United Nations
Office for Sustainable Development

IPCC Guideline vol.3

Industrial Process and Product Use (IPPU)

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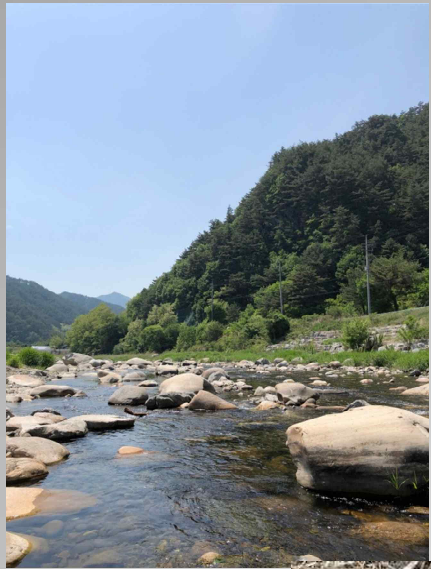

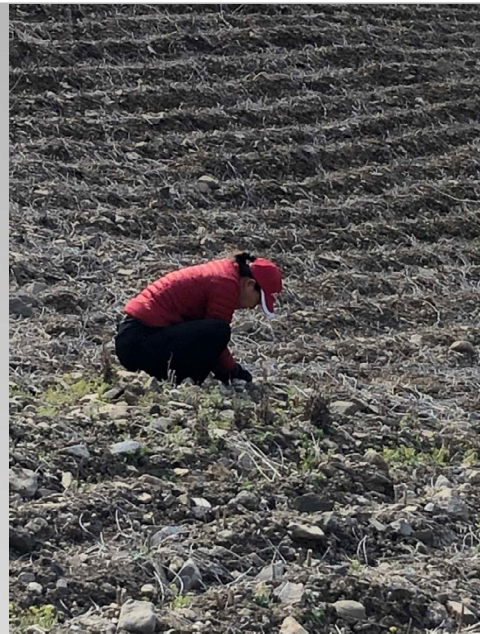

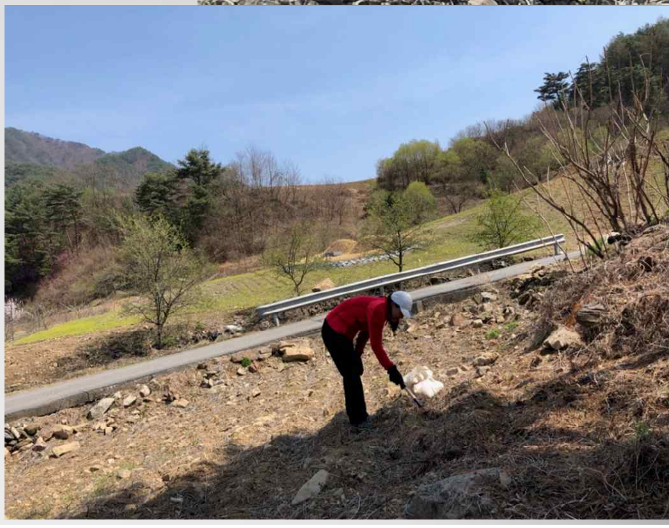

Seeking for my Net-Zero Life

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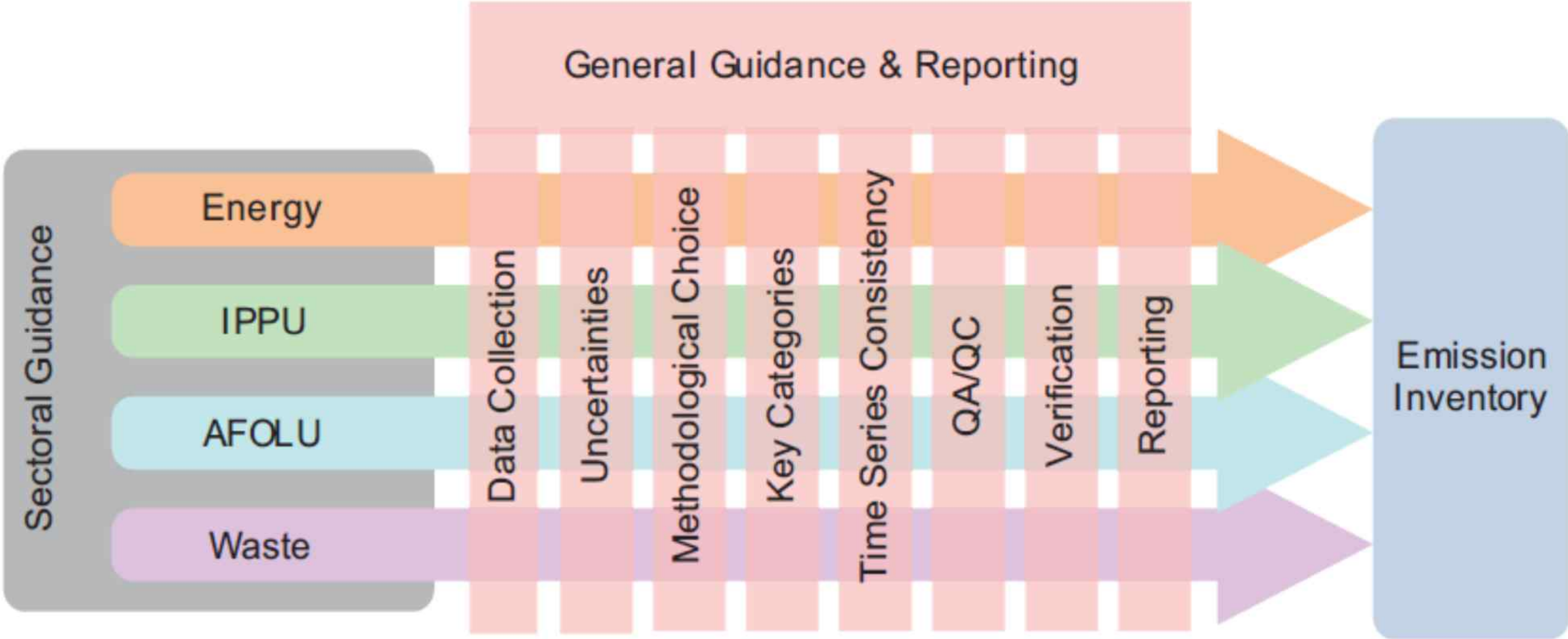


Relationship between General and Sectoral Guidance

IPCC Guidelines

- Contents
  - Introduction
  - Mineral/Chemical/Metal Industry Emissions
  - Non-Energy Product from Fuels and Solvent Use
  - Electronics Industry Emissions
  - Fluorinated Substitutes for Ozone Depleting Substances
  - Other Product Manufacture and Use

IPPU, What is it about?

- Greenhouse gas emissions occurring from
  - industrial processes,
  - the use of greenhouse gases in products,
  - non-energy use of fossil fuel carbon.

What is it really about?

- Chemically or physically transform materials . e.g.:
  - The blast furnace in the iron and steel industry
  - Cement industry
  - Ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock
    - chemically: $NH_3 + O_2 = 0.5\ N_2O\uparrow + 1.5\ H_2O$ (nitric acid production)
    - physically: $CaCO_3 + (Heat) = CaO + CO_2\uparrow$

What is Industrial Process?

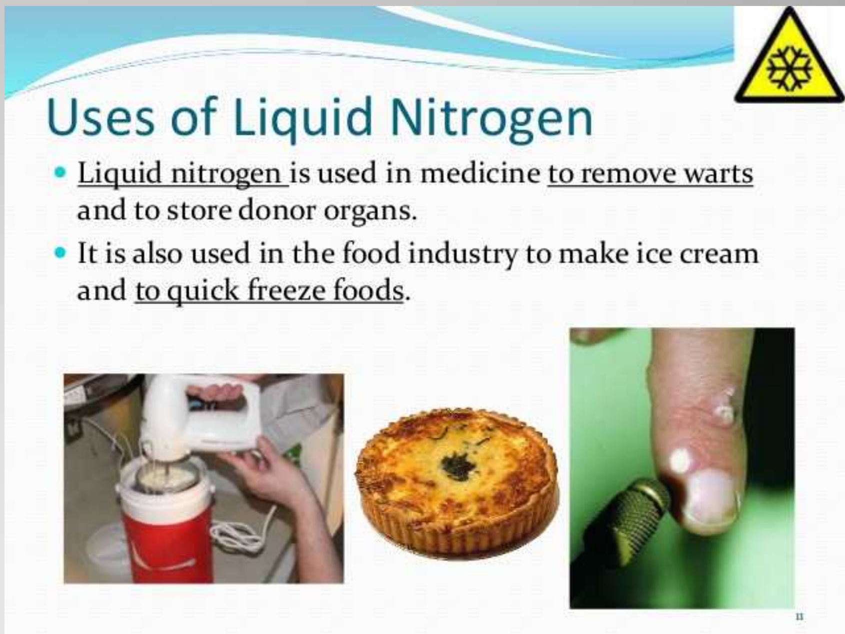
What is Product Use?

- GHG related
- Refrigerators, foams or aerosol cans.
  - HFCs as alternatives to ODS
  - SF_6 used in electrical equipment
  - N_2O used as a propellant in aerosol products in food industry
- End-consumers
  - SF_6 used in running-shoes
  - N_2O used during anesthesia

- Old and new refrigerants

Refrigerants as ODS substitutes

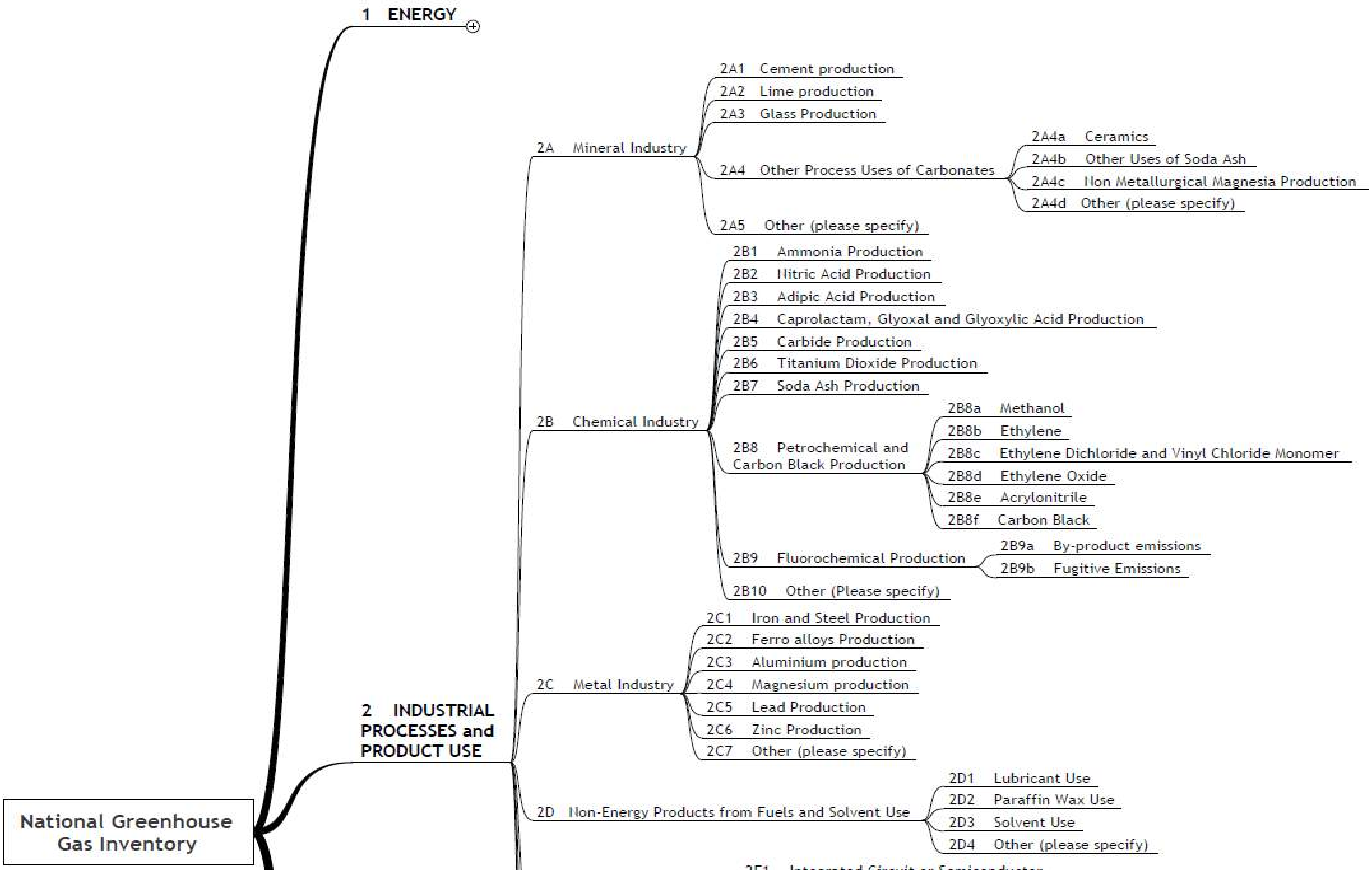
Nitrogen used in the Food Industry



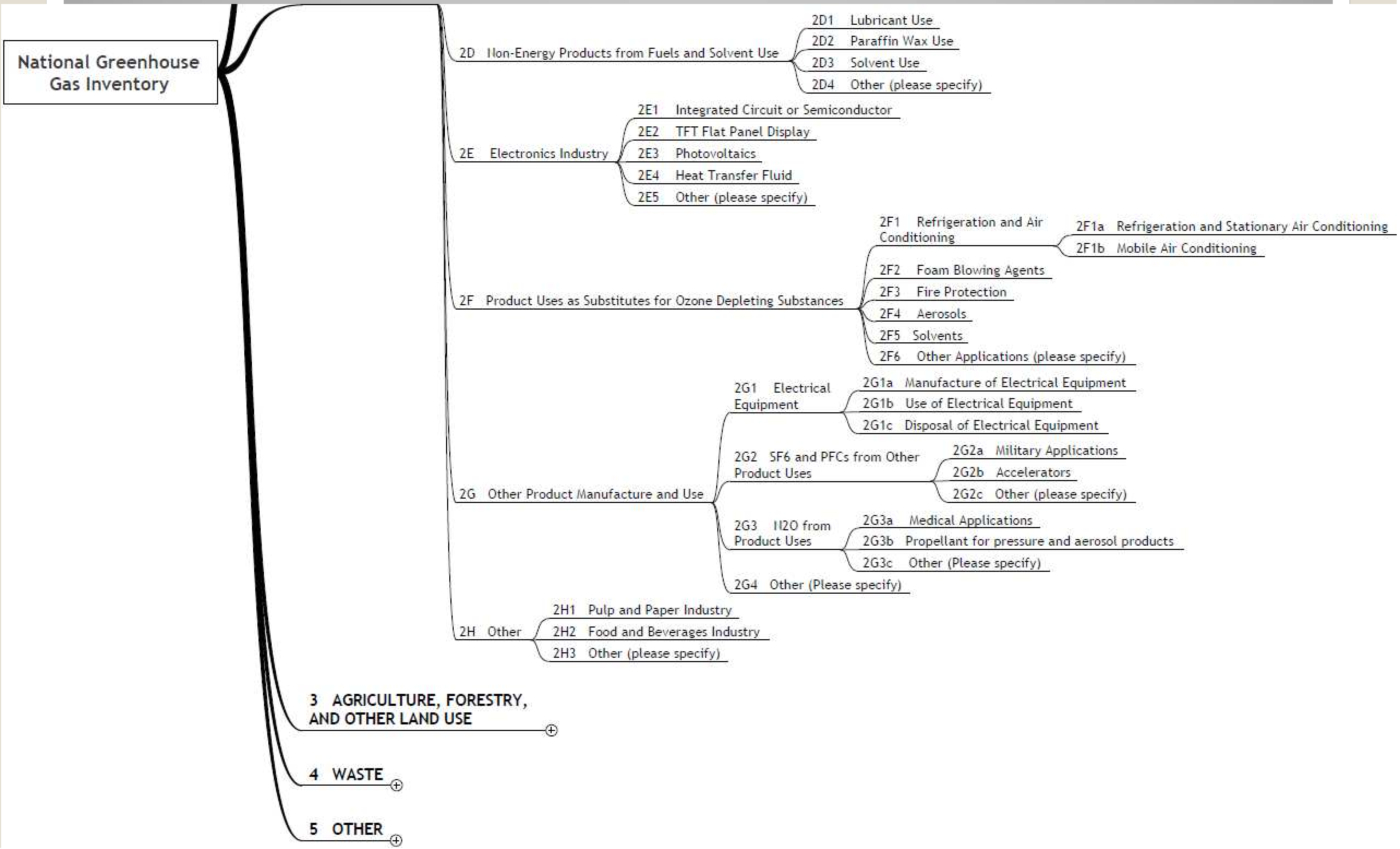
Q. What kinds of main industries does your country have?

Exercise 1

The IPPU Sectors (1/2)



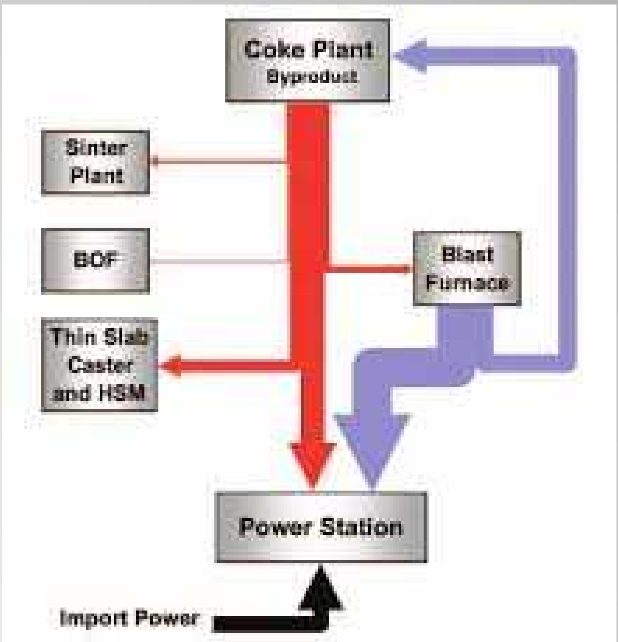
The IPPU Sectors (2/2)



- Allocation / Double Counting
  - by-product fuels or waste gases are transferred from the manufacturing site and combusted elsewhere in quite different activities.
  - to be reported in the IPPU sector or fossil fuel use in an Energy Sector?

The Complicated Issues in IPPU

Example of Allocation Issue – metal industry



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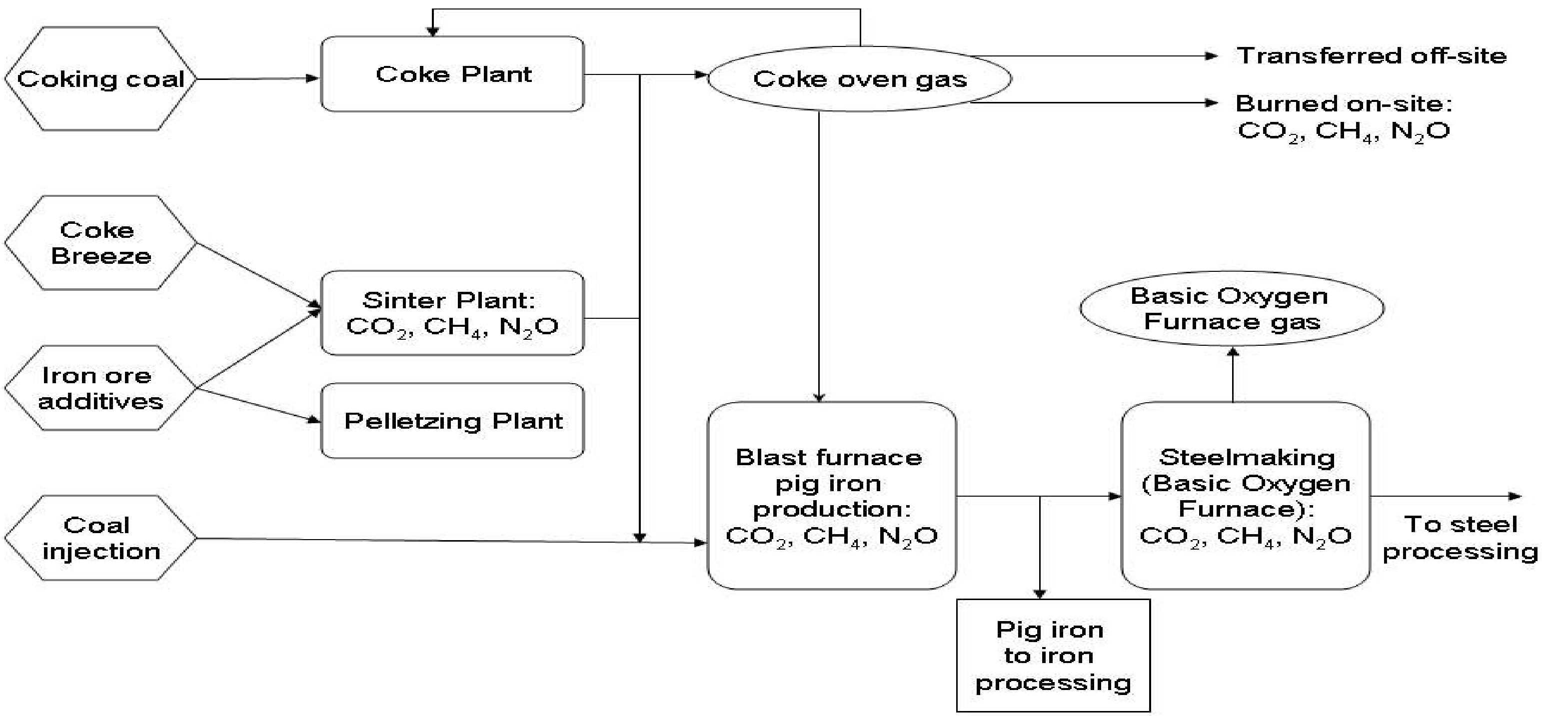
Steel Manufacturing Process

Example of Allocation Issue – metal industry

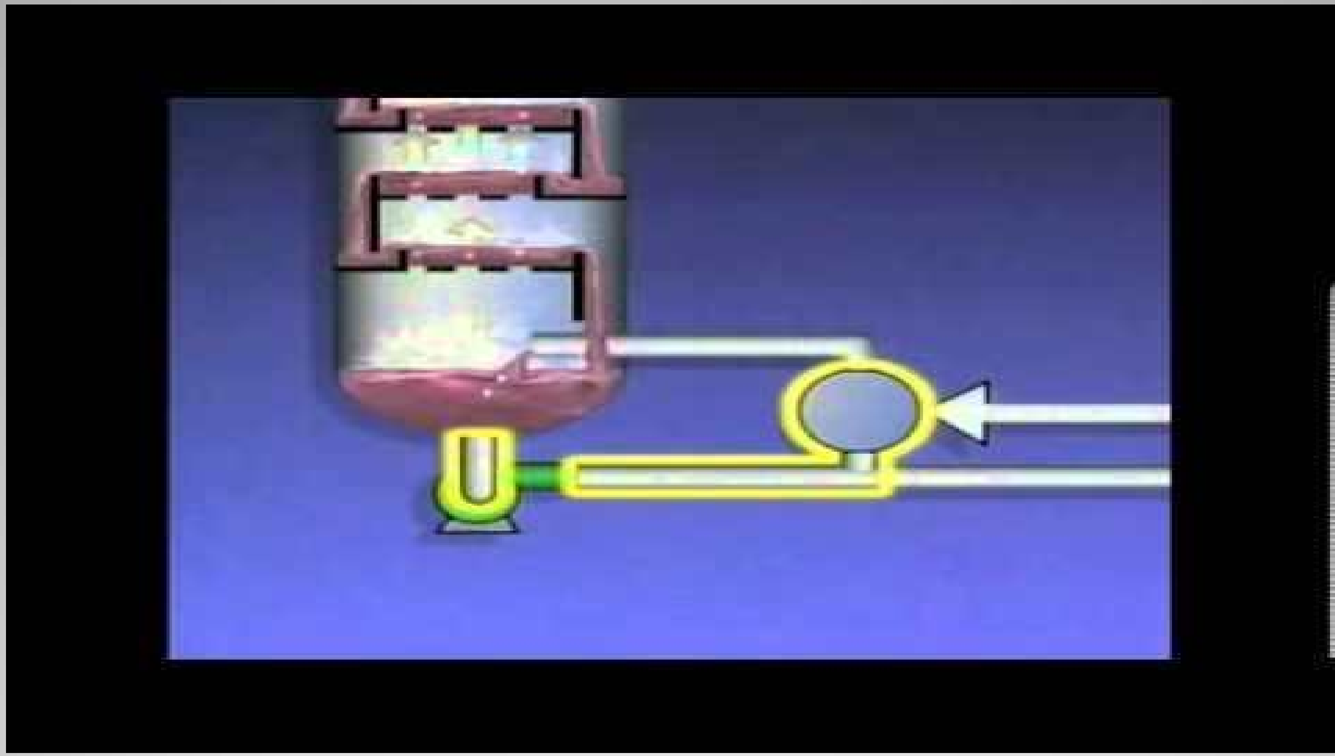


- blast furnace
  - Blast furnace gas is combusted entirely within the Iron and Steel industry (whether for heating blast air, site power needs or for metal finishing operations) the associated emissions are reported in the IPPU subcategory 2C1 (Iron and steel production).
  - If part of the gas is delivered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

Example of Boundary and Allocation Issue

- Naphtha cracking in petrochemical
  - If surplus methane or hydrogen from the steam cracking of naphtha is combusted within the petrochemical site for another process then reported as IPPU, subcategory 2B8.
  - If the gases are passed to a nearby refinery for fuel use, then reported as Energy, 1A1b (Petroleum refining)

Boundary and Allocation



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Refinery Crude Oil Distillation Process

- Refrigerant in Cars, home & office Air Conditioners?
  - capture and emissions for recovery and use or destruction.
  - good practice to account for capture of emissions using detailed country-specific or more suitably plant-level data.

Capture and Abatement

Capture and Abatement

- Carbon Capture Technology
  - good practice to deduct the GHG captured in a higher tier emission calculation, e.g. plant level.
  - emissions from captured in the process may be both combustion- and process-related. Be careful of double-counting.
  - capture and storage issues refer to Volume 2, Section 2.3.4

- Feedstock: used as raw materials in chemical conversion processes in order to produce primarily organic chemicals and inorganic chemicals and their derivatives.

- Reductant: used as reducing agent for the production of various metals and inorganic products.

- Non-energy product: refineries and coke ovens produce some non-energy products. Lubricants and greases, paraffin waxes, etc.

What is Non-Energy Use?

- The mass-balance approach
  - "I know the beginning and the end"
  - Accountant approach
- The emission factor approach
  - "Based on the trend, I can presume"
  - Empirical

GHG Calculation in IPPU
The methods (MB and EF)

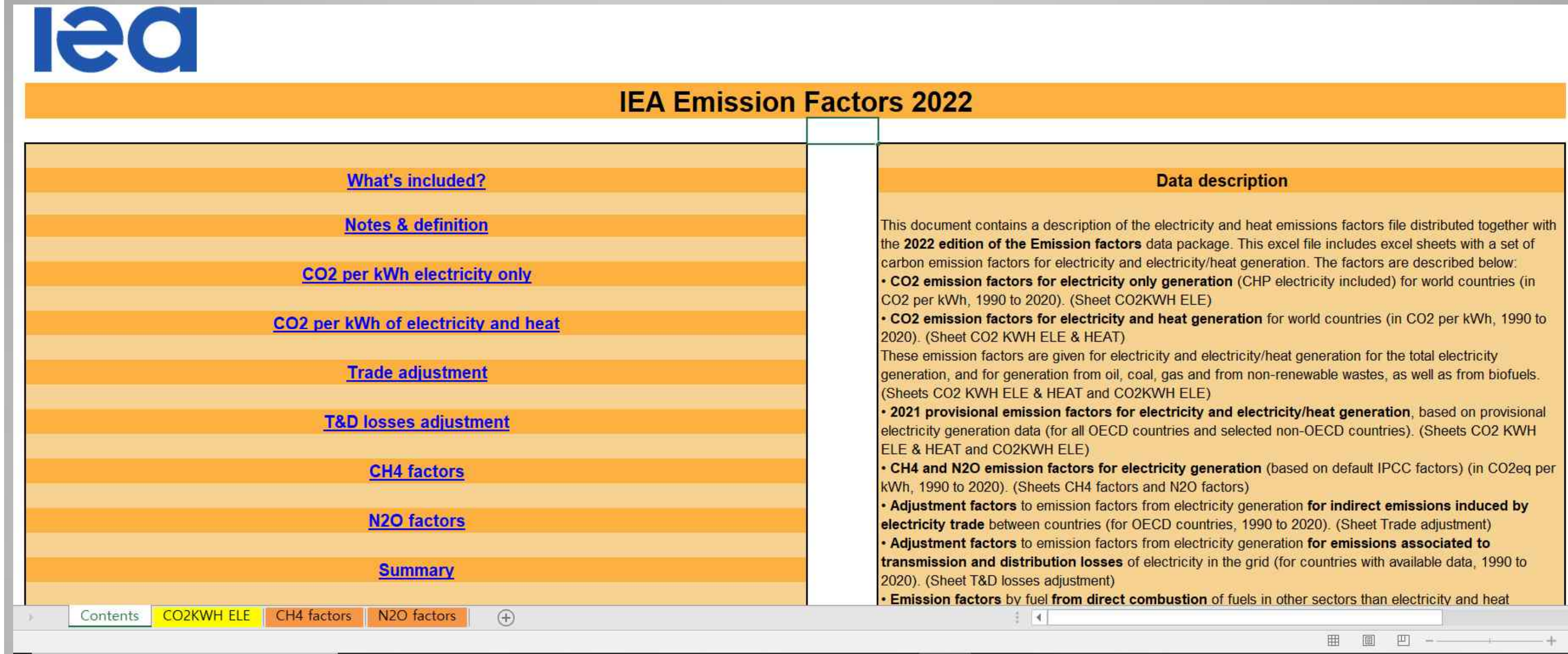
- more accurate when emission rate vary across equipment and facilities, or over time.
- consideration
  - accurate activity data for the MB approach should be a available
  - drawbacks: 1. inaccuracy of measuring devices,
  - 2. slow leakage afterwards. i.e. time lag.

Mass-balance(MB) approach

Emission Factor(EF) approach

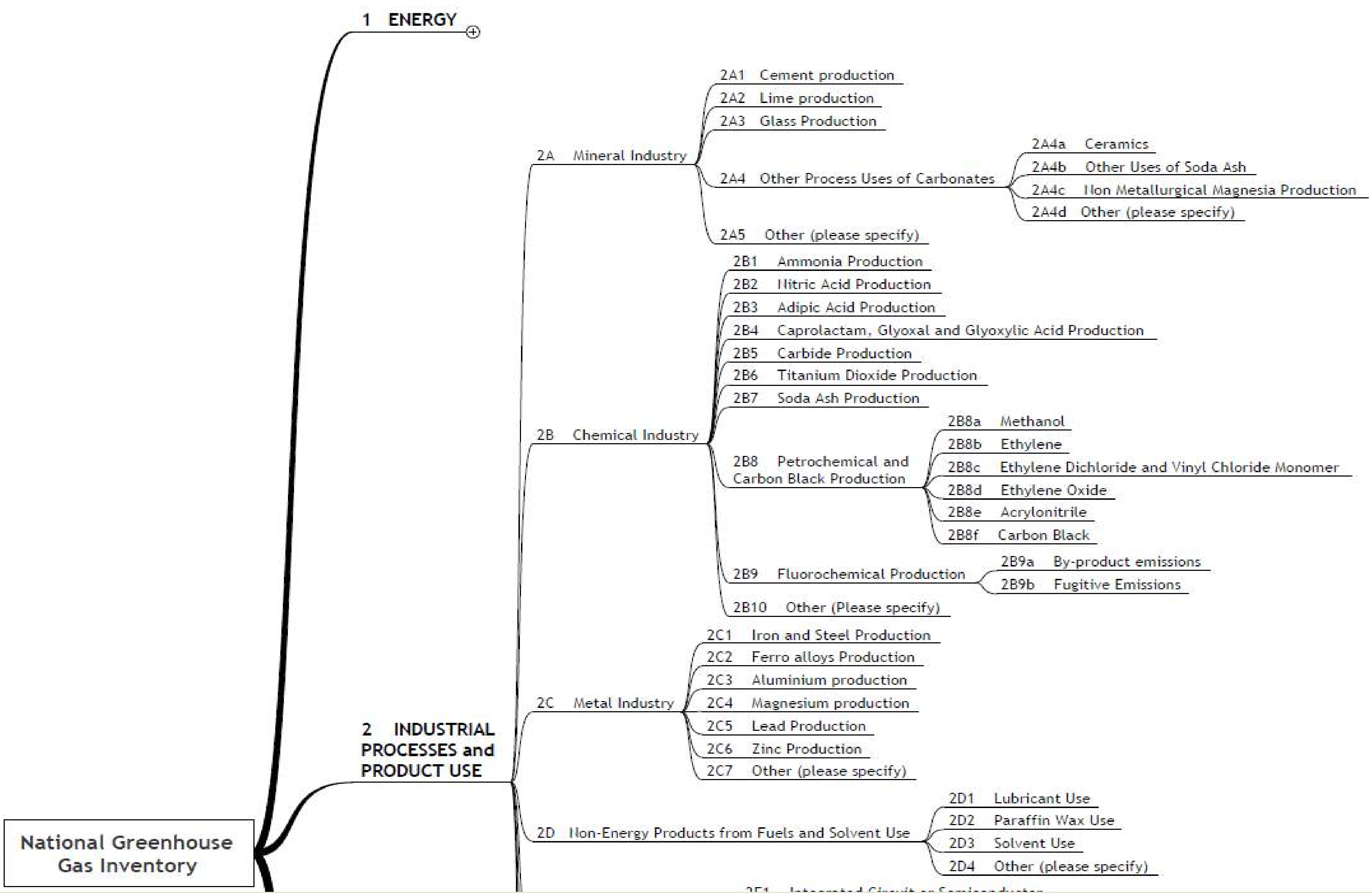
- Using nameplate capacity of the equipment, apparent leak vs actual leak
- Continuing accuracy of its EF is the key for robustness and reliability.
  - periodical check of EF is necessary.
- Limitation: EF for ODS substitutes and SF_6 from electrical equipment do not exist for all regions of the world.

- What is my country’s electricity EF?

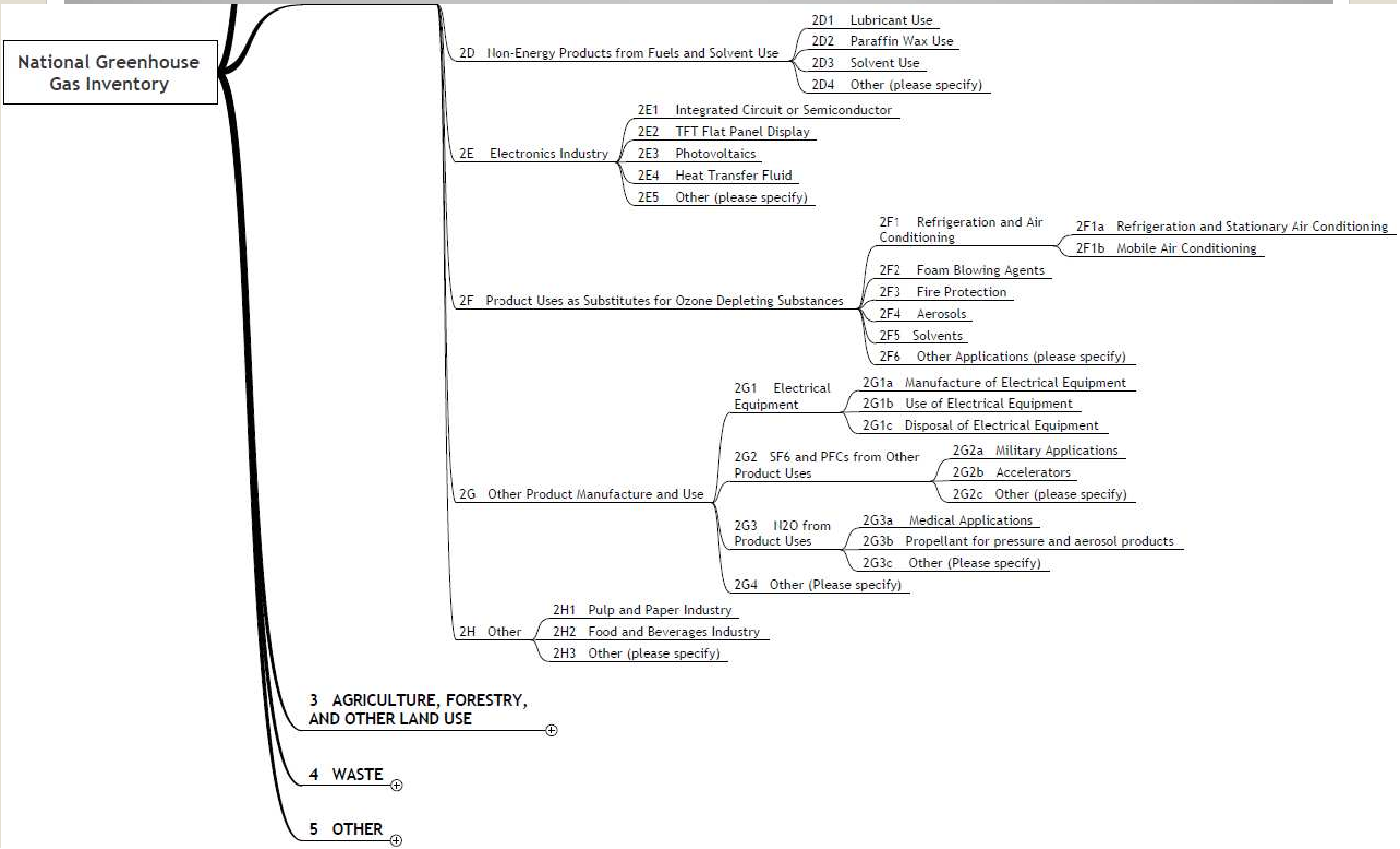


IEA – Emission Factors 2022

The IPPU Sectors (1/2)



The IPPU Sectors (2/2)



- It is about Data Accuracy and Data availability.
  - Tier 1
  - Tier 2
  - Tier 3
- Inventory for small and large GHG emitters, which tier is appropriate?

Methodologies – Understanding the Tier

- Tier 1 – average value of the world
- Tier 2 – national statistical value
- Tier 3 – Actual value (Plant specific data)

Understanding the Tier (e.g. weight)

- Uncertainty Assessment
  - *"Doubt is not a pleasant condition, but certainty is an absurd one." - Voltaire*
- Required uncertainty level

Uncertainty Assessment

Iron & Steel Production GHG calculation– How to?

Total emissions are the sum of Equations 4.4 to 4.8.

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

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

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

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

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

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

EQUATION 4.7
CO_2 EMISSIONS FROM SINTER PRODUCTION (TIER 1)

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

EQUATION 4.8
CO_2 EMISSIONS FROM PELLET PRODUCTION (TIER 1)

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

Tier 1

Where:

$E_{CO2,\, non-energy}$ = emissions of CO_2 to be reported in IPPU Sector, tonnes

BOF= quantity of BOF crude steel produced, tonnes

EAF = quantity of EAF crude steel produced, tonnes

OHF = quantity of OHF crude steel produced, tonnes

IP = quantity of pig iron production not converted to steel, tonnes

DRI = quantity of Direct Reduced Iron produced nationally, tonnes

SI = quantity of sinter produced nationally, tonnes

P = quantity of pellet produced nationally, tonnes

EF_x= emission factor, tonnes CO_2/tonne *x* produced

Iron & Steel Production GHG calculation– How to?

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

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

Where, for iron and steel production:

$E_{CO2,\ non\text{-}energy}$ = emissions of CO_2 to be reported in IPPU Sector, tonnes

PC = quantity of coke consumed in iron and steel production (not including sinter production), tonnes

COB_a = quantity of onsite coke oven by-product *a*, consumed in blast furnace, tonnes

CI= quantity of coal directly injected into blast furnace, tonnes

L = quantity of limestone consumed in iron and steel production, tonnes

D = quantity of dolomite consumed in iron and steel production, tonnes

CE = quantity of carbon electrodes consumed in EAFs, tonnes

O_b = quantity of other carbonaceous and process material *b*, consumed in iron and steel production, such as sinter or waste plastic, tonnes

COG= quantity of coke oven gas consumed in blast furnace in iron and steel production, m^3 (or other unit such as tonnes or GJ. Conversion of the unit should be consistent with Volume 2: Energy)

S = quantity of steel produced, tonnes

IP = quantity of iron production not converted to steel, tonnes

BG = quantity of blast furnace gas transferred offsite, m^3 (or other unit such as tonnes or GJ. Conversion of the unit should be consistent with Volume 2: Energy)

C_x = carbon content of material input or output *x*, tonnes C/(unit for material *x*) [e.g., tonnes C/tonne]

Iron & Steel Production GHG calculation– How to?

EQUATION 4.10
CO_2 EMISSIONS FROM SINTER PRODUCTION (TIER 2)

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

Where, for sinter production:

$E_{CO2,\ non\text{-}energy}$ = emissions of CO_2 to be reported in IPPU Sector, tonnes

CBR = quantity of purchased and onsite produced coke breeze used for sinter production, tonnes

COG= quantity of coke oven gas consumed in blast furnace in sinter production, m^3 (or other unit such as tonnes or GJ. Conversion of the unit should be consistent with Volume 2: Energy)

BG = quantity of blast furnace gas consumed in sinter production, m^3 (or other unit such as tonnes or GJ. Conversion of the unit should be consistent with Volume 2: Energy)

PM_a = quantity of other process material *a*, other than those listed as separate terms, such as natural gas, and fuel oil, consumed for coke and sinter production in integrated coke production and iron and steel production facilities, tonnes

SOG = quantity of sinter off gas transferred offsite either to iron and steel production facilities or other facilities, m^3 (or other unit such as tonnes or GJ. Conversion of the unit should be consistent with Volume 2: Energy)

C_x = carbon content of material input or output *x*, tonnes C/(unit for material *x*) [e.g., tonnes C/tonne]

Non-energy product use calculation – How to?

TABLE 5.1
NON-ENERGY PRODUCT USES OF FUELS AND OTHER CHEMICAL PRODUCTS

Types of fuels used	Examples of non-energy uses	Gases covered in this chapter	
		CO_2	NMVOC, CO
Lubricants	Lubricants used in transportation and industry; Section 5.2	X	
Paraffin waxes	Candles, corrugated boxes, paper coating, board sizing, adhesives, food production, packaging; Section 5.3	X	

EQUATION 5.2
LUBRICANTS – TIER 1 METHOD

$$CO_2\ Emissions = LC \bullet CC_{Lubricant} \bullet ODU_{Lubricant} \bullet 44/12$$

Where:

CO_2 Emissions = CO_2 emissions from lubricants, tonne CO_2

LC = total lubricant consumption, TJ

$CC_{Lubricant}$ = carbon content of lubricants (default), tonne C/TJ (= kg C/GJ)

$ODU_{Lubricant}$ = ODU factor (based on default composition of oil and grease), fraction

Oxidised During Use

44/12 = mass ratio of CO_2/C

EQUATION 5.2
LUBRICANTS – TIER 1 METHOD

$$CO_2\ Emissions = LC \bullet CC_{Lubricant} \bullet ODU_{Lubricant} \bullet 44/12$$

Where:

CO_2 Emissions = CO_2 emissions from lubricants, tonne CO_2

LC = total lubricant consumption, TJ

$CC_{Lubricant}$ = carbon content of lubricants (default), tonne C/TJ (= kg C/GJ)

$ODU_{Lubricant}$ = ODU factor (based on default composition of oil and grease), fraction

44/12 = mass ratio of CO_2/C

For lubricants the default carbon contents factor is 20.0 kg C/GJ on a Lower Heating Value basis. (See Table 1.3 in Chapter 1 of Volume 2).
Note that kg C/GJ is identical to tonne C/TJ.

TABLE 5.2
DEFAULT OXIDATION FRACTIONS FOR LUBRICATING OILS, GREASE AND LUBRICANTS IN GENERAL

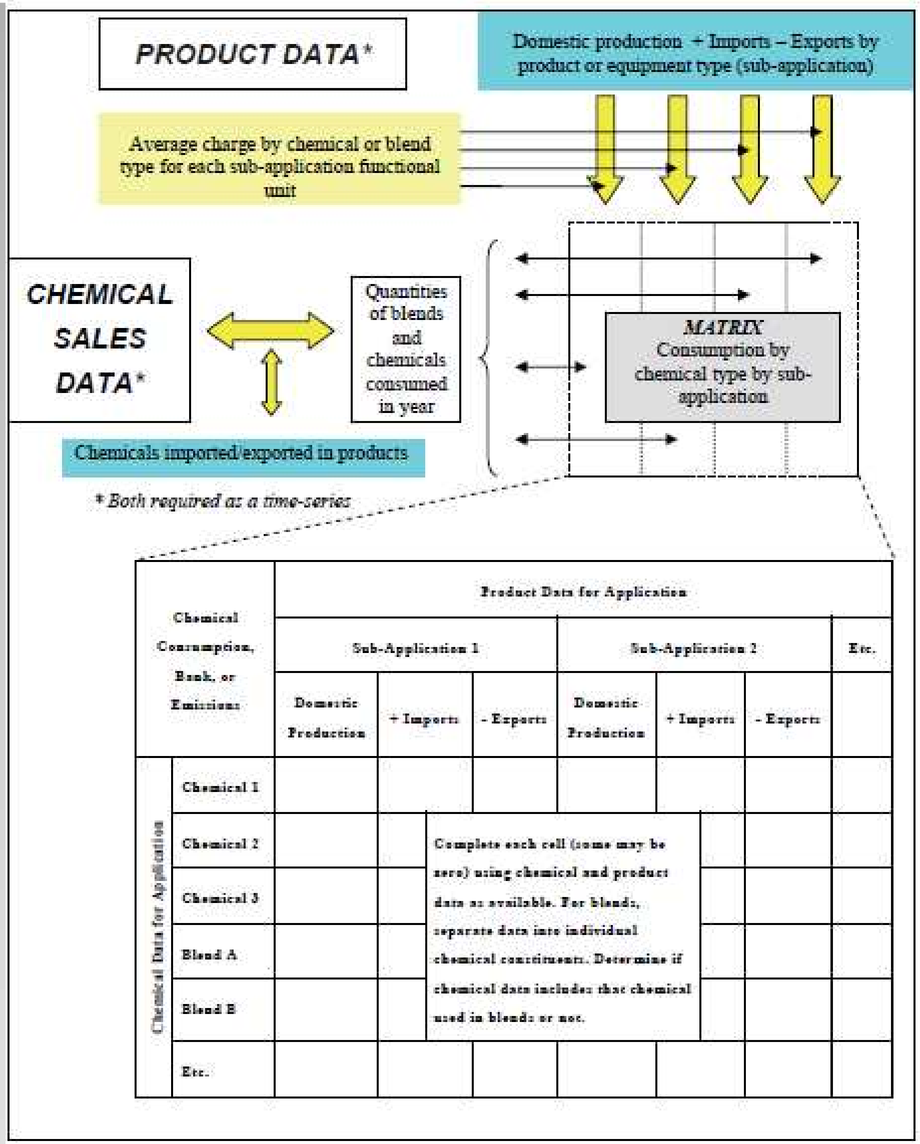
Lubricant / type of use	Default fraction in total lubricant[a] (%)	ODU factor
Lubricating oil (motor oil /industrial oils)	90	0.2
Grease	10	0.05
IPCC Default for total lubricants[b]		**0.2**

[a] Excluding the use in 2-stroke engines.
[b] Assuming 90 percent lubricating oil consumption and 10 percent grease consumption and rounded to one significant digit.
Source: Rinehart (2000).

Lubricant use calculation – How to?

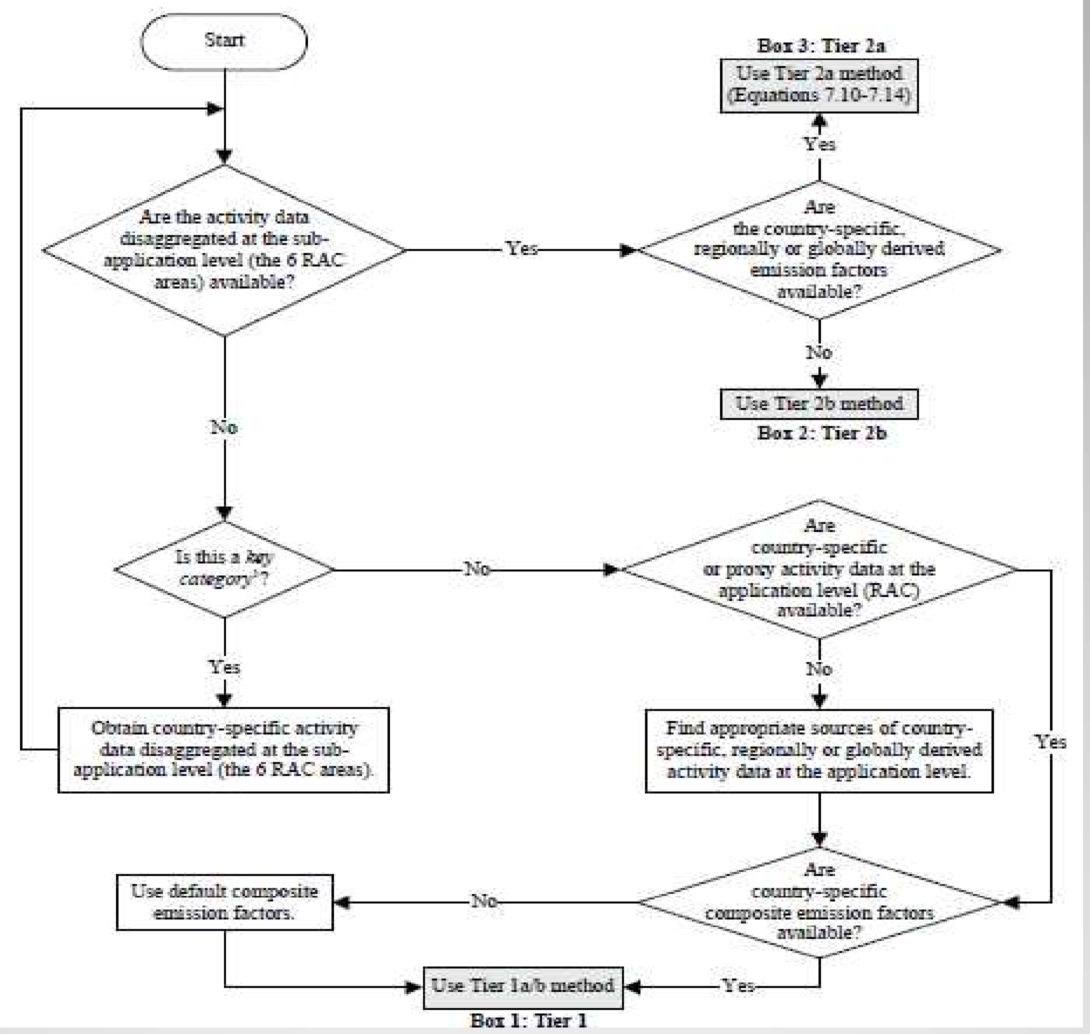
TABLE 7.1
MAIN APPLICATION AREAS FOR HFCS AND PFCS AS ODS SUBSTITUTES [1]

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		



ODS calculation – How to? General methodology

Figure 7.6 Decision tree for actual emissions from the refrigeration and air conditioning (RAC) application



ODS calculation – How to? Decision tree for Tier

The calculation formula for Net Consumption within the Tier 1a method is as follows:

EQUATION 7.1

CALCULATION OF NET CONSUMPTION OF A CHEMICAL IN A SPECIFIC APPLICATION

$$Net\ Consumption = Production + Imports - Exports - Destruction$$

Net Consumption values for each HFC or PFC are then used to calculate annual emissions for applications exhibiting prompt emissions as follows:

EQUATION 7.2A

CALCULATION OF EMISSIONS OF A CHEMICAL FROM A SPECIFIC APPLICATION

$$Annual\ Emissions = Net\ Consumption \bullet Composite\ EF$$

Where:

Net Consumption = net consumption for the application

Composite EF = composite emission factor for the application

ODS calculation – How to? General methodology Tier 1a

ODS calculation – How to?

Tier 1 Refrigeration
Argentina - HFC-143a

HFC-143a

Current Year	2005

Use in current year - 2005 (tonnes)	Data Used Here
Production of HFC-143a	800
Imports in current Year	200
Exports in current year	0
Total new agent to domestic market	*1000*

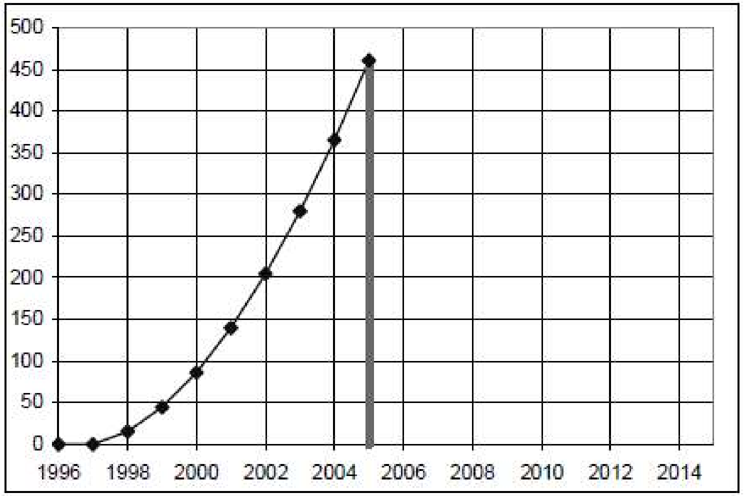
Year of Introduction of HFC-143a	1998
Growth Rate in New Equipment Sales	3.0%

Tier 1 Defaults	
Assumed Equipment Lifetime (years)	15
Emission Factor from installed base	15%
% of HFC-143a destroyed at End-of-Life	0%

Summary

Country: Argentina
Agent: HFC-143a
Year: 2005
Emission: 460.7 tonnes
In Bank: 3071.1 tonnes

Bank:delay in emission



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**

Summary

- What is IPPU
- Allocation Issues
- Tier (1,2,3)
- Mass Balance vs Emission Factors
- Uncertainty
- Calculation of GHG IPPU sector