GHG Emissions: Industrial Processes and Product Use (IPPU)

16 – 19 April 2024

Belize

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CBIT-GSP

Agenda
Day 3

Day 03 - 19/03/2024 (Waste Sector)		
09:00:9:15	Registration, Recap Day 2 and Agenda for Day 3	Faciliator
09:15 – 10:30	IPPU ODS and Exercise	CBIT-GSP
10:15– 10:30	Coffee Break	
10: 30 – 10: 45	Overview of Belize’s Waste Sector GHG Inventory	Host Country
10:45 – 12:00	General Overview of Waste Sector	CBIT-GSP
12:00 - 13:00	Lunch Break	
13:00 - 14:00	Recap exercise	CBIT-GSP
14:00 - 14:45	Open session led by NCCO	All Participants
14:45 – 15:00	Coffee Break	
15:00 - 15:15	Main learnings and evaluation of the event – next steps	Organizers and Host Country
15:15- 16:00	Closing of the Session	Organizers and Host Country

Outline

1. IPPU importance
2. What is the IPPU Sector?
3. IPPU Categories:
    - 2A: Mineral Industry (Cement, Lime)
    - 2B: Chemical Industry
    - 2C: Metal Industry
    - 2D: Non-Energy Products from Fuels & Solvent Use (Asphalt, Lubricants, Paraffins, Solvents)
    - 2E: Electronics Industry
    - 2F: Product Uses as Substitutes for Ozone Depleting Substances (Refrigerations, Air Conditioning, Aerosols)
    - 2G: Other Product Manufacture and Use (Electrical Eq., Military Apps, Medical Apps)
4. IPPU Activity Data
5. Conclusion

Activities within the IPPU Sector in Belize

Greenhouse Gas Source Categories in the IPPU Sector	Status
A. Mineral Products	
1. Cement Production	Not occurring
2. Lime Production	Present
3. Limestone and Dolomite Use	present
6. Road Paving with Asphalt	Present
B. Chemical Industry	Not occurring
C. Metal Production	Not occurring
D. Other Production	
1. Food and Drink	
production of beer, wine, spirits	Present
production of meat, fish, poultry	Present
production of bread	Present
production of animal feed	Present
E. Consumption of Halocarbons and Sulphur Hexafluoride	Not present
1. Refrigeration and Air Conditioning Equipment	Present

Cement Production is a recent activity*

Importance for Non-Annex I Parties

- IPPU sector is considered to be less significant compared to Energy and AFOLU
- Situation varies from country to country
- IPPU sources may become significant in the future as developing countries' economies and industries grow
- Inclusion of F-gases estimates can contribute significantly to the IPPU emissions and influence the total estimates
- IPPU emissions estimation is important to find opportunities for GHG abatement

IPPU Sector

<u>IPPU – GHG emissions:</u>

1. **Industrial Processes**
2. **Product Use**

1. Industrial Processes that chemically or physically transform materials releasing GHG:

- chemically: NH_3 + O2 = 0.5 N_2O↑ + 1.5 H_2O *(nitric acid production)*
- physically: $CaCO_3$ + (Heat) = CaO + CO_2↑

2. Product Use: GHGs are used in products such as refrigerators, foams or aerosol cans

Note: significant time can elapse between the manufacture of the product and the release of GHG. The delay can vary from a few weeks (e.g., for aerosol cans) to several decades (e.g., rigid foams). In refrigeration a fraction of GHG used in the products can be recovered at the end of product's life and either recycled or destroyed.

IPPU Sector

Not IPPU:

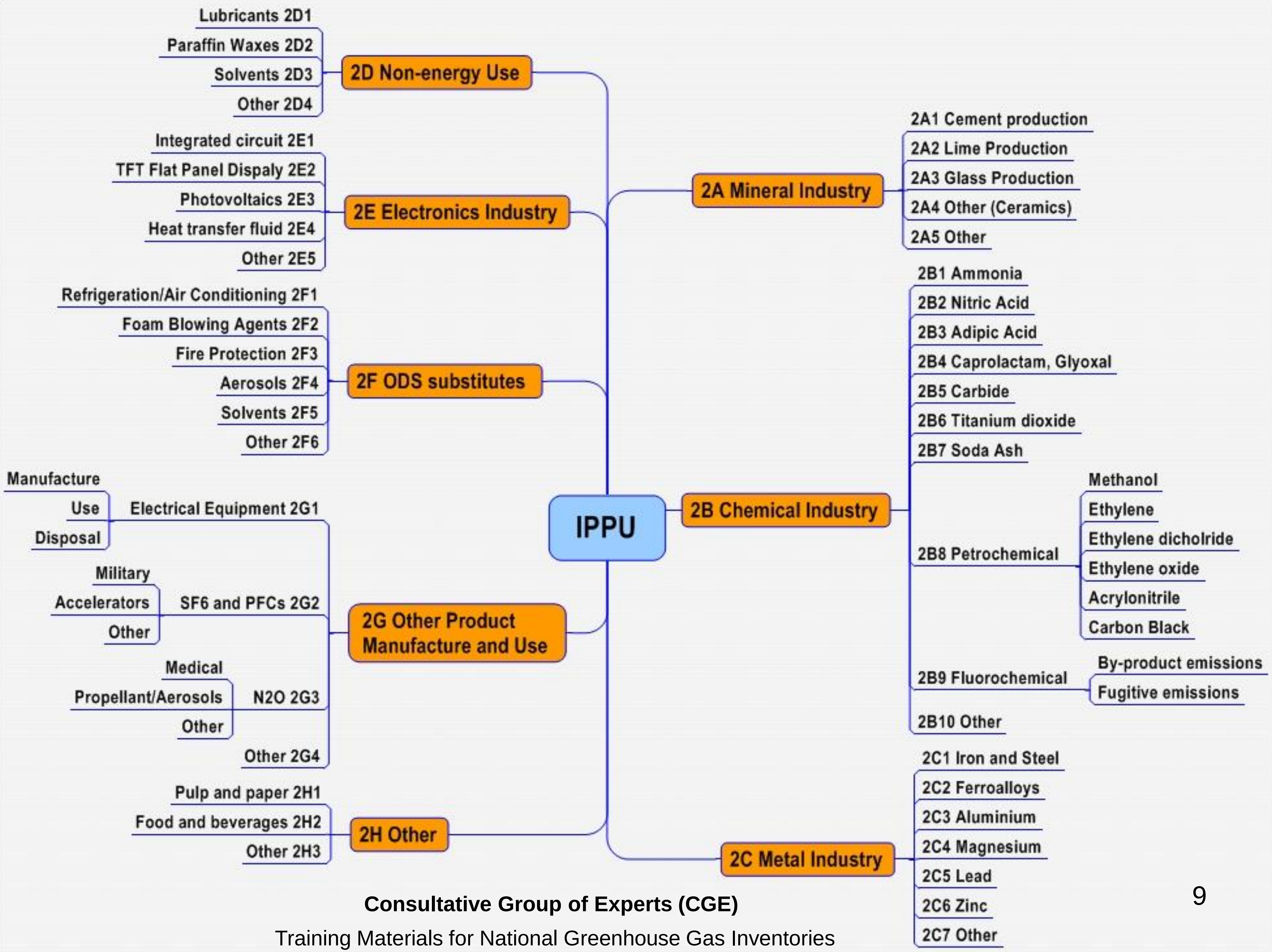
- **Emissions from Fuel combustion in Industrial Sector for energy purposes** (*e.g., cement production*) → **Energy Sector**
- **Fugitive emissions in Oil/Gas industries** → **Energy Sector**
- **Solvents & other products incineration without energy recovery** → **Waste Sector**

Demarcation: IPPU vs. Energy

<u>Combustion emissions</u> from fuels obtained from the <u>feedstock</u> for an IPPU process will normally be allocated the source category in which the process occurs (*these source categories are normally 2B and 2C*). However, if the derived fuels are transferred for combustion in another source category, the emissions should be reported in the appropriate part of the Energy Sector (*normally 1A1 or 1A2*).

Example:
if blast furnace gas is combusted entirely within the Iron and Steel industry (whether for heating blast air, site power needs or for metal finishing operations) the associated emissions are reported in the IPPU source subcategory 2C1. If part of the gas is delivered to a nearby brick works for heat production or a main electricity producer then the emissions are reported in the Energy source subcategories (1A2f or 1A1a).

✓ ***Box 1.1 Chapter 1, Volume 3 2006 IPCC Guidelines***


IPPU
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
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
Methanol
Ethylene
Ethylene dicholride
Ethylene oxide
Acrylonitrile
Carbon Black
2B9 Fluorochemical
By-product emissions
Fugitive emissions
2B10 Other
2C Metal Industry
2C1 Iron and Steel
2C2 Ferroalloys
2C3 Aluminium
2C4 Magnesium
2C5 Lead
2C6 Zinc
2C7 Other

2 Industrial Processes and Product Use (Note 1, 2)	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halo-genated Gases (Note3)
2A Mineral Industry							
2A1: Cement Production	X	*					
2A2: Lime Production	X	*					
2A3: Glass Production	X	*					
2A4: Other Process Uses of Carbonates							
2A4a: Ceramics	X	*					
2A4b: Other Uses of Soda Ash	X	*					
2A4c: Non Metallurgical Magnesia Production	X	*					
2A4d: Other	X	*					
2A5: Other	X	*	*				
2B Chemical Industry							
2B1: Ammonia Production	X	*	*				
2B2: Nitric Acid Production	*	*	X				
2B3: Adipic Acid Production	*	*	X				
2B4: Caprolactam, Glyoxal and Glyoxylic Acid Production	*	*	X				
2B5: Carbide Production	X	X	*				
2B6: Titanium Dioxide Production	X	*	*				
2B7: Soda Ash Production	X	*	*				
2B8: Petrochemical and Carbon Black Production							
2B8a: Methanol	X	X	*				
2B8b: Ethylene	X	X	*				
2B8c: Ethylene Dichloride and Vinyl Chloride Monomer	X	X	*				
2B8d: Ethylene Oxide	X	X	*				
2B8e: Acrylonitrile	X	X	*				
2B8f: Carbon Black	X	X	*				
2B9: Fluorochemical Production (Note 4)							
2B9a: By-product Emissions (Note 5)				X	X	X	X
2B9b: Fugitive Emissions (Note 5)				X	X	X	X
2B10: Other	*	*	*	*	*	*	*

2 Industrial Processes and Product Use (Note 1, 2)	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halo-genated Gases (Note3)
2C Metal Industry							
2C1: Iron and Steel Production	X	X	*				
2C2: Ferroalloys Production	X	X	*				
2C3: Aluminium Production	X	*			X		
2C4: Magnesium Production (Note 6)	X			X	X	X	X
2C5: Lead Production	X						
2C6: Zinc Production	X						
2C7: Other	*	*	*	*	*	*	*
2D Non-Energy Products from Fuels and Solvent Use (Note 7)							
2D1: Lubricant Use	X						
2D2: Paraffin Wax Use	X	*	*				
2D3: Solvent Use (Note 8)							
2D4: Other (Note 9)	*	*	*				
2E Electronics Industry							
2E1: Integrated Circuit or Semiconductor (Note 10)	*		*	X	X	X	X
2E2: TFT Flat Panel Display (Note 10)				X	X	X	X
2E3: Photovoltaics (Note 10)				X	X	X	X
2E4: Heat Transfer Fluid (Note 11)							X
2E5: Other	*	*	*	*	*	*	*

2 Industrial Processes and Product Use (Note 1, 2)	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halo-genated Gases (Note3)
2F Product Uses as Substitutes for Ozone Depleting Substances							
2F1: Refrigeration and Air Conditioning							
2F1a: Refrigeration and Stationary Air Conditioning	*			X	X		*
2F1b: Mobile Air Conditioning	*			X	X		*
2F2: Foam Blowing Agents	*			X	*		*
2F3: Fire Protection	*			X	X		*
2F4: Aerosols				X	X		*
2F5: Solvents (Note 12)				X	X		*
2F6: Other Applications	*	*	*	X	X		*
2G Other Product Manufacture and Use							
2G1: Electrical Equipment							
2G1a: Manufacture of Electrical Equipment (Note 13)					X	X	*
2G1b: Use of Electrical Equipment (Note 13)					X	X	*
2G1c: Disposal of Electrical Equipment (Note 13)					X	X	*
2G2: SF_6 and PFCs from Other Product Uses							
2G2a: Military Applications					*	X	*
2G2b: Accelerators (Note 14)					*	X	*
2G2c: Other					X	X	*
2G3: N_2O from Product Uses							
2G3a: Medical Applications			X				
2G3b: Propellant for Pressure and Aerosol Products			X				
2G3c: Other			X				
2G4: Other	*	*		*			*
2H Other							
2H1: Pulp and Paper Industry (Note 15)	*	*					
2H2: Food and Beverages Industry (Note 15)	*	*					
2H3: Other	*	*	*				

IPPU Gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3)

- **A wide variety of gases:**
  - CO_2, CH_4, N_2O
  - HFCs, PFCs, SF_6
  - Other halogenated gases
  - Ozone/aerosol precursors *(e.g., NMVOCs)*

- **H_2O** and **gases controlled by the Montreal Protocol** (*e.g., CFCs, HCFCs*) are not included

- **Under the UNFCCC, non-Annex I Parties**:
  - should report CO_2, CH_4 and N_2O
  - are encouraged to report HFCs, PFCs, SF_6 and precursors

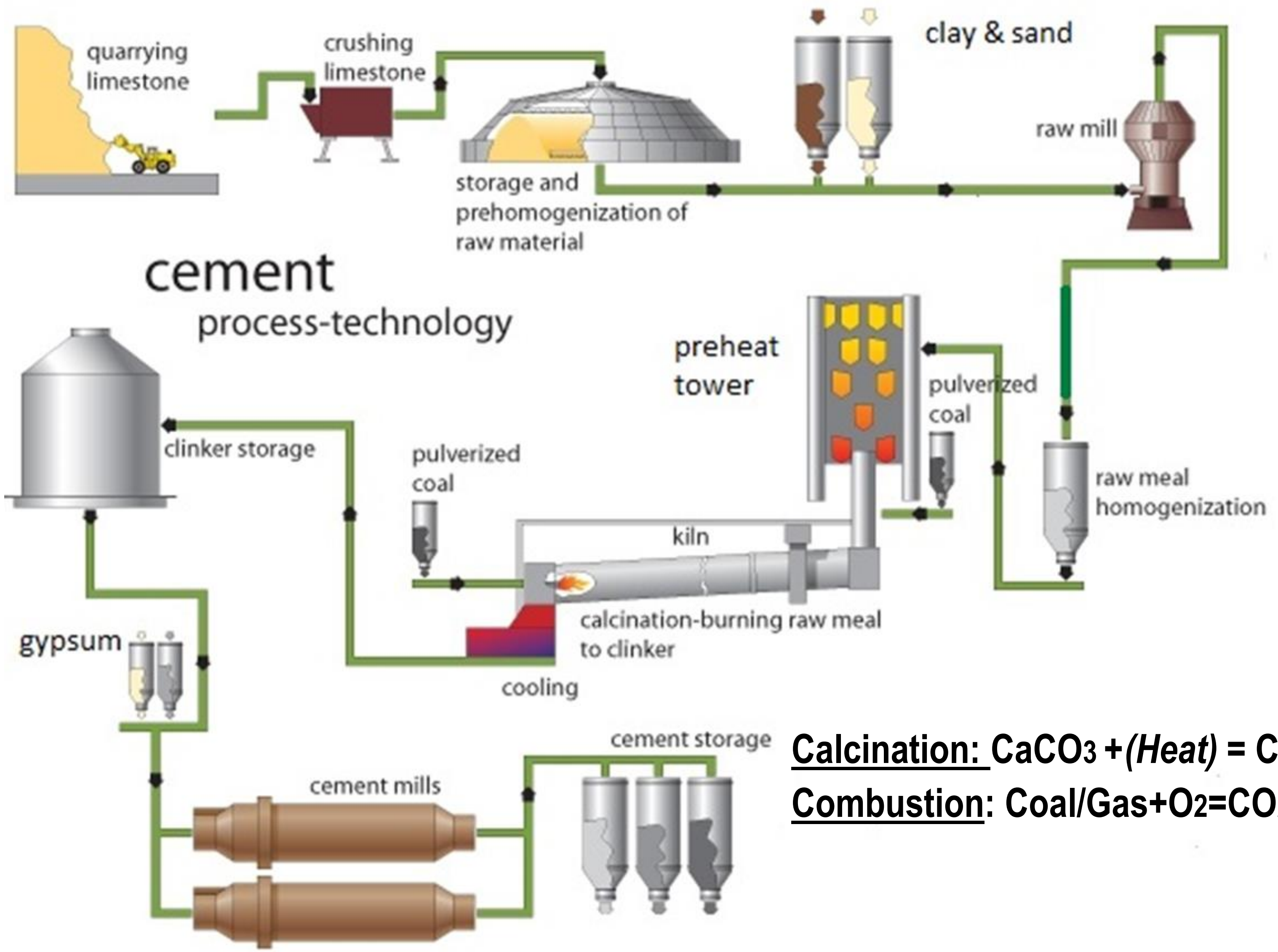
    ✓ ***Inclusion of F-gases is important because of their high global warming potential (GWP), substantial use in industrial processes and in households, significant opportunities for GHG abatement***

2A: Mineral Industry

- Transformation of carbonate-contained compounds – limestone, dolomite, etc. *($CaCO_3$, $MgCO_3$, Na_2CO_3)*
- CO_2 Emissions

Code	Category	Default EF
2A1:	**Cement Production**	0.51 t CO_2/t clinker
2A2:	**Lime Production**	0.75 t CO_2/t lime
2A3:	**Glass Production**	0.20 t CO_2/t glass
2A4:	**Other Process Uses of Carbonates**	
2A4a:	Ceramics	*Chapter 2.5*
2A4b:	Other Uses of Soda Ash	0.41 t CO_2/ t soda ash
2A4c:	Non Metallurgical Magnesia Production	0.52 t CO_2/t magnesite
2A4d:	Other	
2A5:	**Other**	

2A1: Cement Production



<u>Calcination:</u> $CaCO_3$ + *(Heat)* = $CaO + CO_2$ (IPPU)

<u>Combustion</u>: Coal/Gas+O_2=CO_2 + *(Heat)* (Energy)

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

Cement production: Methodological Choice

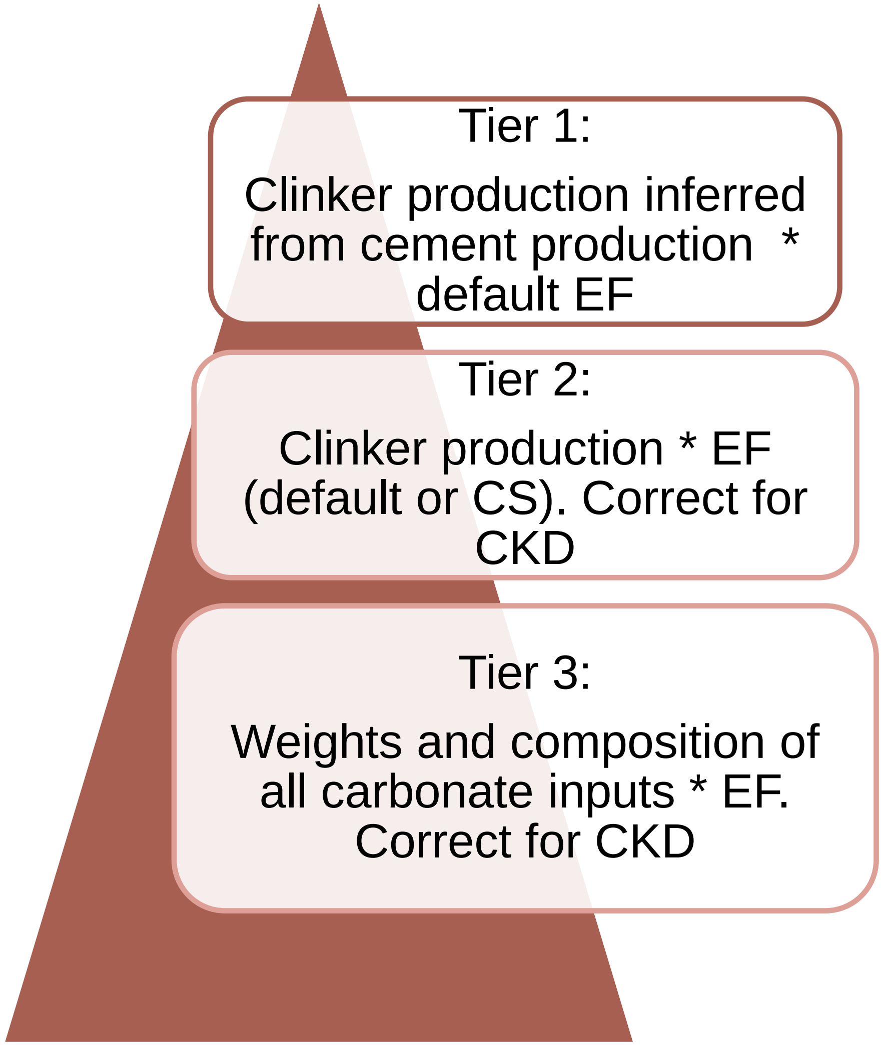
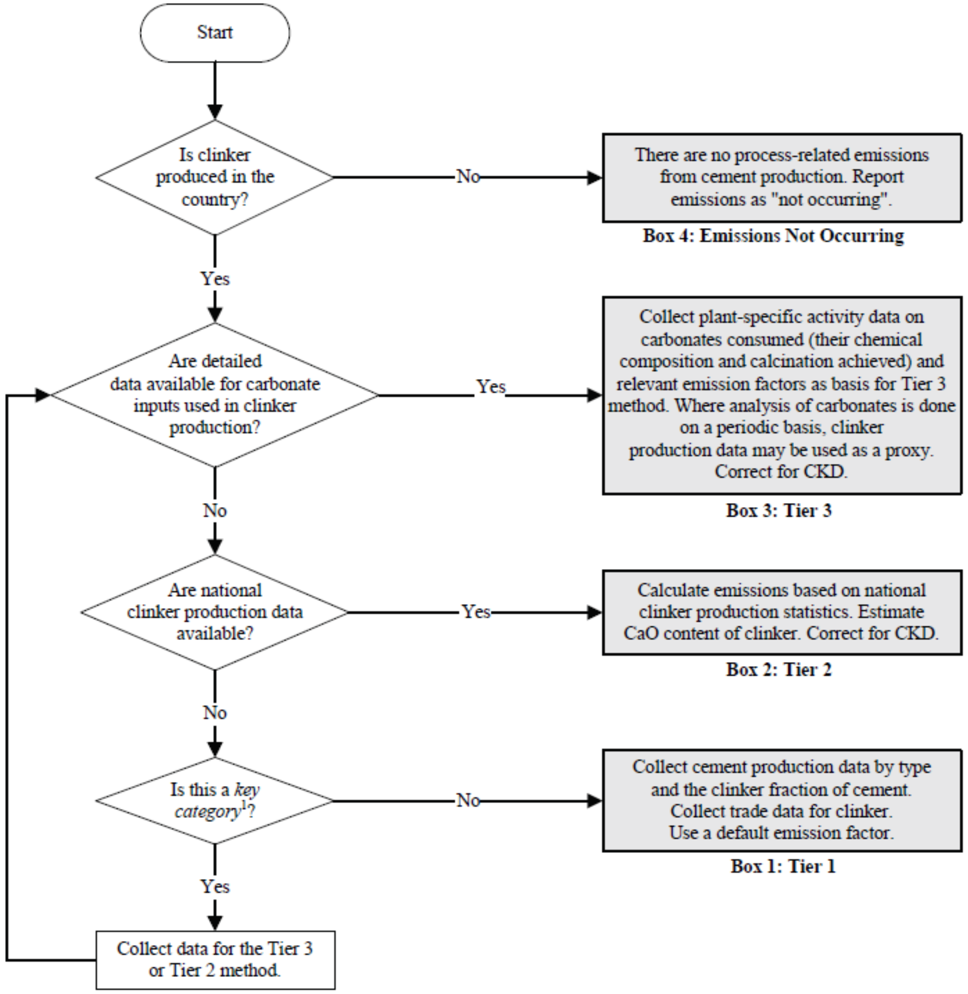


Figure 2.1 **Decision tree for estimation of CO_2 emissions from cement production**



CO_2 from Cement Production (Tier 1)

CO_2 Emissions = AD clinker production x EF clinker

CO_2 Emissions = $[\Sigma(M_{c,i} \times C_{Cl,i}) - Im + Ex] \times EF_{Clc}$

$M_{c,i}$ - *mass of cement produced of type i, tonnes*

$C_{Cl,i}$ - *clinker fraction of cement type i, fraction*

Im - *imports for consumption of clinker, tonnes*

Ex - *exports of clinker, tonnes*

EF_{Clc} - *emission factor for clinker, tonnes CO_2/tonne clinker*

Default EF_{Clc} = 0.52 tonnes CO_2/tonne clinker

(corrected for cement kiln dust (CKD))

Cement production: Tier 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.

1. Estimate clinker based on type of cements (Portland, masonry, etc. - Table 2.2 of 2006 IPCC GL) and clinker fraction in cement type
2. Correct for imports/exports
3. Apply default EF to national clinker production

EF = 0.52 t CO_2/t clinker

If detailed information on cement type is not available, multiply total cement production by:

- *Default C_{cl} = 0.75 (if blended/'masonry' is much)*
- *Default C_{cl} = 0.95 (if all is essentially 'Portland')*

CO_2 from Cement Production (Tier 2)

<u>Tier 2</u> includes a correction addition for emissions associated with Cement Kiln Dust (**CKD**) not recycled to the kiln which is considered to be ‘lost’ and associated emissions are not accounted for by the clinker:

$$\text{CO2 Emissions} = M_{cl} \times EF_{cl} \times CF_{CKD}$$
$$CFCKD = 1 + (Md / Mcl) * Cd * Fd * (EFc / EFcl)$$

CFCKD - *emissions correction factor for CKD, dimensionless*

Md - *weight of CKD not recycled to the kiln, tonnes*

Mcl - *weight of clinker produced, tonnes*

Cd - *fraction of original carbonate in the CKD (i.e., before calcination), fraction*

Fd - *fraction calcination of the original carbonate in the CKD, fraction*

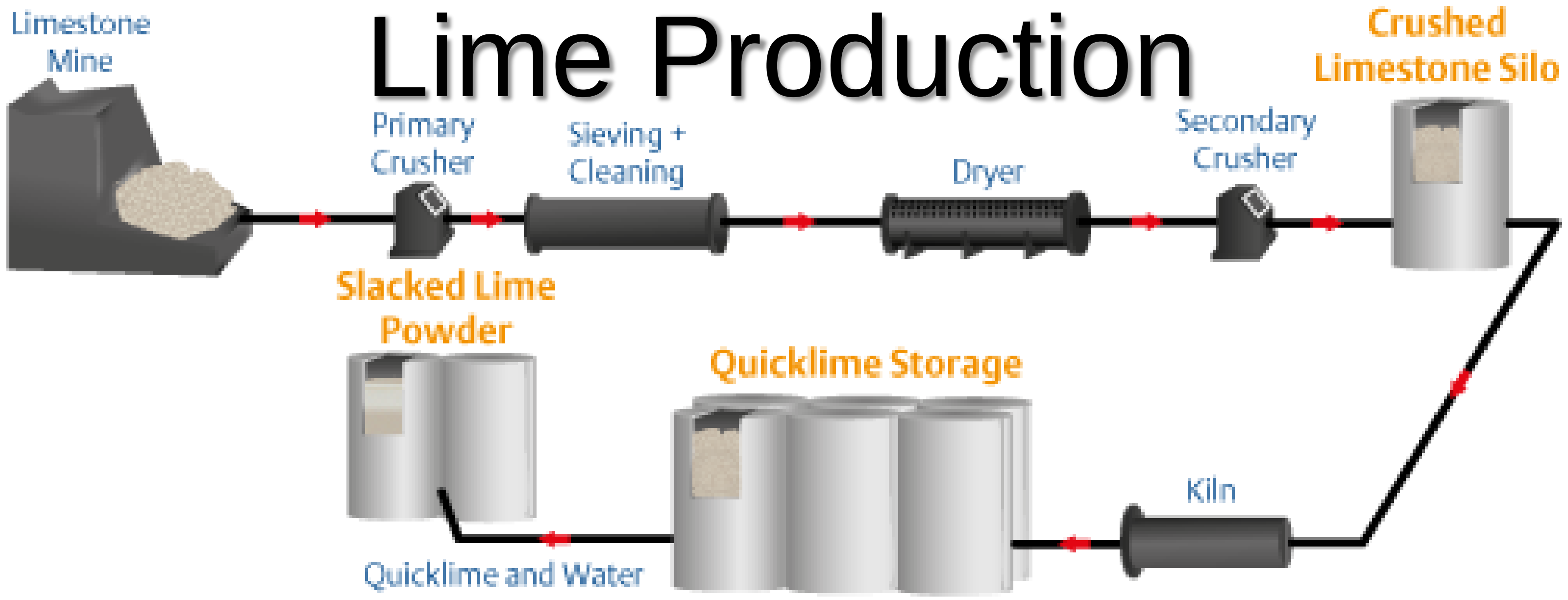
EFc - *emission factor for the carbonate, tonnes CO_2/tonne carbonate*

EFcl - *emission factor for clinker uncorrected for CKD, tonnes CO_2/ tonne clinker (i.e., 0.51)*

Cross-cutting issues

- **Completeness**
  - That all plants are included
  - Be sure that only process-related emissions are included
  - To make clear if clinker or cement production was used as activity data and if export/imports are accounted for
- **Consistent time-series** – e.g. detailed data available only for some years
- **Variability of AD** – to check the cement composition and blends used (since EF may be quite lower)
- **Uncertainty** – 35% for Tier 1, 1-2% - Tier 2; there are default IPCC uncertainty value for different factors in the calculation steps
- **QA/QC** – comparison result using different approaches, CS and default EF, AD checks
- **Reporting** – all data and assumption used (differences depending on the tier)

Lime Production



$CaO + H_2O \rightarrow Ca(OH)_2$ $CaCO_3$ (high-purity limestone) + heat → CaO (quicklime) + CO_2

Lime is used in:
- Metallurgy
- Pulp and paper
- Construction materials
- Effluent treatment
- Water softening
- pH control
- Soil stabilization
- Refining sugar cane or sugar beets (to remove impurities from the juice)

Lime Production

Tier 1:

Quantity of lime produced by type (ideally high calcium lime, dolomitic lime, and hydraulic lime) * default EFs

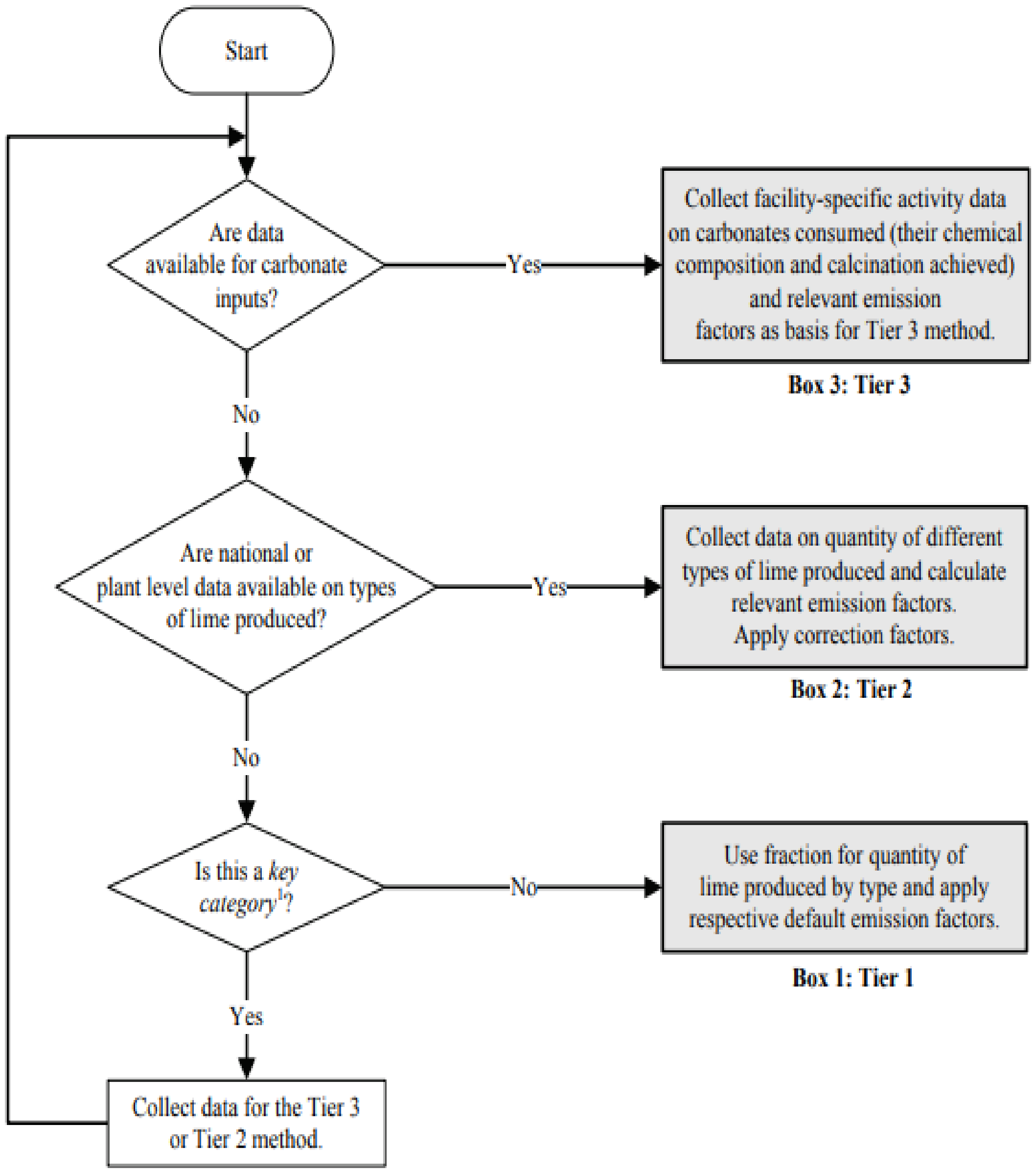
Tier 2:

National data on quantity of lime produced by type, including hydrated lime * default EFs. Correction for LKD.

Tier 3:

Weights and composition of all carbonate inputs * EF. Correct for LKD

Figure 2.2 Decision tree for estimation of CO_2 emissions from lime production



Lime production: Tier 1

In absence of CS data, assume:

- 85% high calcium
- 15% dolomitic lime
- 0% hydraulic lime

EQUATION 2.8

TIER 1 DEFAULT EMISSION FACTOR FOR LIME PRODUCTION

$$EF_{Lime} = 0.85 \bullet EF_{high\ calcium\ lime} + 0.15 \bullet EF_{dolomitic\ lime}$$

EQUATION 2.8

TIER 1 DEFAULT EMISSION FACTOR FOR LIME PRODUCTION

$$EF_{Lime} = 0.85 \bullet EF_{high\ calcium\ lime} + 0.15 \bullet EF_{dolomitic\ lime}$$

$$= 0.85 \bullet 0.75 + 0.15 \bullet 0.77^{a}$$

$$= 0.6375 + 0.1155$$

$$= 0.75 \text{tonnes } CO_2 / \text{tonne lime produced}$$

Notes on defaults in Equation 2.8

a: The default EF for dolomitic lime may be 0.86 or 0.77 depending on the technology used for lime production. See Table 2.4.

The calculation above is for developing countries

EF = 0.753 t CO2/t lime

Lime production: Tier 1

TABLE 2.4 BASIC PARAMETERS FOR THE CALCULATION OF EMISSION FACTORS FOR LIME PRODUCTION					
Lime Type	Stoichiometric Ratio [tonnes CO_2 per tonne CaO or CaO·MgO] (1)	Range of CaO Content [%]	Range of MgO Content[d] [%]	Default Value for CaO or CaO·MgO Content [fraction] (2)	Default Emission Factor [tonnes CO_2 per tonne lime] (1) • (2)
High-calcium lime[a]	0.785	93-98	0.3-2.5	0.95	0.75
Dolomitic lime[b]	0.913	55-57	38-41	0.95 or 0.85[c]	0.86 or 0.77[c]
Hydraulic lime[b]	0.785	65-92[e]	NA	0.75[e]	0.59

Source:

[a] Miller (1999b) based on ASTM (1996) and Schwarzkopf (1995).

[b] Miller (1999a) based on Boynton (1980).

[c] This value depends on technology used for lime production. The higher value is suggested for developed countries, the lower for developing ones.

[d] There is no exact chemical formula for each type of lime because the chemistry of the lime product is determined by the chemistry of the limestone or dolomite used to manufacture the lime.

[e] Total CaO content (including that in silicate phases).

Tier 1 default EF = 0.753 t CO_2/t lime

Belize EF = 0.785 t CO_2/t lime

Lime Production: Tier 2

EQUATION 2.6
TIER 2: EMISSIONS BASED ON NATIONAL LIME PRODUCTION DATA BY TYPE

$$CO_2\ Emissions = \sum_i (EF_{lime,i} \bullet M_{l,i} \bullet CF_{lkd,i} \bullet C_{h,i})$$

Collect AD on high calcium, dolomitic and hydraulic lime. Correct for hydrated lime and LKD.

$EF_{lime,i}$ = emission factor for lime of type *i*, tonnes CO_2/tonne lime

$M_{l,i}$ = lime production of type *i*, tonnes

$CF_{lkd,i}$ = correction factor for lime kiln dust (LKD) for lime of type *i*, dimensionless (default 2%)

$C_{h,i}$ = correction factor for hydrated lime of the type *i* of lime, dimensionless (defaults included in the software, e.g. 0.97)

i = each of the specific lime types listed in Table 2.4

EF per type of lime calculated using table 2.4 as in Tier 1

Cross-cutting issues

➢ **Completeness** – particularly challenging for this category

✓ Lime is produced in some industries and never sold on the market and thus not in national statistics

a) Iron and steel industry
b) Synthetic soda ash
c) Calcium carbide
d) Magnesia and magnesium metal
e) Copper smelters
f) Sugar mills

All lime production should be reported in this source category, whether produced by lime kilns as a marketed product, or whether produced as a non-marketed intermediate reagent

✓ Possibility of double counting with “other process uses of carbonates”.

Default uncertainties for the category

TABLE 2.5 DEFAULT UNCERTAINTY VALUES FOR ESTIMATION OF CO_2 EMISSIONS FROM LIME PRODUCTION		
Uncertainty	**Comment**	**Tier**
4-8%	Uncertainty in assuming an average CaO in lime	1, 2
2%	Emission factor high calcium lime	1, 2
2%	Emission factor dolomitic lime	1, 2
15%	Emission factor hydraulic lime	1, 2
5%	Correction for hydrated lime	1, 2
	Order of magnitude errors possible if non-marketed lime production is not estimated	1, 2, 3
1-2%	Uncertainty of plant-level lime production data. Plants generally do not determine output better than this. Assumes complete reporting.	2
See Table 2.3	Correction for LKD	2, 3
1-3%	Error in assuming 100% carbonate source from limestone (vs. other feeds).	3
1-3%	Uncertainty of plant-level weighing of raw materials	3
Source: Based on expert judgment.		

Data Sources

- National statistics
- Cement/lime facilities- CaO content of clinker/ fraction of CaO from carbonate/CKD and LKD collection and recycling practices
- USGS Minerals Yearbook (cement, lime, soda ash production)
  - https://minerals.usgs.gov/minerals/pubs/commodity/myb/
- Industrial Commodity Statistics Yearbook
- https://www.un-ilibrary.org/economic-and-social-development/industrial-commodity-statistics-yearbook-2015_e79d2dce-en-fr
- UN Commodity Trade Statistics Database: Import/export statistics
- https://comtrade.un.org/db/mr/daCommoditiesResults.aspx?px=H4&cc=252310

2B: Chemical Industry

Code	Category	Default EF		
		CO_2	CH_4	F-gases
2B8:	**Petrochemical and Carbon Black Production**			
2B8a:	❑ Methanol	X	X	
2B8b:	❑ Ethylene	X	X	
2B8c:	❑ Ethylene Dichloride and Vinyl Chloride Monomer	X X	X	
2B8d:	❑ Ethylene Oxide	X	X	
2B8e:	❑ Acrylonitrile	X	X	
2B8f:	❑ Carbon Black	X	X	
2B9:	**Fluorochemical Production**			
2B9a:	❑ By-product Emissions			X
2B9b:	❑ Fugitive Emissions			X

2D: Non-Energy Products from Fuels and Solvent Use

- **GHG emissions from <u>use</u> of non-energy products (lubricants, waxes, greases, solvents) other than:**
  - combustion for energy purposes;
  - use as feedstock or reducing agent;
  - incineration of waste oils/lubricants with/without energy recovery (Energy/Waste Sector).
- **A small proportion of non-energy products oxidises during use**
- **Focus on direct CO_2 emissions and substantial NMVOC/CO emissions which eventually oxidise to CO_2 in the atmosphere**

Code	Category	CO_2	NMVOC, CO
2D1:	Lubricant Use	X	
2D2:	Paraffin Wax Use	X	
2D3:	Solvent Use		X
2D4:	Other (asphalt production and use)		X

Non-energy use: common issues

- **Potential for double counting/omissions:**

  a) This category includes only first use. Where lubricants are burned without energy recovery, emissions are reported in the waste sector; with energy recovery in the energy sector.

- Where **lubricant is used for lubrication** (e.g. in four-stroke engines), it is **IPPU.** When mixed with motor oil in two stroke engines, reported under road transport.

Estimation Tiers

- Basic Tier 1 method (for non-key categories) is:

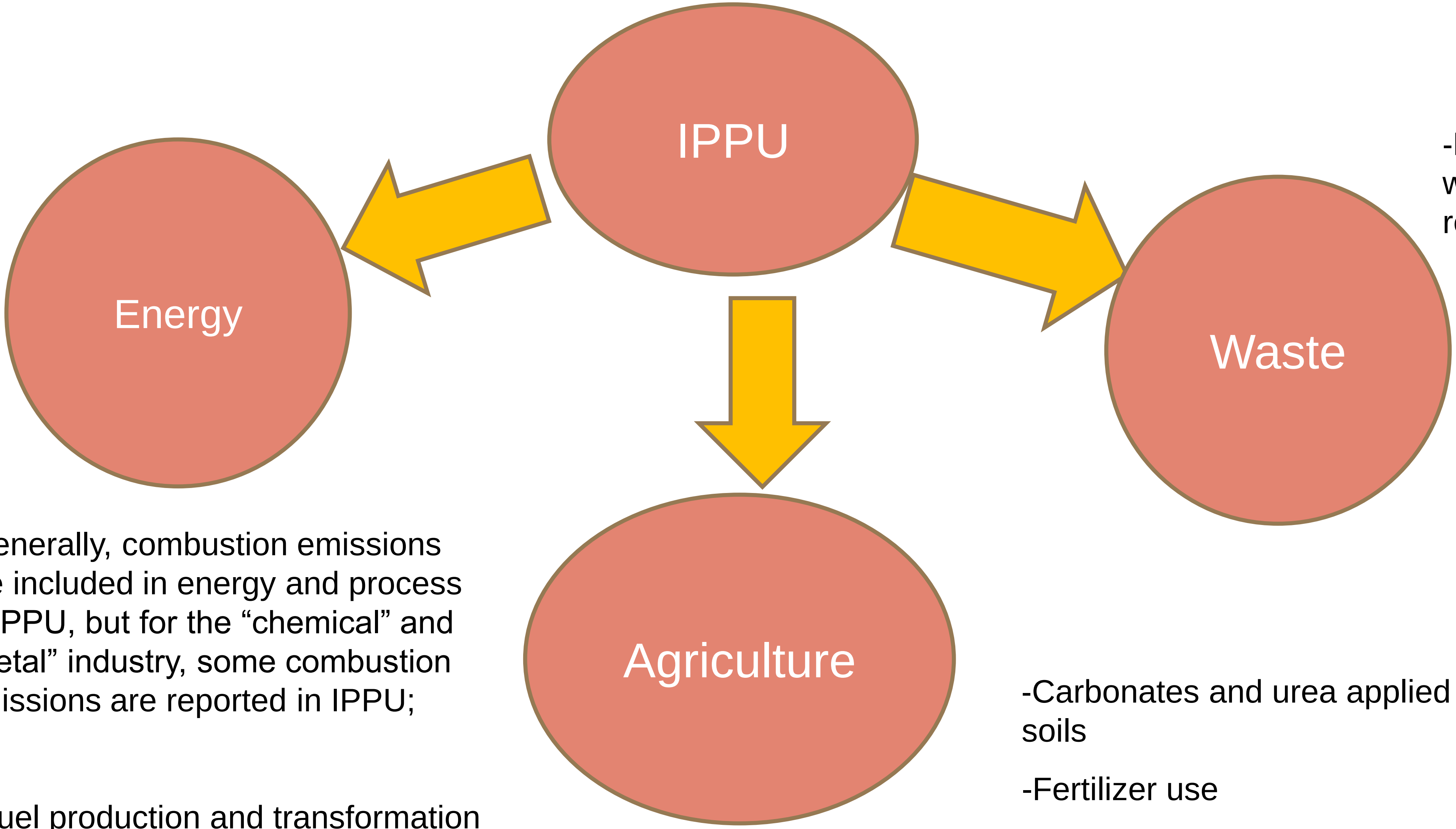
$$CO_2\, emissions = consumption * CC\ * Oxidized\ (ODU) * 44/12$$

Product	ODU factor
Lubricating oil	0.2
Grease	0.05
Default for all lubricants	0.2
Default for paraffin wax	0.2

- Default fractions: oil (90%) ad grease (10%)
- Default carbon content for lubricants and wax is 20 kg C/GJ

- Tier 2 disaggregated by type of lubricant with ideally country-specific EFs

IPPU and other sectors - What is not covered under IPPU



-NEU combustion without energy recovery

-Generally, combustion emissions are included in energy and process in IPPU, but for the “chemical” and “metal” industry, some combustion emissions are reported in IPPU;

- Fuel production and transformation

-Carbonates and urea applied on soils

-Fertilizer use

(production reported under IPPU)

2F: Fluorinated Substitutes for ODS

Code	Category	HFCs	PFCs
2F1:	Refrigeration and Air Conditioning	X	X
2F1a:	Refrigeration and Stationary Air Conditioning	X	X
2F1b:	Mobile Air Conditioning	X	X
2F2:	Foam Blowing Agents	X	X
2F3:	Fire Protection	X	X
2F4:	Aerosols	X	X
2F5:	Solvents	X	X
2F6:	Other Applications	X	X

2F: Fluorinated Substitutes for ODS

- ***Applications* or *Sub-applications*** - major groupings of current and expected usage of the ODS substitutes
- ***Actual emissions*** vs. ***Potential emissions*** (2006 vs.1996)
- ***Prompt emissions*** (within 2 years) **and Delayed emissions**
- ***Bank*** – total amount of substances contained in existing equipment, chemical stockpiles, foams, other products not yet released to the atmosphere (+ExIm)
- **Approaches:**
    - ✓ Emission Factor (a) and Mass-balance (b)
    - ✓ Tier 1 and Tier 2

2F: Fluorinated Substitutes for ODS

Substitutes for ODS Uses in Many Applications

Release of HFCs and PFCs

- Refrigeration and AC
- Fire Suppression
- Aerosols
- Foam Blowing
- Solvent Cleaning

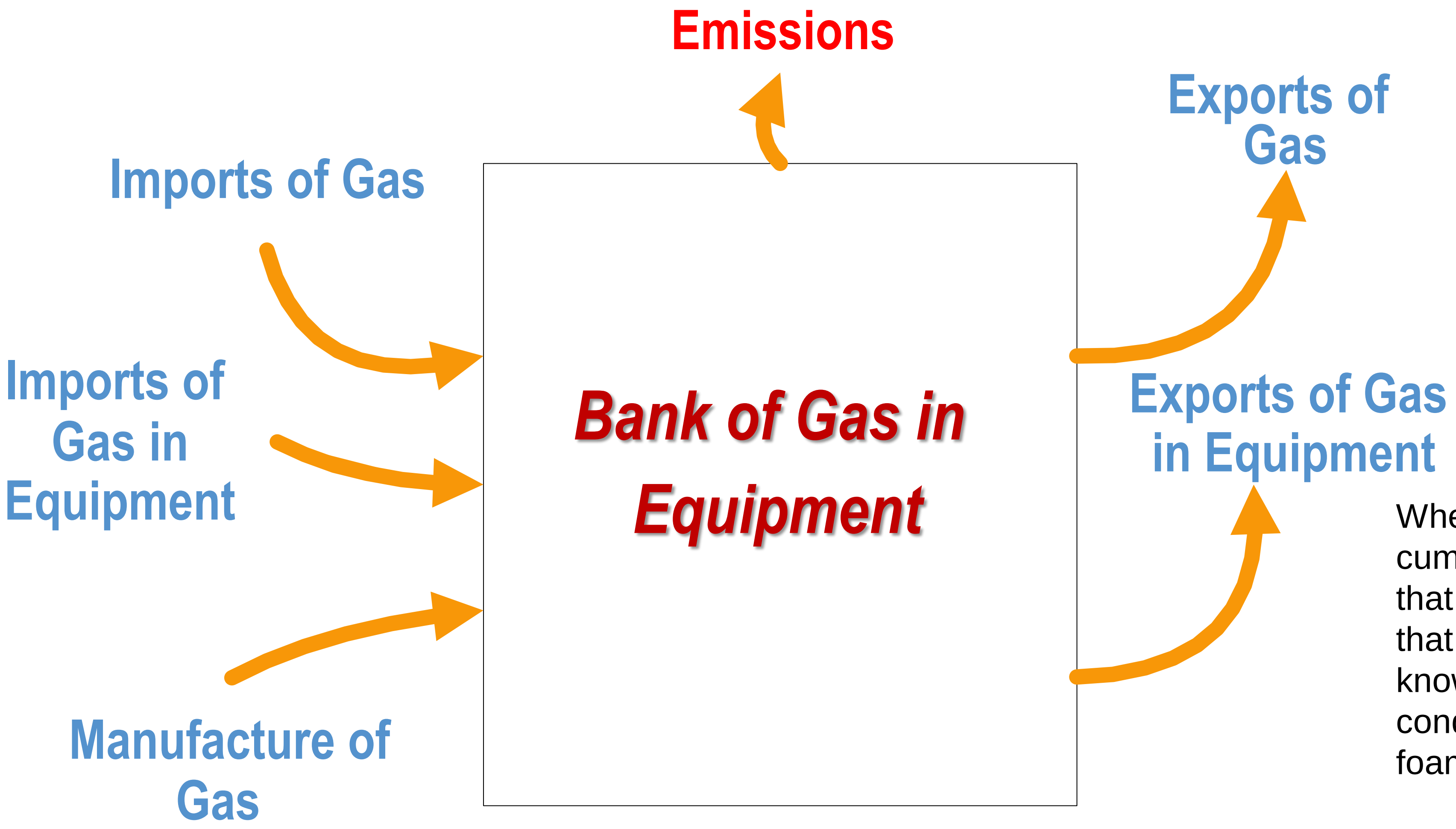
Actual emissions vs. Potential emissions

- **The 2006 IPCC Guidelines provide with methods for estimating *actual emissions* of ODS substitutes in contrast to *potential emissions* approach (***1996 IPCC Guidelines***) taking into account the time lag between consumption of ODS substitutes and emissions.**
- ***Potential emissions* approach assumes that all emissions from an activity occur in the current year (**manufacture + import - export - destruction**), *ignoring the fact they will occur over many years, thus estimates may become very inaccurate***

Example. *A household refrigerator emits little or no refrigerant through leakage during its lifetime and most of its charge is not released until its disposal, many years after production. Even then, disposal may not entail significant emissions if the refrigerant and the blowing agent in the refrigerator are both captured for recycling or destruction*

- **Use of *actual emissions* allows to:**
  - ✓ accurately estimate emissions of ODS substitutes
  - ✓ proper address emission reductions of abatement techniques

Bank



Where delays in emission occur, the cumulative difference between the chemical that has been consumed in an application and that which has already been released is known as a bank (refrigeration and air conditioning, fire protection, closed-cell foams).

Example. Blowing agent still present in foamed products which may have already been land-filled is still part of the bank, since it is chemical which has been consumed and still remains to be released.

Data Collection- Example: Refrigeration

Refrigeration: Assumptions

- Equipment servicing starts 3 years after equipment installation
- Emissions from bank = 15% annually across all sub-applications
- In a mature market, 67% sales for servicing, 33% for new equipment
- Average equipment lifetime is 15 years (average across all sub-applications)
- Complete transition to a new refrigerant takes 10 years.

With these assumptions, what data do you need?

- Sale of specific refrigerant in the year to be reported
- Year of introduction of the refrigerant
- Growth rate in sale of new equipment (usually linear)
- Assumed percentage of new equipment exported and imported

Where to get it:

- *Regulation for phase-out of CFCs and HCFCs* : Countries may have “Refrigerant Management Plans” or “HCFC Phase-out Management Plan”
- Government Statistics
- Refrigerant Manufacturers and Distributors
- Disposal Companies
- Import/Export Companies
- Manufacturer Association
- Marketing Studies

Calculation tool in the 2006 GL uses these assumptions and data

2F: Sub-applications

2F Product Uses as Substitutes for Ozone Depleting Substances			
2F1	**Refrigeration and Air Conditioning**		**- Open foams**
	Domestic (i.e., household) refrigeration		PU Flexible Foam
	Commercial refrigeration including different types of equipment, from vending machines to centralised refrigeration systems in supermarkets		PU Flexible Moulded Foam
	Industrial processes including chillers, cold storage, and industrial heat pumps used in the food, petrochemical and other industries		PU Integral Skin Foam
	Transport refrigeration including equipment and systems used in refrigerated trucks, containers, reefers, and wagons		PU One Component Foam
	Mobile air-conditioning systems used in passenger cars, truck cabins, buses, and trains	**2F3**	**Fire Protection**
			Portable (streaming) equipment
			Fixed (flooding) equipment
2F2	**Foam Blowing Agents**	**2F4**	**Aerosols**
	- Closed Foams		Metered Dose Inhalers (MDIs)
	PU Continuous Panel		Personal Care Products (e.g., hair care, deodorant, shaving cream)
	PU Discontinuous Panel		Household Products (e.g., air-fresheners, oven and fabric cleaners)
	PU Appliance Foam		Industrial Products (e.g., special cleaning sprays such as those for operating electrical contact, lubricants, pipe-freezers)
	PU Injected Foam		Other General Products (e.g., silly string, tyre inflators, klaxons).
	PU Continuous Block	**2F5**	**Solvents**
	PU Discontinuous Block		Precision Cleaning
	PU Continuous Laminate		Electronics Cleaning
	PU Spray Foam		Metal Cleaning
	PU Pipe-in-Pipe		Deposition applications
	Extruded Polystyrene	**2F6**	**Other Applications**
	Phenolic Block		
	Phenolic Laminate	**TOTAL: 32 sub-applications**	

2F: Chemicals and blends

Chemical	Refrigeration and Air Conditioning	Fire Suppression and Explosion Protection	Aerosols		Solvent Cleaning	Foam Blowing	Other Applications
			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 (CF4)		X					
PFC-116 (C2F6)							X
PFC-218 (C3F8)							
PFC-31-10 (C4F10)		X					
PFC-51-14 (C6F14)					X		
BLENDS							

2F: Tiers / Approaches and Data

	Approach A (emission-factor approach)	Approach B (mass-balance approach)
Tier 2 (emission estimation at a **disaggregated** level)	· Data on chemical sales and usage pattern by sub-application · Emission factors by sub-application	· Data on chemical sales by sub-application · Data on historic and current equipment sales adjusted for import/export by sub-application
Tier 1 (emission estimation at an **aggregated** level)	· Data on chemical sales by application · Emission factors by application	· Data on chemical sales by application · Data on historic and current equipment sales adjusted for import/export by application

Need help? No worries!

The IPCC Software will work out!

The IPCC Inventory Software enables you to estimate actual emissions even if you do not have historic data.

(!) But you need to have the data on:

- 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

Regulations for ODS in Belize

- In June 2002, the Pollution Regulations were amended to include, among other things, issues related to the commitments made under the Montreal Protocol on Ozone Depleting Substances.

- This included the prohibition on the imports of equipment using ozone depleting substances and the establishment of a licensing system for the importation of these substances.

- In August 2009, the Pollution Regulations were amended basically to allow Belize to strengthen a requirement of the Montreal Protocol related to the **licensing system for the importation of refrigerants**

- This amendment also complements the Act in addressing the petroleum industry, including refining. **The Refrigeration Technicians (Licensing) Act of 2010 provides for the registration and licensing of refrigeration and air conditioning technicians operating in Belize.**

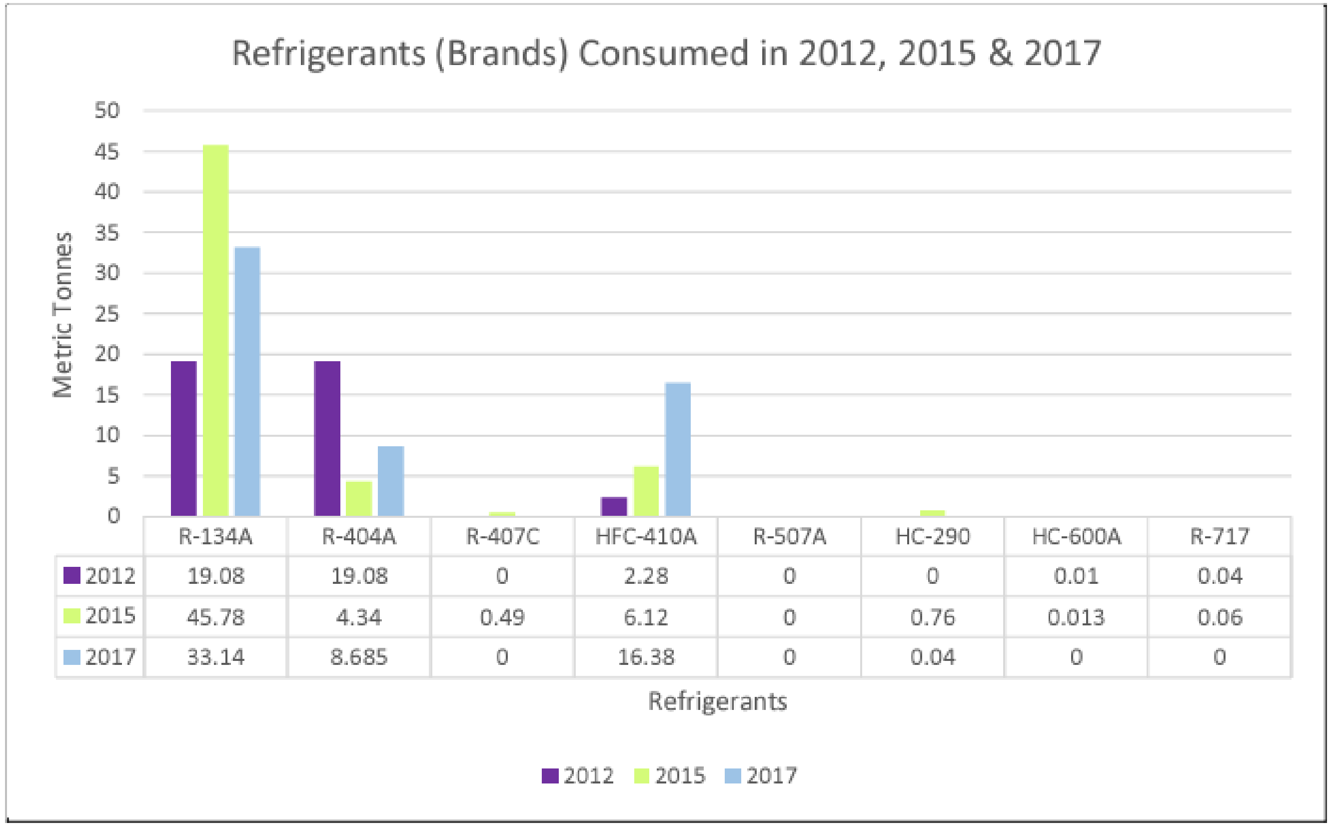
Use of Refrigerants in Belize

- Refrigerants are widely used in two situations**, mobile and stationary**.

- Mobile refrigerant use would be for air-conditioning in vehicles (maybe some boats), while stationary applications include residential, commercial, industrial and public buildings.

- Figure 2.19 shows all refrigerants consumed for the study period.

Figure 2.19: Refrigerants Consumed in 2012, 2015, and 2017 (MT)



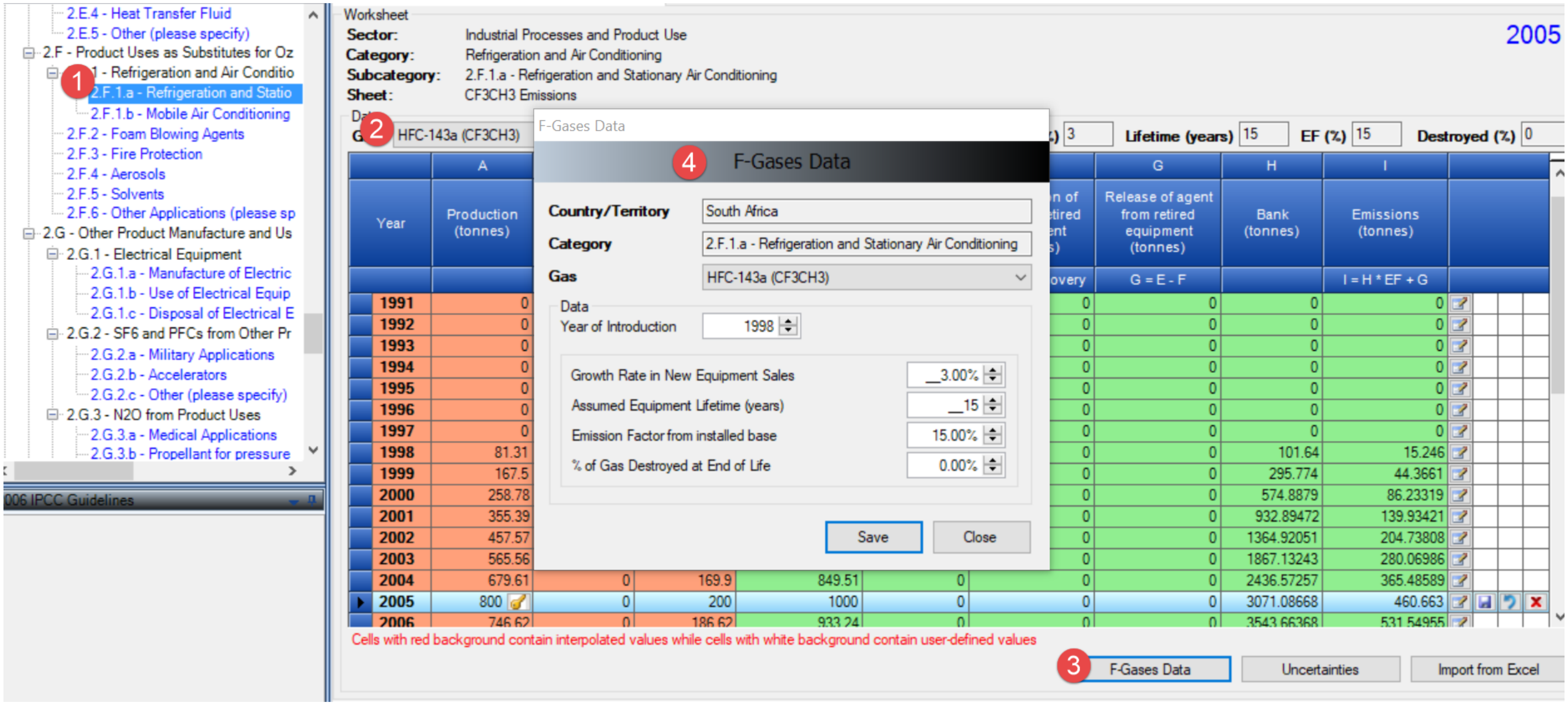
	R-134A	R-404A	R-407C	HFC-410A	R-507A	HC-290	HC-600A	R-717
2012	19.08	19.08	0	2.28	0	0	0.01	0.04
2015	45.78	4.34	0.49	6.12	0	0.76	0.013	0.06
2017	33.14	8.685	0	16.38	0	0.04	0	0

Exercise : ODS substitutes –Refrigerants (2F1) (using IPCC software)

From the National Ozone Unit, you have information on the mobile air-conditioning uses of HFC-134a in 2015 **(45.78t).** There **is no production of air-conditioning equipment in the country** and **no information on** the **previous imports**. Only the year of start of import of equipment using HFC-134a is known 2008.

1. In your data base, create a new inventory year for 2015
2. Calculate the emissions in **2015** using the IPCC software if the life-time of the equipment is estimated to 15, the growth rate in **new equipment sales is assumed 4%** and the **EF is assumed of 10%.**
3. Calculate the emissions in CO_2 eq.

IPCC Software: Refrigeration and AC



1. Select the category
2. Select the refrigerant –Select F-gases data to enter specific information for each refrigerant
3. Enter relevant minimal information

Enter the relevant data into the IPCC Software

Year Introduced

Yearly Growth Rate

Lifetime of gas (year)

EF

Subdivision Unspecified **Gas** HFC-134a (CH2FCF3) Chemical Data

Intro Year 2008 **Growth Rate (%)** 4 **Lifetime (d) (years)** 15 **EF (%)** 10 **Destroyed (%)** 0

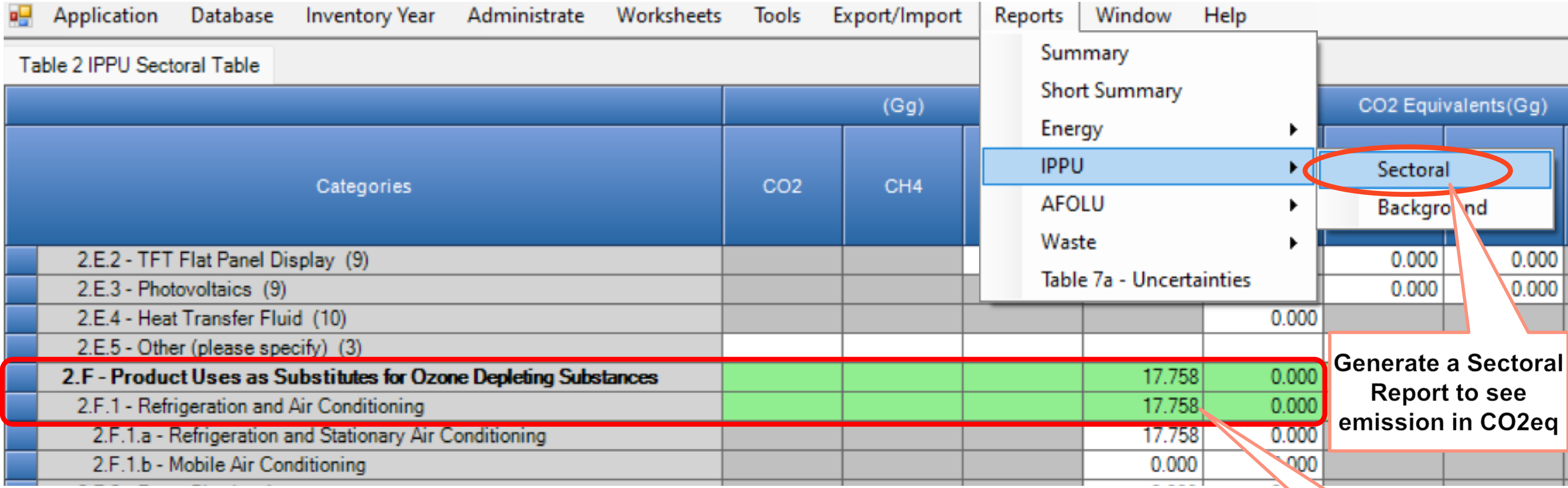
Equation 7.2

Year	Production (tonnes)	Exports (tonnes)	Imports (tonnes)	Total new agent to domestic market (tonnes)	Agent in retired equipment (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions (tonnes)
t	A	B	C	D = A - B + C	E	F = E * (Recovery/100)	G = E - F	H = H(t-1) - I(t-1) + D - E	I = H * (EF/100) + G
2008	0	0	3.26	3.26	0	0	0	3.26	0.326
2009	0	0	6.79	6.79	0	0	0	[illegible]	[illegible]
2010	0	0	10.59	10.59	0	0	0	[illegible]	[illegible]
2011	0	0	14.68	14.68	0	0	0	32.08744	[illegible]
2012	0	0	19.08	19.08	0	0	0	47.9587	[illegible]
2013	0	0	27.98	27.98	0	0	0	71.14283	[illegible]
2014	0	0	36.88	36.88	0	0	0	100.90854	[illegible]
2015	0	0	45.78	45.78	0	0	0	136.59769	13.65977
2016	0	0	39.46	39.46	[illegible]	0	0	162.39792	16.23979
2017	0	0	33.14	33.14	[illegible]	0	0	179.29813	17.92981

Emissions in tonnes of HFC-134a

Insert Activity Data in Tonnes

Answer



ANSWER

17.758 Gg CO2 eq

The Same solution using GWP

Substance	AR1 (1990)	AR2 (1995)	AR3 (2001)	AR4 (2007)	AR5 (2013)
Carbon dioxide, fossil (CO_2)	1	1	1	1	1
Methane, fossil (CH_4)	21	21	23	25	28
Methane, biogenic (CH_4)	18.25	18.25	20.25	22.25	25.25
Dinitrogen monoxide (N_2O)	290	310	296	298	265
HCFC-141b	440	-	700	725	782
HFC-134a	1200	1300	1300	1430	1300
HCFC-22	1500	-	1700	1810	1760
HCFC-142b	1600	-	2400	2310	1980
CFC-11	3500	-	4600	4750	4660
CFC-12	7300	-	10600	10900	10200
Sulfur hexafluoride	-	23900	22200	22800	23500

- Emissions (t) = T of Refrig * Bank (tonnes) *EF
- Convert Tonnes to Gg (1 Gg = 1000 tonnes)

=13.659 tonnes of HFC

=13.659 /1000

= 0.013659 Gg of HFC

= 0.013659 Gg of HFC * GWP

= **0.013659 Gg of HFC * 1300**

= 17. 758 Gg CO2eq

Questions?