability, these AD and emissions are automatically reported in Energy sector***

Tier 1

Equations 4.4-4.8

CO_2 Emissions = $\Sigma(AD_i \times EF_i)$

AD_i - quantity of material *i* produced, tonne

EF_i - emission factor for production of material *i*, tonne CO_2/tonne material *i* produced

EQUATION 4.4
CO_2 EMISSIONS FROM IRON AND STEEL PRODUCTION (TIER 1)

Iron & Steel: $E_{CO2,\,non-energy} = BOF \bullet EF_{BOF} + EAF \bullet EF_{EAF} + OHF \bullet EF_{OHF}$

EQUATION 4.5
CO_2 EMISSIONS FROM PRODUCTION OF PIG IRON NOT PROCESSED INTO STEEL (TIER 1)

Pig Iron Production: $E_{CO2,\,non-energy} = IP \bullet EF_{IP}$

EQUATION 4.6
CO_2 EMISSIONS FROM PRODUCTION OF DIRECT REDUCED IRON (TIER 1)

Direct Reduced Iron: $E_{CO2,\,non-energy} = DRI \bullet EF_{DRI}$

EQUATION 4.7
CO_2 EMISSIONS FROM SINTER PRODUCTION (TIER 1)

Sinter Production: $E_{CO2,\,non-energy} = SI \bullet EF_{SI}$

EQUATION 4.8
CO_2 EMISSIONS FROM PELLET PRODUCTION (TIER 1)

Pellet Production: $E_{CO2,\,non-energy} = P \bullet EF_{P}$

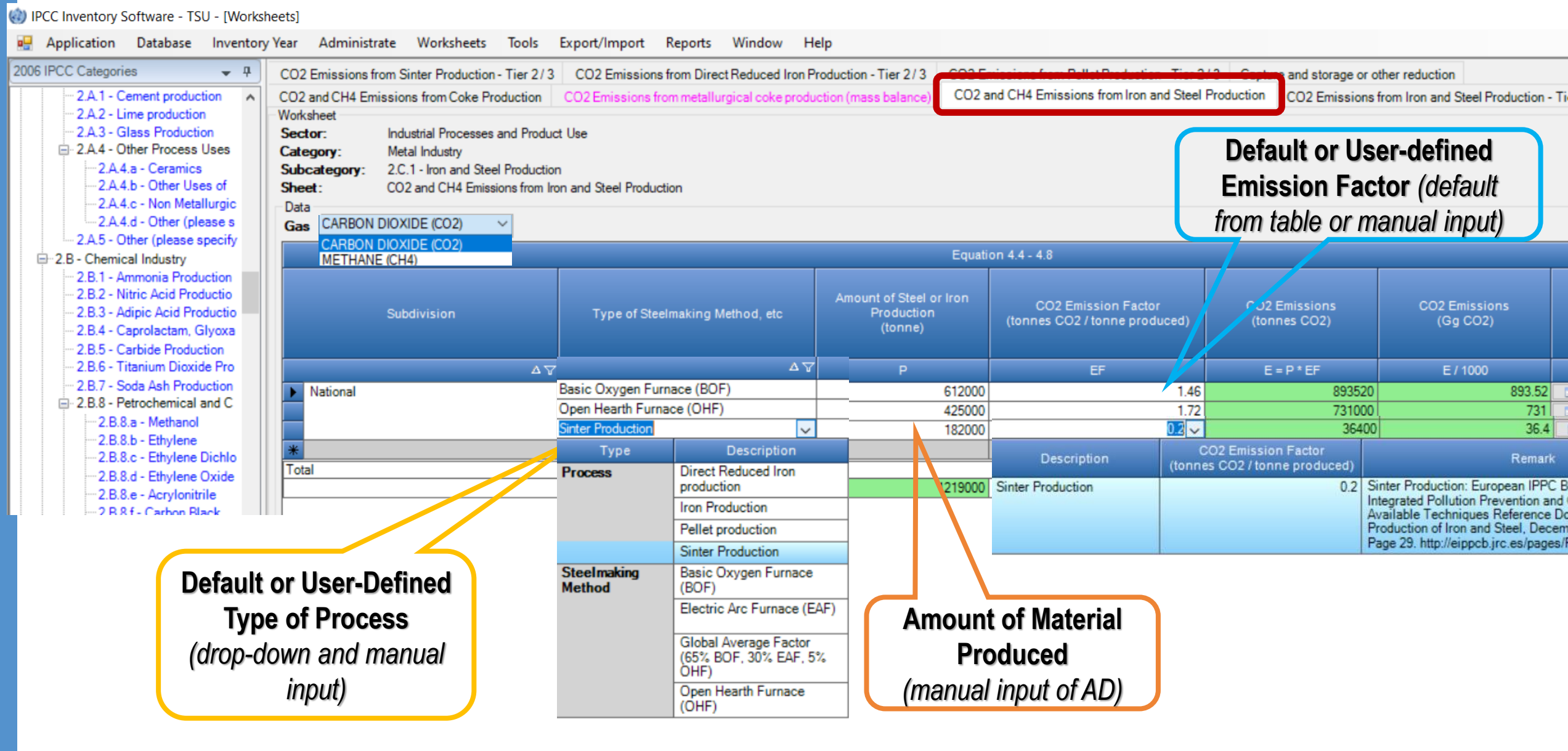
Tier 1 – Default EFs

TABLE 4.1
TIER 1 DEFAULT CO_2 EMISSION FACTORS FOR COKE PRODUCTION AND IRON & STEEL PRODUCTION

Process	Emission Factor	Source
Sinter Production (tonne CO_2 per tonne sinter produced)	0.20	Sinter Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 4.1, Page 29. http://eippcb.jrc.es/pages/FActivities.htm
Coke Oven (tonne CO_2 per tonne coke produced)	0.56	Coke Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 6.2, Page 122. http://eippcb.jrc.es/pages/FActivities.htm
Iron Production (tonne CO_2 per tonne pig iron produced)	1.35	Iron Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Tables 7.2 and 7.3. http://eippcb.jrc.es/pages/FActivities.htm
Direct Reduced Iron production (tonne CO_2 per tonne DRI produced)	0.70	Direct Reduced Iron Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 10.1 Page 322 and Table 10.4 Page 331. http://eippcb.jrc.es/pages/FActivities.htm
Pellet production (tonne CO_2 per tonne pellet produced)	0.03	Pellet Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 5.1 Page 95. http://eippcb.jrc.es/pages/FActivities.htm
Steelmaking Method		
Basic Oxygen Furnace (BOF) (tonne CO_2 per tonne of steel produced)	1.46	Steel Production: Consensus of experts and IISI Environmental Performance Indicators 2003 STEEL (International Iron and Steel Institute, 2004)
Electric Arc Furnace (EAF) (tonne CO_2 per tonne of steel produced) **	0.08	Steel Production: Consensus of experts and IISI Environmental Performance Indicators 2003 STEEL (International Iron and Steel Institute, 2004)
Open Hearth Furnace (OHF) (tonne CO_2 per tonne of steel produced)	1.72	Steel Production: Consensus of experts and IISI Environmental Performance Indicators 2003 STEEL (International Iron and Steel Institute, 2004)
Global Average Factor (65% BOF, 30% EAF, 5% OHF)* (tonne CO_2 per tonne of steel produced)	1.06	Steel Production: Consensus of experts and IISI Environmental Performance Indicators 2003 STEEL (International Iron and Steel Institute, 2004)

✓ ...in the Software

Iron and Steel – Tier 1



2.C.1 Iron and Steel Production

Tier 2/3

2.C.1 Iron and Steel Production

Tier 2 is a mass-balance approach. It is appropriate when the inventory compiler has access to national data on the use of process materials for iron and steel production, sinter production, pellet production, and direct reduced iron production.

Tier 3 uses plant specific data.

EQUATION 4.9
CO_2 EMISSIONS FROM IRON & STEEL PRODUCTION (TIER 2)

$$E_{CO2,non-energy} = \left[PC \bullet C_{PC} + \sum_a (COB_a \bullet C_a) + CI \bullet C_{CI} + L \bullet C_L + D \bullet C_D + CE \bullet C_{CE} + \sum_b (O_b \bullet C_b) + COG \bullet C_{COG} - S \bullet C_S - IP \bullet C_{IP} - BG \bullet C_{BG} \right] \bullet \frac{44}{12}$$

✓ *Mass-balance of Input and Output materials multiplied by Carbon Content. The difference is CO_2 emissions.*

2.C.1 Iron and Steel Production

- **Biogenic component**

  - Some input materials may be of a biogenic origin. Emissions from biogenic component is not included in the national total.
  - In Iron and Steel Production *biochar/charcoal* can be used instead of *coal* or *coke*.

Iron and Steel – Tier 2/3 (#1)

IPCC Inventory Software - TSU - [Worksheets]

Application | Database | Inventory Year | Administrate | Worksheets | Tools | Export/Import | Reports | Window | Help

2006 IPCC Categories

- 2.C - Metal Industry
  - 2.C.1 - Iron and Steel Produ
  - 2.C.2 - Ferroalloys Producti
  - 2.C.3 - Aluminium productio
  - 2.C.4 - Magnesium producti
  - 2.C.5 - Lead Production
  - 2.C.6 - Zinc Production
  - 2.C.7 - Rare Earths Producti
  - 2.C.8 - Other (please specif
- 2.D - Non-Energy Products from
  - 2.D.1 - Lubricant Use
  - 2.D.2 - Paraffin Wax Use
  - 2.D.3 - Solvent Use
  - 2.D.4 - Other (please specif
- 2.E - Electronics Industry
  - 2.E.1 - Integrated Circuit or
  - 2.E.2 - TFT Flat Panel Displ
  - 2.E.3 - Photovoltaics
  - 2.E.4 - Heat Transfer Fluid
  - 2.E.5 - Other (please specify
- 2.F - Product Uses as Substitut
  - 2.F.1 - Refrigeration and Air

CO2 Emissions from Sinter Production - Tier 2 / 3 | CO2 Emissions from Direct Reduced Iron Production - Tier 2 / 3 | CO2 Emissions from Pellet Production - Tier 2 / 3

CO2 and CH4 Emissions from Coke Production | CO2 Emissions from metallurgical coke production (mass balance) | CO2 and CH4 Emissions from Iron and Steel Productio | **CO2 Emissions from Iron and Steel Production - Tier 2 / 3**

Worksheet

Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 Emissions from Iron and Steel Production - Tier 2 / 3

Data

Pop-up Table

Subdivision	Quantity of coke / biochar consumed in iron and steel production (not including sinter production) (tonnes)	Carbon Content of coke / biochar (tonnes C / tonne PC)	Biochar instead of coke	Total Carbon in on-site coke oven by-products consumed in blast furnace (tonnes C)		Quantity of coal / biochar directly injected into blast furnace (tonnes)	Carbon Content of coal / biochar directly injected into blast furnace (tonnes C / tonne Coal)	Biochar instead of coal	Quantity of limestone consumed in iron and steel production (tonnes)	Carbon Content of limestone (tonnes C / tonne Limestone)
	PC	Cpc		BPC		CI	Cci		L	CI
Company ZZZ	800000	0.83	☑	1420		330000	0.73	☑	15000	0.12
		0.82344	■					■		
Total	800000			1420		330000			15000	

Input Materials:
Amount and Carbon Content
(manual input and drop-down for defaults)

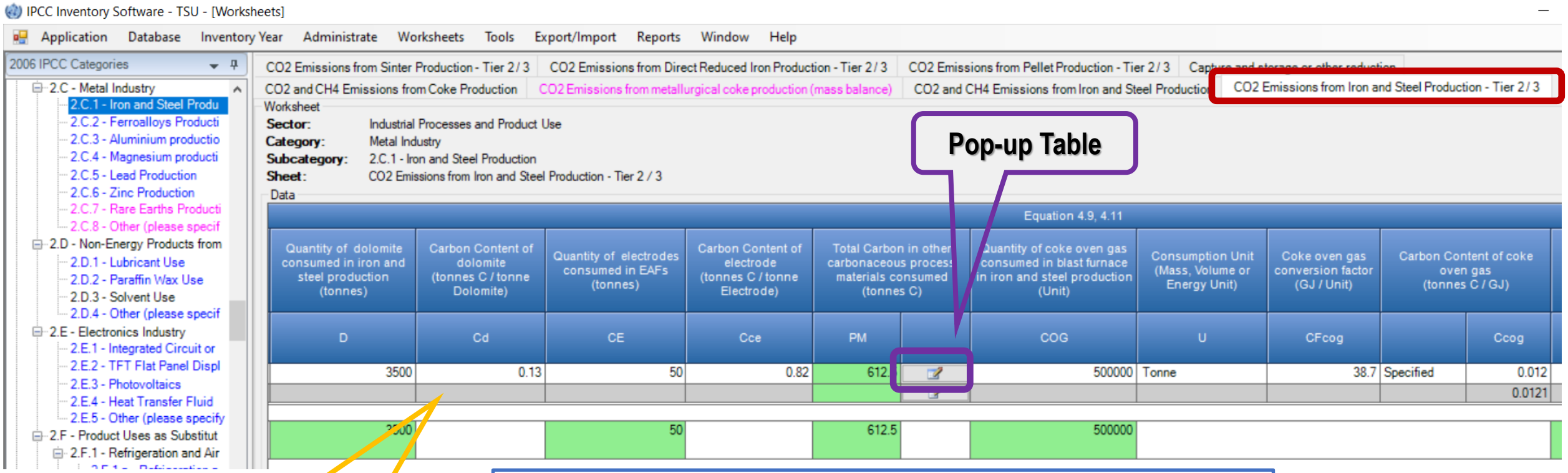
Coke, Coal, Limestone, Coke oven by-products

Iron and Steel production - Consumption of on-site coke oven by-products in blast furnace

By-product	Quantity of on-site coke oven by-product consumed in blast furnace (tonnes)	Carbon Content of by-product (tonnes C/tonne By-product)	Biogenic	Total Carbon in on-site coke oven by-products consumed in blast furnace (tonnes C)	
	BP	CC		C = BP * CC	
Coke oven by-product BP1	8200	0.1	☐	820	✕
By-product gas G1	1000	0.6	☐	600	✕
			■		✕
Total	9200		Total carbon:	1420	
			Biogenic carbon:	0	
			Biogenic fraction:	0	

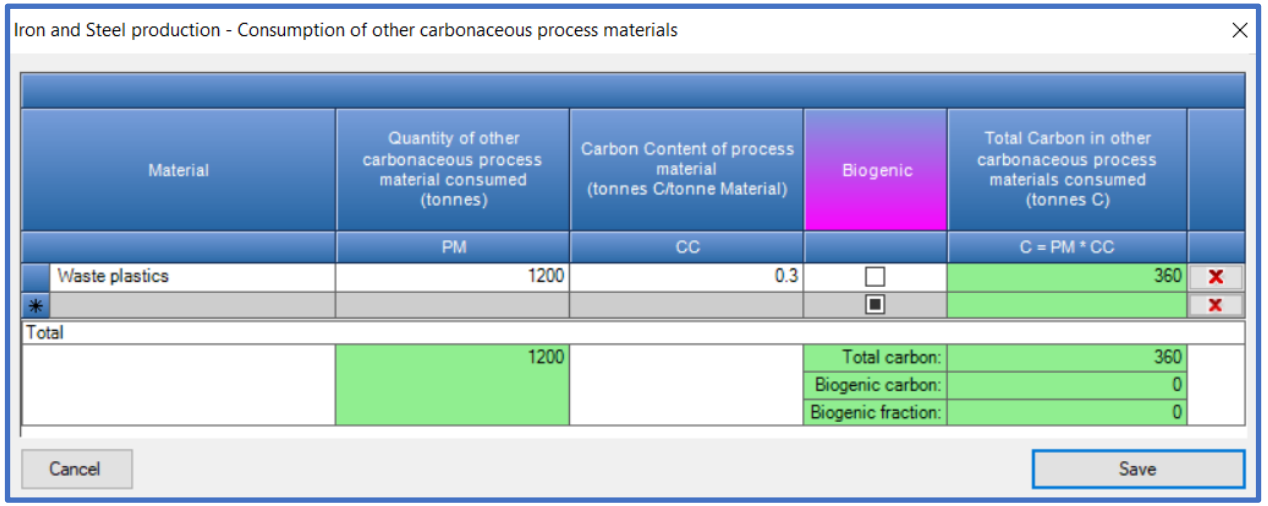
Cancel | Save

Iron and Steel – Tier 2/3 (#2)

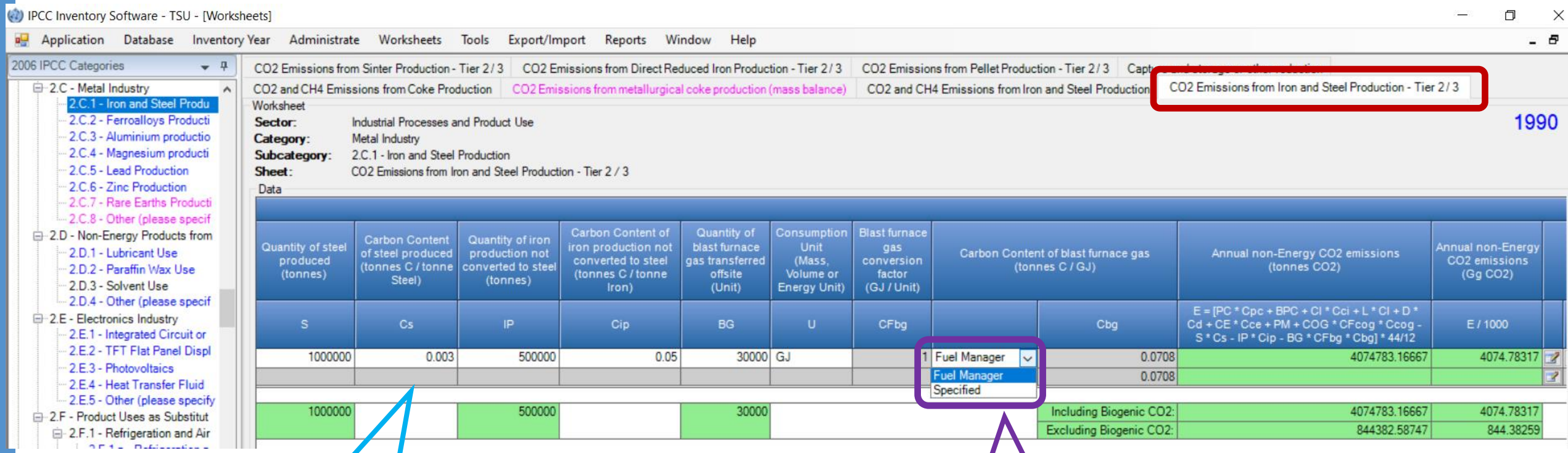


Input Materials:
Amount and Carbon Content
(manual input and drop-down for defaults)

Dolomite, Electrodes, COG, Other



Iron and Steel – Tier 2 (#3)



Output Materials:
Amount and Carbon Content
(manual input and drop-down for defaults)

Steel, Iron, BFG

Drop-down menu for Carbon Content
(either from Fuel Manager or Specified – manual input)

Results

✓ *Now let's do Exercises with Dummy data*

2.C.1 Iron and Steel Production

Tier 1

Dummy Data – Tier 1

- There are two steel-making plants. They use two main steel-making processes:

i) Basic oxygen furnace (BOF), where 612kt of steel was produced in 2015 and 720 kt in 2022

ii) Open hearth furnace (OHF), where 425kt of steel was produced in 2015 and 312 kt in 2022.

Also, 182kt of sinter was produced in 2015 and 199 kt in 2022.

- **Estimate CO_2 emissions from Iron and Steel Production in 2015 and 2022** *(as regards emission factors to be used in the calculation, see Table 4.1 of the 2006 IPCC Guidelines).*

TABLE 4.1
TIER 1 DEFAULT CO_2 EMISSION FACTORS FOR COKE PRODUCTION AND IRON & STEEL PRODUCTION

Process	Emission Factor	Source
Sinter Production (tonne CO_2 per tonne sinter produced)	0.20	Sinter Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 4.1, Page 29. http://eippcb.jrc.es/pages/FActivities.htm
Coke Oven (tonne CO_2 per tonne coke produced)	0.56	Coke Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 6.2, Page 122. http://eippcb.jrc.es/pages/FActivities.htm
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Direct Reduced Iron production (tonne CO_2 per tonne DRI produced)	0.70	Direct Reduced Iron Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 10.1 Page 322 and Table 10.4 Page 331. http://eippcb.jrc.es/pages/FActivities.htm
Pellet production (tonne CO_2 per tonne pellet produced)	0.03	Pellet Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 5.1 Page 95. http://eippcb.jrc.es/pages/FActivities.htm
Steelmaking Method		
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Open Hearth Furnace (OHF) (tonne CO_2 per tonne of steel produced)	1.72	Steel Production: Consensus of experts and IISI Environmental Performance Indicators 2003 STEEL (International Iron and Steel Institute, 2004)
Global Average Factor (65% BOF, 30% EAF, 5% OHF)* (tonne CO_2 per tonne of steel produced)	1.06	Steel Production: Consensus of experts and IISI Environmental Performance Indicators 2003 STEEL (International Iron and Steel Institute, 2004)

2.C.1 Iron and Steel Production

Tier 2/3

Dummy Data – Tier 2/3

- Company ZZZ reports the following input and output materials (in tonnes) in 2015 and 2022:

Input materials	2015	2022	Output Materials	2015	2022
Coke	360 000	450 000	Steel	1 020 000	1 275 000
Coal	160 000	200 000	Iron	980 000	1 225 000
Limestone	75 000	94 000	BFG	5 500 GJ	6 875 GJ
Dolomite	1 000	1 250	*All values are in tonnes, except BFG in GJ*		
Natural Gas	2 200	2 750			
COG	11 000	13 750			

- Assume user applies all IPCC default carbon contents, see Table 4.3 of the *2006 IPCC Guidelines*
- Estimate CO_2 emissions from Iron and Steel Production
- **Also, let's tick the *biogenic* component and see the different results**

TABLE 4.3
TIER 2 MATERIAL-SPECIFIC CARBON CONTENTS FOR IRON & STEEL AND COKE PRODUCTION (kg C/kg)

Process Materials	Carbon Content
Blast Furnace Gas	0.17
Charcoal*	0.91
Coal[1]	0.67
Coal Tar	0.62
Coke	0.83
Coke Oven Gas	0.47
Coking Coal	0.73
Direct Reduced Iron (DRI)	0.02
Dolomite	0.13
EAF Carbon Electrodes[2]	0.82
EAF Charge Carbon[3]	0.83
Fuel Oil[4]	0.86
Gas Coke	0.83
Hot Briquetted Iron	0.02
Limestone	0.12
Natural Gas	0.73
Oxygen Steel Furnace Gas	0.35
Petroleum Coke	0.87
Purchased Pig Iron	0.04
Scrap Iron	0.04
Steel	0.01

Source: Default values are consistent with the those provided in Vol 2 and have been calculated with the assumptions below. Complete references for carbon content data are included in Table 1.2 and 1.3 in Volume 2, Chapter 1.

Notes:

[1] Assumed other bituminous coal

[2] Assumed 80 percent petroleum coke and 20 percent coal tar

[3] Assumed coke oven coke

[4] Assumed gas/diesel fuel

* The amount of CO_2 emissions from charcoal can be calculated by using this carbon content value, but it should be reported as zero in national greenhouse gas inventories. (See Section 1.2 of Volume 1.)

2.C.1 Iron and Steel Production

Coke Production – Tier 1

(to be reported in Energy – 1.A.1.c)

Dummy Data – Tier 1

- Region North produced 45 kt of coke and Region South produced 1.2 kt of coke in 2015. In 2022 – 61 kt and 1.9 kt respectively.
- Estimate CO_2 and CH_4 emissions from Coke Production. As regards emission factors to be used in the calculation, see the Tables 4.1 and 4.2 from the *2006 IPCC Guidelines*.
- **Track CO_2 and CH_4 emissions from Coke Production in Reporting tables !**

Tier 1 default CO_2 emission factor

TABLE 4.1
TIER 1 DEFAULT CO_2 EMISSION FACTORS FOR COKE PRODUCTION AND IRON & STEEL PRODUCTION

Process	Emission Factor	Source
Coke Oven (tonne CO_2 per tonne coke produced)	0.56	Coke Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 6.2, Page 122. http://eippcb.jrc.es/pages/FActivities.htm

Tier 1 default CH_4 emission factor

TABLE 4.2
TIER 1 DEFAULT CH_4 EMISSION FACTORS FOR COKE PRODUCTION AND IRON & STEEL PRODUCTION

Process	Emission Factor	Source
Coke Production	0.1 g per tonne of coke produced	Coke Production: European IPPC Bureau (2001), Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, Table 6.2-3, Page 122. http://eippcb.jrc.es/pages/FActivities.htm

2.B.8 Petrochemical and Carbon Black Production

(Example of Data Input for 2.B.8.b Ethylene)

2.B.8 Petrochemical Industry – Tier 1

Tier 1 product-based emission factor method

The Tier 1 emission factor methodology is applied to estimate CO_2 emissions from the petrochemical process in cases where neither plant specific data nor activity data for carbon flows are available for the petrochemical process. The Tier 1 emission factor method does not require activity data for the consumption of each carbon-containing feedstock to the petrochemical production process. It requires only activity data for the amount of product produced. The Tier 1 methodology does not consider the carbon content of emissions of carbon monoxide or NMVOC that may be generated by the petrochemical processes. The equations in this section for petrochemical production processes also apply to carbon black production.

The Tier 1 method calculates emissions from petrochemical processes on the basis of activity data for production of each petrochemical and the process-specific emission factor for each petrochemical, as shown in the Equation 3.15 for production of each primary petrochemical product (e.g., methanol, ethylene, ethylene dichloride, ethylene oxide, acrylonitrile) and carbon black.

EQUATION 3.15
TIER 1 CO_2 EMISSION CALCULATION

$$ECO2_i = PP_i \bullet EF_i \bullet GAF / 100$$

Where:

$ECO2_i$ = CO_2 emissions from production of petrochemical *i*, tonnes

PP_i = annual production of petrochemical *i*, tonnes

EF_i = CO_2 emission factor for petrochemical *i*, tonnes CO_2/tonne product produced

GAF = Geographic Adjustment Factor (for Tier 1 CO_2 emission factors for ethylene production, See Table 3.15), percent

Emission Factor Approach: AD x EF

Tier 1 default CO_2 EF for Ethylene

TABLE 3.14
STEAM CRACKING ETHYLENE PRODUCTION TIER 1 CO_2 EMISSION FACTORS

	tonnes CO_2/tonne ethylene produced					
Feedstock	**Naphtha**	**Gas Oil**	**Ethane**	**Propane**	**Butane**	**Other**
Ethylene (Total Process and Energy Feedstock Use)	1.73	2.29	0.95	1.04	1.07	1.73
- Process Feedstock Use	1.73	2.17	0.76	1.04	1.07	1.73
- Supplemental Fuel (Energy Feedstock) Use	0	0.12	0.19	0	0	0

Tier 1 default Geographic Adjustment Factor for Ethylene

TABLE 3.15
DEFAULT GEOGRAPHIC ADJUSTMENT FACTORS FOR TIER 1 CO_2 EMISSION FACTORS FOR STEAM CRACKING ETHYLENE PRODUCTION

Geographic Region	Adjustment Factor	Notes
Western Europe	100%	Values in Table 3.14 are based on data from Western European steam crackers
Eastern Europe	110%	Not including Russia
Japan and Korea	90%	
Asia, Africa, Russia	130%	Including Asia other than Japan and Korea
North America and South America and Australia	110%	

2.B.8 Petrochemical Industry – Tier 2

- Mass-balance Approach based on carbon content of:
  - Primary and Secondary Feedstock
  - Primary and Secondary Products
- The difference is CO_2 Emissions

The overall mass balance equation for the Tier 2 methodology is Equation 3.17.

EQUATION 3.17
OVERALL TIER 2 MASS BALANCE EQUATION

$$ECO2_i = \left\{ \sum_k \left(FA_{i,k} \bullet FC_k \right) - \left[PP_i \bullet PC_i + \sum_j \left(SP_{i,j} \bullet SC_j \right) \right] \right\} \bullet 44/12$$

Where:

$ECO2_i$ = CO_2 emissions from production of petrochemical *i*, tonnes

$FA_{i,k}$ = annual consumption of feedstock *k* for production of petrochemical *i*, tonnes

FC_k = carbon content of feedstock *k*, tonnes C/tonne feedstock

PP_i = annual production of primary petrochemical product *i*, tonnes

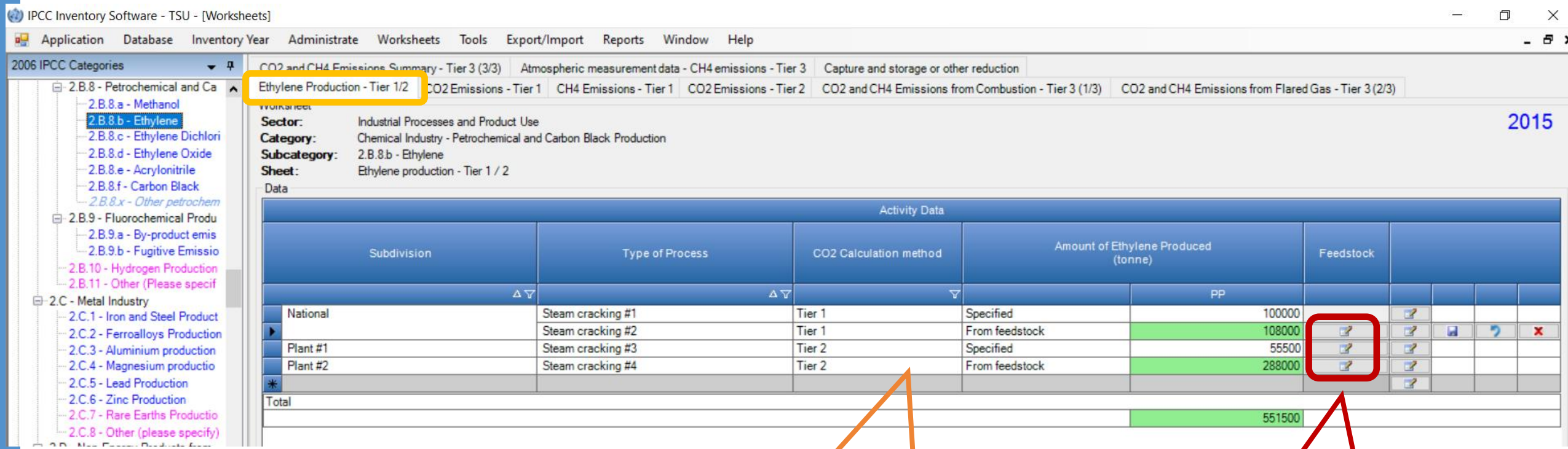
PC_i = carbon content of primary petrochemical product *i*, tonnes C/tonne product

$SP_{i,j}$ = annual amount of secondary product *j* produced from production process for petrochemical *i*, tonnes
[The value of $SP_{i,j}$ is zero for the methanol, ethylene dichloride, ethylene oxide, and carbon black processes because there are no secondary products produced from these processes. For ethylene production and acrylonitrile production, see secondary product production Equations 3.18 and 3.19 below to calculate values for $SP_{i,j}$.]

SC_j = carbon content of secondary product *j*, tonnes C/tonne product

✓ ...in the Software

2.B.8.b Ethylene Production – Data Input – Tier 1/2

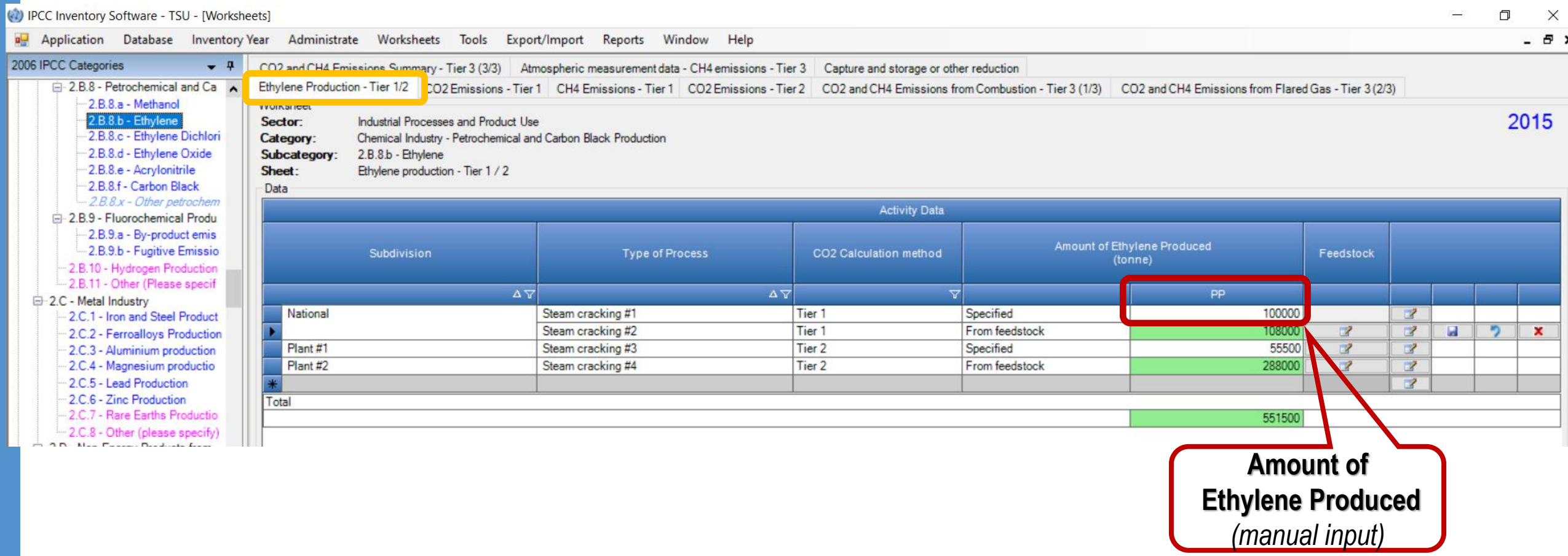


Let's Consider 4 cases:

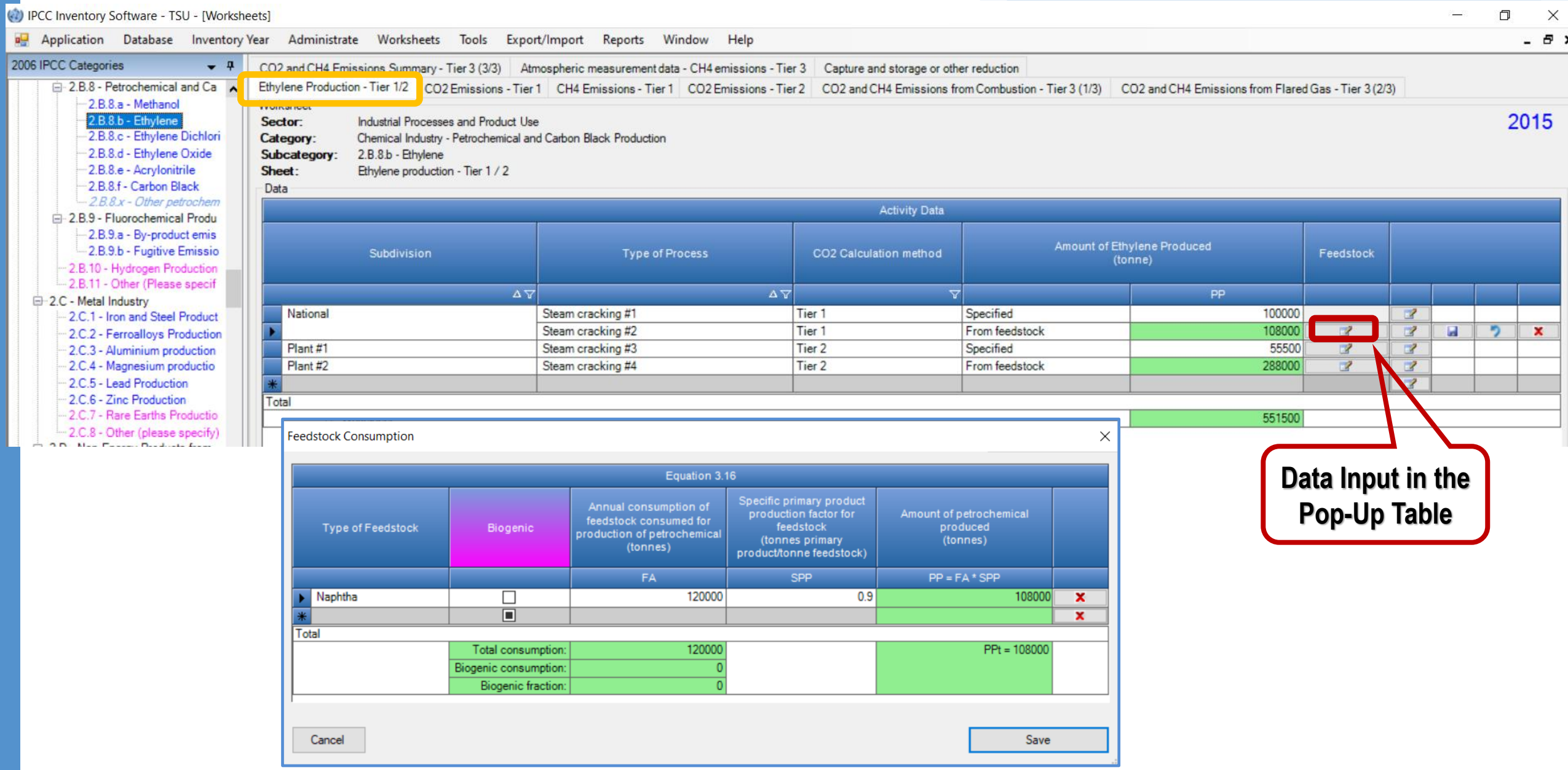
i) **Tier 1 – Specified**
ii) **Tier 1 – From Feedstock**
iii) **Tier 2 – Specified**
iv) **Tier 2 – From Feedstock**

Data Input in the Pop-Up Table (Except Tier 1 – Specified)

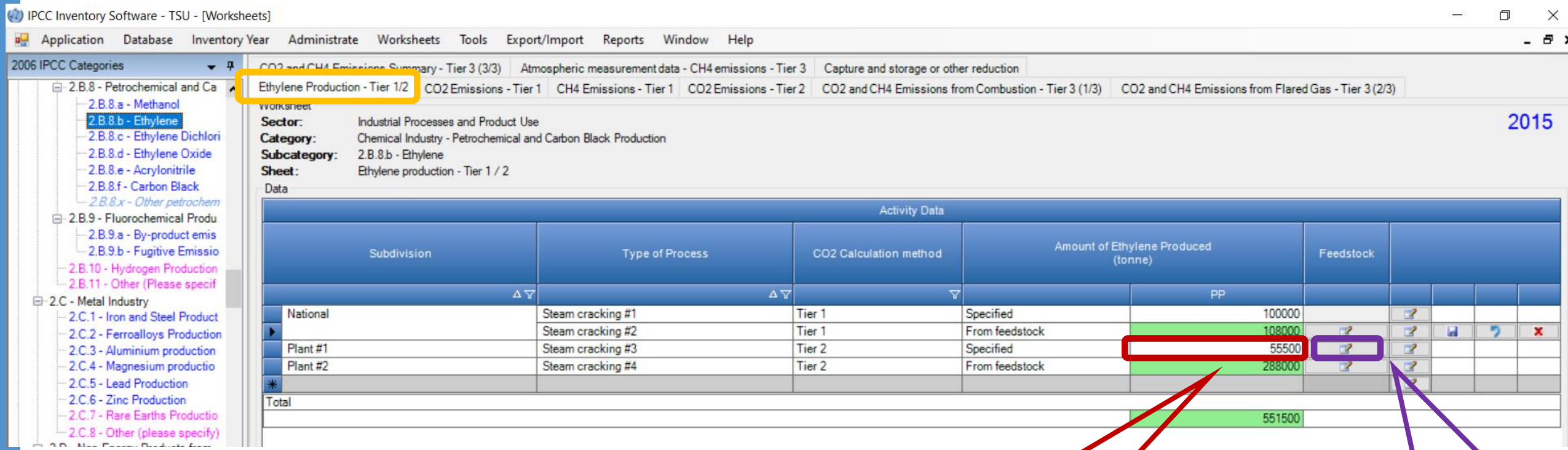
Case #1: Tier 1 – Specified (input)



Case #2: Tier 1 – From feedstock



Case #3: Tier 2 – Specified (#1)

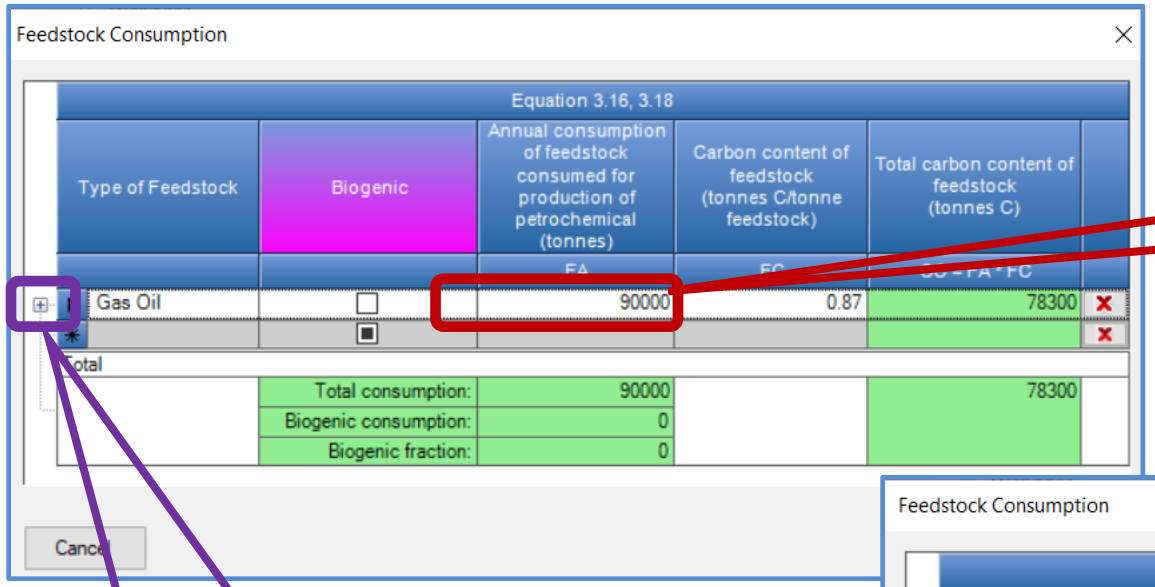


Amount of Ethylene Produced *(manual input)*

Amount of Feedstock and Secondary Products *(in the pop-up table)*

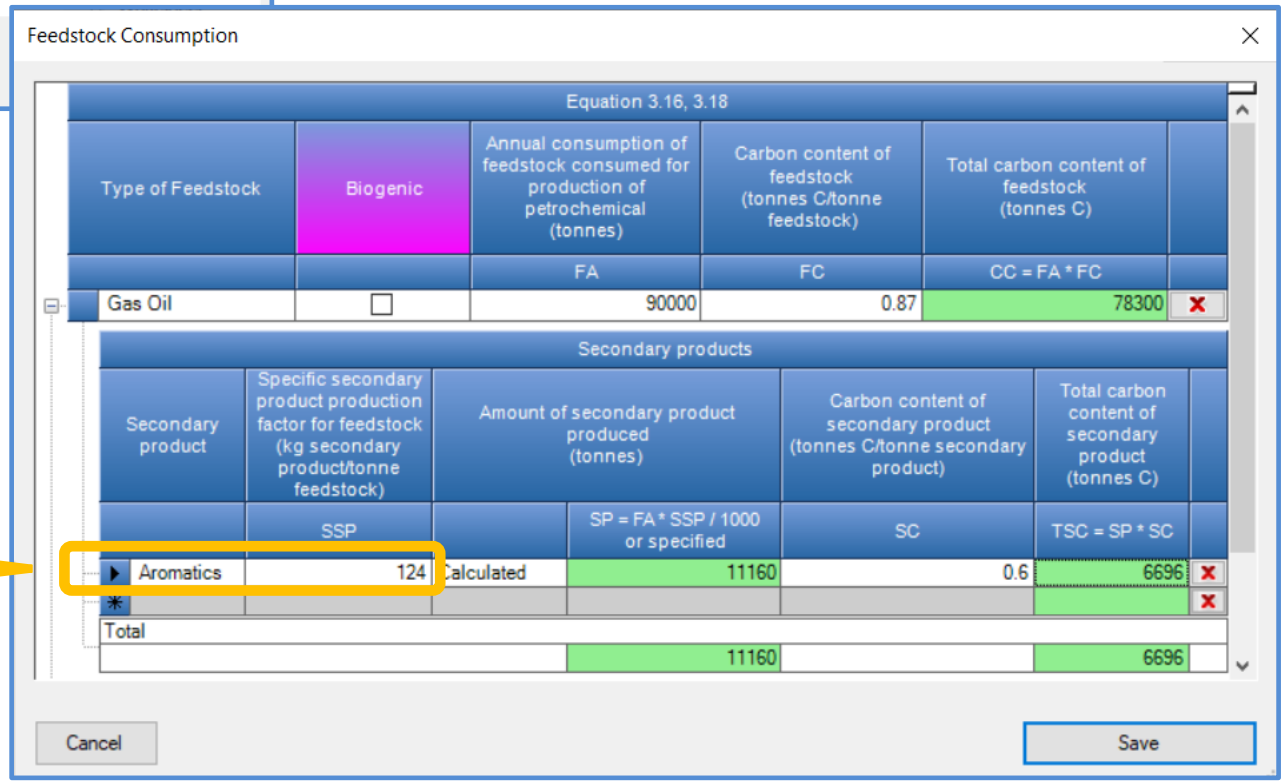
✓ *...when click on the icon*  *(see the next slide)*

Case #3: Tier 2 – Specified (#2)



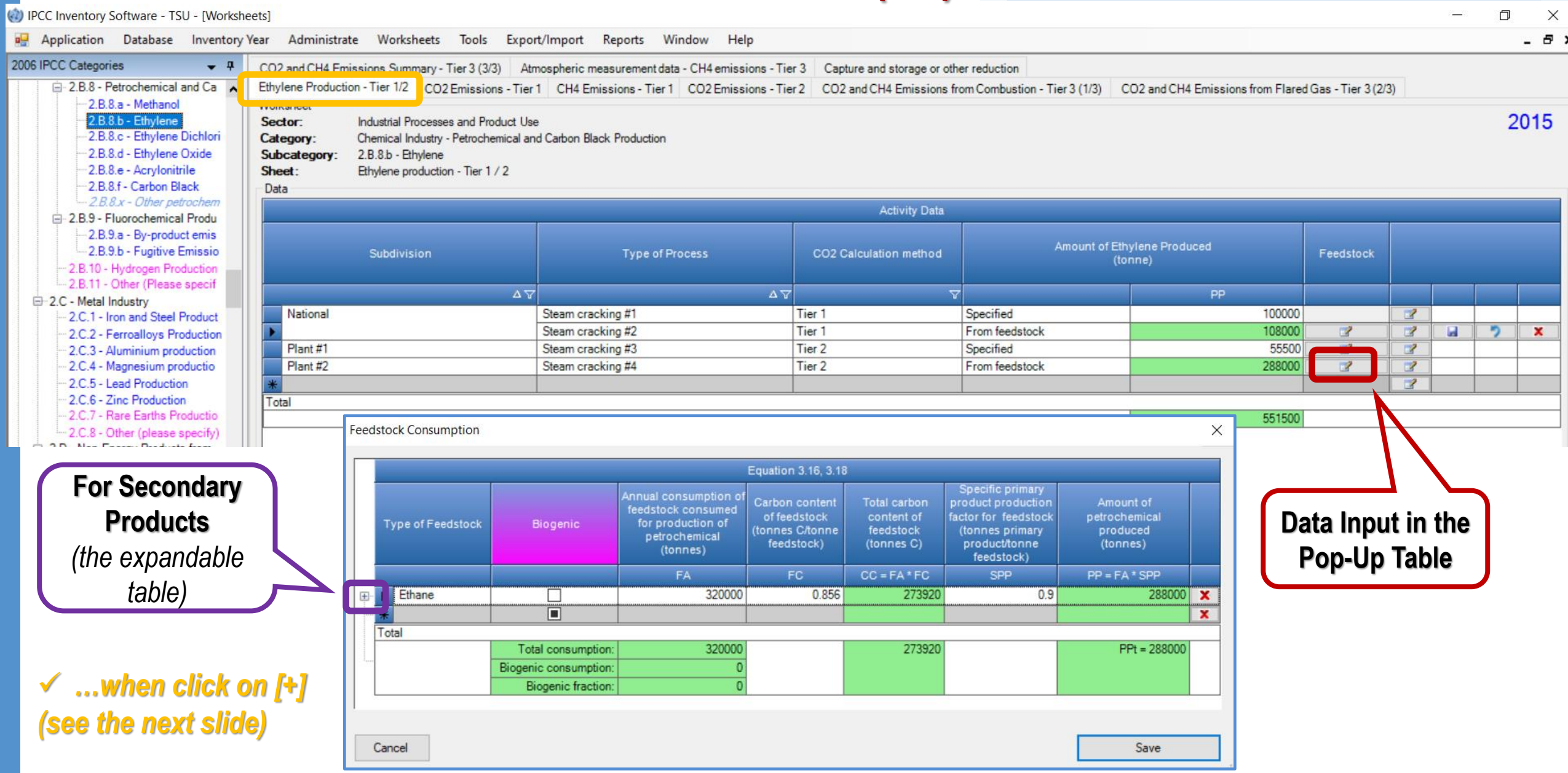
Amount of Feedstock *(manual input)*

For Secondary Products *(the expandable table, **click on [+]**)*



Secondary Products *(drop-down for defaults and manual input)*

Case #4: Tier 2 – From feedstock (#1)



For Secondary Products *(the expandable table)*

✓ ***...when click on [+] (see the next slide)***

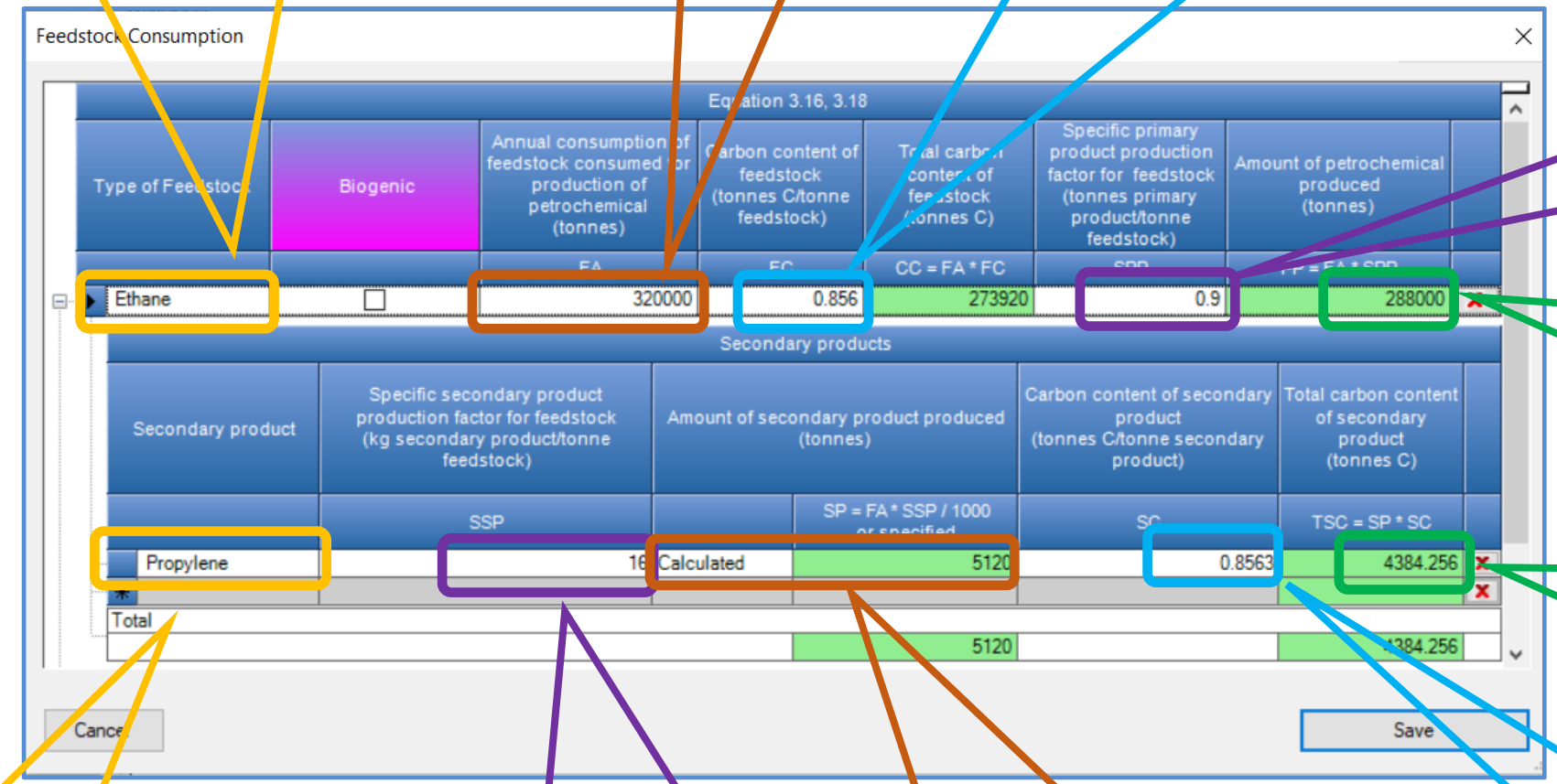
Data Input in the Pop-Up Table

Case #4: Tier 2 – From feedstock (#2)

Type of Feedstock
(drop-down for defaults and manual input)

Amount of Feedstock
(manual input of AD)

Carbon Content of Feedstock
(drop-down for defaults and manual input)



Primary Production Factor
(manual input)

Amount of Ethylene produced

Carbon in Secondary Products

Secondary Products
(drop-down for defaults and manual input)

Secondary Production Factor
(drop-down for defaults and manual input)

Amount of Secondary Product
(Calculated – Feedstock by Secondary Production factor, Specified - manual input)

Carbon Content of Secondary Products
(drop-down for defaults and manual input)

2.B.8.b: Tier 1 – EFs and Results

IPCC Inventory Software - TSU - [Worksheets]

Application | Database | Inventory Year | Administrate | Worksheets | Tools | Export/Import | Reports | Window | Help

2006 IPCC Categories

- 2.B.8 - Petrochemical and Ca
  - 2.B.8.a - Methanol
  - 2.B.8.b - Ethylene
  - 2.B.8.c - Ethylene Dichlori
  - 2.B.8.d - Ethylene Oxide
  - 2.B.8.e - Acrylonitrile
  - 2.B.8.f - Carbon Black
  - *2.B.8.x - Other petrochem*
- 2.B.9 - Fluorochemical Produ
  - 2.B.9.a - By-product emis
  - 2.B.9.b - Fugitive Emissio
- 2.B.10 - Hydrogen Production
- 2.B.11 - Other (Please specif
- 2.C - Metal Industry
  - 2.C.1 - Iron and Steel Product
  - 2.C.2 - Ferroalloys Production
  - 2.C.3 - Aluminium production
  - 2.C.4 - Magnesium productio
  - 2.C.5 - Lead Production
  - 2.C.6 - Zinc Production

CO2 and CH4 Emissions Summary - Tier 3 (3/3) | Atmospheric measurement data - CH4 emissions - Tier 3 | Capture and storage or other reduction

Ethylene Production - Tier 1 | **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 Naked Gas - Tier 3 (2/3)

Worksheet

Sector: Industrial Processes and Product Use
Category: Chemical Industry - Petrochemical and Carbon Black Production
Subcategory: 2.B.8.b - Ethylene
Sheet: CO2 Emissions from Ethylene Production - Tier 1

Data

Equation 3.15

Subdivision	Type of Process	Amount of Ethylene Produced (tonne)	Emission Factor (tonnes CO2/tonne ethylene produced)			Geographic Adjustment Factor (%)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		PP		EF		GAF	E = PP * EF * (GAF/100)	E / 1000
National	Steam cracking #1	100000	Specified	1.81		90	162900	162.9
	Steam cracking #2	108000	From feedstock	1.73		90	168156	168.156
Total								
		208000				Including Biogenic CO2:	331056	331.056
						Excluding Biogenic CO2:	331056	331.056

CO_2 EF for Ethylene
(Specified – manual input;
From feedstock – a pop-up table)

Geographic Adjustment Factor
(drop-down for defaults and manual input)

CO2 Emission Factor

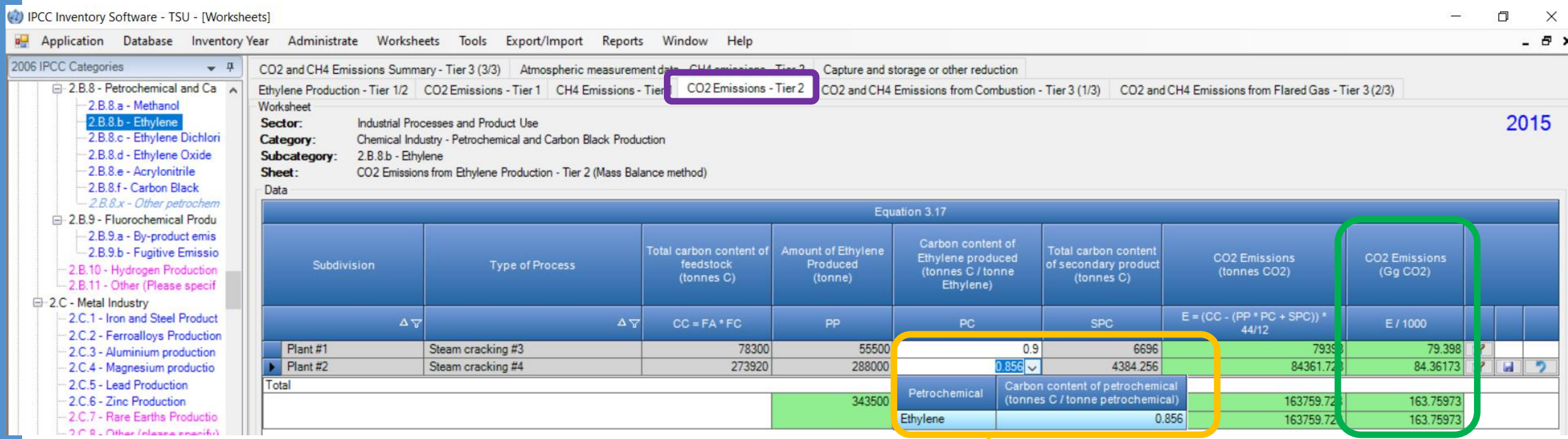
Type of Feedstock	Amount of petrochemical produced (tonnes)	CO2 Emission Factor (tonnes CO2/tonne petrochemical produced)
	PPk	EFk (CO2)
Naphtha	108000	1.73
Total		
	108000	EF = Σ(PPk*EFk)/PPt = 1.73

Cancel | Save

Geographic region	Geographic Adjustment Factor (%)	Remark
Western Europe	100	Values in Table 3.14 are based on data from Western European steam crackers
Eastern Europe	110	Not including Russia
Japan and Korea	90	
Asia, Africa, Russia	130	Including Asia other than Japan and Korea
North America and South America and Australia	110	

Default EF *(and manual input)*

2B8b: Tier 2 – EFs and Results



Carbon Content for Ethylene
(drop-down for defaults and manual input)

Results – CO_2 Emissions from Ethylene Production
(mass-balance approach based on carbon content)

Refrigeration and Air Conditioning (2.F.1)

Outline

Theory and exercises for:

1. F-gases/ blends and the F-gases Manager
2. Refrigeration and Air Conditioning – Tier 1
3. Refrigeration and Air Conditioning – Tier 2

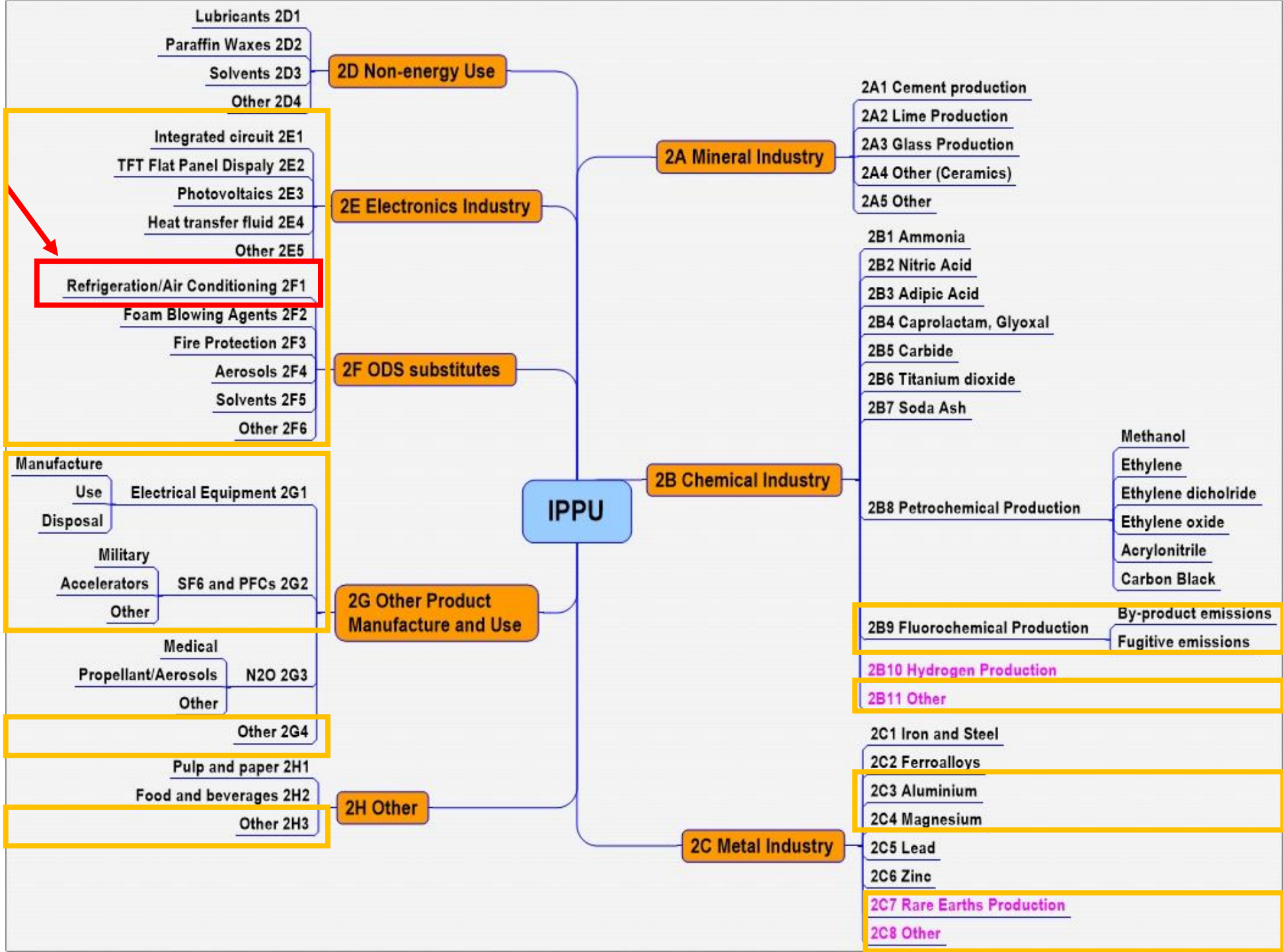
1. F-gases/ blends and the F-gases Manager

IPPU

All categories where F-gases may be produced or consumed-

Learn how to populate the F-gases Manager

Presentation focuses on entering data for Refrigeration and Air Conditioning



F-gases and Blends

Most common highlighted in 2006 IPCC Guidelines

TABLE 7.1
MAIN APPLICATION AREAS FOR HFCS AND PFCS AS ODS SUBSTITUTES [1]

Chemical	Refrigeration and Air Conditioning	Fire Suppression and Explosion Protection	Aerosols		Solvent Cleaning	Foam Blowing	Other Applications[2]
			Propellants	Solvents			
HFC-23	X	X					
HFC-32	X						
HFC-125	X	X					
HFC-134a	X	X	X			X	X
HFC-143a	X						
HFC-152a	X		X			X	
HFC-227ea	X	X	X			X	X
HFC-236fa	X	X					
HFC-245fa				X		X	
HFC-365mfc				X	X	X	
HFC-43-10mee				X	X		
PFC-14[3] (CF_4)		X					
PFC-116 (C_2F_6)							X
PFC-218 (C_3F_8)							
PFC-31-10 (C_4F_{10})		X					
PFC-51-14[4] (C_6F_{14})					X		

TABLE 7.8
BLENDS (MANY CONTAINING HFCS AND/OR PFCS)

Blend	Constituents	Composition (%)
R-400	CFC-12/CFC-114	Should be specified[1]
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)
R-401C	HCFC-22/HFC-152a/HCFC-124	(33.0/15.0/52.0)
R-402A	HFC-125/HC-290/HCFC-22	(60.0/2.0/38.0)
R-402B	HFC-125/HC-290/HCFC-22	(38.0/2.0/60.0)
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)
R-404A	HFC-125/HFC-143a/HFC-134a	(44.0/52.0/4.0)
R-405A	HCFC-22/ HFC-152a/ HCFC-142b/PFC-318	(45.0/7.0/5.5/42.5)
R-406A	HCFC-22/HC-600a/HCFC-142b	(55.0/14.0/41.0)
R-407A	HFC-32/HFC-125/HFC-134a	(20.0/40.0/40.0)
R-407B	HFC-32/HFC-125/HFC-134a	(10.0/70.0/20.0)
R-407C	HFC-32/HFC-125/HFC-134a	(23.0/25.0/52.0)
R-407D	HFC-32/HFC-125/HFC-134a	(15.0/15.0/70.0)
R-407E	HFC-32/HFC-125/HFC-134a	(25.0/15.0/60.0)
R-408A	HFC-125/HFC-143a/HCFC-22	(7.0/46.0/47.0)
R-409A	HCFC-22/HCFC-124/HCFC-142b	(60.0/25.0/15.0)
R-409B	HCFC-22/HCFC-124/HCFC-142b	(65.0/25.0/10.0)
R-410A	HFC-32/HFC-125	(50.0/50.0)
R-410B	HFC-32/HFC-125	(45.0/55.0)
R-411A	HC-1270/HCFC-22/HFC-152a	(1.5/87.5/11.0)
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)
R-412A	HCFC-22/PFC-218/HCFC-142b	(70.0/5.0/25.0)
R-413A	PFC-218/HFC-134a/HC-600a	(9.0/88.0/3.0)
R-414A	HCFC-22/HCFC-124/HC-600a/HCFC-142b	(51.0/28.5/4.0/16.5)
R-414B	HCFC-22/HCFC-124/HC-600a/HCFC-142b	(50.0/39.0/1.5/9.5)
R-415A	HCFC-22/HFC-152a	(82.0/18.0)
R-415B	HCFC-22/HFC-152a	(25.0/75.0)
R-416A	HFC-134a/HCFC-124/HC-600	(59.0/39.5/1.5)
R-417A	HFC-125/HFC-134a/HC-600	(46.6/50.0/3.4)
R-418A	HC-290/HCFC-22/HFC-152a	(1.5/96.0/2.5)
R-419A	HFC-125/HFC-134a/HE-E170	(77.0/19.0/4.0)
R-420A	HFC-134a/HCFC-142b	(88.0/12.0)
R-421A	HFC-125/HFC-134a	(58.0/42.0)
R-421B	HFC-125/HFC-134a	(85.0/15.0)
R-422A	HFC-125/HFC-134a/HC-600a	(85.1/11.5/3.4)
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-501	HCFC-22/CFC-12	(75.0/25.0)
R-502	HCFC-22/CFC-115	(48.8/51.2)
R-503	HFC-23/CFC-13	(40.1/59.9)
R-504	HFC-32/CFC-115	(48.2/51.8)
R-505	CFC-12/HCFC-31	(78.0/22.0)
R-506	CFC-31/CFC-114	(55.1/44.9)
R-507A	HFC-125/HFC-143a	(50.0/50.0)
R-508A	HFC-23/PFC-116	(39.0/61.0)
R-508B	HFC-23/PFC-116	(46.0/54.0)
R-509A	HCFC-22/PFC-218	(44.0/56.0)

[1] R-400 can have various proportions of CFC-12 and CFC-114. The exact composition needs to be specified, e.g., R-400 (60/40).

F-gases and Blends

Complete list in AR5

- **Software calculates emissions from all F-gases in the AR5.**
- **For interoperability:**
  - **If the F-gas appears in CRT 2(II): the corresponding gas maps to that gas in background and sectoral tables.**
  - **If the F-gas does not appear in CRT 2(II): the corresponding gas maps to the "Unspecified mix", as shown in the table.**

HFCs	
HFC-23 (CHF_3)	HFC-23
HFC-32 (CH_2F_2)	HFC-32
HFC-41 (CH_3F)	HFC-41
HFC-43-10mee ($CF_3CHFCHFCF_2CF_3$)	HFC-43-10mee
HFC-125 (CHF_2CF_3)	HFC-125
HFC-134 (CHF_2CHF_2)	HFC-134
HFC-134a (CH_2FCF_3)	HFC-134a
HFC-143 (CH_2FCHF_2)	HFC-143
HFC-143a (CH_3CF_3)	HFC-143a
HFC-152 (CH_2FCH_2F)	HFC-152
HFC-152a (CH_3CHF_2)	HFC-152a
HFC-161 (CH_3CH_2F)	HFC-161
HFC-227ca ($CF_3CF_2CHF_2$)	Unspecified mix of HFCs
HFC-227ea (CF_3CHFCF_3)	HFC-227ea
HFC-236cb ($CH_2FCF_2CF_3$)	HFC-236cb
HFC-236ea (CHF_2CHFCF_3)	HFC-236ea
HFC-236fa ($CF_3CH_2CF_3$)	HFC-236fa
HFC-245ca ($CH_2FCF_2CHF_2$)	HFC-245ca
HFC-245cb ($CF_3CF_2CH_3$)	Unspecified mix of HFCs
HFC-245ea ($CHF_2CHFCHF_2$)	Unspecified mix of HFCs
HFC-245eb ($CH_2FCHFCF_3$)	Unspecified mix of HFCs
HFC-245fa ($CHF_2CH_2CF_3$)	HFC-245fa
HFC-263fb ($CH_3CH_2CF_3$)	Unspecified mix of HFCs
HFC-272ca ($CH_3CF_2CH_3$)	Unspecified mix of HFCs
HFC-329p ($CHF_2CF_2CF_2CF_3$)	Unspecified mix of HFCs
HFC-365mfc ($CH_3CF_2CH_2CF_3$)	HFC-36mfc
HFC-1132a ($CH_2=CF_2$)	Unspecified mix of HFCs
HFC-1141 ($CH_2=CHF$)	Unspecified mix of HFCs
(Z)-HFC-1225ye ($CF_3CF=CHF(Z)$)	Unspecified mix of HFCs
(E)-HFC-1225ye ($CF_3CF=CHF(E)$)	Unspecified mix of HFCs
(Z)-HFC-1234ze ($CF_3CH=CHF(Z)$	Unspecified mix of HFCs
HFC-1234yf (($CF_3CF=CH_2$))	Unspecified mix of HFCs
(E)-HFC-1234ze (trans-$CF_3CH=CHF$)	Unspecified mix of HFCs
(Z)-HFC-1336 ($CF_3CH=CHCF_3(Z)$)	Unspecified mix of HFCs
HFC-1243zf ($CF_3CH=CH_2$)	Unspecified mix of HFCs
HFC-1345zfc ($C_2F_5CH=CH_2$)	Unspecified mix of HFCs
3,3,4,4,5,5,6,6,6- Nonafluorohex -1-ene ($C_4F_9CH=CH_2$)	Unspecified mix of HFCs
3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooct-1-ene ($C_6F_{13}CH=CH_2$)	Unspecified mix of HFCs
3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-Hep-tadecafluorodec-1-ene ($C_8F_{17}CH=CH_2$)	Unspecified mix of HFCs

PFCs	
PFC-14 (CF_4)	CF4
PFC-116 (C_2F_6)	C2F6
PFC-218 (C_3F_8)	C3F8
PFC-31-10 (C_4F_{10})	C4F10
PFC-318 (c-C_4F_8)	c-C4F8
PFC-4-1-12 (n-C_5F_{12})	C5F12
PFC-5-1-14 (n-C_6F_{14})	C6F14
Sulphuryl fluoride (SO_2F_2)	Unspecified mix of PFCs
PFC-c216 (c-C_3F_6)	c-C3F6
PFC-61-16 (n-C_7F_{16})	Unspecified mix of PFCs
PFC-71-18 (C_8F_{18})	Unspecified mix of PFCs
PFC-91-18 ($C_{10}F_{18}$)	C10F18
Perfluorobuta-1,3-diene (C_4F_6)	Unspecified mix of PFCs
Perfluorocyclopentene (c-C_5F_8)	Unspecified mix of PFCs
Perfluorodecalin (cis) (Z-$C_{10}F_{18}$)	Unspecified mix of PFCs
Perfluorodecalin (trans) (E-$C_{10}F_{18}$)	Unspecified mix of PFCs
PFC-1114 ($CF_2=CF_2$)	Unspecified mix of PFCs
PFC-1216 ($CF_3CF=CF_2$)	Unspecified mix of PFCs
Perfluorobut-1-ene ($CF_3CF_2CF=CF_2$)	Unspecified mix of PFCs
Perfluorobut-2-ene ($CF_3CF=CFCF_3$)	Unspecified mix of PFCs

SF_6

NF_3

F-gases for UNFCCC Reporting

TABLE 2(II) SECTORAL REPORT FOR INDUSTRIAL PROCESSES AND PRODUCT USE - EMISSIONS OF HFCs, PFCs, SF_6 AND NF_3 Year

(Sheet 1 of 1) Submission

Country

Back to Index

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	HFC-23	HFC-32	HFC-41	HFC-43-10mee	HFC-125	HFC-134	HFC-134a	HFC-143	HFC-143a	HFC-152	HFC-152a	HFC-161	HFC-227ea	HFC-236cb	HFC-236ea	HFC-236fa	HFC-245ca	HFC-245fa	HFC-365mfc	Unspecified mix of HFCs (1)	Total HFCs	CF_4	C_2F_6	C_3F_8	C_4F_{10}	c-C_4F_8	C_5F_{12}	C_6F_{14}	$C_{10}F_{18}$	c-C_3F_6	Unspecified mix of PFCs (1)	Total PFCs	Unspecified mix of HFCs and PFCs (1)	SF_6	NF_3
	(t)																			CO_2 equivalents (kt) (2)		(t)									CO_2 equivalents (kt) (2)			(t)	
2. Total actual emissions of halocarbons (by chemical), SF_6 and NF_3																																		
2.B. Chemical industry																																		
2.B.9. Fluorochemical production																																		
2.B.9.a. By-product emissions																																		
2.B.9.b. Fugitive emissions																																		
2.B.10. Other																																		
2.C. Metal industry																																		
2.C.3. Aluminium production																																		
2.C.4. Magnesium production																																		
2.C.7. Other																																		
2.E. Electronics industry																																		
2.E.1. Integrated circuit or semiconductor																																		

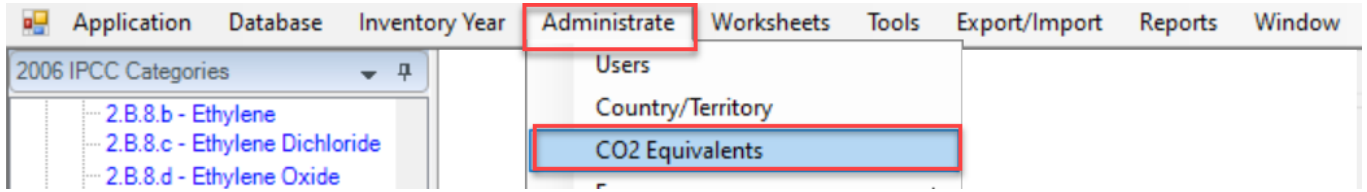
Specific HFCs

Unspecified Mix of HFCs

Unspecified Mix of HFCs and PFCs

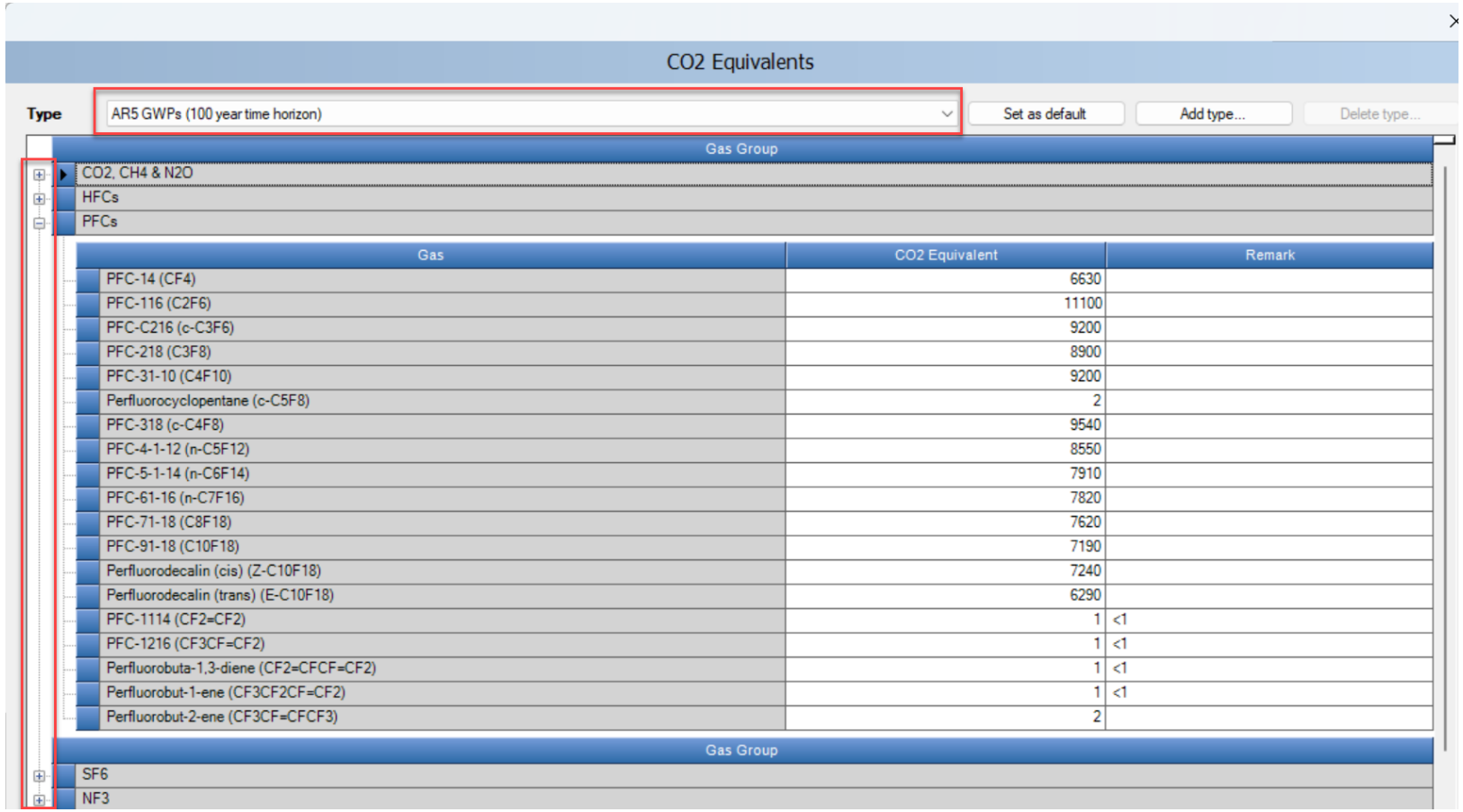
Confirm CO_2 Equivalents Used

- User may view list of F-gases and CO_2 equivalents used in the Software.



- F-gases and blends may be added, if needed, through the F-gases Manager.

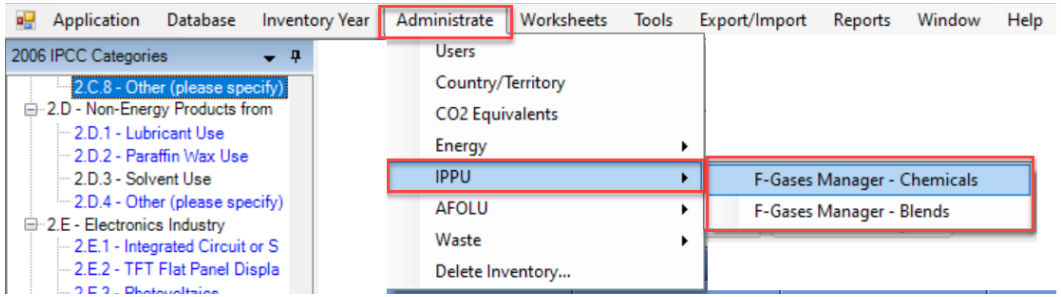
- **For interoperability:** confirm Software shows Type = AR5 GWPs in the Administrate tab (is set by default in latest versions of Software, unless changed by user).



F-gases Manager

- **Purpose of F-gases Manager:**
  - Identify all F-gases consumed (including imported) and/or produced/emitted in the country.
  - Customize *Software* so limited to F-gases relevant for the user.
  - Designate specific gas/category confidential, if applicable, for UNFCCC reporting.
  - Ultimately to minimize double counting.

- **F-gases Manager to be set up for individual F-gas species and blends**



- **2-step process**
  - List F-gases /blends relevant at country level– done through main **Administrate** tab, then
  - Identify those relevant for individual IPCC category – done at **worksheet** level.

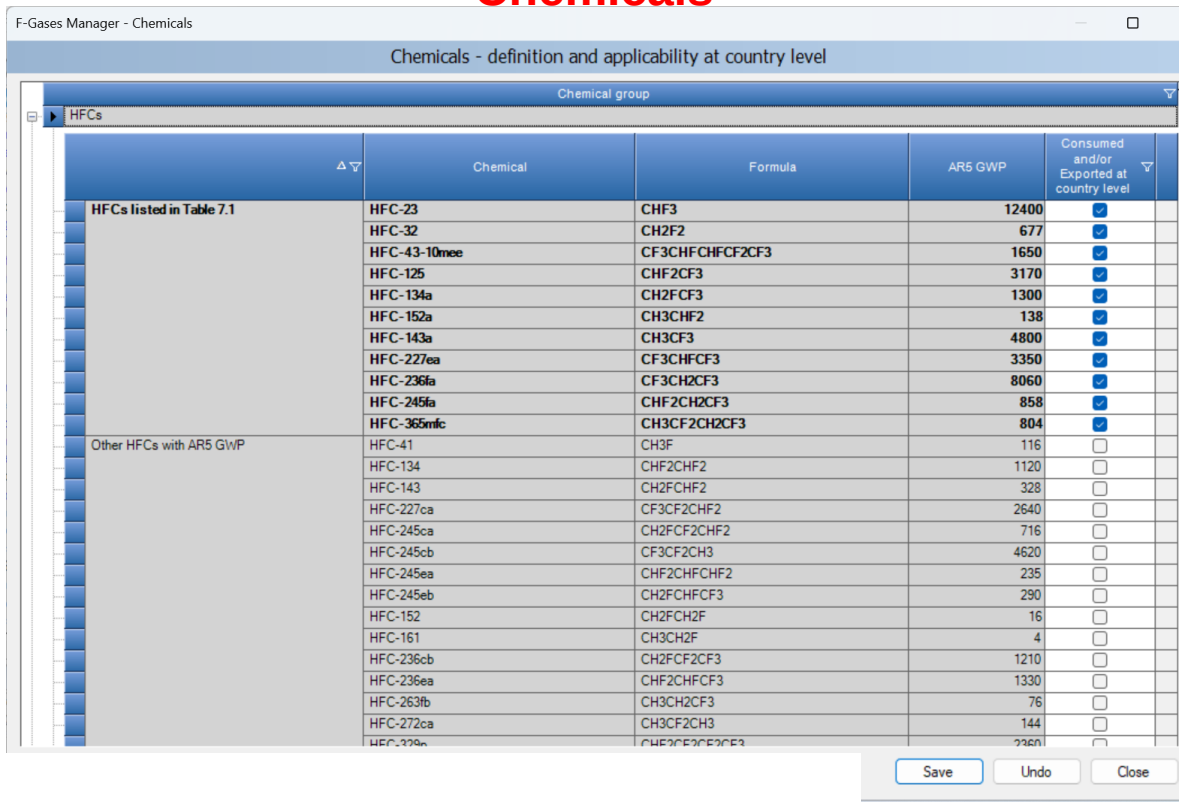
F-gases Manager – Country level

1. **Check /uncheck boxes for F- gases:**
   - ✓ Produced
   - ✓ Imported
   - ✓ Exported
   - ✓ Emitted as Fugitive

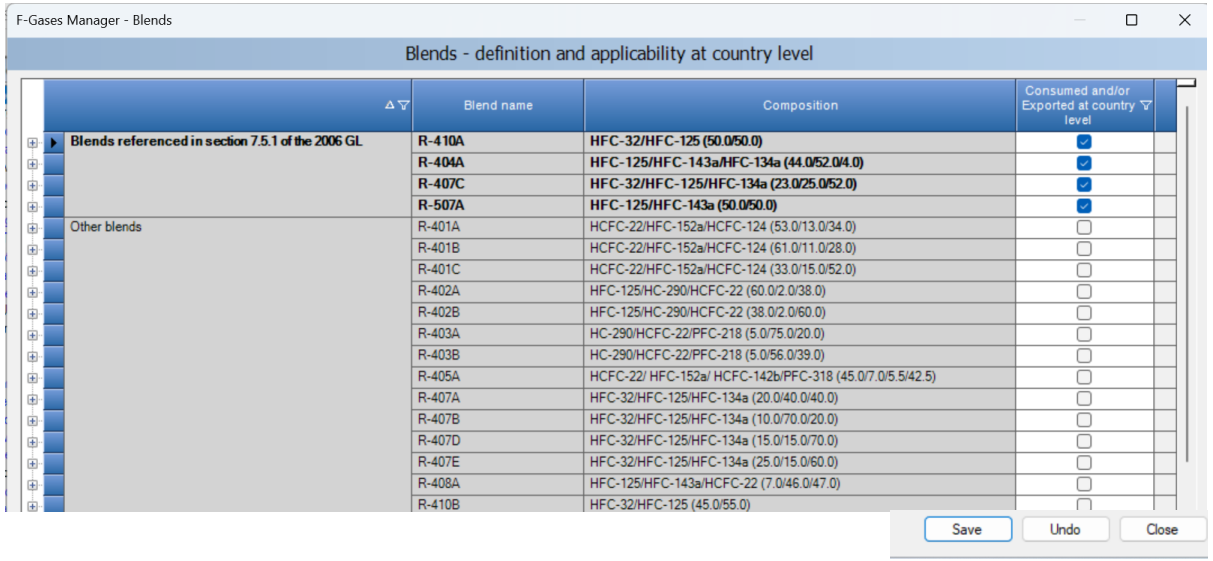
2. Check /uncheck boxes for blends:

Preferable to do inventory calculations based on individual F-gas species and not blends. The Software can accommodate blends, but user should ensure there is no double counting with F-gas species.

Chemicals



Blends



F-gases Manager – Country level

1. User may add country-specific F-gases / Blends - using row with [*].
2. For blends, information on the composition must also be added.

Chemicals

Chemicals - definition and applicability at country level

Chemical group

HFCs

PFCs

	Chemical	Formula	AR5 GWP	Consumed and/or Exported at country level
PFCs listed in Table 7.1	**PFC-14**	**CF4**	**6630**	☑
	PFC-116	**C2F6**	**11100**	☑
	PFC-218	**C3F8**	**8900**	☑
	PFC-31-10	**C4F10**	**9200**	☑
	PFC-5-1-14	**n-C6F14**	**7910**	☑
Other PFCs with AR5 GWP	PFC-C216	c-C3F6	9200	☐
	Perfluorocyclopentane	c-C5F8	2	☐
	PFC-318	c-C4F8	9540	☐
	PFC-4-1-12	n-C5F12	8550	☐
	PFC-61-16	n-C7F16	7820	☐
	PFC-71-18	C8F18	7620	☐
	PFC-91-18	C10F18	7190	☐
	Perfluorodecalin (cis)	Z-C10F18	7240	☐
	Perfluorodecalin (trans)	E-C10F18	6290	☐
	PFC-1114	CF2=CF2	1	☐
	PFC-1216	CF3CF=CF2	1	☐
	Perfluorobuta-1,3-diene	CF2=CFCF=CF2	1	☐
	Perfluorobut-1-ene	CF3CF2CF=CF2	1	☐
	Perfluorobut-2-ene	CF3CF=CFCF3	2	☐
* User-defined PFCs	INSERT country specific name	INSERT country specific formula	200	☑
*				☐

Chemical group

SF6

NF3

Save Undo Close

Blends

F-Gases Manager - Blends

Blends - definition and applicability at country level

	Blend name	Composition	Consumed and/or Exported at country level
	R-412A	HCFC-22/PFC-218/HCFC-142b (70.0/5.0/25.0)	☐
	R-413A	PFC-218/HFC-134a/HC-600a (9.0/88.0/3.0)	☐
	R-515A	HCFC-22/HFC-152a (82.0/18.0)	☐
	R-515B	HCFC-22/HFC-152a (25.0/75.0)	☐
	R-416A	HFC-134a/HCFC-124/HC-600 (59.0/39.5/1.5)	☐
	R-417A	HFC-125/HFC-134a/HC-600 (46.6/50.0/3.4)	☐
	R-418A	HC-290/HCFC-22/HFC-152a (1.5/96.0/2.5)	☐
	R-419A	HFC-125/HFC-134a/HE-E170 (77.0/19.0/4.0)	☐
	R-420A	HFC-134a/HCFC-142b (88.0/12.0)	☐
	R-421A	HFC-125/HFC-134a (58.0/42.0)	☐
	R-421B	HFC-125/HFC-134a (85.0/15.0)	☐
	R-422A	HFC-125/HFC-134a/HC-600a (85.1/11.5/3.4)	☐
	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)	☑
	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)	☐
	R-509A	HCFC-22/PFC-218 (44.0/56.0)	☐
User-defined blends	XYZ	INSERT composition	☑

Constituent	AR5 GWP	Composition (%)
HFC-23	12400	25
HFC-125	3170	25

✓ *Now let's do exercise with dummy data*

Exercise: Customize F-gases Manager

- Country imports F-gases, and the blend R410A.
- No production/export of F-gases.
- List includes all F-gases/blends emitted in any year of time series.
- The following information is known about the use of the different gases/blends in different applications.
- **Exercise:** Please set up the F-gases Manager at the national level for this scenario.

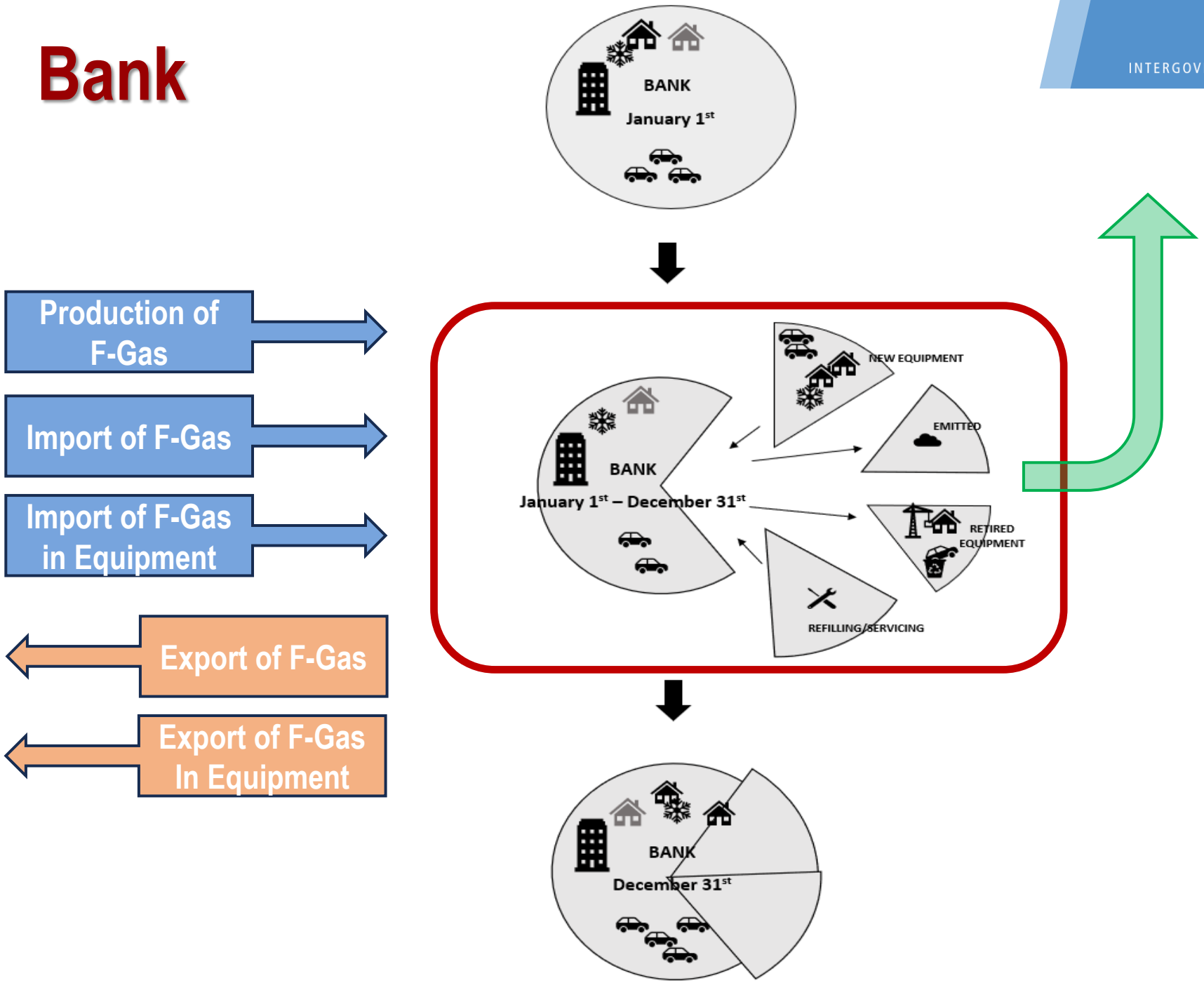
F-gases Consumed	Electronics	Refrigeration and Air Conditioning	Fire protection	Aerosols	Soundproof windows
HFCs					
HFC-23	X	X			
HFC-32		X			
HFC-125		X			
HFC-134a		X		X	
HFC-143a		X			
HFC-152a		X			
HFC-227ea			X	X	
PFCs					
CF4	X				
C2F6	X				
c-C4F8	X				
SF6	X				X
NF3	X				
Blends					
R410A		X			

*The user has customized the Software for all F-gases /blends relevant **in the country**.*

The user must then identify the gases relevant for Refrigeration and Air Conditioning, but first, let's learn more about the category:

2.F.1 Refrigeration and Air Conditioning (RAC)

Bank



F-gas Emissions
(amount?)

Bank = amount of F-gases contained in equipment in use.

Want to know the flow of chemicals into and out of the bank.

2.F.1: Tiers

- **For Refrigeration and Air Conditioning (2.F.1) the *2006 IPCC Guidelines* provide the following Tiers:**

  - **Tier 1** *(default hybrid approach based on a historic development of the bank)*
    - **Estimates emissions at the application level** (i.e. emissions calculated for all RAC, except mobile air conditioning combined (category 2.F.1.a)), and mobile air conditioning (category 2.F.1.b).

  - **Tier 2 requires separate data for 6 RAC sub-applications** (commercial, domestic, industrial, transport, stationary air conditioning and mobile air conditioning)

    - **Tier 2a** *(EF approach).*

    - **Tier 2b** *(mass-balance approach).*

2.F.1: Deciding Among Tiers

	Tier 1	Tier 2a	Tier 2b
Consumption by sub-application (e.g. domestic refrigeration versus commercial refrigeration)		X	X
Year of introduction of chemical	X	X	X
Domestic production of chemical in current year	X	X	X
Imports of chemical in current year (bulk and in equipment)	X (total)	X	X
Exports of chemical in current year (bulk and in new equipment)	X (total)	X	X
Growth rate in new equipment sales	X		
Destroyed in current year	X	X	X
Exported in used equipment for subsequent year		X	X
Amount added to /withdrawn from stockpile (if any)			X
Amount used to fill new equipment factory charged/not factory charged			X

Notes:

- *Additional parameters required, but there are defaults. Generally, if destruction is not known, assume 0*
- *Table 7.9 of Vol. 3 Chpt 7, contains defaults for charge/ equipment*

F-gases Consumption Quality Check

- **Important** not to double count consumption.
- A QC check to ensure consistency of F-gases available versus consumption to mitigate double counting.
- Function to be incorporated into *Software* in future.

Step 1:
Estimate national consumption per gas/per year

Step 2:
Allocate to end use applications

Step 3: Compare top-down estimates of consumption per gas/category/year with bottom-up consumption estimates input into *Software*

F-gases Consumption Quality Check

Step 1:
Estimate national consumption per gas/per year

	A	B	C	D	E	F	G	H	I
		Net consumption for year X							
		Total national consumption						Chemical in country used to produce blends (if known) and if blends accounted separately)	Chemical/blend available for consumption in year (B+C+D-E-F+G-H)
		Production	Imports		Exports		Recycled		
	(tonnes)		in Bulk	In equipment	in Bulk	In equipment			
	Chemical #1								
	Chemical #2								
	Chemical #N								
	Blend # 1								
	Blend # N								

Step 2:
Allocate to end use applications

F-gases Consumed	2.C.4 Magensium Production	2.C.8 Other (Metal industry)	2.E Electronics Industry				2.F.1.a Refrigeration and AC	2.F.1.b Mobile Air Conditioning	2.F.3 Fire Extinguishers	2.F.4 Aerosols	2.F.6 Other Applications	2.G.1 Electrical Equipment	2.G.2 SF6 and PFCs from Other Products	2.G.4 Other (SF6 and PFCs from other product use)	2.H.3 Other (IPPU)
			2.E.1 Integrated Circuit or Semiconductor	2.E.2 TFT Flat Panel Display	2.E.4 Heat Transfer Fluid	2.E.5 Other (Electronics)									
Chemical #1															
Chemical #2															
Chemical #N															
Blend # 1															
Blend # N															

Step 3:
Compare top-down (Step 2) with bottom-up (worksheets)

A	B	C	D
Check for refrigeration and air conditioning			
	Top down	Bottom up	Comparison
Chemical #1	ESTIMATED ALLOCATION - Step 2	Total of each F-gas Consumed in Tier 1 and Tier 2 worksheets *(e.g. IPCC 2.F.1.a <F-gas emissions> <gas = BH2><year= current inventory year> <Value in column D> PLUS IPCC 2.F.1.a <F-gas emissions - Tier 2a> <Subapplication = all> <gas = BH2><year= current inventory year> Value in column H/1,000 PLUS IPCC 2.F.1.a <F-gas emissions -Tier 2b> <Subapplication = all> <gas = BH2><year= current inventory year>Value in column G/1,000)*	Column C-B

- ✓ Category by category comparison
- ✓ Can the user explain differences between total national consumption and the sum of data entered in worksheets?

Tier 1

2.F.1 Refrigeration and Air Conditioning

2.F.1: Tier 1

- **The Tier 1 method back-calculates the development of a bank of a refrigerant from the current reporting year to the year of its introduction.**

- **Enables estimation of actual emissions, even if there are no historic data available.**

- **Minimum data requirements /assumptions needed:**

  - Year of introduction of chemical
  - Domestic production of chemical in current year
  - Imports of chemical in current year
  - Exports of chemical in current year
  - Growth rate of sales of equipment that uses the chemical

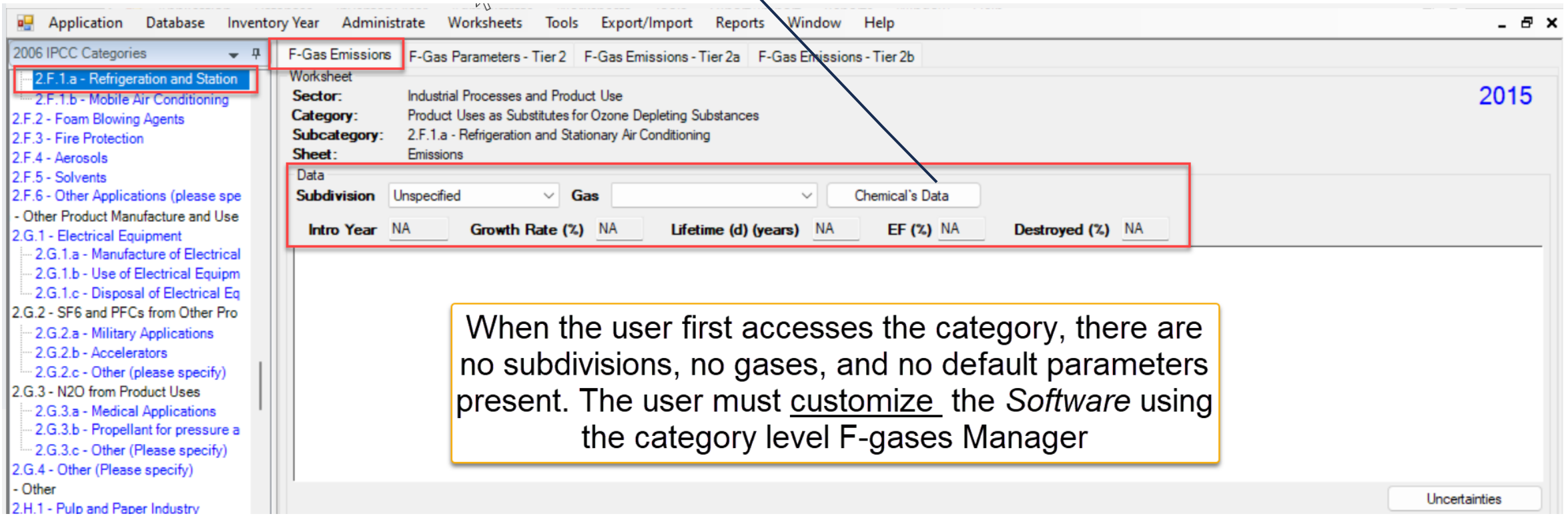
EQUATION 7.2B
CALCULATION OF EMISSIONS OF A CHEMICAL FROM AN APPLICATION WITH BANKS

$$Annual\ Emissions = Net\ Consumption \bullet Composite\ EF_{FY} + Total\ Banked\ Chemical \bullet Composite\ EF_{B}$$

- **Defaults available for other parameters.**

2.F.1: Tier 1

For Tier 1 RAC, access to the category-level F-gases Manager through Chemicals' Data tab

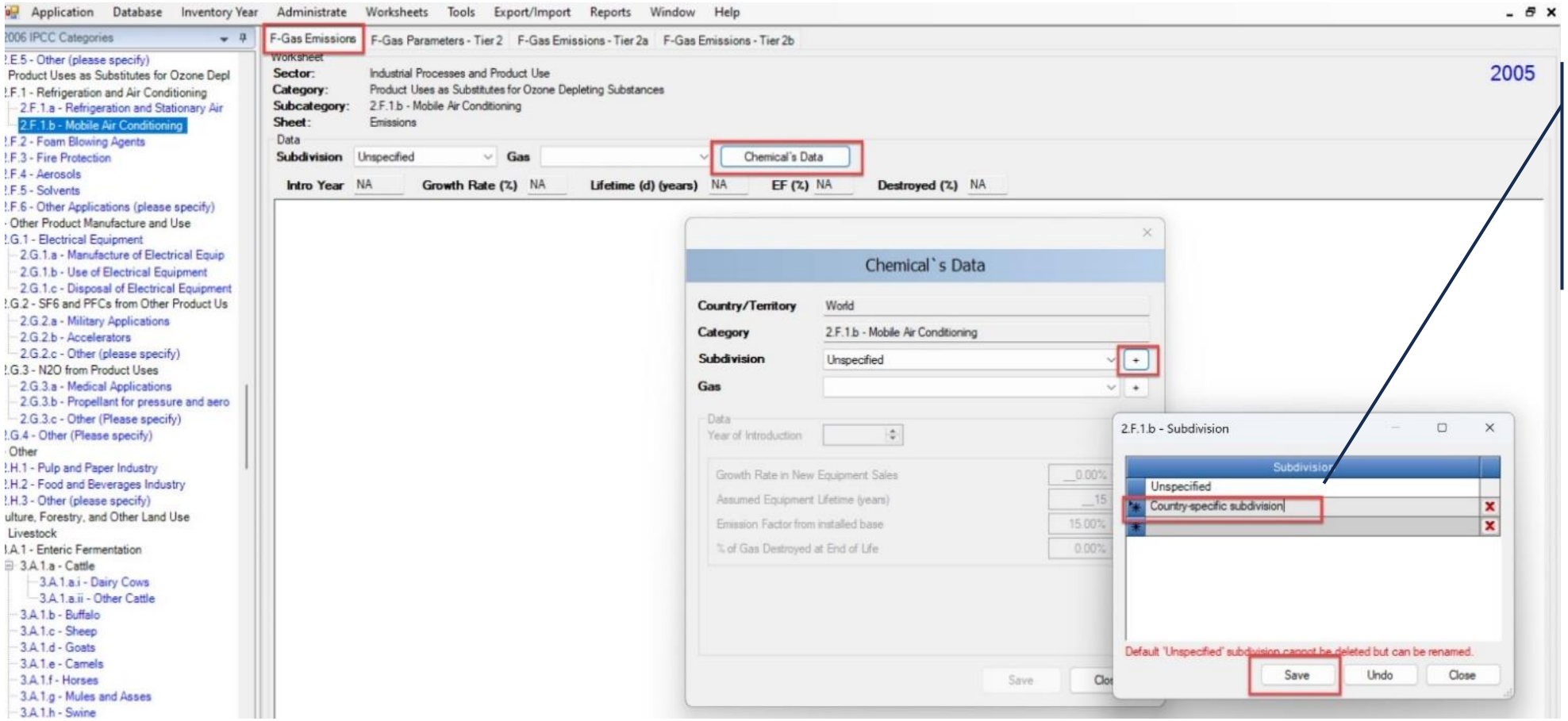


When the user first accesses the category, there are no subdivisions, no gases, and no default parameters present. The user must customize the *Software* using the category level F-gases Manager

Chemicals' Data tab:

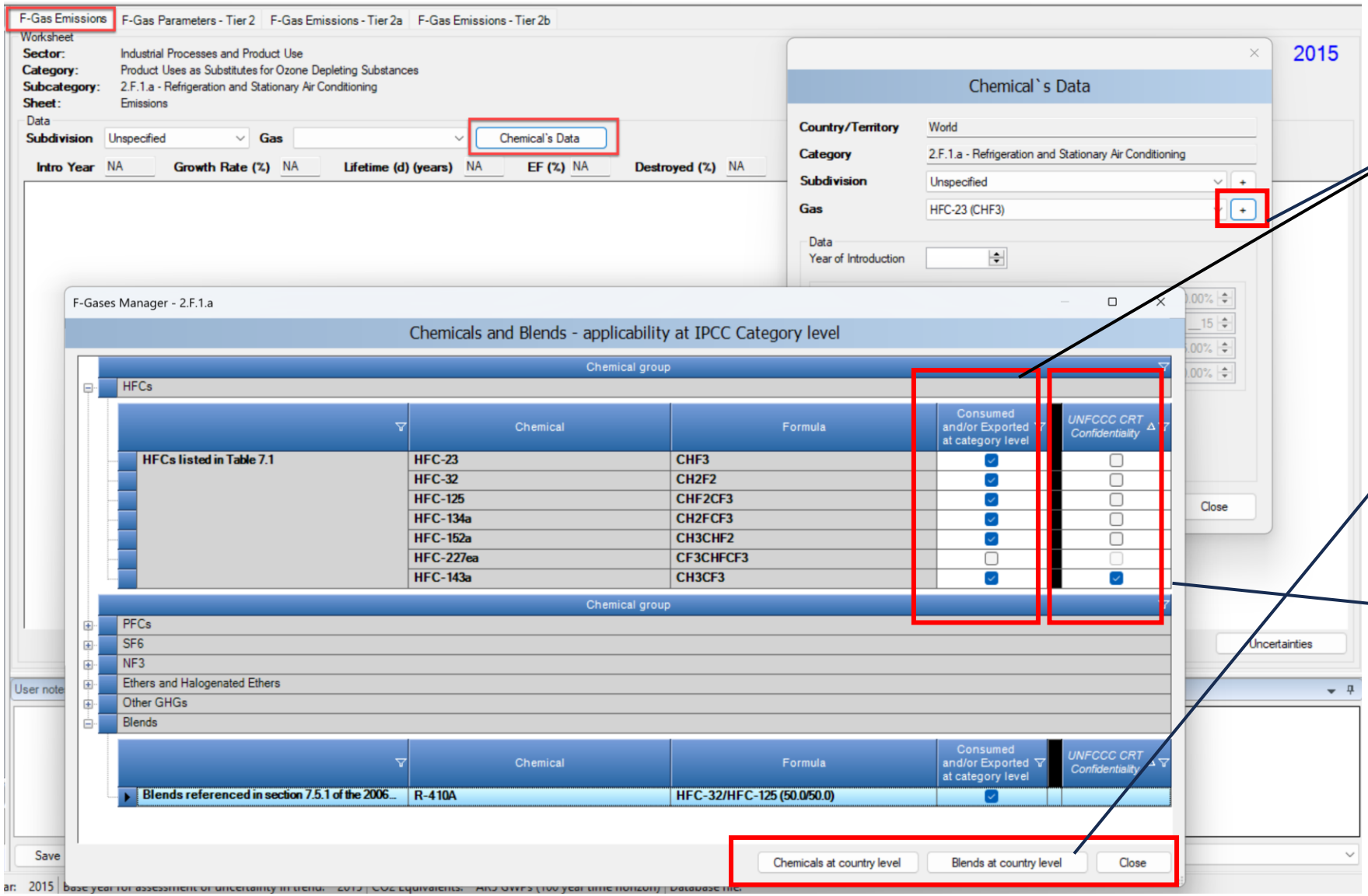
- ✓ Add relevant F-gases for IPCC category
- ✓ Add subdivisions, if applicable
- ✓ Add parameters

2.F.1: Tier 1



1. Enter subdivision(s) for country – may be single national or multiple.

2.F.1: Tier 1



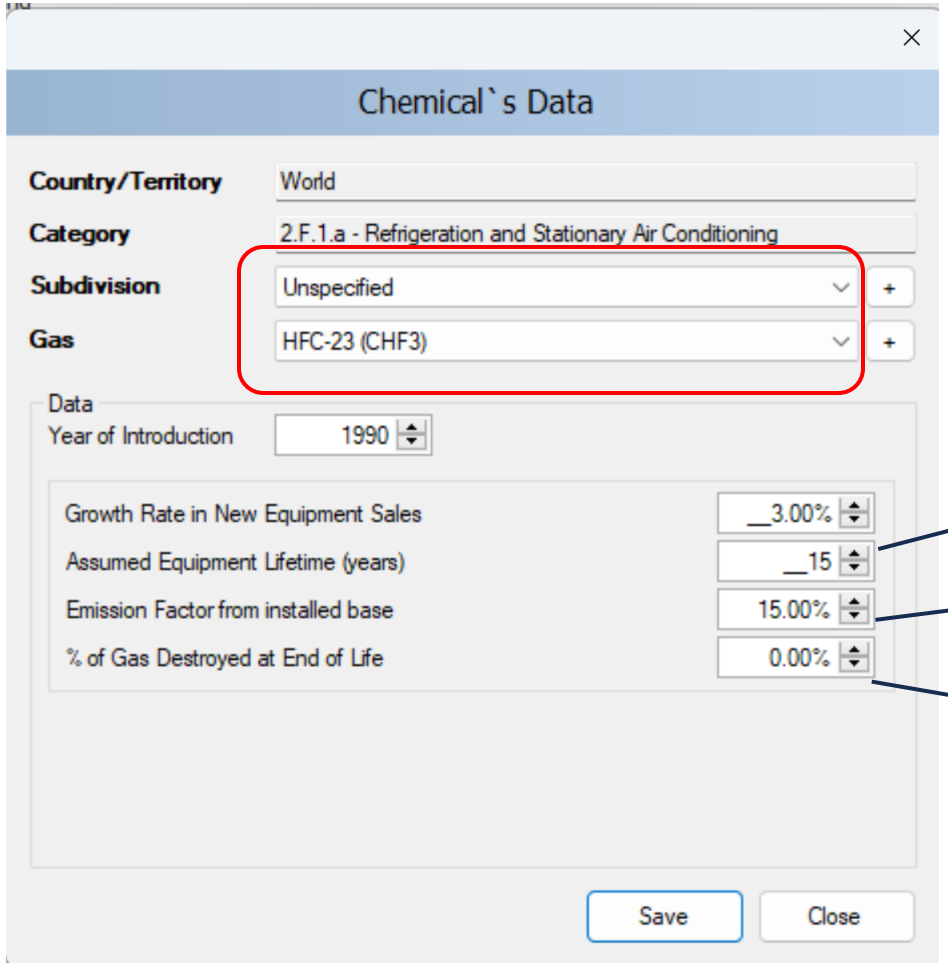
2. Select gases consumed (including imported) and/or exported in the IPCC category level F-gases Manager.

3. If gas not available for selection, must first be selected in national level F-gases Manager.

4. **For interoperability:** user may indicate if the gas in this category is confidential- all confidential emissions will be reported, in tCO_2 eq in 2.H.3 as unspecified mix of HFCs and PFCs.

2.F.1: Tier 1

Then, for each combination of subdivision and gas/blend, enter parameters:



Default is 15 years

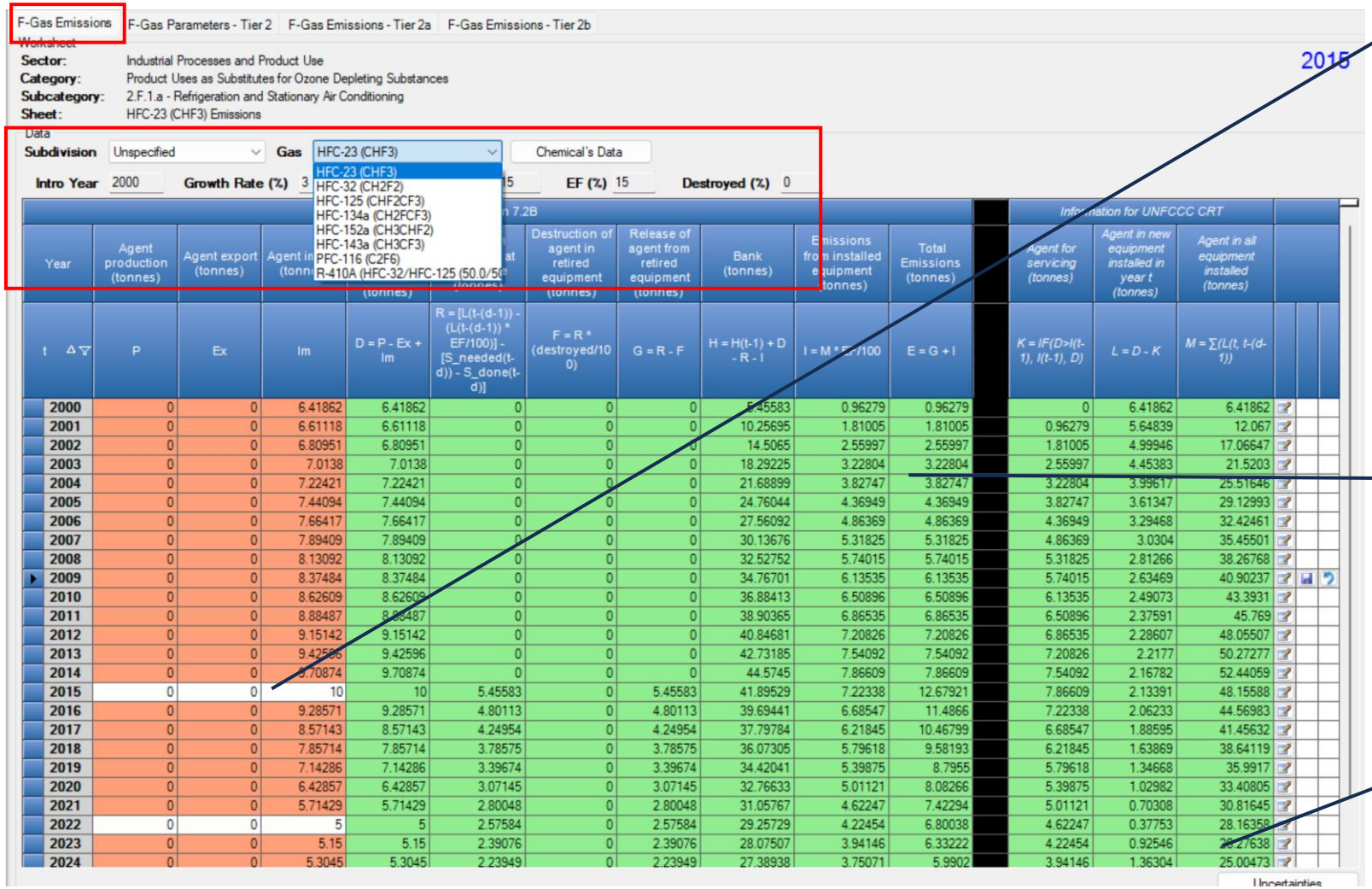
Default is 15%

Generally, where information is not available for a GHG Inventory, destruction is assumed to be 0

Source: Figure 7.7 of volume 3, chpt 7 of the 2006 IPCC Guidelines

2.F.1: Tier 1

Then, the user enters consumption data for each gas/blend


F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: HFC-23 (CHF3) Emissions

2015

Data

Subdivision Unspecified **Gas** HFC-23 (CHF3) Chemical's Data

HFC-23 (CHF3)
HFC-32 (CH2F2)
HFC-125 (CHF2CF3)
HFC-134a (CH2FCF3)
HFC-152a (CH3CHF2)
HFC-143a (CH3CF3)
PFC-116 (C2F6)
R-410A (HFC-32/HFC-125 (50.0/5

Intro Year 2000 **Growth Rate (%)** 3 15 **EF (%)** 15 **Destroyed (%)** 0

Year	Agent production (tonnes)	Agent export (tonnes)	Agent in (tonn	Destruction of agent in retired equipment	Release of agent from retired equipment	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Information for UNFCCC CRT: Agent for servicing (tonnes)	Agent in new equipment installed in year t (tonnes)	Agent in all equipment installed (tonnes)
t	P	Ex	Im	F = R * (destroyed/100)	G = R - F	H = H(t-1) + D - R - I	I = M * EF/100	E = G + I	K = IF(D>I(t-1), I(t-1), D)	L = D - K	M = ∑(L(t, t-(d-1))
2000	0	0	6.41862	0	0	5.45583	0.96279	0.96279	0	6.41862	6.41862
2001	0	0	6.61118	0	0	10.25695	1.81005	1.81005	0.96279	5.64839	12.067
2002	0	0	6.80951	0	0	14.5065	2.55997	2.55997	1.81005	4.99946	17.06647
2003	0	0	7.0138	0	0	18.29225	3.22804	3.22804	2.55997	4.45383	21.5203
2004	0	0	7.22421	0	0	21.68899	3.82747	3.82747	3.22804	3.99617	25.51646
2005	0	0	7.44094	0	0	24.76044	4.36949	4.36949	3.82747	3.61347	29.12993
2006	0	0	7.66417	0	0	27.56092	4.86369	4.86369	4.36949	3.29468	32.42461
2007	0	0	7.89409	0	0	30.13676	5.31825	5.31825	4.86369	3.0304	35.45501
2008	0	0	8.13092	0	0	32.52752	5.74015	5.74015	5.31825	2.81266	38.26768
2009	0	0	8.37484	0	0	34.76701	6.13535	6.13535	5.74015	2.63469	40.90237
2010	0	0	8.62609	0	0	36.88413	6.50896	6.50896	6.13535	2.49073	43.3931
2011	0	0	8.88487	0	0	38.90365	6.86535	6.86535	6.50896	2.37591	45.769
2012	0	0	9.15142	0	0	40.84681	7.20826	7.20826	6.86535	2.28607	48.05507
2013	0	0	9.42596	0	0	42.73185	7.54092	7.54092	7.20826	2.2177	50.27277
2014	0	0	9.70874	0	0	44.5745	7.86609	7.86609	7.54092	2.16782	52.44059
2015	0	0	10	5.45583	5.45583	41.89529	7.22338	12.67921	7.86609	2.13391	48.15588
2016	0	0	9.28571	4.80113	4.80113	39.69441	6.68547	11.4866	7.22338	2.06233	44.56983
2017	0	0	8.57143	4.24954	4.24954	37.79784	6.21845	10.46799	6.68547	1.88595	41.45632
2018	0	0	7.85714	3.78575	3.78575	36.07305	5.79618	9.58193	6.21845	1.63869	38.64119
2019	0	0	7.14286	3.39674	3.39674	34.42041	5.39875	8.7955	5.79618	1.34668	35.9917
2020	0	0	6.42857	3.07145	3.07145	32.76633	5.01121	8.08266	5.39875	1.02982	33.40805
2021	0	0	5.71429	2.80048	2.80048	31.05767	4.62247	7.42294	5.01121	0.70308	30.81645
2022	0	0	5	2.57584	2.57584	29.25729	4.22454	6.80038	4.62247	0.37753	28.16358
2023	0	0	5.15	2.39076	2.39076	28.07507	3.94146	6.33222	4.22454	0.92546	28.27638
2024	0	0	5.3045	2.23949	2.23949	27.38938	3.75071	5.9902	3.94146	1.36304	25.00473

Uncertainties

Consumption data entered for each gas, must know at least current year (but should add all known years). Consumption for unknown years extrapolated back based on equipment growth rate.

Green cells automatically calculated based on parameters entered.

Column E = Total Emissions
Columns K, L, M calculated AD for interoperability.

✓ *Now let's do exercise with dummy data*

Exercise: Estimate 2.F.1.using Tier 1 Method

Exercise #1a: Set up the IPCC category level F-gases Manager

Recall earlier dataset and the F-gases consumed for RAC. The user should populate the IPCC category level F-gases Manager for 2.F.1.a.

- *Note that this is a category level Manager, so gases entered will be available for all subdivisions and Tier 2 calculations also.*

Indicate that HFC-152a is confidential.

In Exercise #1b the users will input all data for each gas/subdivision to estimate emissions.

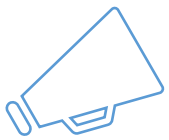
F-gases Consumed	Electronics	Refrigeration and Air Conditioning	Fire protection	Aerosols	Soundproof windows
HFCs					
HFC-23	X	X			
HFC-32		X			
HFC-125		X			
HFC-134a		X		X	
HFC-143a		X			
HFC-152a		X			
HFC-227ea			X	X	
PFCs					
CF4	X				
C2F6	X				
c-C4F8	X				
SF6	X				X
NF3	X				
Blends					
R410A		X			

Exercise: Estimate 2.F.1.using Tier 1 Method

Exercise 1b: Estimate emissions, in tonnes, for 2015 and 2022 for category 2.F.1.a, using the following data/assumptions:

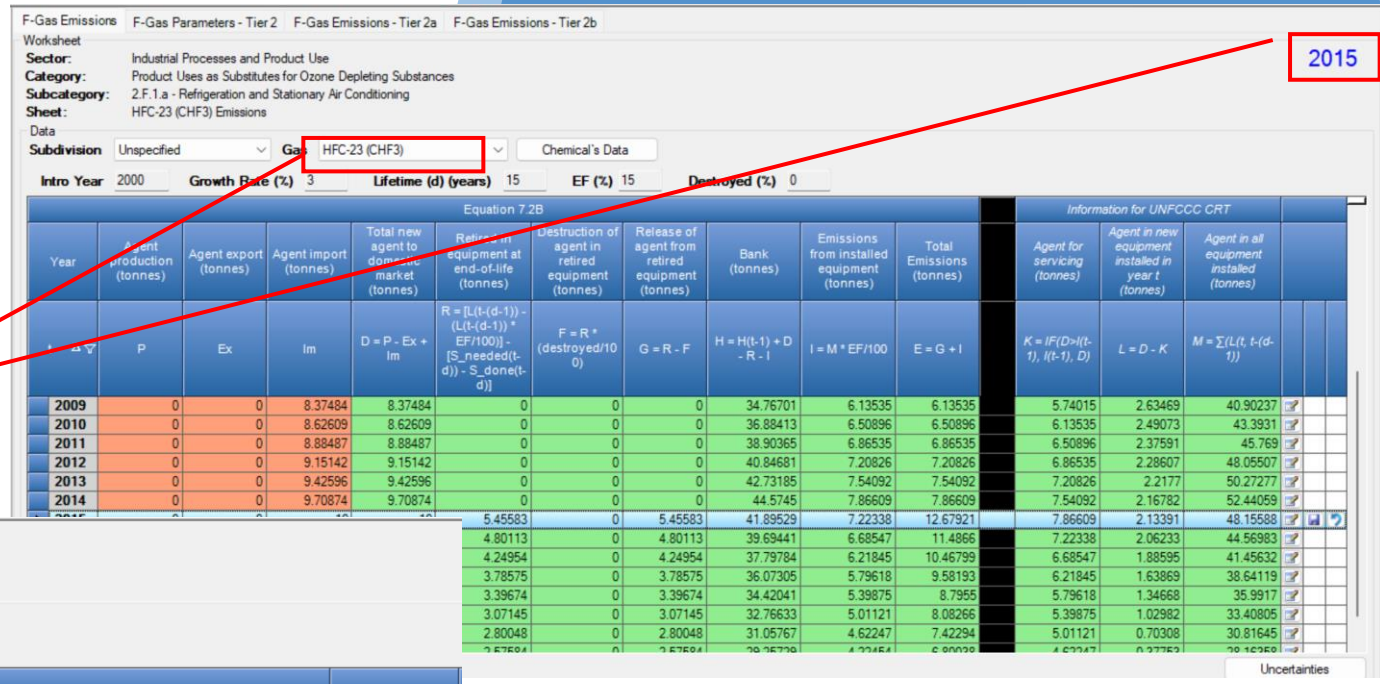
- The country does not have any subdivisions.
- All gases/blends, except HFC-125, were introduced in 2000, HFC-125 introduced in 1995.
- Imported quantities for 2015 and 2022 are as shown.
- Equipment growth rate is 3.0%.
- No information is available on F-gas destruction at the end of life.
- IPCC defaults used for lifetime and EF from installed base.

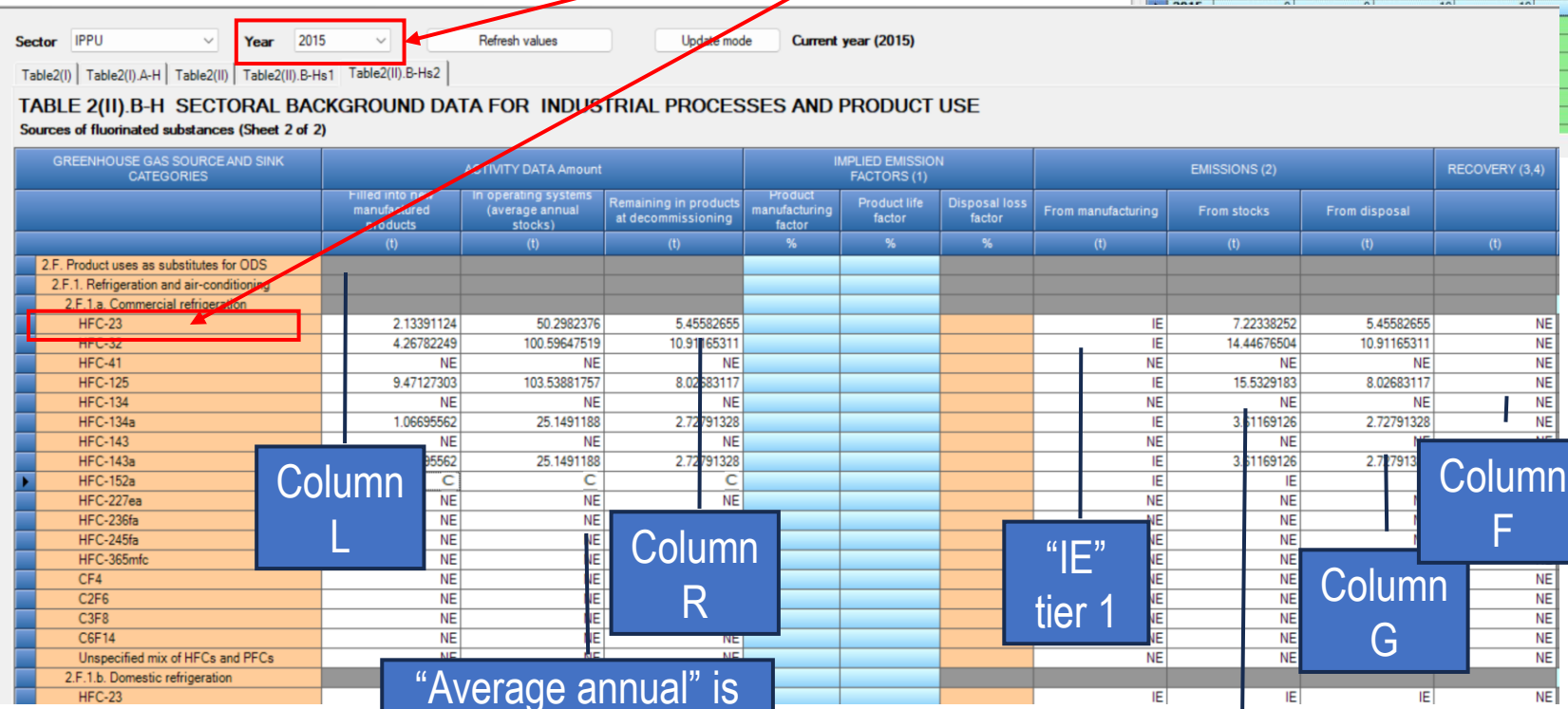
F-gases Consumed	Refrigeration and Air Conditioning	Imports (t)	
		2015	2022
HFCs			
HFC-23	X	10	5
HFC-32	X	15	10
HFC-125	X	20	10
HFC-134a	X	5	20
HFC-143a	X	5	5
HFC-152a	X	5	5
Blends			
R410A	X	10	20



Hint! First enter the information for each chemical in **Chemical's Data,** then add the imports

2.F.1: Preview
Interoperability with UNFCCC ETF Reporting Tool for Tier 1





Note for interoperability:

For Tier 1, all maps to commercial refrigeration (see "IE" for domestic refrigeration)

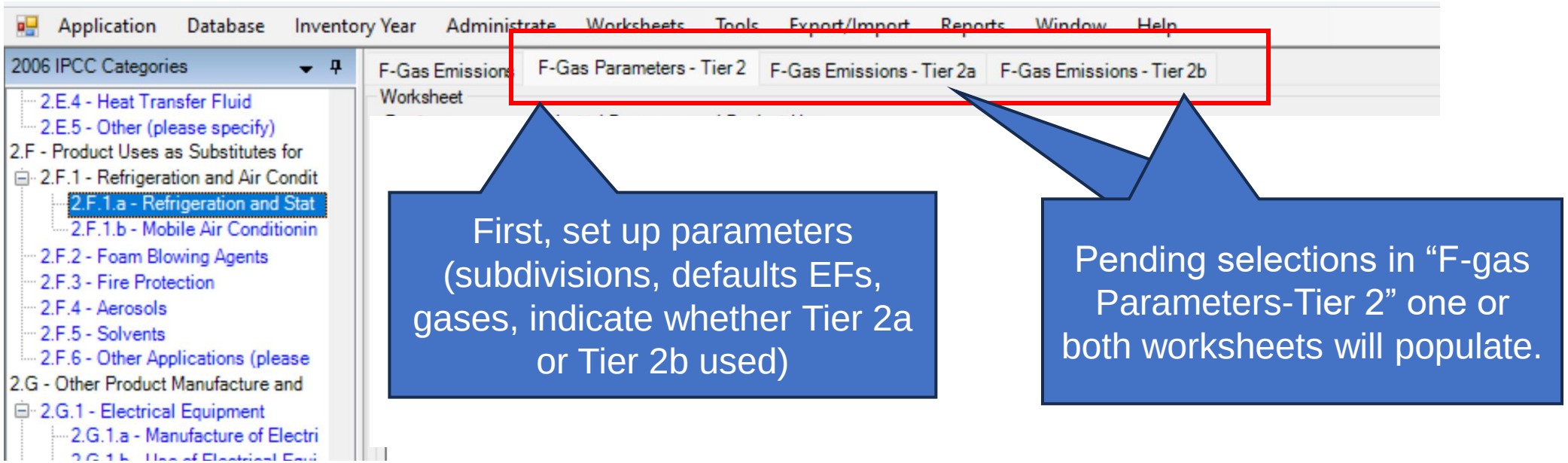
Note inclusion of all gases added in *Software.*

See "C" for AD of HFC-152a and "IE" for emissions?

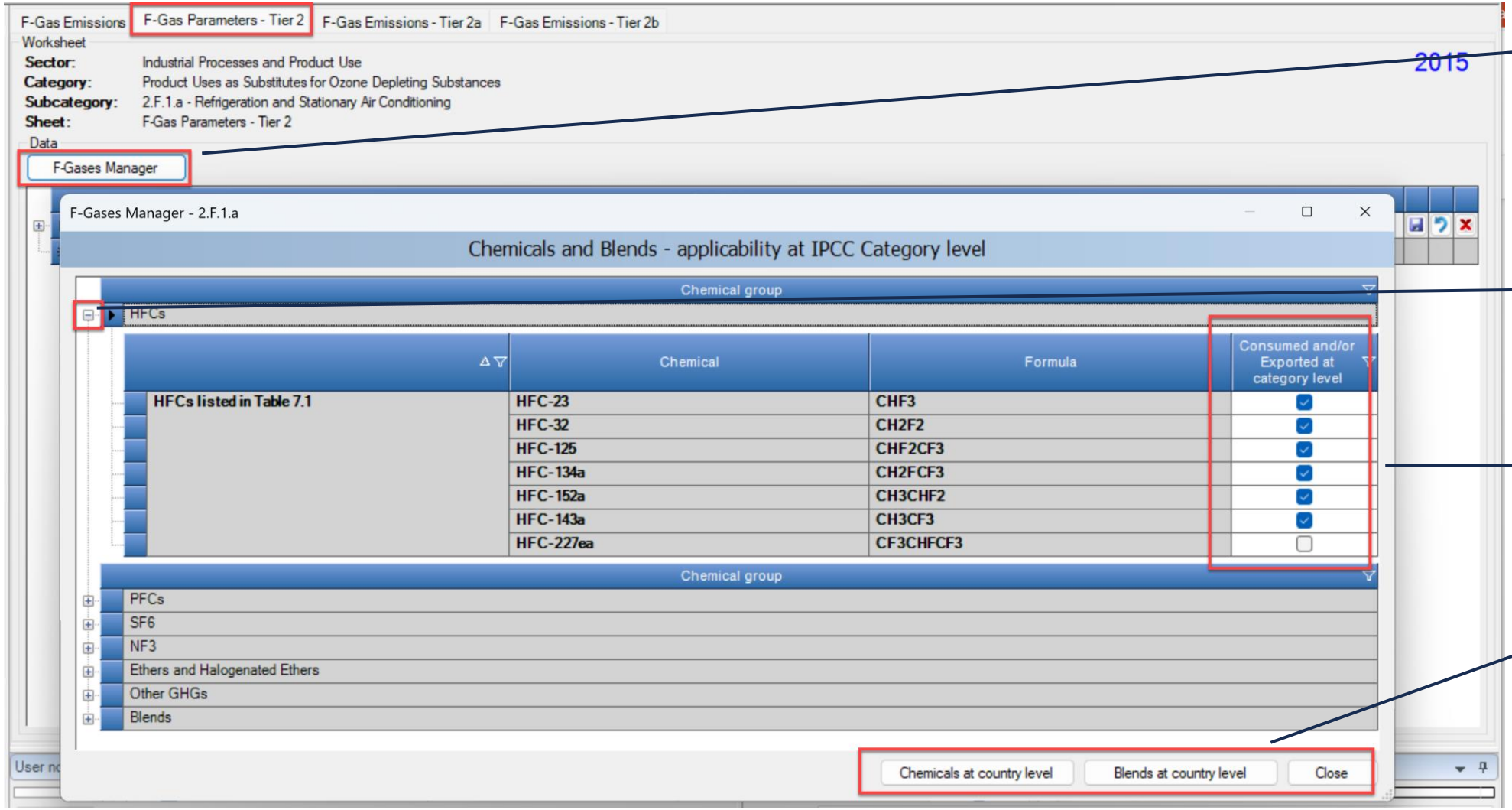
2.F.1 Refrigeration and Air Conditioning

Tier 2

2.F.1: Steps to estimating emissions following Tier 2 method



2.F.1: F-Gas Parameters – Tier 2



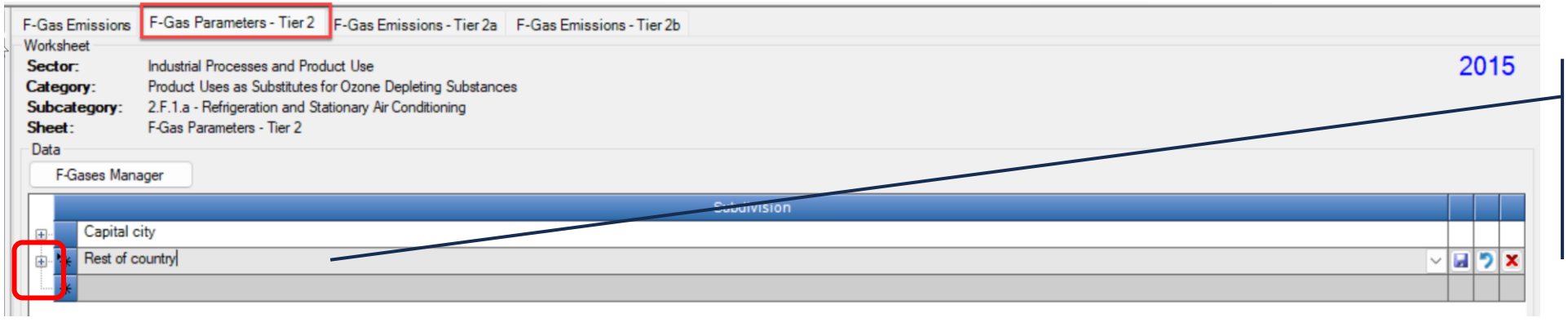
1. Select **F-Gases Manager** to set up category level F-gases Manager.

2. In pop-up box, select [+] to open drop-downs for gas/blend.

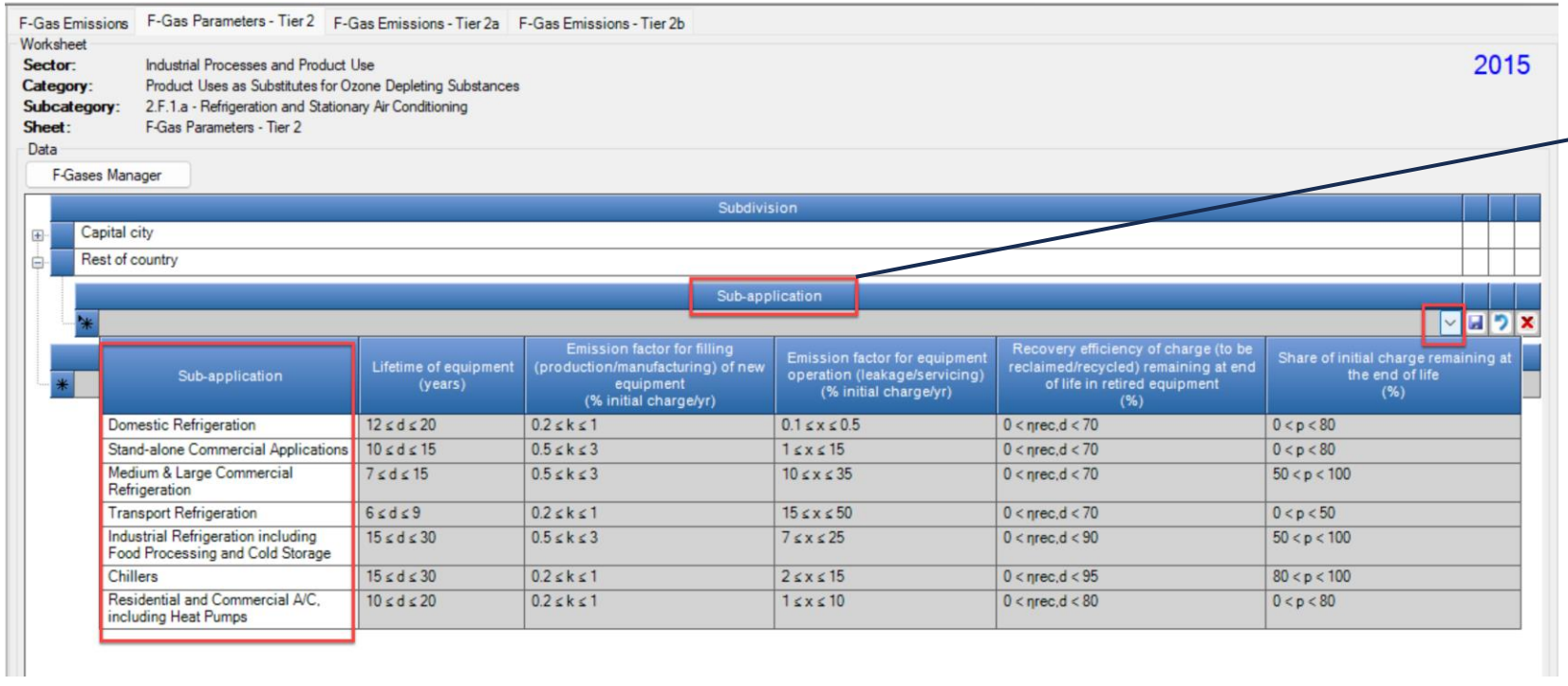
3. Select species/blends relevant for 2.F.1.

4. If gas not available for selection, must first be selected in national level F-gases Manager.

2.F.1: Steps to estimating emissions following Tier 2 method



5. Enter subdivision(s) for country – may be single national or multiple. Add subdivisions by directly typing in row.

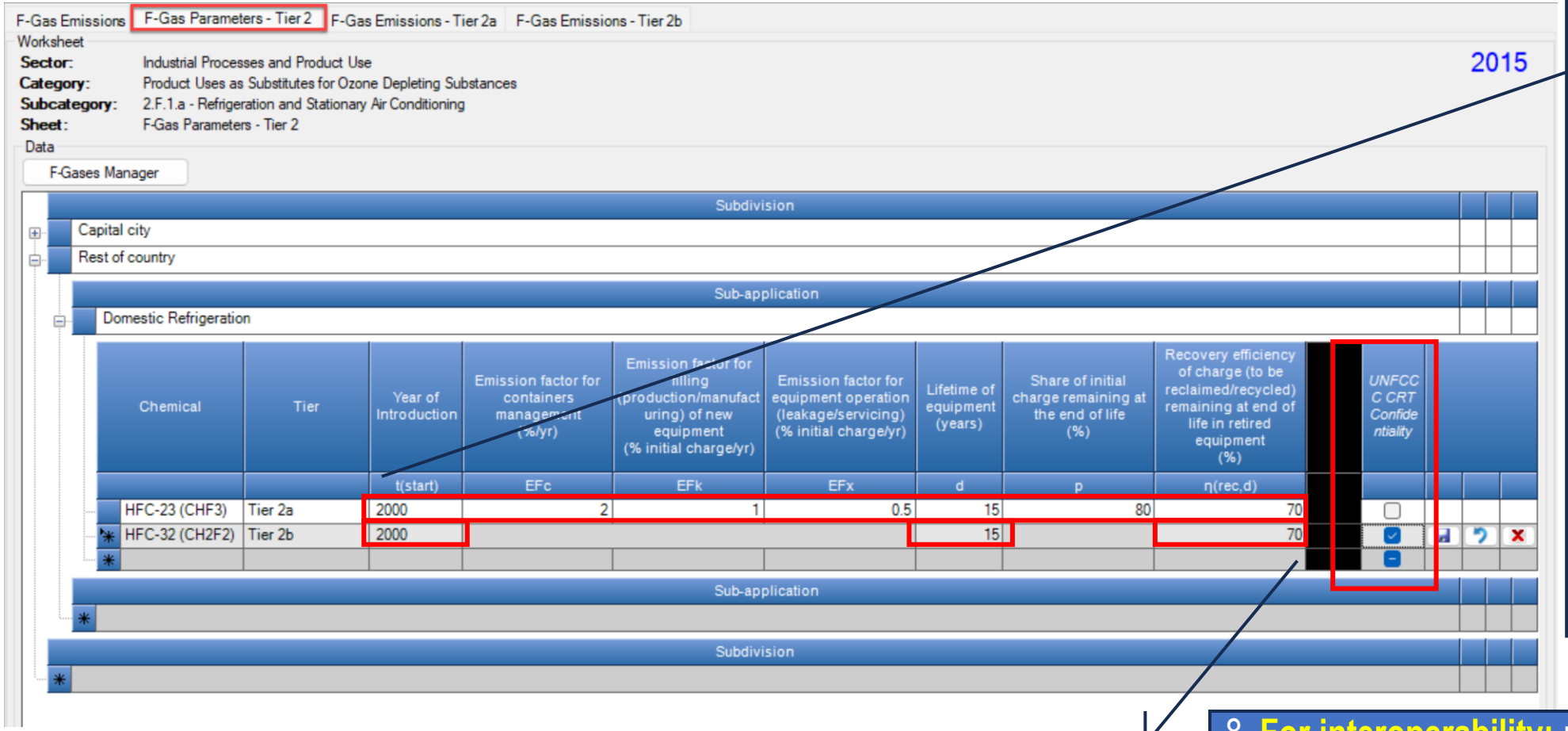


Sub-application	Lifetime of equipment (years)	Emission factor for filling (production/manufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	Recovery efficiency of charge (to be reclaimed/recycled) remaining at end of life in retired equipment (%)	Share of initial charge remaining at the end of life (%)
Domestic Refrigeration	$12 \le d \le 20$	$0.2 \le k \le 1$	$0.1 \le x \le 0.5$	$0 < \eta rec,d < 70$	$0 < p < 80$
Stand-alone Commercial Applications	$10 \le d \le 15$	$0.5 \le k \le 3$	$1 \le x \le 15$	$0 < \eta rec,d < 70$	$0 < p < 80$
Medium & Large Commercial Refrigeration	$7 \le d \le 15$	$0.5 \le k \le 3$	$10 \le x \le 35$	$0 < \eta rec,d < 70$	$50 < p < 100$
Transport Refrigeration	$6 \le d \le 9$	$0.2 \le k \le 1$	$15 \le x \le 50$	$0 < \eta rec,d < 70$	$0 < p < 50$
Industrial Refrigeration including Food Processing and Cold Storage	$15 \le d \le 30$	$0.5 \le k \le 3$	$7 \le x \le 25$	$0 < \eta rec,d < 90$	$50 < p < 100$
Chillers	$15 \le d \le 30$	$0.2 \le k \le 1$	$2 \le x \le 15$	$0 < \eta rec,d < 95$	$80 < p < 100$
Residential and Commercial A/C, including Heat Pumps	$10 \le d \le 20$	$0.2 \le k \le 1$	$1 \le x \le 10$	$0 < \eta rec,d < 80$	$0 < p < 80$

6. Select sub-applications.

Note for interoperability:
It is best to select from pre-defined list and not alter. Any user-specific sub-applications will be reported together under Stationary Air Conditioning in CRT

2.F.1: Steps to estimating emissions following Tier 2 method


F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: F-Gas Parameters - Tier 2

2015

Data

F-Gases Manager

Subdivision

- Capital city
- Rest of country

Sub-application

- Domestic Refrigeration

Chemical	Tier	Year of Introduction	Emission factor for containers management (%/yr)	Emission factor for filling (production/manufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	Lifetime of equipment (years)	Share of initial charge remaining at the end of life (%)	Recovery efficiency of charge (to be reclaimed/recycled) remaining at end of life in retired equipment (%)	UNFCCC CRT Confidentiality
		t(start)	EFc	EFk	EFx	d	p	η(rec,d)	
HFC-23 (CHF3)	Tier 2a	2000	2	1	0.5	15	80	70	☐
HFC-32 (CH2F2)	Tier 2b	2000				15		70	☑

Sub-application

Subdivision

7. For each sub-application, select Tier used.

Default parameters / EFs here must be filled before estimating emissions.

Each Tier has different data requirements.

8. **For interoperability:** user may indicate if the gas in this category is confidential- all confidential emissions will be reported, in tCO_2 eq in 2.H.3 as unspecified mix of HFCs and PFCs.

2.F.1 Refrigeration and Air Conditioning

Tier 2a

2.F.1: Tier 2a

- **Tier 2a** *(Emission Factor Approach):*

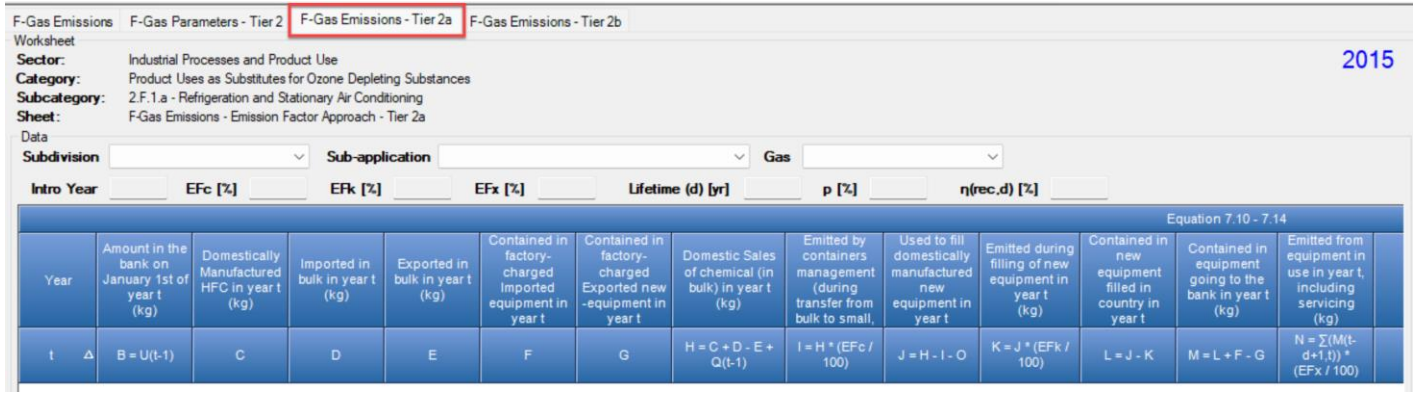
EQUATION 7.10
SUMMARY OF SOURCES OF EMISSIONS

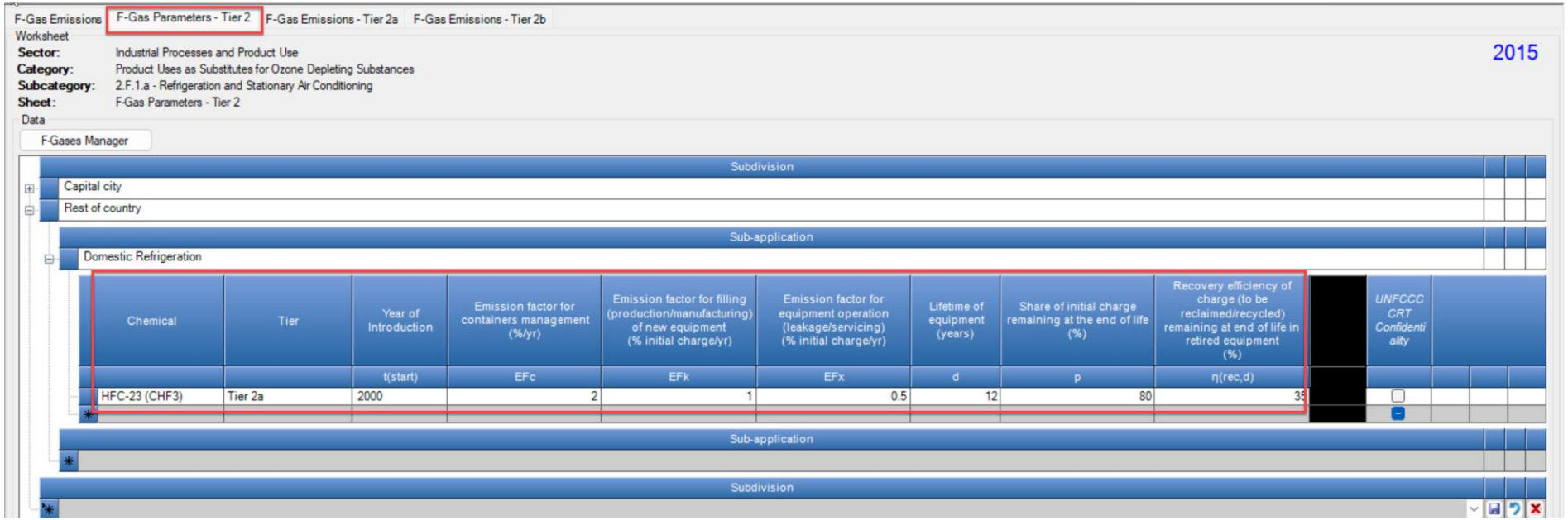
$$E_{total,t} = E_{containers,t} + E_{Charge,t} + E_{lifetime,t} + E_{end-of-life,t}$$

$E_{containers,t}$	$E_{Charge,t}$	$E_{lifetime,t}$	$E_{end-of-life,t}$
HFC market for new equipment and servicing * EF for container management	HFC charged into new equipment * EF for losses during charging	HFC banked in existing systems * EF from annual leakage during use/servicing	Initial HFC charged in new equipment * residual charge (% of initial at end of life) * (1 – recovery efficiency at disposal)

2.F.1: Tier 2a

The Tier 2a worksheet will be blank until all EFs and Parameters are added in worksheet F-gas Parameters – Tier 2

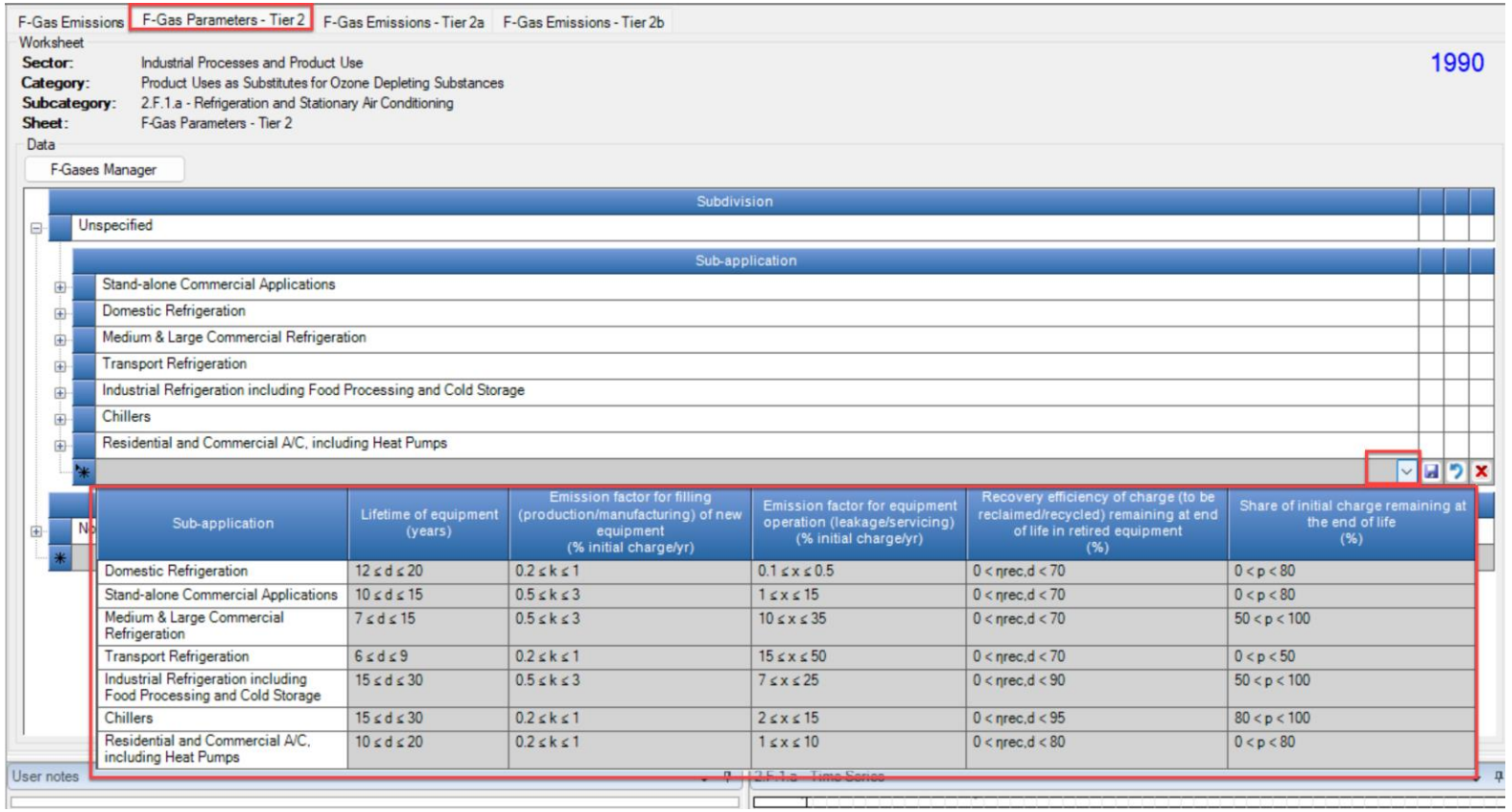




2.F.1: Tier 2a – EF

Default parameters and EFs can be found in:

- **Worksheet: F-Gas Parameters- Tier 2**
- **Table 7.9** of the 2006 IPCC Guidelines
- **EF for container management between 2-10% (see equation 7.11)**



Sub-application	Lifetime of equipment (years)	Emission factor for filling (production/manufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	Recovery efficiency of charge (to be reclaimed/recycled) remaining at end of life in retired equipment (%)	Share of initial charge remaining at the end of life (%)
Domestic Refrigeration	12 ≤ d ≤ 20	0.2 ≤ k ≤ 1	0.1 ≤ x ≤ 0.5	0 < ηrec,d < 70	0 < p < 80
Stand-alone Commercial Applications	10 ≤ d ≤ 15	0.5 ≤ k ≤ 3	1 ≤ x ≤ 15	0 < ηrec,d < 70	0 < p < 80
Medium & Large Commercial Refrigeration	7 ≤ d ≤ 15	0.5 ≤ k ≤ 3	10 ≤ x ≤ 35	0 < ηrec,d < 70	50 < p < 100
Transport Refrigeration	6 ≤ d ≤ 9	0.2 ≤ k ≤ 1	15 ≤ x ≤ 50	0 < ηrec,d < 70	0 < p < 50
Industrial Refrigeration including Food Processing and Cold Storage	15 ≤ d ≤ 30	0.5 ≤ k ≤ 3	7 ≤ x ≤ 25	0 < ηrec,d < 90	50 < p < 100
Chillers	15 ≤ d ≤ 30	0.2 ≤ k ≤ 1	2 ≤ x ≤ 15	0 < ηrec,d < 95	80 < p < 100
Residential and Commercial A/C, including Heat Pumps	10 ≤ d ≤ 20	0.2 ≤ k ≤ 1	1 ≤ x ≤ 10	0 < ηrec,d < 80	0 < p < 80

TABLE 7.9
ESTIMATES[1] FOR CHARGE, LIFETIME AND EMISSION FACTORS FOR REFRIGERATION AND AIR-CONDITIONING SYSTEMS

Sub-application	Charge (kg)	Lifetimes (years)[2]	Emission Factors (% of initial charge/year)[3]		End-of-Life Emission (%)	
Factor in Equation	(M)	(d)	(k)	(x)	($\eta_{rec,d}$)	(p)
			Initial Emission	Operation Emission	Recovery Efficiency[4]	Initial Charge Remaining
Domestic Refrigeration	0.05 ≤ M ≤ 0.5	12 ≤ d ≤ 20	0.2 ≤ k ≤ 1	0.1 ≤ x ≤ 0.5	0 < $\eta_{rec,d}$ < 70	0 < p < 80
Stand-alone Commercial Applications	0.2 ≤ M ≤ 6	10 ≤ d ≤ 15	0.5 ≤ k ≤ 3	1 ≤ x ≤ 15	0 < $\eta_{rec,d}$ < 70	0 < p < 80
Medium & Large Commercial Refrigeration	50 ≤ M ≤ 2000	7 ≤ d ≤ 15	0.5 ≤ k ≤ 3	10 ≤ x ≤ 35	0 < $\eta_{rec,d}$ < 70	50 < p < 100
Transport Refrigeration	3 ≤ M ≤ 8	6 ≤ d ≤ 9	0.2 ≤ k ≤ 1	15 ≤ x ≤ 50	0 < $\eta_{rec,d}$ < 70	0 < p < 50
Industrial Refrigeration including Food Processing and Cold Storage	10 ≤ M ≤ 10,000	15 ≤ d ≤ 30	0.5 ≤ k ≤ 3	7 ≤ x ≤ 25	0 < $\eta_{rec,d}$ < 90	50 < p < 100
Chillers	10 ≤ M ≤ 2000	15 ≤ d ≤ 30	0.2 ≤ k ≤ 1	2 ≤ x ≤ 15	0 < $\eta_{rec,d}$ < 95	80 < p < 100
Residential and Commercial A/C, including Heat Pumps	0.5 ≤ M ≤ 100	10 ≤ d ≤ 20	0.2 ≤ k ≤ 1	1 ≤ x ≤ 10	0 < $\eta_{rec,d}$ < 80	0 < p < 80
Mobile A/C	0.5 ≤ M ≤ 1.5	9 ≤ d ≤ 16	0.2 ≤ k ≤ 0.5	10 ≤ x ≤ 20[5]	0 < $\eta_{rec,d}$ < 50	0 < p < 50

[1] Based on information contained in UNEP RTOC Reports (UNEP-RTOC, 1999; UNEP-RTOC, 2003)
[2, 3] Lower value for developed countries and higher value for developing countries
[4] The lower threshold (0%) highlights that there is no recovery in some countries.
[5] Schwarz and Harnisch (2003) estimates leakage rates of 5.3% to 10.6%; these rates apply only to second generation mobile air conditioners installed in European models in 1996 and beyond.

Source: 2006 IPCC Guidelines

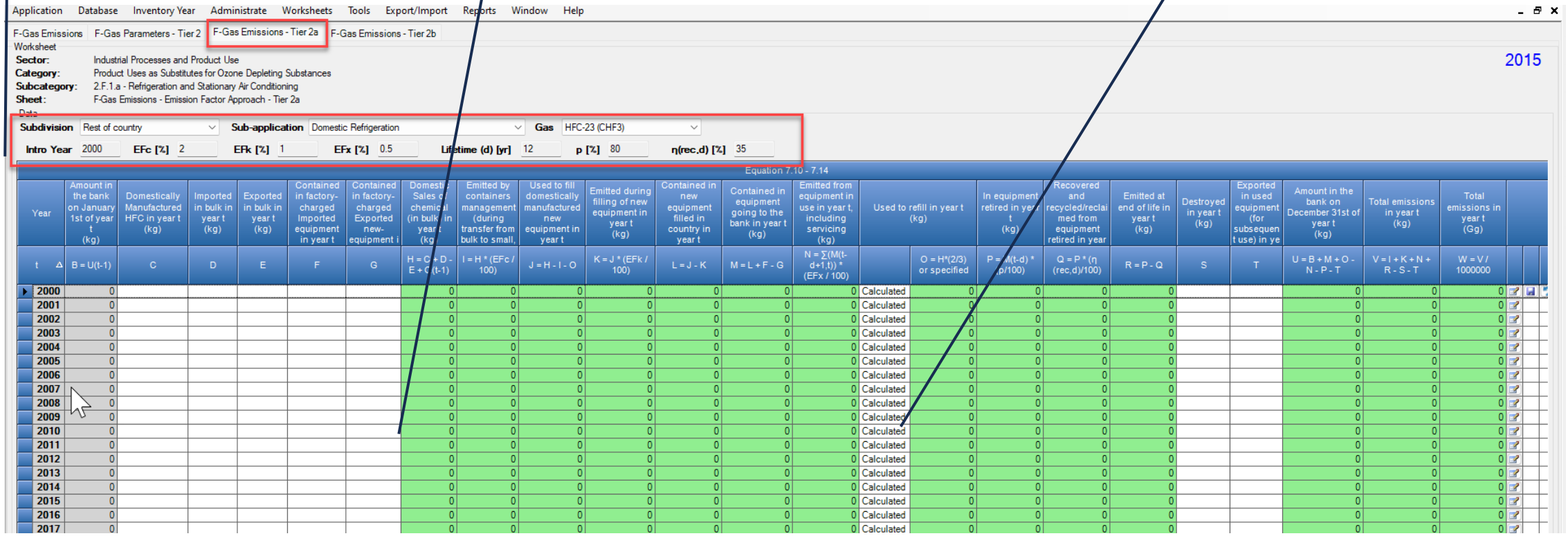
2.F.1: Tier 2a - AD

Once all parameters are entered in F-gas Parameters-Tier 2, the times series data entry grid appears in worksheet F-Gas Emissions-Tier 2a, ready for AD entry.

Selected parameters/ EFs visible here

White cells = data input
Green cells = calculated

Choice of calculated /or data input (specified)



Year	Amount in the bank on January 1st of year t (kg)	Domestically Manufactured HFC 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 i	Domesti Sales of chemical (in bulk in year t (kg	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	Contained in equipment going to the bank in year t (kg)	Emitted from equipment in use in year t, including servicing (kg)	Used to refill in year t (kg)		In equipment retired in year t (kg)	Recovered and recycled/reclaimed from equipment retired in year	Emitted at end of life in year t (kg)	Destroyed in year t (kg)	Exported in used equipment (for subsequent use) in ye	Amount in the bank on December 31st of year t (kg)	Total emissions in year t (kg)	Total emissions in year t (Gg)			
t Δ	B = U(t-1)	C	D	E	F	G	H = C + D - E + (t-1)	I = H * (EFc / 100)	J = H - I - O	K = J * (EFk / 100)	L = J - K	M = L + F - G	N = ∑(M(t-d+1,t)) * (EFx / 100)		O = H*(2/3) or specified	P = (t-d) * p/100)	Q = P * (η (rec,d)/100)	R = P - Q	S	T	U = B + M + O - N - P - T	V = I + K + N + R - S - T	W = V / 1000000			
2000	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2001	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2002	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2003	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2004	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2005	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2006	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2007	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2008	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2009	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2010	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2011	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2012	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2013	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2014	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2015	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2016	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			
2017	0						0	0	0	0	0	0	0	Calculated	0	0	0	0			0	0	0			

2.F.1 Refrigeration and Air Conditioning

Tier 2b

2.F.1: Tier 2b

EQUATION 7.9
DETERMINATION OF REFRIGERANT EMISSIONS BY MASS BALANCE

$$Emissions = Annual\ Sales\ of\ New\ Refrigerant - Total\ Charge\ of\ New\ Equipment + Original\ Total\ Charge\ of\ Retiring\ Equipment - Amount\ of\ Intentional\ Destruction$$

- **Annual Sales of New Refrigerant:** the amount of a chemical introduced in a given year. It includes all chemical used to fill or refill equipment, whether the chemical is charged into equipment at the factory, charged into equipment after installation, or used to recharge equipment at servicing. It does not include recycled or reclaimed chemical.

- **Total Charge of New Equipment:** the sum of the full charges of all the new equipment that is sold in a given year. It includes both the chemical required to fill equipment in the factory and the chemical required to fill the equipment after installation. It does not include charging emissions or chemical used to recharge equipment at servicing.

- **Original Total Charge of Retiring Equipment:** the sum of the full charges of all the retiring equipment decommissioned in a given year. It assumes that the equipment will have been serviced right up to its decommissioning and will therefore contain its original charge.

- **Amount of Intentional Destruction:** quantity of the chemical duly destroyed by a recognised destruction technology.

2.F.1: Tier 2b

The Tier 2b worksheet will be blank until all EFs and Parameters are added in worksheet F-gas Parameters – Tier 2

F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: F-Gas Emissions - Mass Balance Approach - Tier 2b

2015

Data

Subdivision | **Sub-application** | **Gas**

Intro Year | **Lifetime (d) [yr]** | **η(rec,d) [%]** | **Stockpile**

Equation 7.9

Year	Domestically Manufactured HFC 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 / 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	Recov recycled/re equipment r (k
t Δ	B	C	D	E	F	G = B + C - D + E - F								

F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: F-Gas Parameters - Tier 2

2015

Data

F-Gases Manager

Subdivision

- Capital city
- Rest of country

Sub-application

- Domestic Refrigeration

Chemical	Tier	Year of Introduction	Emission factor for containers management (%/yr)	Emission factor for filling (production/manufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	Lifetime of equipment (years)	Share of initial charge remaining at the end of life (%)	Recovery efficiency of charge (to be reclaimed/recycled) remaining at end of life in retired equipment (%)		UNFCCC CRT Confidentiality			
		t(start)	EFc	EFk	EFx	d	p	η(rec,d)					
HFC-23 (CHF3)	Tier 2a	2000	2	1	0.5	15	70	80		☐			
HFC-32 (CH2F2)	Tier 2b	2000				15		80		☐			
										−			

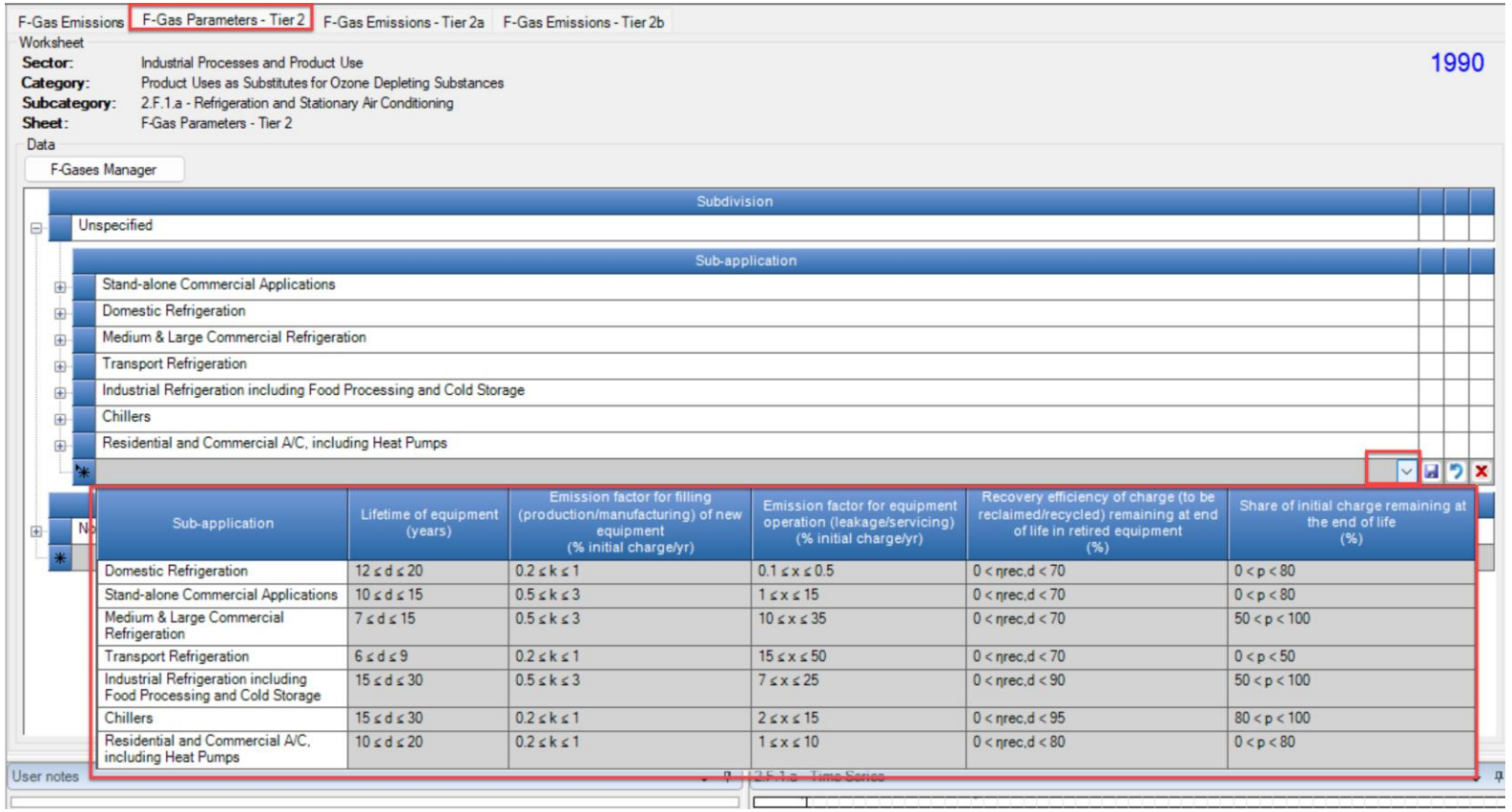
Sub-application

Subdivision

2.F.1: Tier 2b – parameters

Default parameters for lifetime and recovery efficiency:

- **Worksheet: F-Gas Parameters- Tier 2**
- **Table 7.9** of the 2006 IPCC Guidelines



Sub-application	Lifetime of equipment (years)	Emission factor for filling (production/manufacturing) of new equipment (% initial charge/yr)	Emission factor for equipment operation (leakage/servicing) (% initial charge/yr)	Recovery efficiency of charge (to be reclaimed/recycled) remaining at end of life in retired equipment (%)	Share of initial charge remaining at the end of life (%)
Domestic Refrigeration	12 ≤ d ≤ 20	0.2 ≤ k ≤ 1	0.1 ≤ x ≤ 0.5	0 < ηrec,d < 70	0 < p < 80
Stand-alone Commercial Applications	10 ≤ d ≤ 15	0.5 ≤ k ≤ 3	1 ≤ x ≤ 15	0 < ηrec,d < 70	0 < p < 80
Medium & Large Commercial Refrigeration	7 ≤ d ≤ 15	0.5 ≤ k ≤ 3	10 ≤ x ≤ 35	0 < ηrec,d < 70	50 < p < 100
Transport Refrigeration	6 ≤ d ≤ 9	0.2 ≤ k ≤ 1	15 ≤ x ≤ 50	0 < ηrec,d < 70	0 < p < 50
Industrial Refrigeration including Food Processing and Cold Storage	15 ≤ d ≤ 30	0.5 ≤ k ≤ 3	7 ≤ x ≤ 25	0 < ηrec,d < 90	50 < p < 100
Chillers	15 ≤ d ≤ 30	0.2 ≤ k ≤ 1	2 ≤ x ≤ 15	0 < ηrec,d < 95	80 < p < 100
Residential and Commercial A/C, including Heat Pumps	10 ≤ d ≤ 20	0.2 ≤ k ≤ 1	1 ≤ x ≤ 10	0 < ηrec,d < 80	0 < p < 80

TABLE 7.9
ESTIMATES[1] FOR CHARGE, LIFETIME AND EMISSION FACTORS FOR REFRIGERATION AND AIR-CONDITIONING SYSTEMS

Sub-application	Charge (kg)	Lifetimes (years)[2]	Emission Factors (% of initial charge/year)[3]		End-of-Life Emission (%)	
Factor in Equation	(M)	(d)	(k)	(x)	($\eta_{rec,d}$)	(p)
			Initial Emission	Operation Emission	Recovery Efficiency[4]	Initial Charge Remaining
Domestic Refrigeration	0.05 ≤ M ≤ 0.5	12 ≤ d ≤ 20	0.2 ≤ k ≤ 1	0.1 ≤ x ≤ 0.5	0 < $\eta_{rec,d}$ < 70	0 < p < 80
Stand-alone Commercial Applications	0.2 ≤ M≤ 6	10 ≤ d ≤ 15	0.5 ≤ k ≤ 3	1 ≤ x ≤ 15	0 < $\eta_{rec,d}$ < 70	0 < p < 80
Medium & Large Commercial Refrigeration	50 ≤ M ≤ 2000	7 ≤ d ≤ 15	0.5 ≤ k ≤ 3	10 ≤ x ≤ 35	0 < $\eta_{rec,d}$ < 70	50 < p < 100
Transport Refrigeration	3 ≤ M ≤ 8	6 ≤ d ≤ 9	0.2 ≤ k ≤ 1	15 ≤ x ≤ 50	0 < $\eta_{rec,d}$ < 70	0 < p < 50
Industrial Refrigeration including Food Processing and Cold Storage	10 ≤ M ≤ 10,000	15 ≤ d ≤ 30	0.5 ≤ k ≤ 3	7 ≤ x ≤ 25	0 < $\eta_{rec,d}$ < 90	50 < p < 100
Chillers	10 ≤ M≤ 2000	15 ≤ d ≤ 30	0.2 ≤ k ≤ 1	2 ≤ x ≤ 15	0 < $\eta_{rec,d}$ < 95	80 < p < 100
Residential and Commercial A/C, including Heat Pumps	0.5 ≤ M≤ 100	10 ≤ d ≤ 20	0.2 ≤ k ≤ 1	1 ≤ x ≤ 10	0 < $\eta_{rec,d}$ < 80	0 < p < 80
Mobile A/C	0.5 ≤ M ≤ 1.5	9 ≤ d ≤ 16	0.2 ≤ k ≤ 0.5	10 ≤ x ≤ 20[5]	0 < $\eta_{rec,d}$ < 50	0 < p < 50

[1] Based on information contained in UNEP RTOC Reports (UNEP-RTOC, 1999; UNEP-RTOC, 2003)
[2, 3] Lower value for developed countries and higher value for developing countries
[4] The lower threshold (0%) highlights that there is no recovery in some countries.
[5] Schwarz and Harnisch (2003) estimates leakage rates of 5.3% to 10.6%; these rates apply only to second generation mobile air conditioners installed in European models in 1996 and beyond.

Source: 2006 IPCC Guidelines

2.F.1: Tier 2b - AD

Once all parameters are entered in F-gas Parameters-Tier 2, the times series data entry grid appears in worksheet F-Gas Emissions-Tier 2b, ready for AD entry.

F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: F-Gas Emissions - Mass Balance Approach - Tier 2b

2015

Data

Subdivision Rest of country **Sub-application** Domestic Refrigeration **Gas** HFC-32 (CH2F2)

Intro Year 2000 **Lifetime (d) [yr]** 15 **n(rec,d) [%]** 80 **Stockpile** 157

	Equation 7.9																		Information for UNFCCC CRT	
	Year	Domestically Manufactured HFC 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 (kg)	Contained in factory-charged Exported new-equipment in year t (kg)	Domestic Sales of new chemical in year t (kg)	To / from stockpile (kg)	Used in year t to fill new equipment not factory-charged (kg)	Used in year t to fill new equipment factory-charged (kg)	Total Charge in new-equipment in year t (kg)	Used in year t-d to fill new equipment not factory-charged (kg)	Used in year t-d to fill new equipment factory-charged (kg)	Original Total Charge in year t-d of Equipment Retiring in year t (kg)	Recovered and recycled/reclaimed from equipment retired in year t (kg)		Destroyed in year t (kg)	Exported in used equipment in year t (kg)	Total emissions in year t (kg)	Total emissions in year t (Gg)	Bank (kg)	
	t	B	C	D	E	F	G = B + C - D + E - F	S	H	I	J = H + I	K = H(t-d)	L = I(t-d)	M = K + L		N = M * (η (rec,d)/100) or specified	O	P	Q = (G - S) - J + M - N - O - P	R = Q / 1000000	X = ∑(J(t-d+1,t)) - Mt	
	2000	1000			100		1100	25	1000		1000	0	0	0	Calcul...	0		25	50	0.00005	1000	
	2001	1100			100		1200	22	1000		1000	0	0	0	Calcul...	0		25	153	0.00015	2000	
	2002	1211			100		1311	0	1000		1000	0	0	0	Calcul...	0		30	281	0.00028	3000	
	2003	2000			100		2100	0	1000		1000	0	0	0	Calcul...	0		30	1070	0.00107	4000	
	2004	3000			100		3100	0	1000		1000	0	0	0	Calcul...	0		40	2060	0.00206	5000	
	2005	1000			100		1100	0	1000		1000	0	0	0	Calcul...	0			100	0.0001	6000	
	2006	2000			100		2100	0	1000		1000	0	0	0	Calcul...	0		24	1076	0.00108	7000	
	2007	1600			100		1700	0	1000		1000	0	0	0	Calcul...	0		56	644	0.00064	8000	
	2008	2000			100		2100	0	1000		1000	0	0	0	Calcul...	0		35	1065	0.00107	9000	
	2009	4000			100		4100	0	1000		1000	0	0	0	Calcul...	0		30	3070	0.00307	10000	
	2010	1000			100		1100	0	1000		1000	0	0	0	Calcul...	0			100	0.0001	11000	
	2011	1500			100		1600	100	1000		1000	0	0	0	Calcul...	0			500	0.0005	12000	
	2012	2000			100		2100	10	1000		1000	0	0	0	Calcul...	0		100	990	0.00099	13000	
	2013	1000			100		1100	0	1000		1000	0	0	0	Calcul...	0			100	0.0001	14000	
	2014	900	90		100		1090	0	1000		1000	0	0	0	Calcul...	0			90	0.00009	15000	
▶	2015	1000	100		100		1200	0	1200		1200	1000	0	1000	Calcul...	800	100		100	0.0001	14200	
	2016	1000	100		1000		2100	0	1200		1200	1000	0	1000	Calcul...	800	25		1075	0.00108	14400	
	2017	1590	25		900		2515	0	1200		1200	1000	0	1000	Calcul...	800	100		1415	0.00142	14600	
	2018	2000	1000		800		3800	0	1200		1200	1000	0	1000	Calcul...	800	200		2600	0.0026	14800	
	2019	233	25		900		1158	0	1200		1200	1000	0	1000	Calcul...	800			158	0.00016	15000	
	2020	1000	25		1000		2025	0	1200		1200	1000	0	1000	Calcul...	800			1025	0.00103	15200	
	2021						0				0	1000	0	1000	Calcul...	800			200	0.0002	14200	
	2022						0				0	1000	0	1000	Calcul...	800			200	0.0002	13200	

Uncertainties

✓ *Now let's do exercise with dummy data*

Exercise: Add gases for Tier 2 method

Scenario: The user has already populated the IPCC **category level** F-gases Manager for the Tier 1 exercise. As the Manager is for category level, these F-gases/blends also appear for Tier 2.

However, assume that the user realizes that for the part of the country applying the Tier 2 method, C_2F_6 is also imported for industrial refrigeration.

Exercise #2a: Modify the IPCC category level F-gases Manager to include C_2F_6 emissions for category 2.F.1.

F-gases Consumed	Electronics	Refrigeration and Air Conditioning	Fire protection	Aerosols	Soundproof windows
HFCs					
HFC-23	X	X			
HFC-32		X			
HFC-125		X			
HFC-134a		X		X	
HFC-143a		X			
HFC-152a		X			
HFC-227ea			X	X	
PFCs					
CF4	X				
C2F6	X	X (added)			
c-C4F8	X				
SF6	X				X
NF3	X				
Blends					
R410A		X			

Exercise: Set Subdivision and sub-applications for Tier 2

The user has added all possible F-gases for Tier 2. Now it is time to create subdivisions in the country and identify the applications for calculating emissions

Exercise 2b:

Add two subdivisions for the country:

- ✓ "Capital city" and "Rest of country"
- ✓ For "Capital City" set the *Software* so that the following sub-applications exist:
  - ✓ Domestic Refrigeration
  - ✓ Medium & Large Commercial Refrigeration
  - ✓ Transport Refrigeration
  - ✓ Industrial Refrigeration including Food Processing and Cold Storage
  - ✓ Residential and Commercial A/C, including Heat Pumps
- ✓ No further modification for subdivision "Rest of country" needed for this exercise.

Note for Interoperability

Sub-application per IPCC	Mapping to CRT
Domestic Refrigeration	Maps to domestic refrigeration in CRT
Medium & Large Commercial Refrigeration	Maps to commercial refrigeration in CRT
Standalone commercial applications	
Chillers	
Industrial Refrigeration, incl. food processing and cold storage	Maps to industrial refrigeration in CRT
Transport Refrigeration	Maps to transport refrigeration in CRT
Residential and commercial A/C, incl heat pumps	Maps to stationary air conditioning in CRT
User defined sub-applications	

Exercise: Set EFs and parameters

This exercise will focus on adding EFs and parameters for one gas, in one sub-application, in one subdivision.

Exercise 2c:

In subdivision= Capital City

In sub-application= Domestic Refrigeration

Enter relevant information for gas = HFC-134a (not confidential)

Indicate use of the Tier 2a method

HINTs:

- ✓ Information added in worksheet **F-gas Parameters – Tier 2**
- ✓ Default data – See how data fall in ranges of Table 7.9 of the 2006 IPCC Guidelines and the EF for container management from equation 7.11.

Table 1

Sub-division:	Capital City	
Sub-application =	Domestic Refrigeration	
Gas=	HFC-134a	
Tier 2a parameters	**Parameter name**	**Data**
Year of introduction	t(stsart)	2000
EF for containers	EFc	2
EF for filling	EFk	0.5
EF for equipment operation	EFx	0.25
Lifetime	d	12
Share of initial charge remaining at end of life	ρ	80
Recovery efficiency	η (rec,d)	35

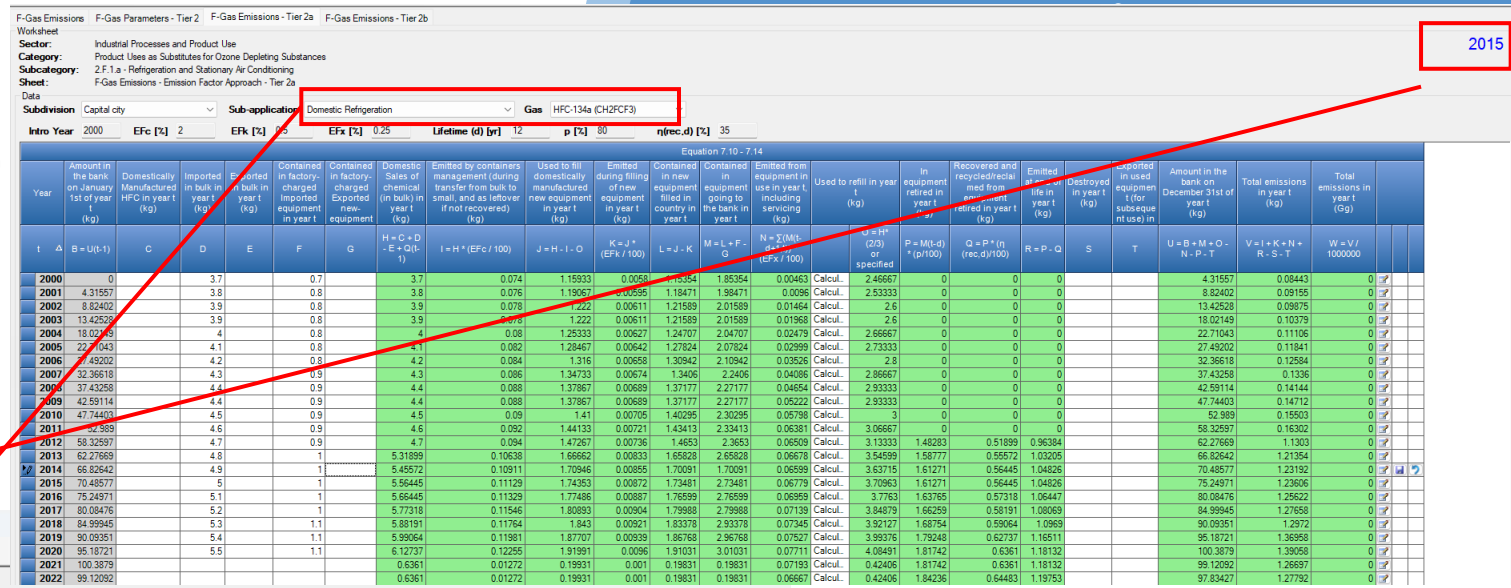
2.F.1: Enter AD and Estimate Emissions

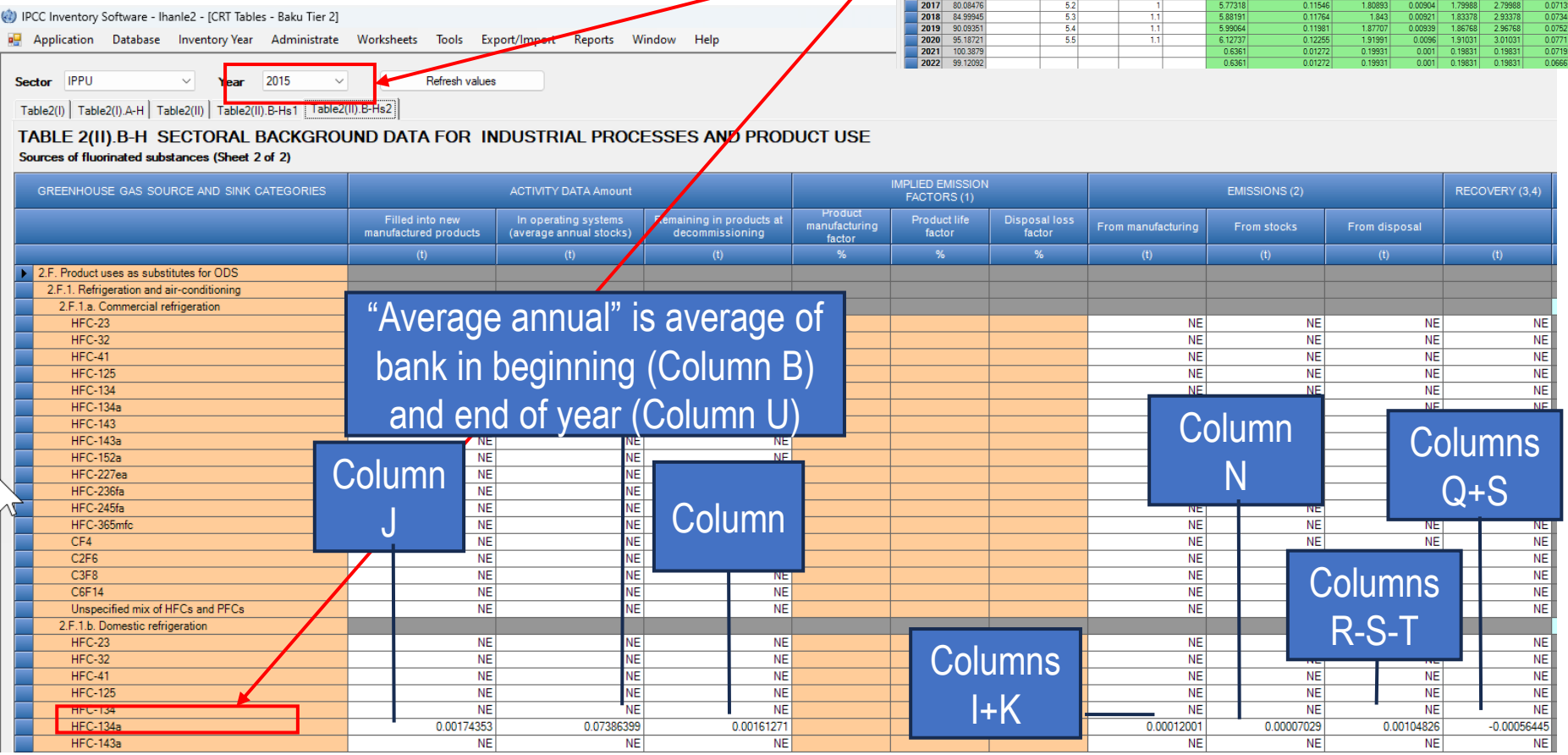
Exercise 2d:

- Estimate emissions of HFC-134a, following Tier 2a method, for subdivision = capital city, sub-application = Domestic Refrigeration
- All consumption from imports (bulk and in equipment) ; no production or export.
- Assume input data were known for 2015 and 2022 (see table).
  - Note: The user did not want to use Tier 1 and decided to extrapolate existing AD to full time series, noting that there was a 2% change in AD between 2015 and 2022, the user extrapolated back the 2% to the year of introduction of the gas.
- No country-specific information on the amount of gas used to refill equipment versus for new equipment, so calculate with default.
- No data on destruction for each year.
- No export of gas in used equipment.

	Imports in bulk (kg)	Contained in factory-charged imported equipment (kg)
2000	3.7	0.7
2001	3.8	0.8
2002	3.9	0.8
2003	3.9	0.8
2004	4.0	0.8
2005	4.1	0.8
2006	4.2	0.8
2007	4.3	0.9
2008	4.4	0.9
2009	4.4	0.9
2010	4.5	0.9
2011	4.6	0.9
2012	4.7	0.9
2013	4.8	1.0
2014	4.9	1.0
2015	5.0	1.0
2016	5.1	1.0
2017	5.2	1.0
2018	5.3	1.1
2019	5.4	1.1
2020	5.5	1.1
2021	5.6	1.1
2022	5.7	1.1

2.F.1: Preview
Interoperability with UNFCCC ETF Reporting Tool for Tier 2a





GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA Amount			IMPLIED EMISSION FACTORS (1)			EMISSIONS (2)			RECOVERY (3,4)
	Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	From manufacturing	From stocks	From disposal	
	(t)	(t)	(t)	%	%	%	(t)	(t)	(t)	(t)
2.F. Product uses as substitutes for ODS										
2.F.1. Refrigeration and air-conditioning										
2.F.1.a. Commercial refrigeration										
HFC-23							NE	NE	NE	NE
HFC-32							NE	NE	NE	NE
HFC-41							NE	NE	NE	NE
HFC-125							NE	NE	NE	NE
HFC-134							NE	NE	NE	NE
HFC-134a										
HFC-143										
HFC-143a	NE		NE							
HFC-152a	NE		NE							
HFC-227ea	NE		NE							
HFC-236fa	NE		NE							
HFC-245fa	NE		NE				NE	NE		
HFC-365mfc	NE		NE				NE	NE	NE	NE
CF4	NE		NE				NE	NE	NE	NE
C2F6	NE		NE				NE			NE
C3F8	NE		NE				NE			NE
C6F14	NE		NE				NE			NE
Unspecified mix of HFCs and PFCs	NE		NE				NE			NE
2.F.1.b. Domestic refrigeration										
HFC-23	NE	NE	NE				NE			NE
HFC-32	NE	NE	NE				NE			NE
HFC-41	NE	NE	NE				NE	NE	NE	NE
HFC-125	NE	NE	NE				NE	NE	NE	NE
HFC-134	NE	NE	NE				NE	NE	NE	NE
HFC-134a	0.00174353	0.07386399	0.00161271				0.00012001	0.00007029	0.00104826	-0.00056445
HFC-143a	NE	NE	NE				NE	NE	NE	NE

"Average annual" is average of bank in beginning (Column B) and end of year (Column U)

Column J

Column

Column N

Columns Q+S

Columns R-S-T

Columns I+K

Note for interoperability:

Tier 2 maps to relevant gas and sub-application.

Software values divided by 1,000 to convert to tonnes.

IEFs will calculate in UNFCCC tool.

Emissions are "net" of recovery/ destruction/oxidation/etc.

THANK YOU

FOR YOUR ATTENTION

STAY IN TOUCH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✓ Check

Results of Exercises

Results of Data Input

Cement Production (2.A.1)

2.A.1 Cement Production

Tier 1

Results (1/2) and (2/2) - 2015

IPCC Inventory Software - TSU - [Worksheets]

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 2.A.1 - Cement production
- 2.A.2 - Lime production
- 2.A.3 - Glass Production
- 2.A.4 - Other Process Uses
  - 2.A.4.a - Ceramics
  - 2.A.4.b - Other Uses of
  - 2.A.4.c - Non Metallurgic
  - 2.A.4.d - Other (please s
- 2.A.5 - Other (please specify
- 2.B - Chemical Industry
  - 2.B.1 - Ammonia Production
  - 2.B.2 - Nitric Acid Productio
  - 2.B.3 - Adipic Acid Productio
  - 2.B.4 - Caprolactam, Glyoxa
  - 2.B.5 - Carbide Production
  - 2.B.6 - Titanium Dioxide Pro
  - 2.B.7 - Soda Ash Production
  - 2.B.8 - Petrochemical and C
    - 2.B.8.a - Methanol

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction

Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

2015

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

Data

Equation 2.1

Subdivision	Individual Type of Cement Produced	Mass of Individual Type of Cement Produced (tonne)	Clinker Fraction in Cement (Fraction)	Mass of Clinker in the Individual Type of Cement Produced (tonne)
		A	B	C=A*B
Company A	Product Mix - 30/70	2534000	0.817	2070278
Company B	Masonry	1204000	0.75	903000
Total				
		3738000		2973278

IPCC Inventory Software - TSU - [Worksheets]

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 2.A.1 - Cement production
- 2.A.2 - Lime production
- 2.A.3 - Glass Production
- 2.A.4 - Other Process Uses
  - 2.A.4.a - Ceramics
  - 2.A.4.b - Other Uses of
  - 2.A.4.c - Non Metallurgic
  - 2.A.4.d - Other (please s
- 2.A.5 - Other (please specify
- 2.B - Chemical Industry
  - 2.B.1 - Ammonia Production
  - 2.B.2 - Nitric Acid Productio
  - 2.B.3 - Adipic Acid Productio
  - 2.B.4 - Caprolactam, Glyoxa
  - 2.B.5 - Carbide Production
  - 2.B.6 - Titanium Dioxide Pro
  - 2.B.7 - Soda Ash Production
  - 2.B.8 - Petrochemical and C

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction

Cement Production (1/2) | **Cement Production (2/2)** | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

2015

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

Data

Equation 2.1

Subdivision	Mass of Clinker for Subdivision (tonne)	Imports for Consumption of Clinker (tonne)	Export of Clinker (tonne)	Emission Factor for the Clinker (tonnes CO2/tonne Clinker)		CKD correction	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	A	B	C		D	E	F = (A - B + C) * D * E	G = F / 1000
Company A	2070278	0	0	Specified	0.51	1.02	1076958.6156	1076.95862
Company B	903000	0	45000	Specified	0.51	1.02	493149.6	493.1496
Total								
	2973278						1570108.2156	1570.10822

Results (1/2) and (2/2) - 2022

IPCC INTERGOVERNMENTAL PANEL ON climate change

WMO UN environment programme

IPCC Inventory Software - IPCC - [Worksheets]

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 1.C.2 - Injection and Storage
  - 1.C.2.a - Injection
  - 1.C.2.b - Storage
- 1.C.3 - Other
- 2 - Industrial Processes and Product
  - 2.A - Mineral Industry
    - 2.A.1 - Cement production
    - 2.A.2 - Lime production
    - 2.A.3 - Glass Production
    - 2.A.4 - Other Process Uses of
      - 2.A.4.a - Ceramics
      - 2.A.4.b - Other Uses of S
      - 2.A.4.c - Non Metallurgica
      - 2.A.4.d - Other (please sp
    - 2.A.5 - Other (please specify)
  - 2.B - Chemical Industry
    - 2.B.1 - Ammonia Production
    - 2.B.2 - Nitric Acid Production
    - 2.B.3 - Adipic Acid Production
    - 2.B.4 - Caprolactam, Glyoxal

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction

Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

2022

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

Data

Equation 2.1

Subdivision	Individual Type of Cement Produced	Mass of Individual Type of Cement Produced (tonne)	Clinker Fraction in Cement (Fraction)	Mass of Clinker in the Individual Type of Cement Produced (tonne)
		A	B	C=A*B
Company A	Product Mix - 30/70	3112000	0.817	2542504
Company B	Masonry	4205000	0.75	3153750
Total				
		7317000		5696254

IPCC Inventory Software - IPCC - [Worksheets]

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 1.C.2 - Injection and Storage
  - 1.C.2.a - Injection
  - 1.C.2.b - Storage
- 1.C.3 - Other
- 2 - Industrial Processes and Product
  - 2.A - Mineral Industry
    - 2.A.1 - Cement production
    - 2.A.2 - Lime production
    - 2.A.3 - Glass Production
    - 2.A.4 - Other Process Uses of
      - 2.A.4.a - Ceramics
      - 2.A.4.b - Other Uses of S
      - 2.A.4.c - Non Metallurgica
      - 2.A.4.d - Other (please sp
    - 2.A.5 - Other (please specify)
  - 2.B - Chemical Industry
    - 2.B.1 - Ammonia Production
    - 2.B.2 - Nitric Acid Production

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction

Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

2022

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

Data

Equation 2.1

Subdivision	Mass of Clinker for Subdivision (tonne)	Imports for Consumption of Clinker (tonne)	Export of Clinker (tonne)	Emission Factor for the Clinker (tonnes CO2/tonne Clinker)		CKD correction	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
	A	B	C		D	E	F = (A - B + C) * D * E	G = F / 1000
Company A	2542504	0	0	Specified	0.51	1.02	1322610.5808	1322.61058
Company B	3153750	0	67000	Specified	0.51	1.02	1675434.15	1675.43415
Total								
	5696254						2998044.7308	2998.04473

2.A.1 Cement Production

Tier 2

2.A.1 Tier 2 – Results – 2015

IPCC Inventory Software - TSU - [Worksheets]

Application | Database | Inventory Year | Administrate | Worksheets | Tools | Export/Import | Reports | Window | Help

2006 IPCC Categories

- 2.A.1 - Cement production
- 2.A.2 - Lime production
- 2.A.3 - Glass Production
- 2.A.4 - Other Process Uses
  - 2.A.4.a - Ceramics
  - 2.A.4.b - Other Uses of
  - 2.A.4.c - Non Metallurgic
  - 2.A.4.d - Other (please s
- 2.A.5 - Other (please specify
- 2.B - Chemical Industry
  - 2.B.1 - Ammonia Production
  - 2.B.2 - Nitric Acid Productio
  - 2.B.3 - Adipic Acid Productio
  - 2.B.4 - Caprolactam, Glyoxa
  - 2.B.5 - Carbide Production
  - 2.B.6 - Titanium Dioxide Pro
  - 2.B.7 - Soda Ash Production
  - 2.B.8 - Petrochemical and C
    - 2.B.8.a - Methanol

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction

Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

Worksheet

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

2015

Data

Equation 2.2

Subdivision	Name of plant or type of clinker	Clinker production (tonnes)	Emission Factor (tonnes CO2/tonne Clinker)		Correction Factor for Cement Kiln Dust (CF ckd) (dimensionless)	CO2 Emissions (Gg CO2)
		A		B	C	D = A*B*C/10^3
National	CementCarbo	534000	Calculated	0.51044	1.10523	301.25769
Total						
		534000				301.25769

Emission Factor

Equation 2.4

Percentage CaO Content of Clinker (CaO) (%)	Percentage Non-carbonate sources of CaO	Percentage CaO content of clinker from carbonate sources (%)	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)	Percent MgO derived from carbonate (optional) (%)	Emission Factor (tonnes CO2 / tonne Clinker)
A	B	C = A - B	D	E = C / D	F	G = E * F	H	I = G + (H * 0.011)
65	0	65	56.03	1.16009	0.44	0.51044	0	0.51044

Cancel | Save

IPCC Inventory Software

Correction Factor for Cement Kiln Dust, CF ckd

Weight of CKD not recycled to the kiln (tonnes), Md	65,230.00000
Weight of clinker produced (tonnes), Mcl	534,000.00000
Fraction of original carbonate in the CKD (i.e., before calcination) (fraction), Cd	1.00000
Fraction calcination of the original carbonate in the CKD (fraction), Fd	1.00000
Emission factor for the carbonate (tonnes CO2/ tonne carbonate), EFc	0.43971
Emission factor for clinker uncorrected for CKD (tonnes CO2/tonne clinker), EFcl	0.51044
CF ckd	1.10523

Copy last | Apply to worksheet cell | Cancel

2.A.1 Tier 2 – Results – 2022

IPCC Inventory Software - IPCC - [Worksheets]

Application | Database | Inventory Year | Administrate | Worksheets | Tools | Export/Import | Reports | Window | Help

2006 IPCC Categories

- 1.C.2 - Injection and Storage
  - 1.C.2.a - Injection
  - 1.C.2.b - Storage
- 1.C.3 - Other
- 2 - Industrial Processes and Product
  - 2.A - Mineral Industry
    - 2.A.1 - Cement production
    - 2.A.2 - Lime production
    - 2.A.3 - Glass Production
    - 2.A.4 - Other Process Uses of
      - 2.A.4.a - Ceramics
      - 2.A.4.b - Other Uses of S
      - 2.A.4.c - Non Metallurgica
      - 2.A.4.d - Other (please sp
    - 2.A.5 - Other (please specify)
  - 2.B - Chemical Industry
    - 2.B.1 - Ammonia Production
    - 2.B.2 - Nitric Acid Production
    - 2.B.3 - Adipic Acid Production

CO2 Emissions from carbon-bearing non-fuel materials - Tier 3 (3/4) | CO2 Emissions summary - Tier 3 (4/4) | Capture and storage or other reduction

Cement Production (1/2) | Cement Production (2/2) | Clinker production - Tier 2 | CO2 Emissions from carbonates - Tier 3 (1/4) | CO2 Emissions from uncalcined CKD not recycled to the kiln - Tier 3 (2/4)

Worksheet

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

2022

Data

Equation 2.2

Subdivision	Name of plant or type of clinker	Clinker production (tonnes)	Emission Factor (tonnes CO2/tonne Clinker)		Correction Factor for Cement Kiln Dust (CF ckd) (dimensionless)	CO2 Emissions (Gg CO2)
		A		B	C	D = A*B*C/10^3
National	CementCarbo	612000	Calculated	0.51044	1.10548	345.34166
Total		612000				345.34166

Emission Factor

Equation 2.4

Percentage CaO Content of Clinker (CaO) (%)	Percentage Non-carbonate sources of CaO	Percentage CaO content of clinker from carbonate sources (%)	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)	Percent MgO derived from carbonate (optional) (%)	Emission Factor (tonnes CO2 / tonne Clinker)
A	B	C = A - B	D	E = C / D	F	G = E * F	H	I = G + (H * 0.011)
65	0	65	56.03	1.16009	0.44	0.51044	0	0.51044

Cancel | Save

IPCC Inventory Software

Correction Factor for Cement Kiln Dust, CF ckd

Weight of CKD not recycled to the kiln (tonnes), Md	74,940.00000
Weight of clinker produced (tonnes), Mcl	612,000.00000
Fraction of original carbonate in the CKD (i.e., before calcination) (fraction), Cd	1.00000
Fraction calcination of the original carbonate in the CKD (fraction), Fd	1.00000
Emission factor for the carbonate (tonnes CO2/ tonne carbonate), EFc	0.43971
Emission factor for clinker uncorrected for CKD (tonnes CO2/tonne clinker), EFcl	0.51044
CF ckd	1.10548

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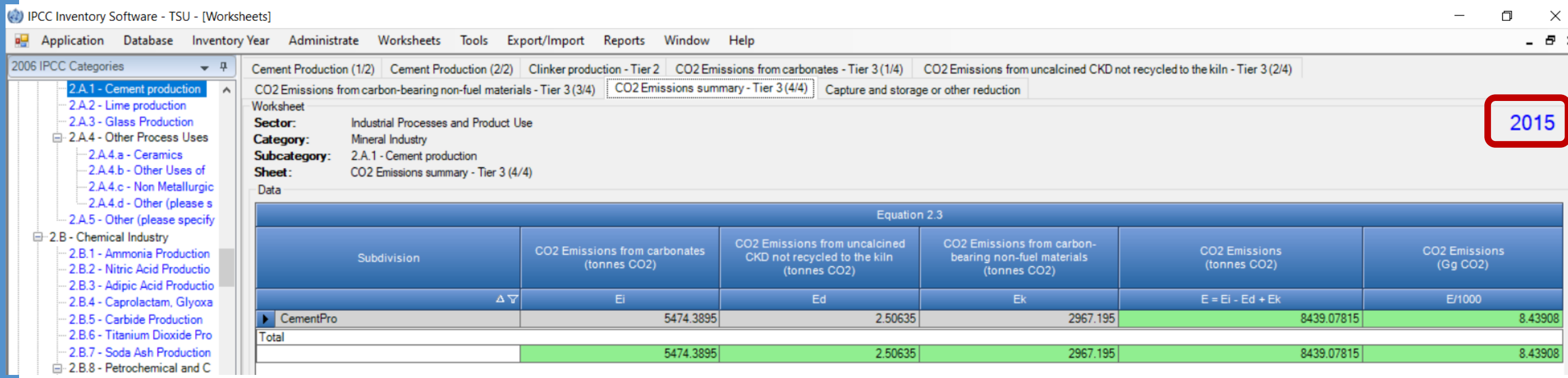
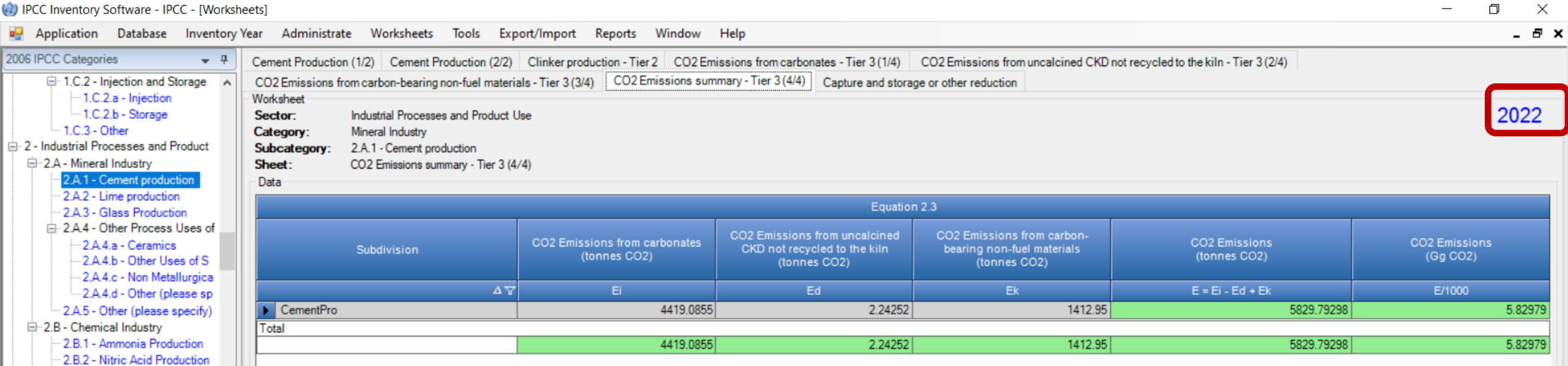
2.A.1 Cement Production

Tier 3

2.A.1 Tier 3 – Results

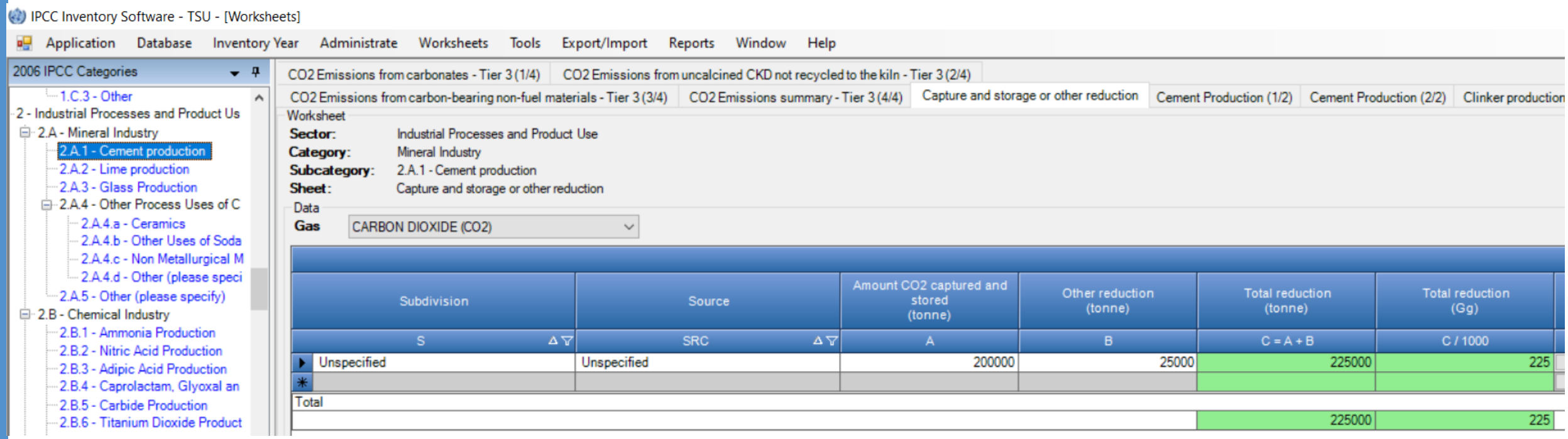




2.A.1 Cement Production

CO_2 Capture

2.A.1 Cement Production



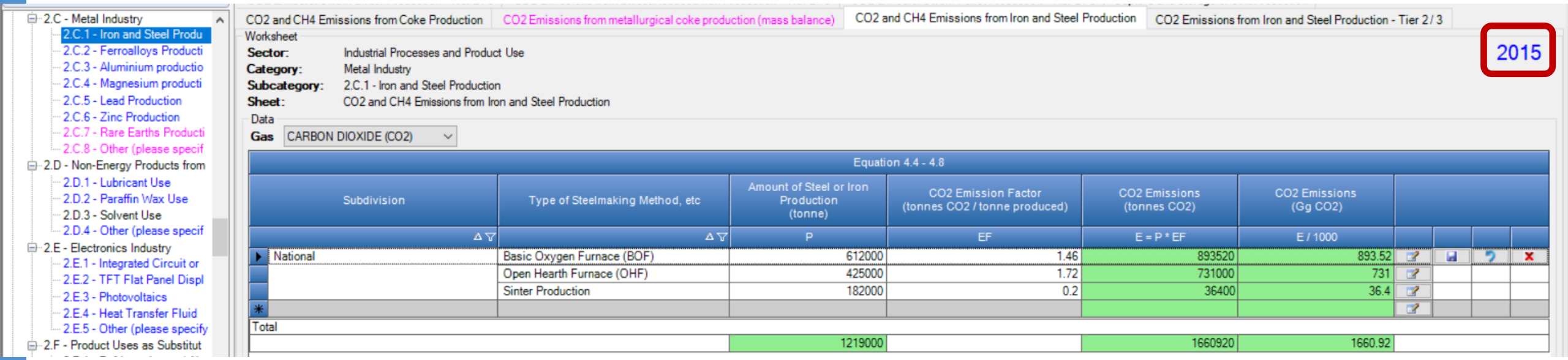
Results of Data Input

Iron and Steel (2.C.1)

2.C.1 Iron and Steel Production

Tier 1

Results – 2015 and 2022



- 2.C - Metal Industry
  - 2.C.1 - Iron and Steel Produ
  - 2.C.2 - Ferroalloys Producti
  - 2.C.3 - Aluminium productio
  - 2.C.4 - Magnesium producti
  - 2.C.5 - Lead Production
  - 2.C.6 - Zinc Production
  - 2.C.7 - Rare Earths Producti
  - 2.C.8 - Other (please specif
- 2.D - Non-Energy Products from
  - 2.D.1 - Lubricant Use
  - 2.D.2 - Paraffin Wax Use
  - 2.D.3 - Solvent Use
  - 2.D.4 - Other (please specif
- 2.E - Electronics Industry
  - 2.E.1 - Integrated Circuit or
  - 2.E.2 - TFT Flat Panel Displ
  - 2.E.3 - Photovoltaics
  - 2.E.4 - Heat Transfer Fluid
  - 2.E.5 - Other (please specify
- 2.F - Product Uses as Substitut

CO2 and CH4 Emissions from Coke Production | CO2 Emissions from metallurgical coke production (mass balance) | CO2 and CH4 Emissions from Iron and Steel Production | CO2 Emissions from Iron and Steel Production - Tier 2 / 3

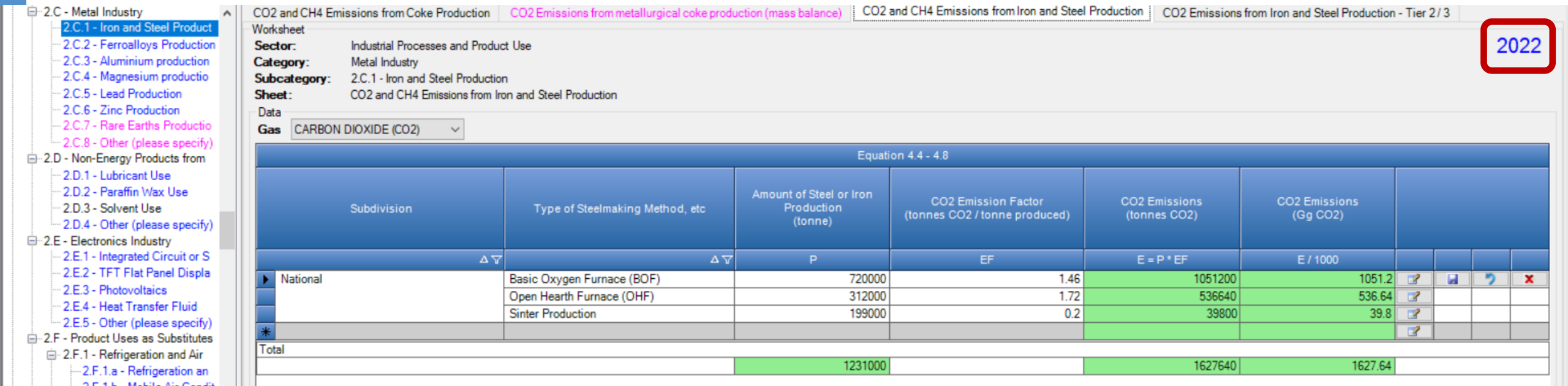
Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 and CH4 Emissions from Iron and Steel Production

2015

Data
Gas CARBON DIOXIDE (CO2)

Equation 4.4 - 4.8

Subdivision	Type of Steelmaking Method, etc	Amount of Steel or Iron Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		P	EF	E = P * EF	E / 1000
National	Basic Oxygen Furnace (BOF)	612000	1.46	893520	893.52
	Open Hearth Furnace (OHF)	425000	1.72	731000	731
	Sinter Production	182000	0.2	36400	36.4
Total		1219000		1660920	1660.92



- 2.C - Metal Industry
  - 2.C.1 - Iron and Steel Product
  - 2.C.2 - Ferroalloys Production
  - 2.C.3 - Aluminium production
  - 2.C.4 - Magnesium productio
  - 2.C.5 - Lead Production
  - 2.C.6 - Zinc Production
  - 2.C.7 - Rare Earths Productio
  - 2.C.8 - Other (please specify)
- 2.D - Non-Energy Products from
  - 2.D.1 - Lubricant Use
  - 2.D.2 - Paraffin Wax Use
  - 2.D.3 - Solvent Use
  - 2.D.4 - Other (please specify)
- 2.E - Electronics Industry
  - 2.E.1 - Integrated Circuit or S
  - 2.E.2 - TFT Flat Panel Displa
  - 2.E.3 - Photovoltaics
  - 2.E.4 - Heat Transfer Fluid
  - 2.E.5 - Other (please specify)
- 2.F - Product Uses as Substitutes
  - 2.F.1 - Refrigeration and Air
    - 2.F.1.a - Refrigeration an

CO2 and CH4 Emissions from Coke Production | CO2 Emissions from metallurgical coke production (mass balance) | CO2 and CH4 Emissions from Iron and Steel Production | CO2 Emissions from Iron and Steel Production - Tier 2 / 3

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 and CH4 Emissions from Iron and Steel Production

2022

Data
Gas CARBON DIOXIDE (CO2)

Equation 4.4 - 4.8

Subdivision	Type of Steelmaking Method, etc	Amount of Steel or Iron Production (tonne)	CO2 Emission Factor (tonnes CO2 / tonne produced)	CO2 Emissions (tonnes CO2)	CO2 Emissions (Gg CO2)
		P	EF	E = P * EF	E / 1000
National	Basic Oxygen Furnace (BOF)	720000	1.46	1051200	1051.2
	Open Hearth Furnace (OHF)	312000	1.72	536640	536.64
	Sinter Production	199000	0.2	39800	39.8
Total		1231000		1627640	1627.64

2.C.1 Iron and Steel Production

Tier 2/3

Results – 2015

Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 Emissions from Iron and Steel Production - Tier 2 / 3

Data

Subdivision	Quantity of coke / biochar consumed in iron and steel production (not including sinter production)	Carbon Content of coke / biochar (tonnes C / tonne PC)	Biochar instead of coke	Total Carbon in on-site coke oven by-products consumed in blast furnace (tonnes C)		Quantity of coal / biochar directly injected into blast furnace (tonnes)	Carbon Content of coal / biochar directly injected into blast furnace (tonnes C / tonne Coal)	Biochar instead of coal	Quantity of limestone consumed in iron and steel production (tonnes)	Carbon Content of limestone (tonnes C / tonne Limestone)	Quantity of dolomite consumed in iron and steel production (tonnes)	Carbon Content of dolomite (tonnes C / tonne Dolomite)
	PC	Cpc		BPC		CI	Cci		L	CI	D	Cd
Company ZZZ	360000	0.82344	☐			160000	0.67	☐	75000	0.12	1000	0.13
			■					■				

Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 Emissions from Iron and Steel Production - Tier 2 / 3

Data

Equation 4.9, 4.11

Quantity of electrodes consumed in EAFs (tonnes)	Carbon Content of electrode (tonnes C / tonne Electrode)	Total Carbon in other carbonaceous process materials consumed (tonnes C)		Quantity of coke oven gas consumed in blast furnace in iron and steel production (Unit)	Consumption Unit (Mass, Volume or Energy Unit)	Coke oven gas conversion factor (GJ / Unit)	Carbon Content of coke oven gas (tonnes C / GJ)		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)
CE	Cce	PM		COG	U	CFcog		Ccog	S	Cs	IP	Cip
0	0	1606		11000	tonne	38.7	Fuel Manager	0.0121	1020000	0.01	980000	0.04
								0.0121				

2015

Iron and Steel production - Consumption of other carbonaceous process materials

Material	Quantity of other carbonaceous process material consumed (tonnes)	Carbon Content of process material (tonnes C/tonne Material)	Biogenic	Total Carbon in other carbonaceous process materials consumed (tonnes C)	
	PM	CC		C = PM * CC	
Natural gas	2200	0.73	☐	1606	✕
			■		✕
Total					
	2200		Total carbon:	1606	
			Biogenic carbon:	0	
			Biogenic fraction:	0	

Cancel Save

Quantity of blast furnace gas transferred offsite (Unit)	Consumption Unit (Mass, Volume or Energy Unit)	Blast furnace gas conversion factor (GJ / Unit)	Carbon Content of blast furnace gas (tonnes C / GJ)		Annual non-Energy CO2 emissions (tonnes CO2)	Annual non-Energy CO2 emissions (Gg CO2)
BG	U	CFbg		Cbg	E = [PC * Cpc + BPC + CI * Cci + L * CI + D * Cd + CE * Cce + PM + COG * CFcog * Ccog - S * Cs - IP * Cip - BG * CFbg * Cbg] * 44/12	E / 1000
5500	GJ	1	Fuel Manager	0.0708	1355698.55667	1355.69856
				0.0708		

Results – 2022

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 Emissions from Iron and Steel Production - Tier 2 / 3

Data

Subdivision	Quantity of coke / biochar consumed in iron and steel production (not including sinter production) (tonnes)	Carbon Content of coke / biochar (tonnes C / tonne PC)	Biochar instead of coke	Total Carbon in on-site coke oven by-products consumed in blast furnace (tonnes C)		Quantity of coal / biochar directly injected into blast furnace (tonnes)	Carbon Content of coal / biochar directly injected into blast furnace (tonnes C / tonne Coal)	Biochar instead of coal	Quantity of limestone consumed in iron and steel production (tonnes)	Carbon Content of limestone (tonnes C / tonne Limestone)	Quantity of dolomite consumed in iron and steel production (tonnes)	Carbon Content of dolomite (tonnes C / tonne Dolomite)
	PC	Cpc		BPC		CI	Cci		L	CI	D	Cd
Company ZZZ	450000	0.82344	☐			200000	0.67	☐	94000	0.12	1250	0.13
			■									

Iron and Steel production - Consumption of other carbonaceous process materials

Material	Quantity of other carbonaceous process material consumed (tonnes)	Carbon Content of process material (tonnes C/tonne Material)	Biogenic	Total Carbon in other carbonaceous process materials consumed (tonnes C)	
	PM	CC		C = PM * CC	
Natural Gas	2750	0.73	☐	2007.5	✕
			■		✕
Total					
	2750		Total carbon:	2007.5	
			Biogenic carbon:	0	
			Biogenic fraction:	0	

Cancel Save

Worksheet
Sector: Industrial Processes and Product Use
Category: Metal Industry
Subcategory: 2.C.1 - Iron and Steel Production
Sheet: CO2 Emissions from Iron and Steel Production - Tier 2 / 3

Data

Equation 4.9, 4.11								
Quantity of electrodes consumed in EAFs (tonnes)	Carbon Content of electrode (tonnes C / tonne Electrode)	Total Carbon in other carbonaceous process materials consumed (tonnes C)		Quantity of coke oven gas consumed in blast furnace in iron and steel production (Unit)	Consumption Unit (Mass, Volume or Energy Unit)	Coke oven gas conversion factor (GJ / Unit)	Carbon Content of coke oven gas (tonnes C / GJ)	
CE	Cce	PM		COG	U	CFcog		Ccog
0	0	2007.5		13750	Tonne	38.7	Fuel Manager	0.0121
								0.0121

2022

Data

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)	Carbon Content of blast furnace gas (tonnes C / GJ)		Annual non-Energy CO2 emissions (tonnes CO2)	Annual non-Energy CO2 emissions (Gg CO2)
S	Cs	IP	Cip	BG	U	CFbg		Cbg	E = [PC * Cpc + BPC + CI * Cci + L * CI + D * Cd + CE * Cce + PM + COG * CFcog * Ccog - S * Cs - IP * Cip - BG * CFbg * Cbg] * 44/12	E / 1000
1275000	0.01	1225000	0.04	6875	GJ	1	Fuel Manager	0.0708	1694733.19583	1694.7332
								0.0708		

Results – *Biogenic* – 2022

With Biogenic

Subdivision	Quantity of coke / biochar consumed in iron and steel production (not including sinter production)	Carbon Content of coke / biochar (tonnes C / tonne PC)	Biochar instead of coke	Total Carbon in on-site coke oven by-products consumed in blast furnace (tonnes C)		Quantity of coal / biochar directly injected into blast furnace (tonnes)	Carbon Content of coal / biochar directly injected into blast furnace (tonnes C / tonne Coal)	Biochar instead of coal
	PC	Cpc		BPC		CI	Cci	
Company ZZZ	450000	0.82344	☑			200000	0.67	☑

ntent of blast furnace gas onnes C / GJ)	Annual non-Energy CO2 emissions (tonnes CO2)	Annual non-Energy CO2 emissions (Gg CO2)
Cbg	E = [PC * Cpc + BPC + CI * Cci + L * CI + D * Cd + CE * Cce + PM + COG * CFcog * Ccog - S * Cs - IP * Cip - BG * CFbg * Cbg] * 44/12	E / 1000
0.0708	1694733.19583	1694.7332
0.0708		
Including Biogenic CO2:	1694733.19583	1694.7332
Excluding Biogenic CO2:	64270.97969	64.27098

Biogenic CO_2 = 1694.73-64.27 = 1 630.46

Without Biogenic

Subdivision	Quantity of coke / biochar consumed in iron and steel production (not including sinter production) (tonnes)	Carbon Content of coke / biochar (tonnes C / tonne PC)	Biochar instead of coke	Total Carbon in on-site coke oven by-products consumed in blast furnace (tonnes C)		Quantity of coal / biochar directly injected into blast furnace (tonnes)	Carbon Content of coal / biochar directly injected into blast furnace (tonnes C / tonne Coal)	Biochar instead of coal
	PC	Cpc		BPC		CI	Cci	
Company ZZZ	450000	0.82344	☐			200000	0.6	☐

ntent of blast furnace gas (tonnes C / GJ)	Annual non-Energy CO2 emissions (tonnes CO2)	Annual non-Energy CO2 emissions (Gg CO2)
Cbg	E = [PC * Cpc + BPC + CI * Cci + L * CI + D * Cd + CE * Cce + PM + COG * CFcog * Ccog - S * Cs - IP * Cip - BG * CFbg * Cbg] * 44/12	E / 1000
0.0708	1694733.19583	1694.7332
0.0708		
Including Biogenic CO2:	1694733.19583	1694.7332
Excluding Biogenic CO2:	1694733.19583	1694.7332

✓ ***Assuming*** *biochar has the same carbon content as coal or coke,* ***which is not !!***

Reports: IPPU/Background - 2022

Biogenic CO_2 = 1694.73-64.27 = 1 630.46

IPCC Inventory Software - TSU - [IPPU Backgound Tables]

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

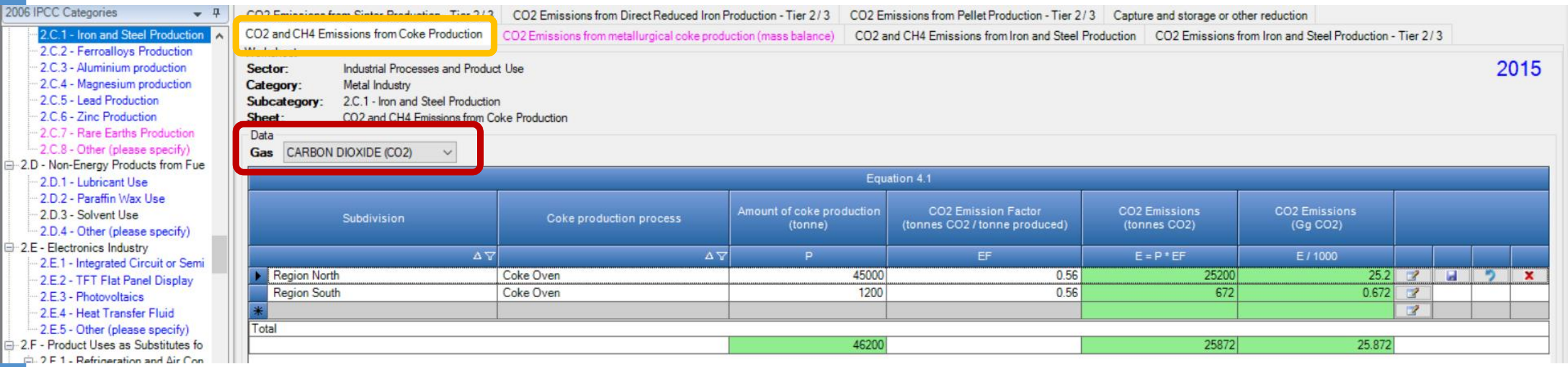
Table 2.3 IPPU Background Table: 2.C Metal Industry CO2, CH4 and N2O | Table 2.4 IPPU Background Table: 2.C Metal Industry HFCs, PFCs, SF6 and ot

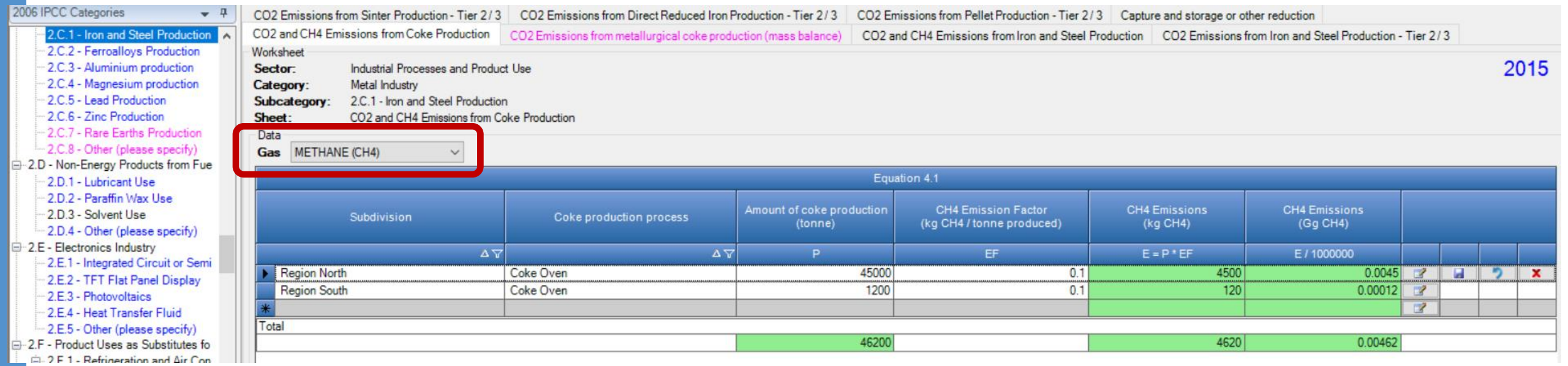
Categories	Activity Data				
	Production/Consumption Quantity				
	Description (1)	Quantity	Unit (2)	Emissions (3)	Information Item Biogenic CO2
2.C - Metal Industry				8347.914	4013.144
2.C.1 - Iron and Steel Production	Basic Oxygen Furnace...	1231000.000	t	2452.794	1630.462
2.C.2 - Ferroalloys Production	Ferrochromium; Ferro...	983500.000	t	4983.311	1838.333
2.C.3 - Aluminium production	Prebake; Soderberg;...	209500.000	t	136.555	
2.C.4 - Magnesium production	Dolomite; Magnesite;...	68250.000	t	122.320	
2.C.5 - Lead Production	From Direct Smelting (...	120500.000	t	57.405	329.908
2.C.6 - Zinc Production	Default Factor; Electro...	234500.000	t	380.810	214.440
2.C.7 - Rare Earths Production	Rare Earth Metal prod...	101567.000	t	162.239	
2.C.8 - Other (please specify)				52.480	

Coke Production – Tier 1

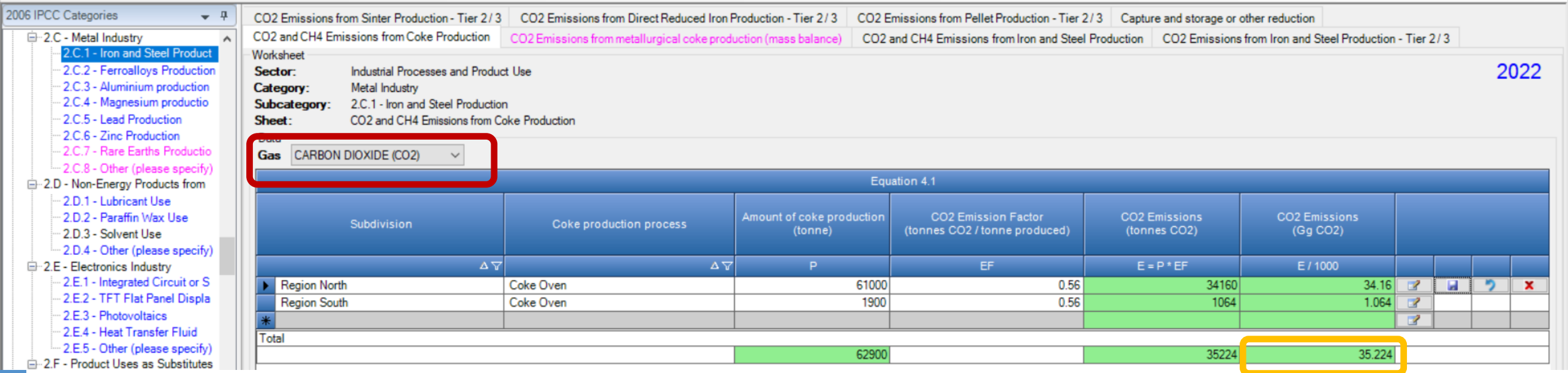
(to be reported in Energy – 1A1c)

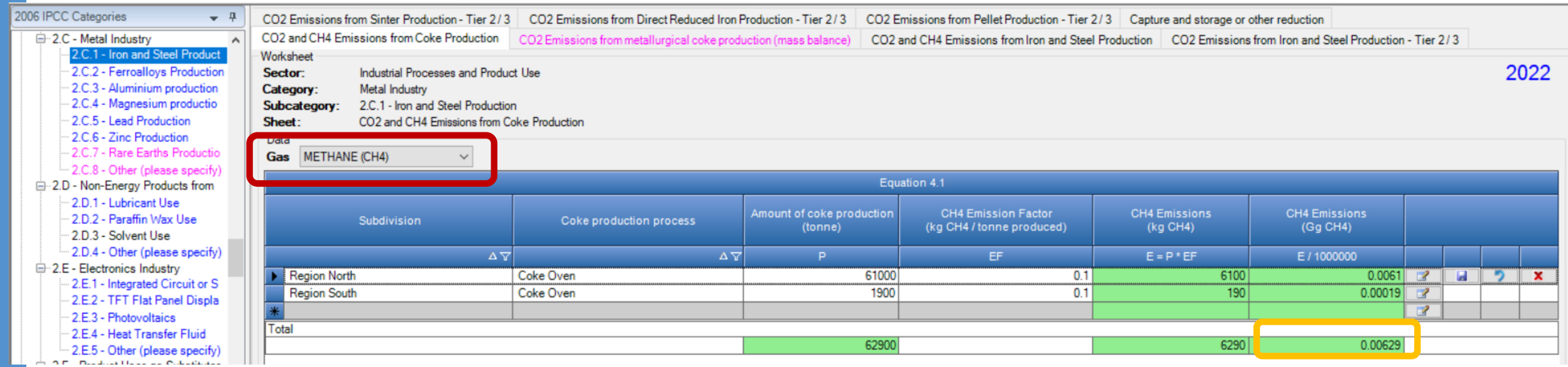
Results – CO_2 and CH_4 – 2015





Results – CO_2 and CH_4 – 2022





Reports: Energy/Background - 2022

IPCC Inventory Software - TSU - [Energy Background Tables]

Application | Database | Inventory Year | Administrate | Worksheets | Tools | Export/Import | Reports | Window | Help

Table 1.1 Energy Background Table: 1.A.1 - 1.A.2 | Table 1.2 Energy Background Table: 1.A.3 - 1.A.5 | Table 1.3 Energy Background Table: 1.B | Table 1.4b Energy Background Table: 1.C - Overview | Table 1.5 Energy Background Table: Reference Approach

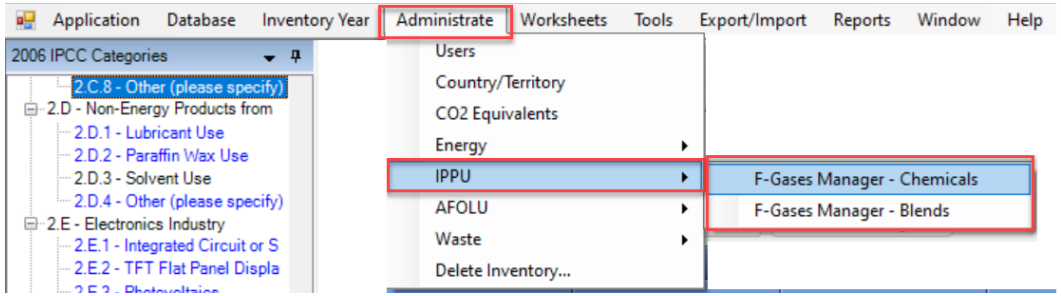
2006 IPCC Categories	Activity (TJ)						Emissions Solid Fuels (Gg)			Emissions Liquid Fuels (Gg)			Emissions Gaseous Fuels (Gg)			Emissions Other Fossil Fuels (Gg)			Emissions Peat (Gg) (1)			Emissions Biomass (Gg)		Emissions Total (Gg)		
	Solid Fuels	Liquid Fuels	Gaseous Fuels	Other Fossil Fuels	Peat	Biomass	CO2	CH4	N2O	CO2	CH4	N2O	CO2	CH4	N2O	CO2	CH4	N2O	CO2	CH4	N2O	CH4	N2O	CO2	CH4	N2O
1.A - Fuel Combustion Activities							35.224	0.006																35.224	0.006	
1.A.1 - Energy Industries							35.224	0.006																35.224	0.006	
1.A.1.a - Main Activity Electricity and Heat Production																										
1.A.1.a.i - Electricity Generation																										
1.A.1.a.ii - Combined Heat and Power Generation (CHP)																										
1.A.1.a.iii - Heat Plants																										
1.A.1.b - Petroleum Refining																										
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries							35.224	0.006																35.224	0.006	
1.A.1.c.i - Manufacture of Solid Fuels							35.224	0.006																35.224	0.006	
1.A.1.c.ii - Other Energy Industries																										
1.A.2 - Manufacturing Industries and Construction																										
1.A.2.a - Iron and Steel																										
1.A.2.b - Non-Ferrous Metals																										
1.A.2.c - Chemicals																										
1.A.2.d - Pulp, Paper and Print																										
1.A.2.e - Food Processing, Beverages and Tobacco																										
1.A.2.f - Non-Metallic Minerals																										

2.F.1 Refrigeration and Air Conditioning

F-gases Manager

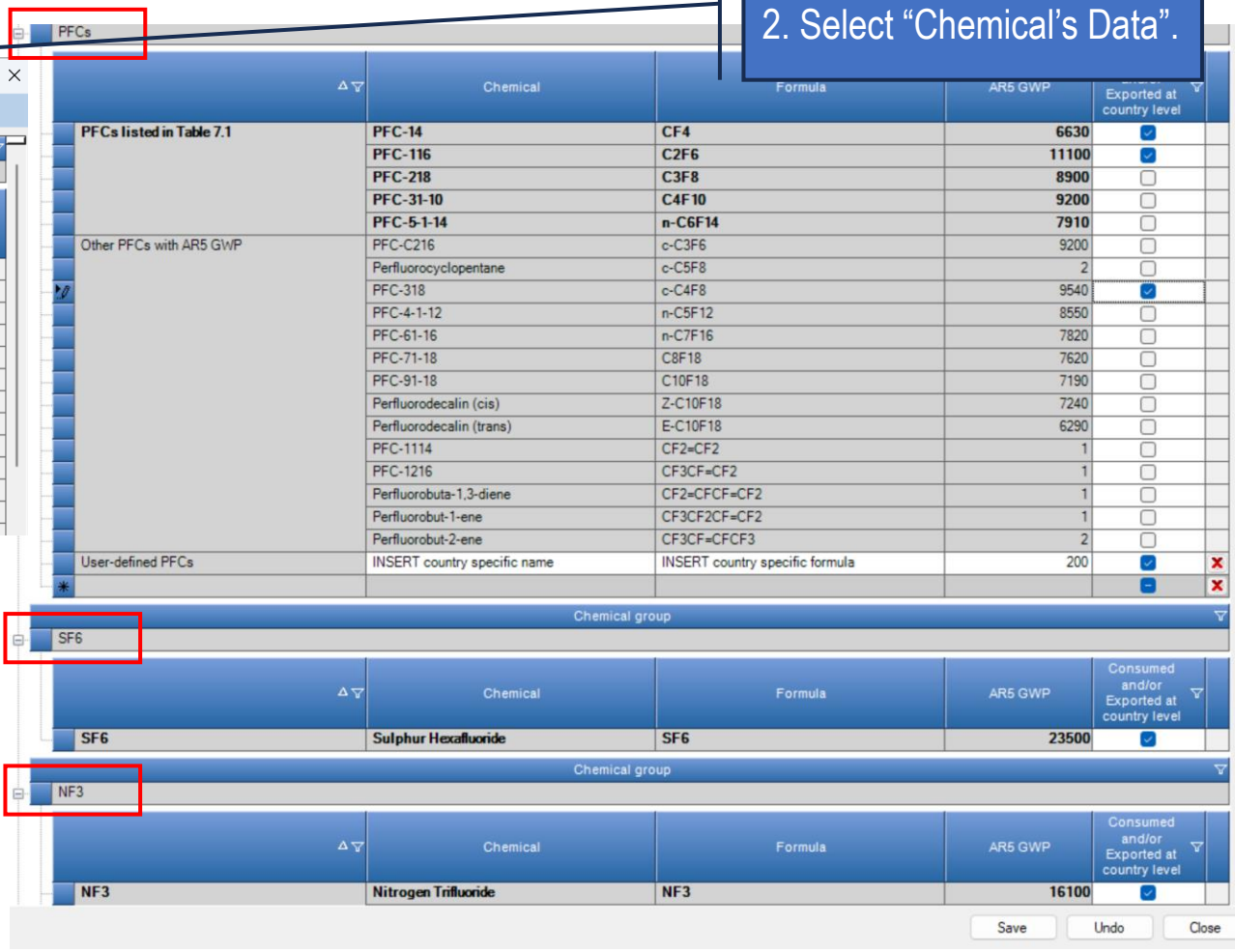
Answers: Customize F-gases Manager

1

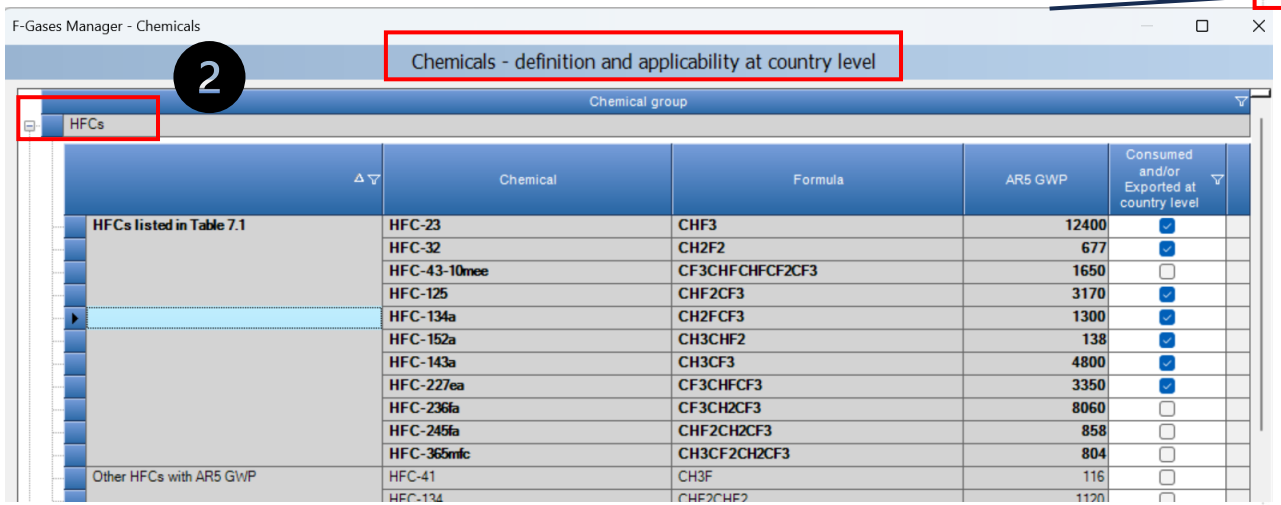


2. Select “Chemical’s Data”.

3



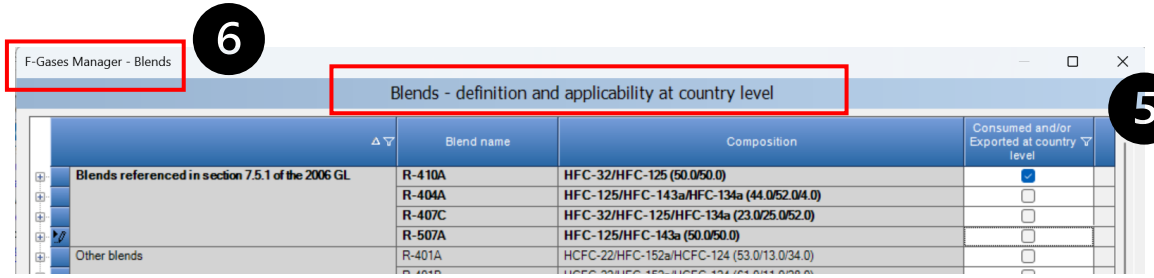
2



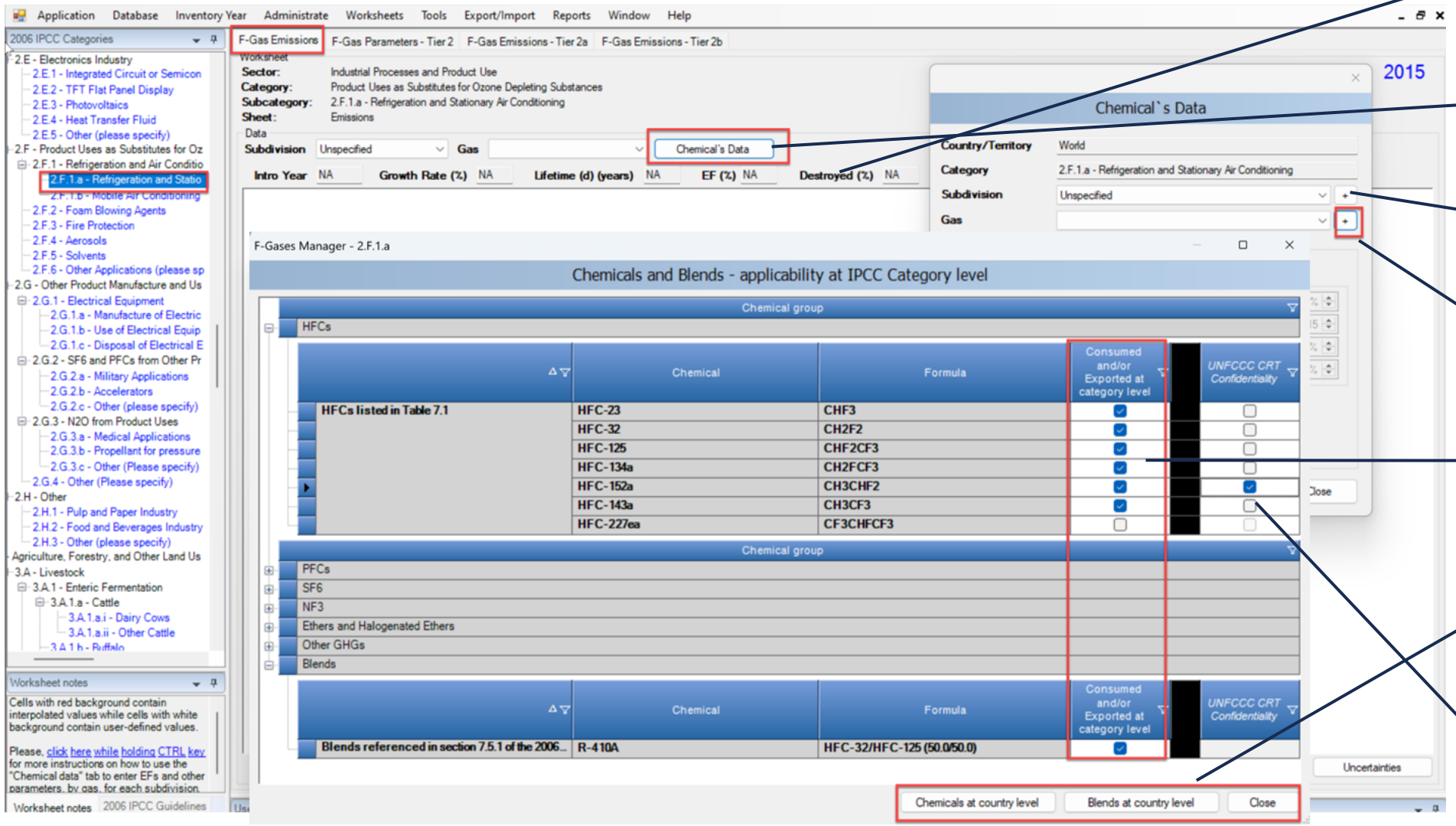
4

5

6



2.F.1:Answers: Set up the IPCC category level F-gases Manager



1. Note worksheet and parameters are blank at first.

2. Select “Chemical’s Data”.

3. One subdivision- Unspecified

4. Select [+] to see list of F-gases/blends for selection.

5. Select F-gases/blends relevant for category 2.F.1.a.

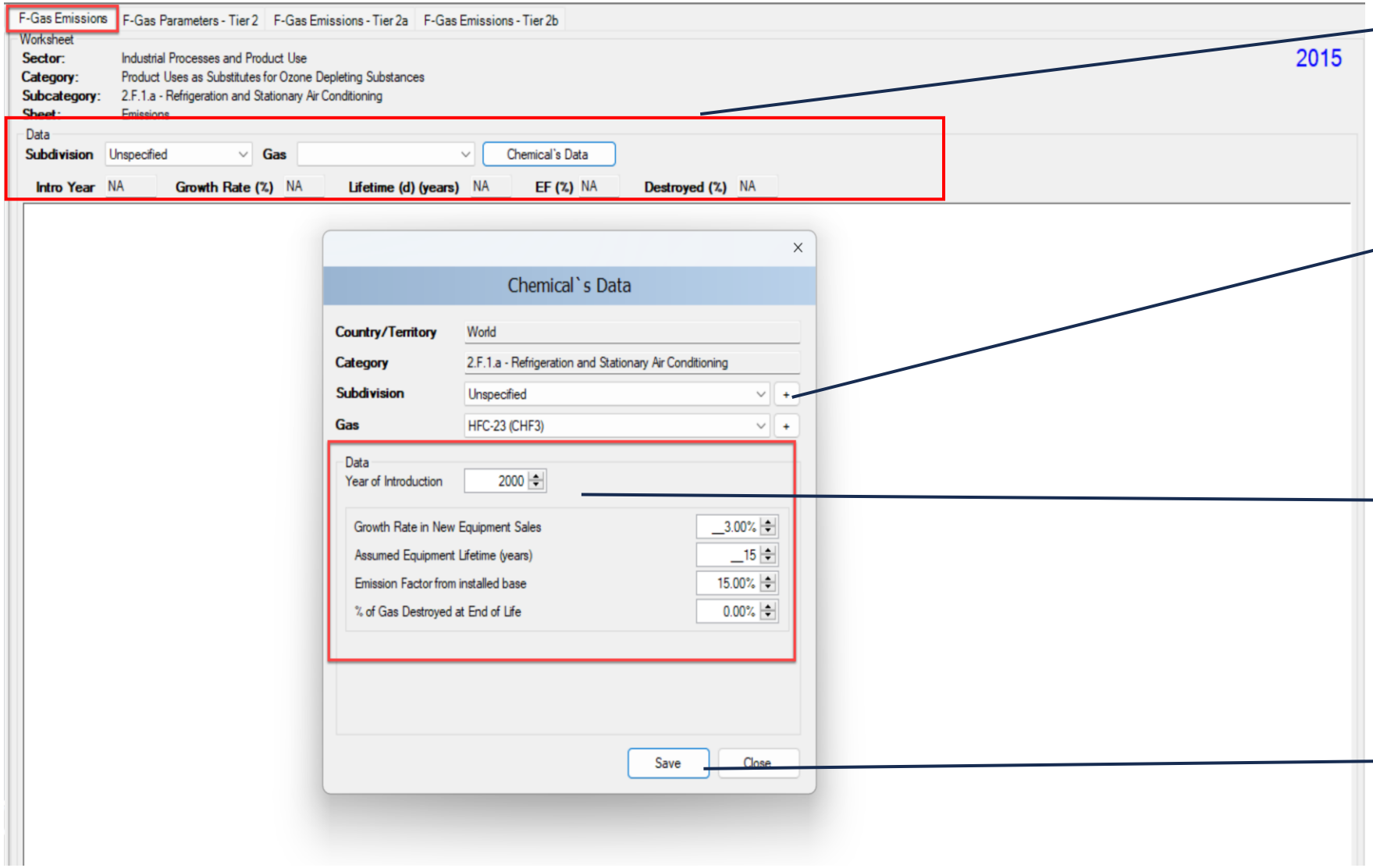
6. If an F-gas/blend is missing, click here to first add them at national level.

7. Note HFC-152a is confidential.

2.F.1 Refrigeration and Air Conditioning

Tier 1

2.F.1:Answers: Enter EFs / Parameters



1. Note that before entering information in, the gas and parameters are blank, and there is no worksheet for data entry.

2. There are no subdivisions added.

3. For each gas added in the previous step, the corresponding information is added in. Note that "year of introduction" for HFC-125 is 1995. All other information for each gas appears as in this screen.

4. Select "Save" after entering information for each gas.

2.F.1:Answers: Enter AD and Estimate Emissions

F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet
Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: HFC-23 (CHF3) Emissions

Data
Subdivision Unspecified **Gas** HFC-23 (CHF3) Chemical's Data
Intro Year 2000 **Growth Rate (%)** 3 **Lifetime (d) (years)** 15 **EF (%)** 15 **Destroyed (%)** 0

2015

	Equation 7.2B										Information for UNFCCC CRT		
Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Agent for servicing (tonnes)	Agent in new equipment installed in year t (tonnes)	Agent in all equipment installed (tonnes)
t	P	Ex	Im	D = P - Ex + Im	R = [L(t-(d-1)) - (L(t-(d-1)) * EF/100)] - [S_needed(t-d)) - S_done(t-d)]	F = R * (destroyed/100)	G = R - F	H = H(t-1) + D - R - I	I = M * EF/100	E = G + I	K = IF(D>I(t-1), I(t-1), D)	L = D - K	M = Σ(L(t, t-(d-1))
2000	0	0	6.41862	6.41862	0	0	0	5.45583	0.96279	0.96279	0	6.41862	6.41862
2001	0	0	6.61118	6.61118	0	0	0	10.25695	1.81005	1.81005	0.96279	5.64839	12.067
2002	0	0	6.80951	6.80951	0	0	0	14.5065	2.55997	2.55997	1.81005	4.99946	17.06647
2003	0	0	7.0138	7.0138	0	0	0	18.29225	3.22804	3.22804	2.55997	4.45383	21.5203
2004	0	0	7.22421	7.22421	0	0	0	21.68899	3.82747	3.82747	3.22804	3.99617	25.51646
2005	0	0	7.44094	7.44094	0	0	0	24.76044	4.36949	4.36949	3.82747	3.61347	29.12993
2006	0	0	7.66417	7.66417	0	0	0	27.56092	4.86369	4.86369	4.36949	3.29468	32.42461
2007	0	0	7.89409	7.89409	0	0	0	30.13676	5.31825	5.31825	4.86369	3.0304	35.45501
2008	0	0	8.13092	8.13092	0	0	0	32.52752	5.74015	5.74015	5.31825	2.81266	38.26768
2009	0	0	8.37484	8.37484	0	0	0	34.76701	6.13535	6.13535	5.74015	2.63469	40.90237
2010	0	0	8.62609	8.62609	0	0	0	36.88413	6.50896	6.50896	6.13535	2.49073	43.3931
2011	0	0	8.88487	8.88487	0	0	0	38.90365	6.86535	6.86535	6.50896	2.37591	45.769
2012	0	0	9.15142	9.15142	0	0	0	40.84681	7.20826	7.20826	6.86535	2.28607	48.05507
2013	0	0	9.42596	9.42596	0	0	0	42.73185	7.54092	7.54092	7.20826	2.2177	50.27277
2014	0	0	9.70874	9.70874	0	0	0	44.5745	7.86609	7.86609	7.54092	2.16782	52.44059
2015	0	0	10	10	5.45583	0	5.45583	41.89529	7.22338	12.67921	7.86609	2.13391	48.15588
2016	0	0	9.28571	9.28571	4.80113	0	4.80113	39.69441	6.68547	11.4866	7.22338	2.06233	44.56983
2017	0	0	8.57143	8.57143	4.24954	0	4.24954	37.79784	6.21845	10.46799	6.68547	1.88595	41.45632
2018	0	0	7.85714	7.85714	3.78575	0	3.78575	36.07305	5.79618	9.58193	6.21845	1.63869	38.64119
2019	0	0	7.14286	7.14286	3.39674	0	3.39674	34.42041	5.39875	8.7955	5.79618	1.34668	35.9917
2020	0	0	6.42857	6.42857	3.07145	0	3.07145	32.76633	5.01121	8.08266	5.39875	1.02982	33.40805
2021	0	0	5.71429	5.71429	2.80048	0	2.80048	31.05767	4.62247	7.42294	5.01121	0.70308	30.81645
2022	0	0	5	5	2.57584	0	2.57584	29.25729	4.22454	6.80038	4.62247	0.37753	28.16358

1. Note that after the EFs/ parameters for a gas are entered in "Chemical's Data" the parameters appear here, and a worksheet for data entry appears. Note IPCC defaults for lifetime and EF.

2. AD are entered in orange cells. Where country-specific data are entered (2015, 2022), cells become white. Remaining orange cells are calculated/ interpolated based on the growth rate.
Note: Do NOT add zeros for years data are not known, the system will interpolate from a "0"

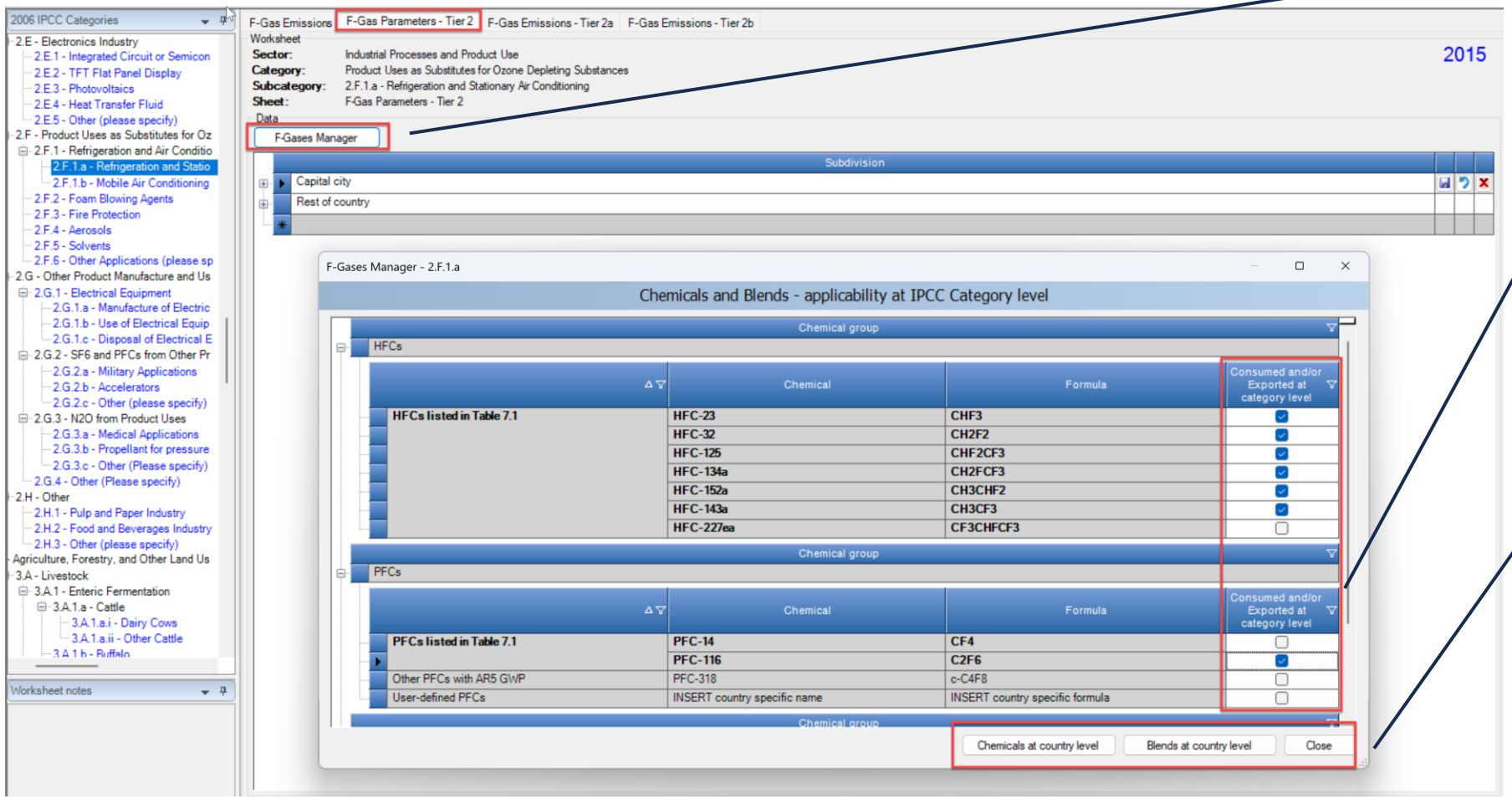
3. Green cells are calculated.

4. Note that although the user is in the 2015 inventory year, F-gases are calculated for entire time series.

2.F.1 Refrigeration and Air Conditioning

Tier 2

2.F.1:Answers: Add gas for Tier 2

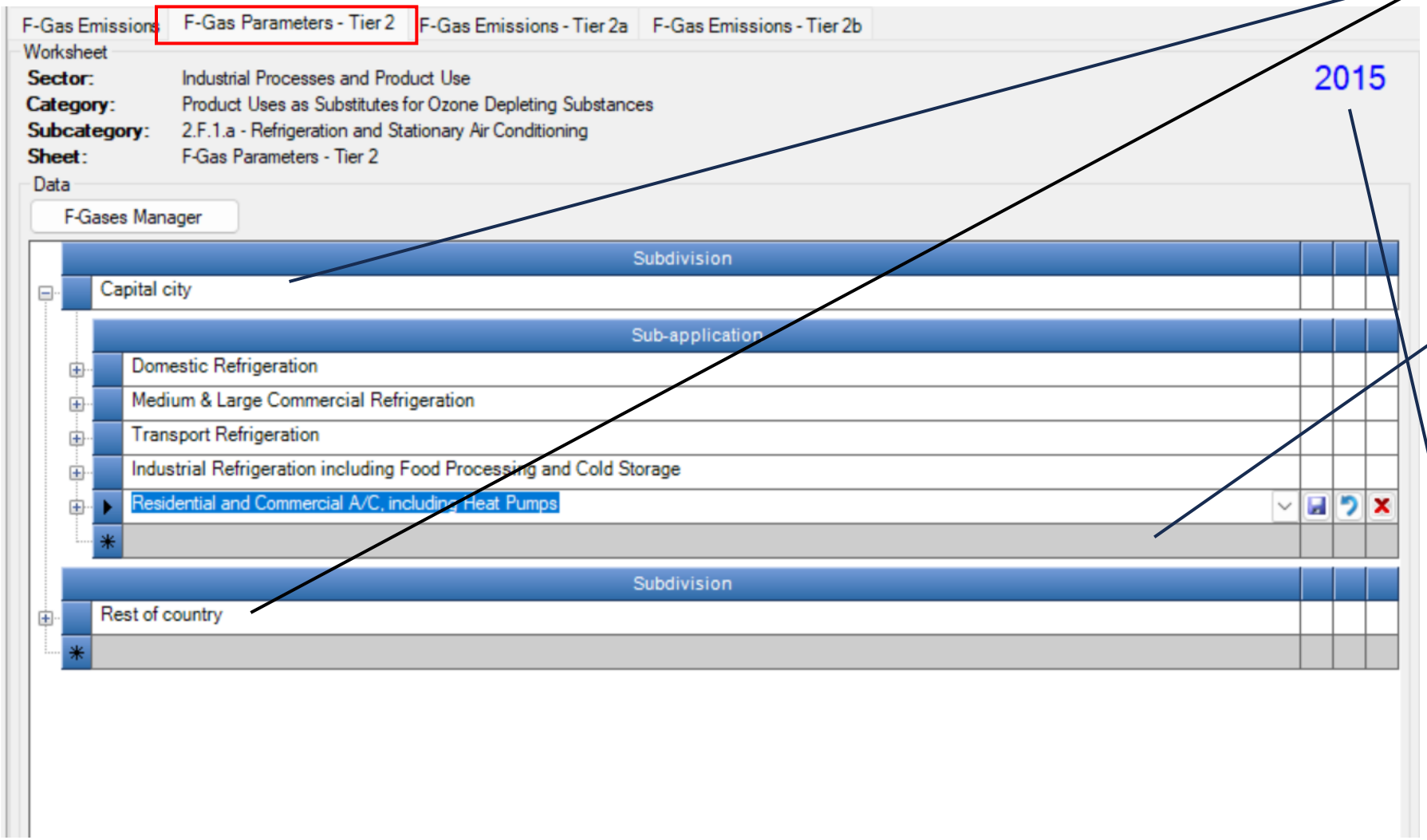


1. Select “F-gases Manager” to check that all relevant F-gases consumed in 2.F.1 checked.

2. All HFCs (and the blend) will be automatically checked. PFCs in initially unchecked because that was not included in Exercise 1a. Check C_2F_6.

Remember: if the user wants to add a gas not already identified at the national level, it will not appear for selection. The user must return to national level to add any gases/blends.

2.F.1:Answers: Add subdivisions and sub-applications



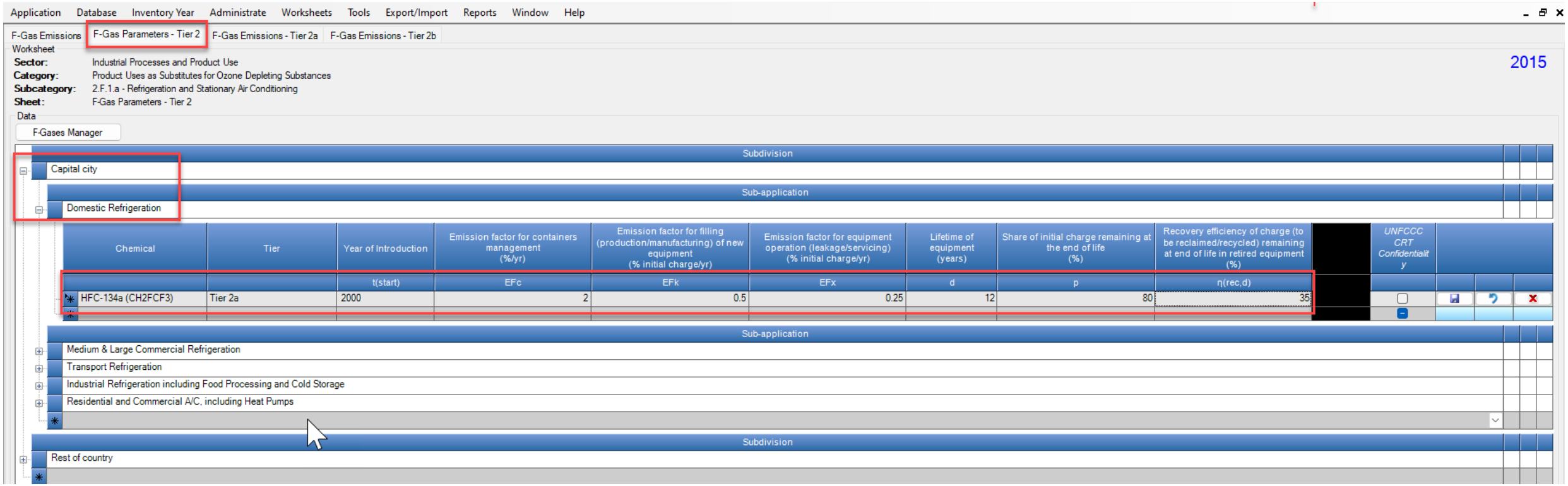
1. Add names of subdivisions.

2. In “Capital city” subdivision, select the relevant dropdowns for sub-applications. Select “Save” after entering each one.

Remember, for interoperability, user should only modify sub-applications names if necessary. Any modified names will map to stationary air conditioning in CRT.

Although the user is in 2015, the information will be applied to the entire time series.

2.F.1:Answers: Enter EFs and Parameters



2.F.1:Answers: Enter AD and Estimate Emissions – Tier 2a

1. Note data added in “Parameters”.

2. System automatically calculated servicing. If amount known, select “Specified” and add data .

3. Note that these activities were not known to occur. In IPCC software, this can be left blank. The Software is an estimation tool, not a reporting tool, so notation keys such as “NO” not accepted.

4. System calculates emissions in kg and Gg.

F-Gas Emissions | F-Gas Parameters - Tier 2 | F-Gas Emissions - Tier 2a | F-Gas Emissions - Tier 2b

Worksheet

Sector: Industrial Processes and Product Use
Category: Product Uses as Substitutes for Ozone Depleting Substances
Subcategory: 2.F.1.a - Refrigeration and Stationary Air Conditioning
Sheet: F-Gas Emissions - Emission Factor Approach - Tier 2a

2015

Data

Subdivision Capital city | **Sub-application** Domestic Refrigeration | **Gas** HFC-134a (CH2FCF3)

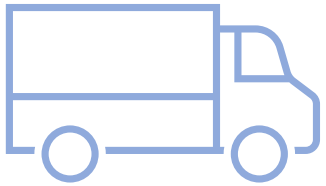
Intro Year 2000 | **EFc [%]** 2 | **EFk [%]** 0.5 | **EFx [%]** 0.25 | **Lifetime (d) [yr]** 12 | **p [%]** 80 | **η(rec,d) [%]** 35

Equation 7.10 7.1

Year	Amount in the bank on January 1st of year t (kg)	Domestically Manufactured HFC 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 i	Domestic Sales of chemical (in bulk) in year t (kg)	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	Contained in equipment going to the bank in year t (kg)	Emitted from equipment in use in year t, including servicing (kg)	Used to refill in year t (kg)	In equipment retired in year t (kg)	Recovered and recycled/reclaimed from equipment retired in year	Emitted at end of life in year t (kg)	Destroyed in year t (kg)	Exported in used equipment (for subsequent use) in year t	Amount in the bank on December 31st of year t (kg)	Total emissions in year t (kg)	Total emissions in year t (Gg)
t Δ	B = U(t-1)	C	D	E	F	G	H = C + D - E + Q(t-1)	I = H * (EFc / 100)	J = H - I - O	K = J * (EFk / 100)	L = J - K	M = L + F - G	N = ∑(M(t-d+1,t)) * (EFx / 100)		O = H*(2/3) or specified	P = M(t-d) * (p/100)	Q = P * (η (rec,d)/100)	R = P - Q	S	T	U = B + M + O - N - P - T	V = I + K + N + R - S - T	W = V / 1000000
2000	0		3.7		0.7		3.7	0.074	1.15933	0.0058	1.15354	1.85354	0.00463	Calculated	2.46667	0	0	0			4.31557	0.08443	0
2001	4.31557		3.8		0.8		3.8	0.076	1.19067	0.00595	1.18471	1.98471	0.0096	Calculated	2.53333	0	0	0			8.82402	0.09155	0
2002	8.82402		3.9		0.8		3.9	0.078	1.222	0.00611	1.21589	2.01589	0.01464	Calculated	2.6	0	0	0			13.42528	0.09875	0
2003	13.42528		3.9		0.8		3.9	0.078	1.222	0.00611	1.21589	2.01589	0.01968	Calculated	2.6	0	0	0			18.02149	0.10379	0
2004	18.02149		4		0.8		4	0.08	1.25333	0.00627	1.24707	2.04707	0.02479	Calculated	2.66667	0	0	0			22.71043	0.11106	0
2005	22.71043		4.1		0.8		4.1	0.082	1.28467	0.00642	1.27824	2.07824	0.02999	Calculated	2.73333	0	0	0			27.49202	0.11841	0
2006	27.49202		4.2		0.8		4.2	0.084	1.316	0.00658	1.30942	2.10942	0.03526	Calculated	2.8	0	0	0			32.36618	0.12584	0
2007	32.36618		4.3		0.9		4.3	0.086	1.34733	0.00674	1.3406	2.2406	0.04086	Calculated	2.86667	0	0	0			37.43258	0.1336	0
2008	37.43258		4.4		0.9		4.4	0.088	1.37867	0.00689	1.37177	2.27177	0.04654	Calculated	2.93333	0	0	0			42.59114	0.14144	0
2009	42.59114		4.4		0.9		4.4	0.088	1.37867	0.00689	1.37177	2.27177	0.05222	Calculated	2.93333	0	0	0			47.74403	0.14712	0
2010	47.74403		4.5		0.9		4.5	0.09	1.41	0.00705	1.40295	2.30295	0.05798	Calculated	3	0	0	0			52.989	0.15503	0
2011	52.989		4.6		0.9		4.6	0.092	1.44133	0.00721	1.43413	2.33413	0.06381	Calculated	3.06667	0	0	0			58.32597	0.16302	0
2012	58.32597		4.7		0.9		4.7	0.094	1.47267	0.00736	1.4653	2.3653	0.06509	Calculated	3.13333	1.48283	0.51899	0.96384			62.27669	1.1303	0
2013	62.27669		4.8		1		5.31899	0.10638	1.66662	0.00833	1.65828	2.65828	0.06678	Calculated	3.54599	1.58777	0.55572	1.03205			66.82642	1.21354	0
2014	66.82642		4.9		1		5.45572	0.10911	1.70946	0.00855	1.70091	2.70091	0.06849	Calculated	3.63715	1.61271	0.56445	1.04826			71.48327	1.23442	0
2015	71.48327		5		1		5.56445	0.11129	1.74353	0.00872	1.73481	2.73481	0.07029	Calculated	3.70963	1.61271	0.56445	1.04826			76.24471	1.23856	0
2016	76.24471		5.1		1		5.66445	0.11329	1.77486	0.00887	1.76599	2.76599	0.07209	Calculated	3.7763	1.63765	0.57318	1.06447			81.07726	1.25872	0
2017	81.07726		5.2		1		5.77318	0.11546	1.80893	0.00904	1.79988	2.79988	0.07389	Calculated	3.84879	1.66259	0.58191	1.08069			85.98945	1.27908	0
2018	85.98945		5.3		1.1		5.88191	0.11764	1.843	0.00921	1.83378	2.93378	0.07595	Calculated	3.92127	1.68754	0.59064	1.0969			91.08101	1.2997	0
2019	91.08101		5.4		1.1		5.99064	0.11981	1.87707	0.00939	1.86768	2.96768	0.07777	Calculated	3.99376	1.79248	0.62737	1.16511			96.17221	1.37208	0
2020	96.17221		5.5		1.1		6.12737	0.12255	1.91991	0.0096	1.91031	3.01031	0.07961	Calculated	4.08491	1.81742	0.6361	1.18132			101.3704	1.39308	0
2021	101.3704		5.6		1.1		6.2361	0.12472	1.95398	0.00977	1.94421	3.04421	0.08155	Calculated	4.1574	1.81742	0.6361	1.18132			106.67304	1.39736	0
2022	106.67304		5.7		1.1		6.3361	0.12672	1.98531	0.00993	1.97538	3.07538	0.08348	Calculated	4.22406	1.84236	0.64483	1.19753			112.04665	1.41766	0

Preview….IPPU and Interoperability

Preview on IPPU and Interoperability



Software:

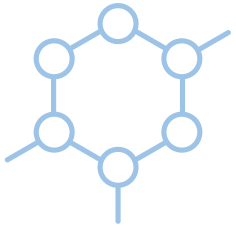
- Is a valuable tool to aid in emissions calculations for this sector, which has a variety of industries following a variety of methods.

- Accommodates these multiple tiers relying on different types of AD (e.g. production versus consumption).

- Visualizes the CRT, allowing users to see how data will appear in the CRT.

- Allows for addition of notation keys, including explanations, and method/EF used.

- Tracks emissions from biogenic feedstocks/ - these are not reported to UNFCCC.



- Allows users to designate information, particularly AD, as confidential. User responsibility to understand how confidentiality works.

FOR YOUR ATTENTION

STAY IN TOUCH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