Industrial Processes and Product Use (IPPU)

Remote Training on the IPCC Inventory Software for National Greenhouse Gas Inventories for the Latin American Region

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IPCC TFI TSU

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IPPU Sector

IPPU – GHG emissions:

1. Industrial Processes
2. Product Use

1. Industrial Processes.

Chemical or physical transformation of materials releasing GHGs

- chemically: $NH_3 + O_2 = 0.5\ N_2O\uparrow + 1.5\ H_2O$ *(nitric acid production)*
- physically: $CaCO_3 + (Heat) = CaO + CO_2\uparrow$

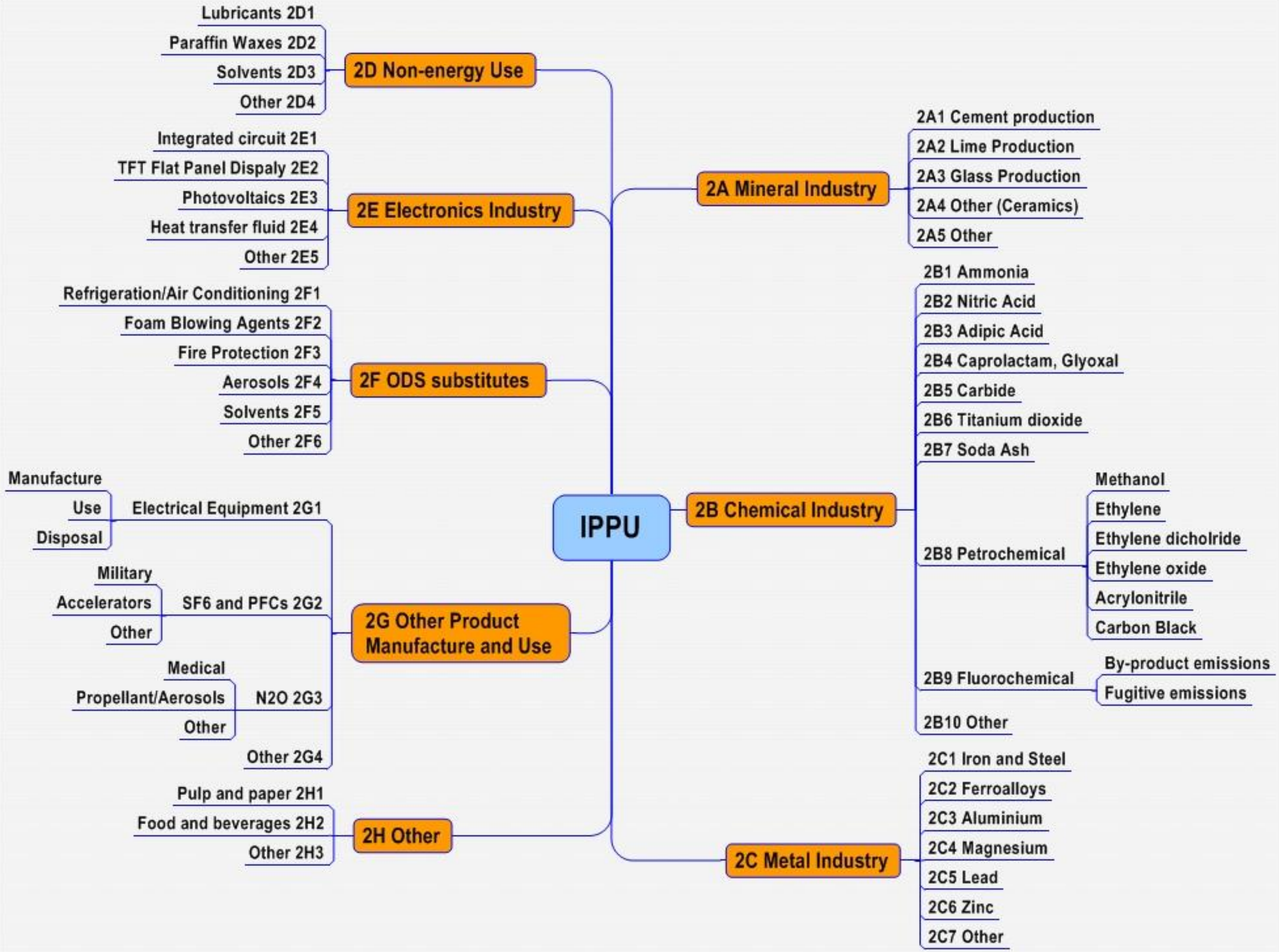
2. Product Use.

GHGs are used in products such as refrigerators, foams or aerosol cans

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**


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
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2F ODS substitutes
Refrigeration/Air Conditioning 2F1
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2G Other Product Manufacture and Use
Electrical Equipment 2G1
Manufacture
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SF6 and PFCs 2G2
Military
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Other
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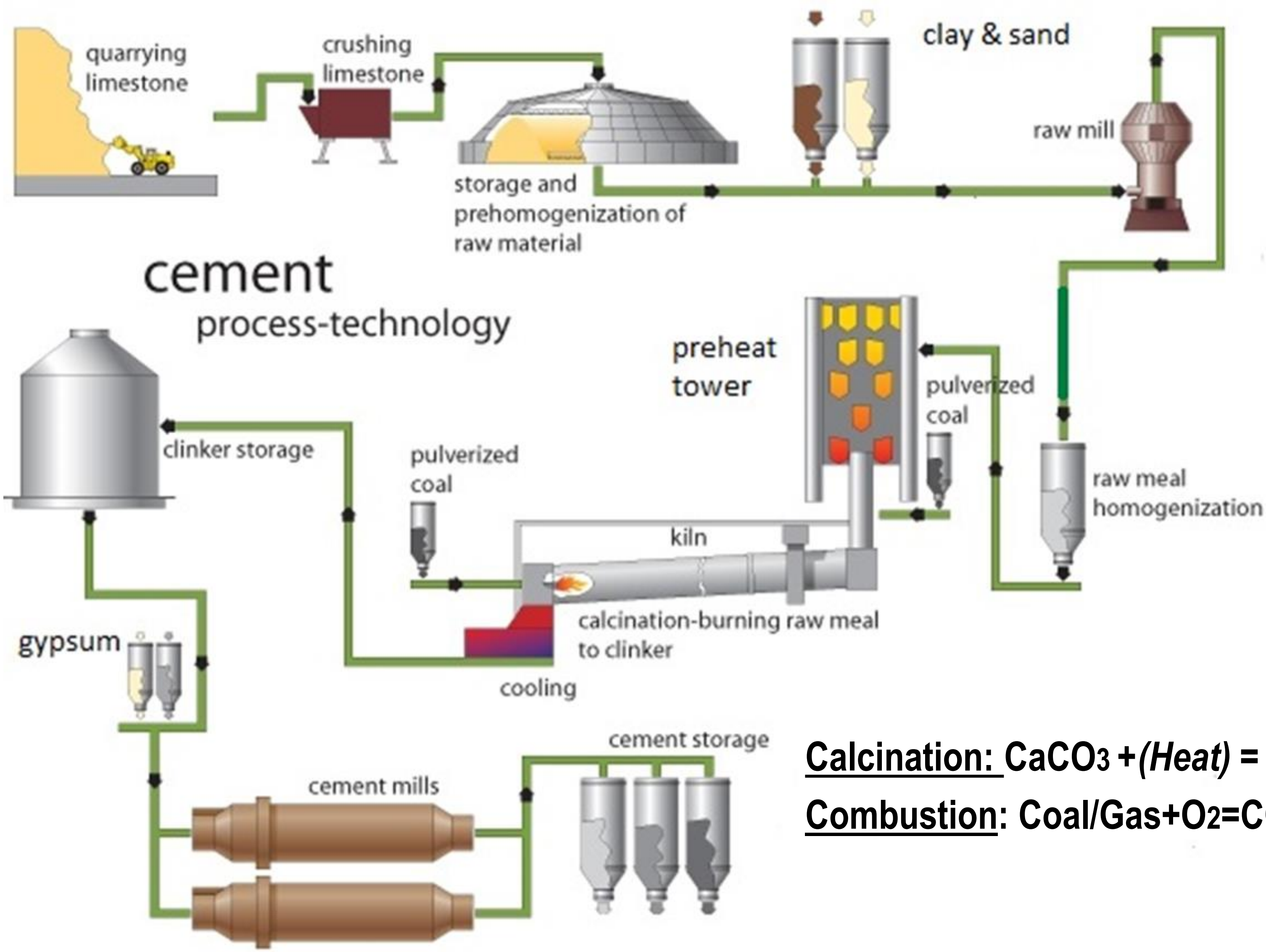
Medical
Propellant/Aerosols
Other
Other 2G4
2H Other
Pulp and paper 2H1
Food and beverages 2H2
Other 2H3
2A Mineral Industry
2A1 Cement production
2A2 Lime Production
2A3 Glass Production
2A4 Other (Ceramics)
2A5 Other
2B Chemical Industry
2B1 Ammonia
2B2 Nitric Acid
2B3 Adipic Acid
2B4 Caprolactam, 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

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**	0.10 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)*

2A1: CO_2 from Cement Production (Tier 1)

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

$$CO_2 \text{ Emissions} = AD_{\text{clinker production}} \times EF_{\text{clinker}}$$

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

$M_{c,i}$ - *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))

2A1: CO_2 from Cement Production (Tier 1)

To estimate clinker production based on the cement data:

- **National-level data should be collected on:**
  - Cement production by type (Portland, masonry, etc.)
  - Clinker fraction by cement type

- **If detailed information on cement type is not available, multiply total cement production by:**
  - Default Ccl = 0.75 (if blended/'masonry' is much)
  - Default Ccl = 0.95 (if all is essentially 'Portland')

- **Data should be obtained on the amount of clinker imported and exported**

2A1: CO_2 from Cement Production (Tier 2)

- Tier 2 includes a correction for CO_2 emissions associated with CKD not recycled to the kiln (these emissions are considered to be 'lost' and not accounted for)
  - ✓ *The amount of CO_2 from lost CKD can vary, but ranges are typically from about 1.5% for a modern plant to about 20% for a plant losing a lot of highly calcinated CKD. In the absence of data, the default CKD correction factor (CFckd) is 1.02 (i.e., add 2% to the CO_2 calculated for clinker).*

$$CO_2\ Emissions = M_{cl} \times EF_{cl} \times CF_{CKD}$$

EFcl - *emission factor for clinker uncorrected for CKD, 0.51 tonnes CO_2/tonne clinker (for Tier 1 – 0.51 x 1.02 = 0.52 t CO_2/t clinker).*

- Where data are available, a correction factor for CKD can be calculated using the following equation:

$$CF_{CKD} = 1 + (M_d / M_{cl}) * C_d * F_d * (EF_c / EF_{cl})$$

CF_{CKD} - *emissions correction factor for CKD, dimensionless*

M_d - *weight of CKD not recycled to the kiln, tonne*

M_{cl} - *weight of clinker produced, tonne*

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

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

EF_c - *emission factor for the carbonate, tonne CO_2/tonne carbonate*

2A1: CO_2 from Cement Production (Tier 3)

- Limestones and shales (raw materials) also may contain a proportion of organic carbon (kerogen); other raw materials (e.g., fly ash) may contain carbon residues, which would yield additional CO_2
- Detailed plant-level data on the carbonate raw materials is needed

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

$$CO_2\ Emissions = \underbrace{\sum_i (EF_i \bullet M_i \bullet F_i)}_{\text{Emissions from carbonates}} - \underbrace{M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d}_{\text{Emissions from uncalcined CKD not recycled to the kiln}} + \underbrace{\sum_k (M_k \bullet X_k \bullet EF_k)}_{\text{Emissions from carbon-bearing non-fuel materials}}$$

2B: Chemical Industry

Code	Category	Default EF		
		CO_2	N_2O	CH_4
2B1:	Ammonia Production	X		
2B2:	Nitric Acid Production		X	
2B3:	Adipic Acid Production		X	
2B4:	Caprolactam, Glyoxal and Glyoxylic Acid Production		X X X	
2B5:	Carbide Production - SiC - CaC_2	 X X		X
2B6:	Titanium Dioxide Production	X		
2B7:	Soda Ash Production	X		

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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

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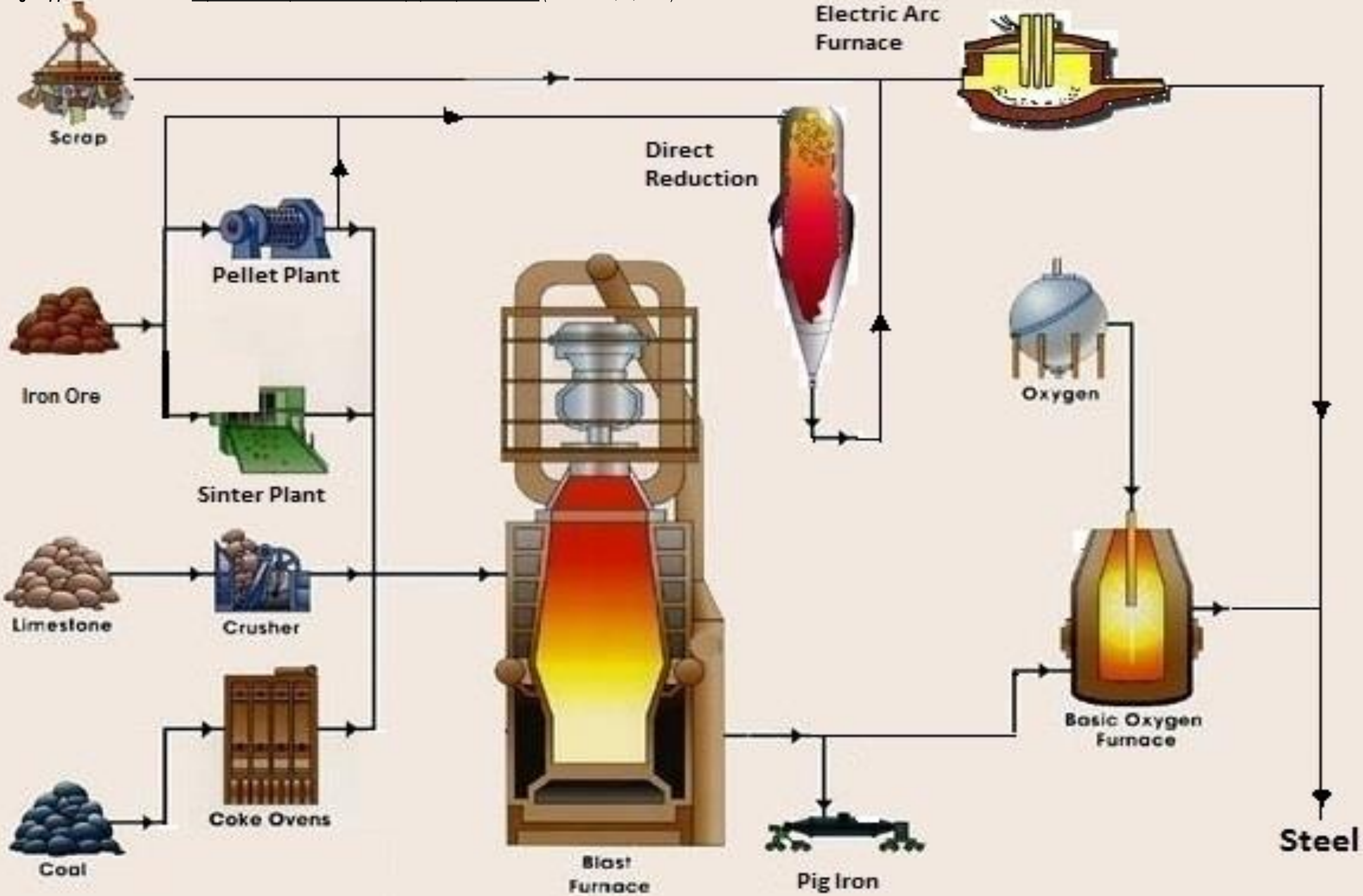
2C: Metal Industry

Code	Category	CO_2	CH_4	F-gases
2C1:	Iron and Steel Production	X	X	
2C2:	Ferroalloys Production	X	X	
2C3:	Aluminium Production	X		X
2C4:	Magnesium Production	X		X
2C5:	Lead Production	X		
2C6:	Zinc Production	X		
2C7:	Other			

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



Coke production: (Energy)

Coal + (*Heat*) = Coke + Carbon Dioxide

Iron Production: Coke + Iron Ore = Iron + Carbon Dioxide (IPPU)

Combustion: Coke + Oxygen = Carbon Dioxide + (*Heat*) (IPPU)

2C1: CO_2 from Iron and Steel Production (Tier 1)

CO_2 emissions from Iron & Steel production:

$$CO_2 \text{ Emissions} = \Sigma(AD_i \times EF_i)$$

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

Material *i*	Default EF	Global average default EF for Steel
	tonne CO2/tonne material *i*	
▪ Crude steel from Basic Oxygen Furnace	1.46	1.06
▪ Crude steel from Electric Arc Oxygen Furnace	0.08	
▪ Crude steel from Open Hearth Furnace	1.72	
▪ Pig iron not converted to steel	1.35	(If activity data on steel production for each process is not available, multiply total steel production by this EF)
▪ Direct reduced iron	0.70	
▪ Sinter	0.20	
▪ Pellet	0.03	

2C1: CO_2 from Iron and Steel Production (Tier 2)

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

CO_2 EMISSIONS FROM IRON & STEEL PRODUCTION (TIER 2)

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

CO_2 EMISSIONS FROM SINTER PRODUCTION (TIER 2)

$$E_{CO2,non-energy} = \left[CBR \bullet C_{CBR} + COG \bullet C_{COG} + BG \bullet C_{BG} + \sum_a (PM_a \bullet C_a) - SOG \bullet C_{SOG} \right] \bullet \frac{44}{12}$$

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2C1: CO_2 from Iron and Steel Production (Tier 2)

CO_2 EMISSIONS FROM IRON & STEEL PRODUCTION (TIER 2)

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

PC - quantity of coke consumed in iron and steel production (not including sinter production), tonne
COBa - quantity of onsite coke oven by-product a, consumed in blast furnace, tonne
CI - quantity of coal directly injected into blast furnace, tonne
L - quantity of limestone consumed in iron and steel production, tonne
D - quantity of dolomite consumed in iron and steel production, tonne
CE - quantity of carbon electrodes consumed in EAFs, tonne
O_b - quantity of other carbonaceous and process material *b*, consumed in iron and steel production, such as sinter or waste plastic, tonne
COG - quantity of coke oven gas consumed in blast furnace, m3 (or tonne or GJ)
S - quantity of steel produced, tonne
IP - quantity of iron production not converted to steel, tonne
BG - quantity of blast furnace gas transferred offsite, m_3 (or other unit such as tonne or GJ)
C_x - carbon content of material input or output *x*, tonne C/(unit for material *x*)

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2C1: CO_2 from Iron and Steel Production (Tier 3)

- Unlike the Tier 2 method, the Tier 3 method uses plant specific data.
- If actual measured CO_2 emissions data are available from iron and steel making facilities, these data can be aggregated to account for national CO_2 emissions.
- If facility-specific CO_2 emissions data are not available, CO_2 emissions can be calculated from plant-specific activity data for individual reducing agents, exhaust gases, and other process materials and products. Total national emissions will equal the sum of emissions reported from each facility.
  - ✓ *Equations for Tier 2 describe the parameters that are necessary for an accounting of plant-specific emissions using the Tier 3 method and plant-specific activity data at a facility level. Plant-specific carbon contents for each material are required for the Tier 3 method.*

CO_2 Emissions from Coke Production

- Metallurgical coke is produced either at the Iron and steel facility (‘onsite’) or at separate facilities (‘offsite’).
- The Tier 1 method calculates emissions from all coke production using default CO_2 and CH_4 EFs applied to national coke production.
- The Tier 2 method for estimating CO_2 emissions distinguishes between onsite and offsite coke production. It uses national activity data for the consumption and production of process materials (e.g., coking coal consumed, coke produced, and coal tar products produced).
- Tier 2 method is not applicable to estimating CH_4 emissions (it is a mass-balance for Carbon and subsequent CO_2).

✓ ***Emissions from Coke Production should be reported in the <u>Energy Sector</u>***

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

2E: Electronics Industry

Code	Category
2E1:	Integrated Circuit or Semiconductor
2E2:	TFT Flat Panel Display
2E3:	Photovoltaics
2E4:	Heat Transfer Fluid
2E5:	Other

Gases: CF_4, C_2F_6, C_3F_8, c-C_4F_8, c-C_4F_8O, C_4F_6, C_5F_8, CHF_3, CH_2F_2, nitrogen trifluoride (NF_3), sulfur hexafluoride (SF6)

Electronics industry:

several advanced electronics manufacturing processes utilise fluorinated compounds for plasma etching silicon containing materials, cleaning reactor chambers, and temperature control. The specific electronic industries include semiconductor, thin-film-transistor flat panel display (TFT-FPD), and photovoltaic (PV) manufacturing

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: 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**	

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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: Blends

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)

Actual emissions vs. *Potential emissions*

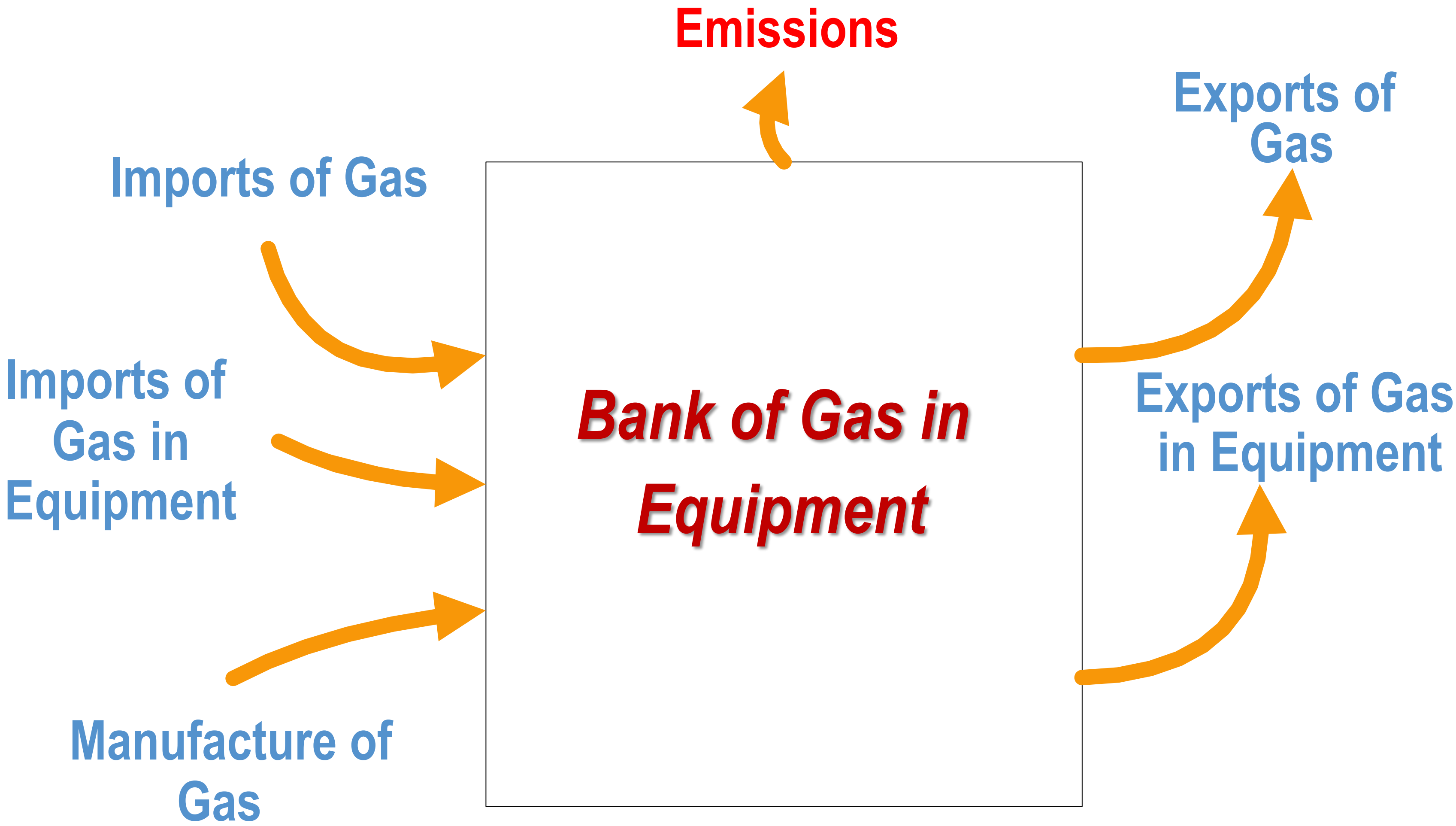
- **The 2006 IPCC Guidelines provide with methods for estimating *actual emissions* of ODS substitutes in contrast to *potential emissions* approach (***1996 IPCC Guidelines***) taking into account the time lag between consumption of ODS substitutes and emissions.**

- ***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

Estimating Bank and Emissions



2F1: Refrigeration and Air Conditioning (Tier 1)

- **The Tier 1 method calculates back the development of a bank of a refrigerant from the current reporting year to the year of its introduction. The 2006 IPCC Guidelines contain the MS Excel spreadsheet for such estimation, and it is implemented in the IPCC Inventory Software**

- **The IPCC Inventory Software enables to estimate actual emissions, even if there is no have historic data, but the following assumptions/data should be input:**
  - 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

Tier 1 Refrigeration
Argentina - HFC-143a

HFC-143a	
Current Year	2005
	Data Used Here
Use in current year - 2005 (tonnes)	
Production of HFC-143a	800
Imports in current Yea	200
Exports in current yea	0
Total new agent to domestic marke	*1000*
Year of Introduction of HFC-143	1998
Growth Rate in New Equipment Sales	3.0%
Tier 1 Defaults	
Assumed Equipment Lifetime (years	15
Emission Factor from installed bas	15%
% of HFC-143a destroyed at End-of-Lif	0%

***Example 1**. In Country X the production of a specific refrigerant (HFC-143a) is 800 tonnes with an additional 200 tonnes in imported equipment, making a total consumption of 1 000 tonnes in 2005. There is no data for previous years.*

To enter only:

Year of introduction of chemical - 1998

Domestic production of chemical in current year - 800

Imports of chemical in current year - 200

Exports of chemical in current year - 0

Growth rate of sales of equipment that uses the chemical – 3%

Default parameters:

Equipment lifetime – 15 years

EF from the bank – 15%

EF end-of-life destruction – 0%

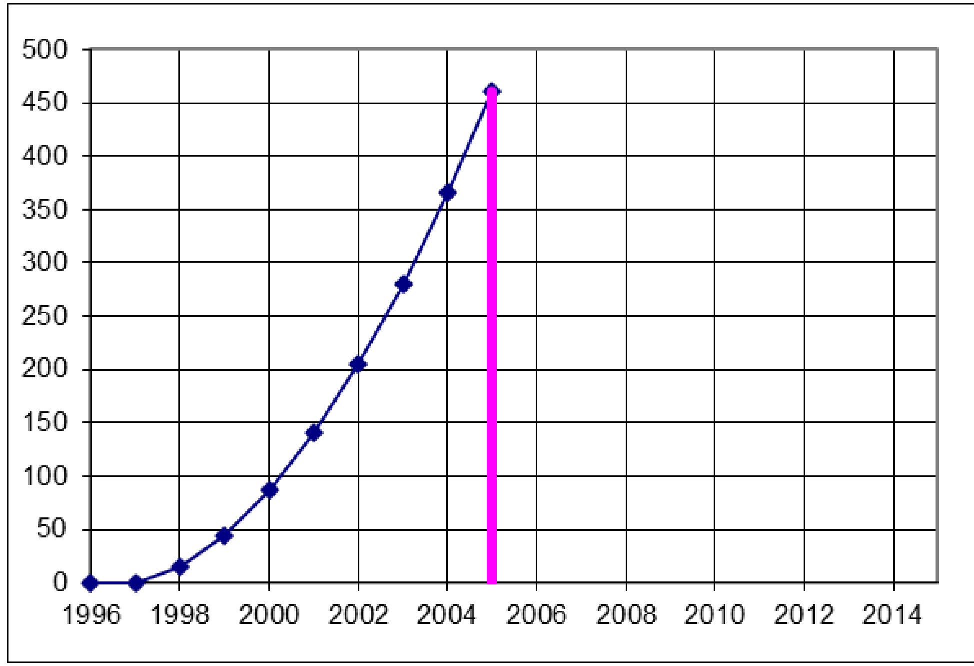
Estimated data for earlier years	1996	1997	1998	1999	2000	2001	2002	2003	2004	**2005**
Production	0	0	81	167	259	355	458	566	680	**800**
Agent in Exports	0	0	0	0	0	0	0	0	0	**0**
Agent in Imports	0	0	20	42	65	89	114	141	170	**200**
Total New Agent in Domestic Equipment	0	0	102	209	323	444	572	707	850	**1000**
Agent in Retired Equipment	0	0	0	0	0	0	0	0	0	**0**
Destruction of agent in retired equipment	0	0	0	0	0	0	0	0	0	**0**
Release of agent from retired equipment	0	0	0	0	0	0	0	0	0	**0**
Bank	0	0	102	296	575	933	1365	1867	2437	**3071**
Emission	0	0	15	44	86	140	205	280	365	**461**

Example 1. ***Based on the consumption figure of 1000 tonnes, the model calculates back the development of a bank of a refrigerant from the current reporting year (2005) to the year of its introduction (1998). So, in the 2005 the bank is estimated to be 3 071 tonnes and emissions are 461 tonnes.***

Tier 1 Refrigeration
Argentina - HFC-143a

HFC-143a

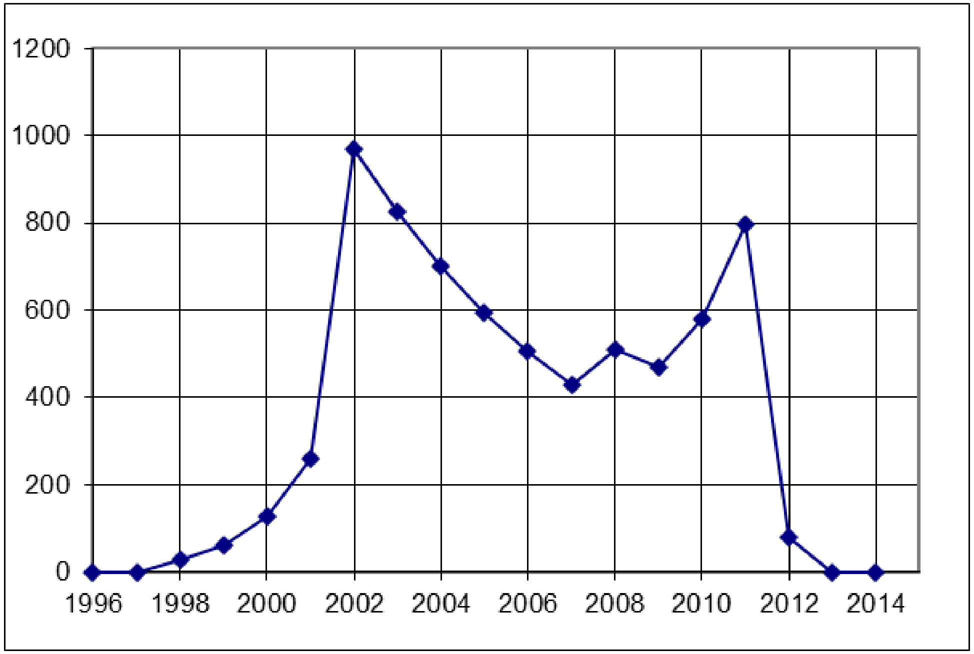
Current Year	2005
	Data Used Here
Use in current year - 2005 (tonnes)	
Production of HFC-143a	800
Imports in current Year	200
Exports in current year	0
Total new agent to domestic market	*1000*
Year of Introduction of HFC-143a	1998
Growth Rate in New Equipment Sales	3.0%
Tier 1 Defaults	
Assumed Equipment Lifetime (years)	15
Emission Factor from installed base	15%
% of HFC-143a destroyed at End-of-Life	0%



Estimated data for earlier years	1996	1997	1998	1999	2000	2001	2002	2003	2004	**2005**
Production	0	0	81	167	259	355	458	566	680	**800**
Agent in Exports	0	0	0	0	0	0	0	0	0	**0**
Agent in Imports	0	0	20	42	65	89	114	141	170	**200**
Total New Agent in Domestic Equipment	0	0	102	209	323	444	572	707	850	**1000**
Agent in Retired Equipment	0	0	0	0	0	0	0	0	0	**0**
Destruction of agent in retired equipment	0	0	0	0	0	0	0	0	0	**0**
Release of agent from retired equipment	0	0	0	0	0	0	0	0	0	**0**
Bank	0	0	102	296	575	933	1365	1867	2437	**3071**
Emission	0	0	15	44	86	140	205	280	365	**461**

Example 2. **Country X imported the refrigerant HFC-134a in years 1998-2002 only. There is no production, export and import after 2002** (the import data for 1998-2002 presented in the table below).

Based on the import data and factors from Example 1 (except lifetime is 10 years), it can be estimated that emissions still will take place till 2012 taking into account development of the bank and emissions from retired equipment.



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Production																		
Agent in Exports																		
Agent in Imports		200	250	500	1000	5000												
Total New Agent in Domestic Equipment		200	250	500	1000	5000												
Agent in Retired Equipment												170	213	425	784	81		
Destruction of agent in retired equipment												0	0	0	0	0		
Release of agent from retired equipment												170	213	425	784	81		
Bank		200	420	857	1728	6469	5499	4674	3973	3377	2870	2270	1717	1034	95	0	0	0
Emission		30	63	129	259	970	825	701	596	507	431	510	470	580	799	81	0	0

2F1: Refrigeration and Air Conditioning (Tier 2)

Tier 2a *(Emission Factor Approach):*

$$Emissions = E_{containers} + E_{charge} + E_{lifetime} + E_{end\text{-}of\text{-}life}$$

- $E_{containers} = RM * c/100$
- $E_{charge} = M * k/100$
- $E_{lifetime} = B * x/100$
- $E_{end\text{-}of\text{-}life} = M * p/100 * (1- n/100)$

EFs: c, k, x, p, n

Tier 2b *(Mass Balance Approach):*

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

2G: Other Product Manufacture and Use

Code	Category	Code	Category
2G1	Electrical Equipment	2G2c	Other
2G1a	Manufacture	2G3	N_2O from Product Uses
2G1b	Use	2G3a	Medical Applications
2G1c	Disposal	2G3b	Propellant for Pressure
2G2	SF_6/PFCs from Other Uses	2G3c	Other
2G2a	Military Applications	2G4	Other
2G2b	Accelerators		

- **SF_6 and PFCs: electrical equipment:** gas insulated switchgear and substations (GIS), gas circuit breakers (GCB), high voltage gas-insulated lines (GIL), gas-insulated power transformers (GIT). **Military equipment:** ground and airborne radar, avionics, missile guidance systems, ECM (Electronic Counter Measures), sonar, amphibious assault vehicles, other surveillance aircraft, lasers, SDI (Strategic Defense Initiative), stealth aircraft. PFCs for cooling electric motors, e.g., in ships and submarines. **Cosmetic and medical applications, research particle accelerators.**
- **N_2O: Medical applications, Auto-racing, Propellant in aerosol products**

Conclusion

- **Diversity of sources and gases in the IPPU Sector**
  - Difficult to exhaustively include all sources & gases
  - At least major sources & gases *(key categories*) must be included
- **Care to Activity Data:**
  - Difficult to collect activity data *(input/output data, plant-specific data)*
  - Data allocation and Double-counting
  - Confidential data from private companies
- **Various opportunities for GHG abatement**
  - Capture and abatement at plants *(N_2O destruction at nitric acid production plants*)
  - Recovery at the end of product's life and subject to either recycled or destroyed *(HFCs in refrigerators)*

Thank you

https://www.ipcc-nggip.iges.or.jp/index.html

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INTERGOVERNMENTAL PANEL ON climate change

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