



ESTIMATING EMISSIONS – INDUSTRIAL PROCESSES & PRODUCT USE

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Ministry of Tourism and Environment
Republic of Maldives

CBIT Maldives

Capacity Building for Improved Transparency of
Climate Change Mitigation and Adaptation Actions in
the Maldives Project



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INVESTING IN OUR PLANET



INTRODUCTION

- The Industrial Processes and Product Use (IPPU) sector accounts for greenhouse gas emissions generated through industrial activities.
- In the Maldives context, greenhouse gas emissions primarily come from the use of products rather than industrial processes.
- Hydrofluorocarbons (HFCs) have are widely used in refrigeration and air conditioning equipment
- HFCs are commonly used as alternatives to ozone-depleting substances (ODS) in cooling systems across our resorts, residential buildings, and fish processing facilities
- Source categories under IPCC
 - 2A. Mineral Industry
 - 2B. Chemical Industry
 - 2C. Metal Industry
 - 2D. Non-Energy Products from Fuels and Solvent Use
 - 2E. Electronic Industry
 - 2F. Product Uses as Substitutes for Ozone Depletion Substances (ODS)
 - 2G. Other Product Manufacture and Use

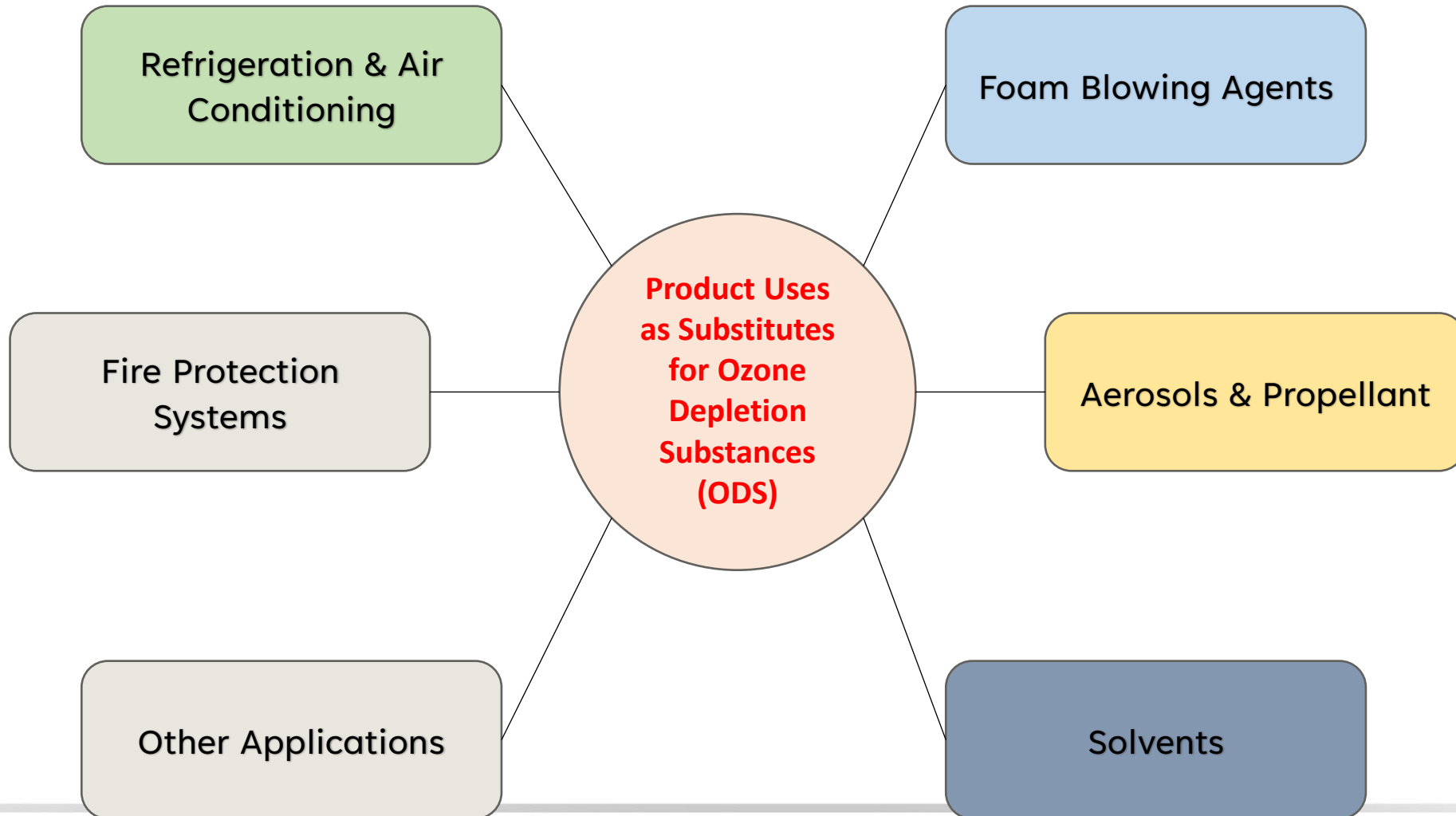


INTRODUCTION

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 - 2A. Mineral Industry
 - 2B. Chemical Industry
 - 2C. Metal Industry
 - 2D. Non-Energy Products from Fuels and Solvent Use
 - 2E. Electronic Industry
 - 2F. Product Uses as Substitutes for Ozone Depletion Substances (ODS)
 - 2G. Other Product Manufacture and Use
- **Most relevant to Maldives is Product Uses as Substitutes for Ozone Depletion Substances (ODS)**
- Hydrofluorocarbons (HFCs) have are widely used in refrigeration and air conditioning equipment
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INTRODUCTION



METHODOLOGICAL APPROACHES

- Two approaches, Emissions Factor approach and Mass Balance approach
- Mass Balance approach - based on the principle of conservation of mass, where the total amount of a chemical entering a system must equal the amount stored, consumed, or emitted.
- This method follows the chemicals from their import into the country through their life cycle in various equipment and systems.
 - Chemical Consumption: Tracking the amount of chemicals (e.g., HFCs, PFCs) purchased or produced.
 - Equipment Stocks: Monitoring changes in the inventory of equipment that contains these chemicals (e.g., air conditioners, refrigerators, or industrial systems).
 - Emissions Calculation: Emissions are derived by accounting for the difference between the chemicals added to the system and those stored or destroyed. For example, if a certain amount of refrigerant is added to equipment but not recovered during maintenance or disposal, the difference is assumed to have been emitted



METHODOLOGICAL APPROACHES

- Emission Factor approach - calculate emissions by combining data on quantity of chemical stored in equipment (chemical bank) and predefined emission factors, which represent the rate at which these chemicals are released into the atmosphere
- Chemical Banks: Estimating the total amount of chemicals stored in equipment or products (e.g., refrigerants in air conditioners, foam blowing agents in insulation). Banks are the amounts of chemical that have accumulated throughout the lifecycle, either in supply chains, products, equipment or even waste streams but which, as of the end of the most recent year, has not been emitted.
- Emission Factors: Using predefined factors that describe the fraction of the chemical bank emitted annually. These factors are often based on empirical data, such as leakage rates from equipment or release rates during product use or disposal.
- Emissions Calculation: Emissions are calculated by multiplying the size of the chemical bank by the appropriate emission factor. For example, if a country has 1,000 tons of HFCs stored in refrigeration systems and the emission factor is 5% per year, the annual emissions would be 50 tons.

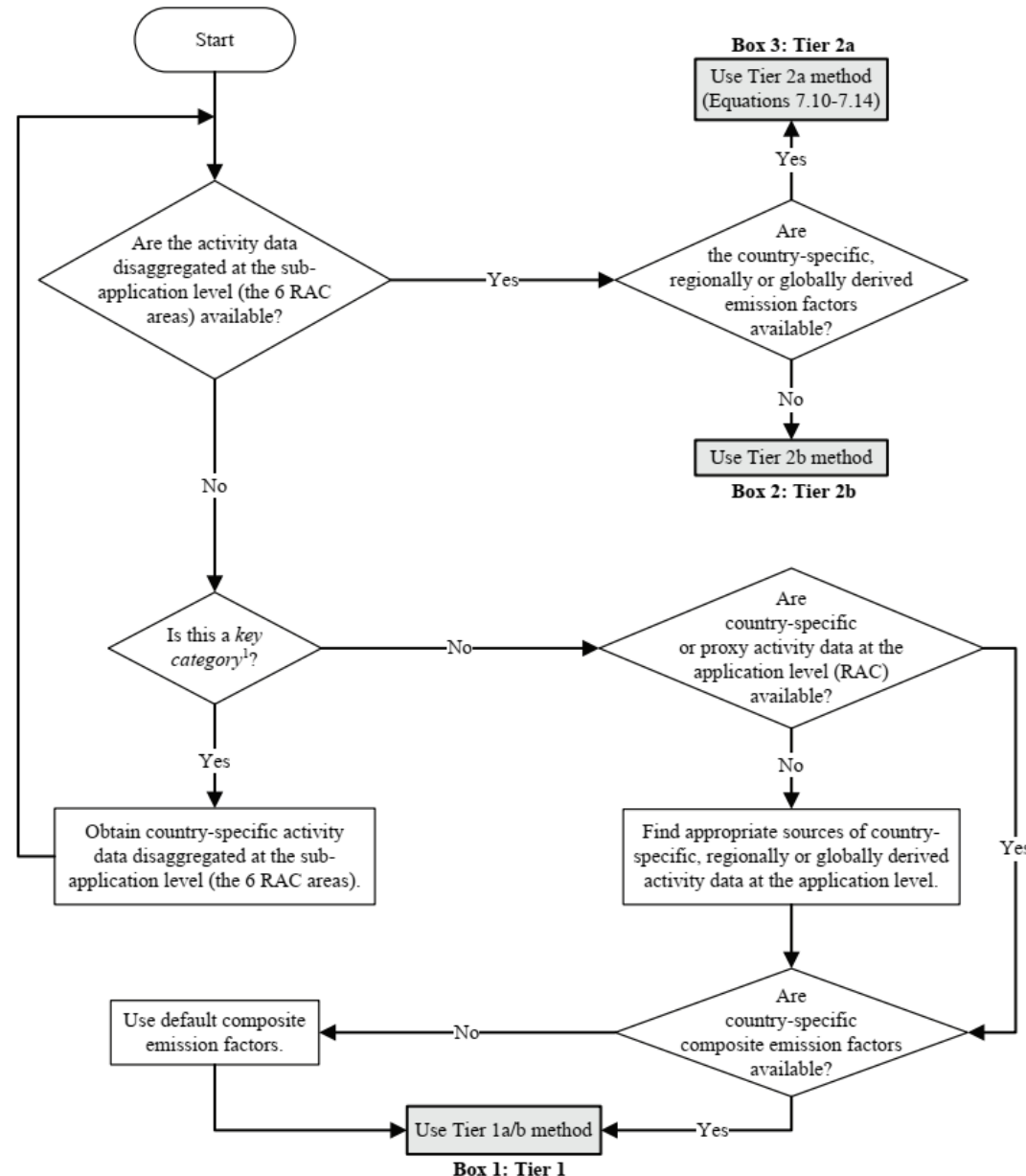


CHOICE OF TIERS

- Three Tier approaches available
- **Tier 1** approach uses aggregated data and simpler calculations, making it suitable for countries with limited data availability.
- **Tier 2** method requires detailed, disaggregated data for more precise calculations
- **Tier 3** involves direct measurement of emissions from point source which is rarely carried in ODS.
- In more practical terms, **Tier 1** and **Tier 2** are **commonly used**



DECISION TREE FOR TIERS



COMPARISON OF APPROACH AND TIER

Data requirements for both approaches

	Approach A (emission-factor approach)	Approach B (mass-balance approach)
Tier 1 (emission estimation at an aggregated level)	<ul style="list-style-type: none"> • Data on chemical sales by application [country-specific or globally/regionally derived] • Emission factors by application [country specific or (composite) default] 	<ul style="list-style-type: none"> • Data on chemical sales by application [country-specific or globally/regionally derived] • Data on historic and current equipment sales adjusted for import/export by application [country-specific or globally/regionally derived]
Tier 2 (emission estimation at a disaggregated level)	<ul style="list-style-type: none"> • Data on chemical sales and usage pattern by sub-application [country-specific or globally/regionally derived] • Emission factors by sub-application [country-specific or default] 	<ul style="list-style-type: none"> • Data on chemical sales by sub-application [country-specific or globally/regionally derived] • Data on historic and current equipment sales adjusted for import/export by sub application [country-specific or globally/regionally derived]



TIER 1 APPROACH

- Tier 1 method is simpler and looks at emission estimates carried out at the application level rather than the individual products or equipment or at sub-application level.
- Tier 1 is sometimes used as Tier 1a and Tier 1b approaches or as a combination of both depending on the data availability
- The following formula can be used

$$\text{Annual Emissions} = \text{Net Consumption} \times \text{Composite EF}$$

- If banked chemical information is used, it can be modified as follows

$$\text{Annual Emissions} = \text{Net Consumption} \times \text{Composite EF}_{FY} + \text{Total banked chemical} \times \text{Composite EF}_B$$

- Where:

$$\text{Net Consumption} = \text{Production} + \text{Imports} - \text{Exports} - \text{Destruction}$$

Composite EF_{FY} is composite emission factor for the application for first year

Total banked chemical is the bank of the chemical for the application

Composite EF_B is composite emission factor for the application of bank



TIER 2 APPROACH

- Tier 2 approaches analyze emissions for specific chemicals and equipment types within each sub-application category
- This approach requires to establish a comprehensive consumption baseline for emission calculations by monitoring chemical use in distinct applications such as household refrigerators, various stationary cooling equipment, foam materials in appliances, building insulation panels, pipe insulation systems, and other relevant product categories
- Emissions are estimated through one of two methodologies:
- The emissions factor approach (Tier 2a), applies specific emission factors that account for the distinctive release patterns associated with different processes, products, and equipment types.
- Alternatively, mass balance approach (Tier 2b) method employs a mass-balance approach that incorporates detailed information about new equipment installations and retiring units at the sub-application level to track the movement of chemicals throughout their lifecycle



TIER 2 APPROACH

- In the Tier 2a, emissions calculations breaks down emissions into multiple phases: initial filling (installation), annual leakage during operation, losses during maintenance (servicing), and releases when equipment reaches end-of-life (decommissioning).
- Each of these stages can have its own specific emission factor, making this approach much more detailed and reflective of real-world conditions. It also explicitly tracks the 'bank' — the amount of gas already installed in equipment from prior years — to account for legacy emissions.
- This method, while more complex, provides a more accurate long-term emissions estimate, especially for equipment with long service lives
- In the Tier 2b, emissions are calculated based on the net amount of gas consumed during the year and applies a single, representative annual emission factor (leak rate) for each product type.
- This approach assumes that all equipment of a certain type leaks at the same average rate, combining installation, operational, servicing, and disposal leaks into a single value
- **Using a Tier 2a approach is the recommended method for Maldives**



CHOICE OF EMISSION FACTORS

- Choice of emission factor depends on how similar the products are within each category, the calculation method being used, how local practices affect leakage rates, how chemicals accumulate over time, and any unique national circumstances
- Since Tier 1 methods work at the broader application level, they require composite emission factors. These can be created by taking weighted averages of known emission factors from more specific sub-categories, or by using tested estimation approaches (country specific or default)
- For Tier 2 methods, it is vital to understand the specific conditions affecting the countries sub-applications.
- While products and equipment may be similar worldwide, emission factors can vary significantly throughout a product's lifetime due to climate differences, building practices, regulations, and especially servicing methods.
- Particularly important is how products are disposed of at the end of their useful life, since this can dramatically impact total emissions - equipment may still contain 90% or more of the original chemical when discarded. Different applications have their own specific emission factor considerations.
- Currently Maldives does not have country specific emissions factors and therefore default factors are used



ACTIVITY DATA COLLECTION

- Data required for the emissions from ODS can be from national Customs statistics.
- Maldives only imports HFCs in cylinders, small canisters and in pre-charged equipment
- No exports
- Higher tier, it would be good practice to obtain data from users or industrial to get information about the leakage rates, lifetimes and storage information
- Chemical used annually within a specific application, sub-application, or even at a more detailed level, such as by equipment or product type is required for Tier 2
- Main focus is given on the following

Refrigeration and Air-Conditioning (RAC)

2.F.1.a – Refrigeration and Stationary Air-Conditioning

2.F.1.b – Mobile Air-Conditioning



REFRIGERATION & AIR CONDITIONING (RAC) IN MALDIVES

- As per IPCC, RAC) systems can be organized into as many as six distinct sub-application categories

Domestic Refrigeration

- Home refrigerators (ice lined refrigerators)
- Freezers (deep freezers and chest freezers)
- Household food preservation systems
- Family-scale cold storage units

Commercial Refrigeration

- Beverage and food dispensing machines
- Display cases and merchandising coolers such as vending machines
- Supermarket integrated refrigeration networks

Industrial Processes

- Chillers
- Temperature-controlled production environments
- Cold storage facilities
- Large systems/freezer containers
- Central AC plants
- Cold rooms (Walk-in coolers, Walk-in freezers)
- Ice plants
- Industrial heat pumps
- Heat extraction systems for industrial applications

Transport Refrigeration

- Temperature-controlled shipping containers
- Refrigerated delivery vehicles
- Climate-controlled freight transport systems
- Reefers, chilled container and wagons

Stationary air conditioning

- Temperature-controlled shipping containers
- Refrigerated delivery vehicles
- Climate-controlled freight transport systems
- Reefers, chilled container and wagons

Mobile air conditioning systems

- Personal vehicle air conditioning
- Public transport cooling solutions such as buses and trains

HFC USES IN MALDIVES

Sector	Type of HFCs and HFC blends							HCs
Domestic Refrigeration	R-134a	R-404a						HC-600a
Commercial Refrigeration	R-134a	R-404a	R-507a	R-23				
Industrial Refrigeration	R-134a	R-404a	R-407c	R-410a	R-507a	R-23	R-438a	
Mobile Air Conditioning	R-134a							
Transport refrigeration	R-134a	R-404a						
Residential and Commercial Air Conditioning	R-134a	R-407c	R-410a	R-417a	R32			HC- 290



BLENDS, HFC RATIOS AND GWP

Refrigerant	Components and Percentages	Component GWPs (AR5)	Composite GWP
R-32	Pure compound (100% HFC-32)	HFC-32: 677	677
R-134a	Pure compound (100% HFC-134a)	HFC-134a: 1,300	1,300
R-407C	23% HFC-32, 25% HFC-125, 52% HFC-134a	HFC-32: 677, HFC-125: 3,170, HFC-134a: 1,300	1,624
R-410A	50% HFC-32, 50% HFC-125	HFC-32: 677, HFC-125: 3,170	1,924
R-404A	44% HFC-125, 52% HFC-143a, 4% HFC-134a	HFC-125: 3,170, HFC-143a: 4,800, HFC-134a: 1,300	3,943
R-438A	8.5% HFC-32, 45% HFC-125, 44.2% HFC-134a, 1.7% HC-600, 0.6% HC-601a	HFC-32: 677, HFC-125: 3,170, HFC-134a: 1,300, HC-600: 4, HC-601a: ~4	2,059
R-417A	46.6% HFC-125, 50% HFC-134a, 3.4% HC-600	HFC-125: 3,170, HFC-134a: 1,300, HC-600: 4	2,127
R-507A	50% HFC-125, 50% HFC-143a	HFC-125: 3,170, HFC-143a: 4,800	3,985
R-23	Pure compound (100% HFC-23)	HFC-23: 12,400	12,400
R-22	Pure compound (100% HCFC-22)	HCFC-22: 1,760	1,760
R-401A	53% HCFC-22, 13% HFC-152a, 34% HCFC-124	HCFC-22: 1,760, HFC-152a: 138, HCFC-124: 527	1,182
R-290	Pure compound (100% HC-290) Propane	HC-290: 3	3
R-600	Pure compound (100% HC-600) Butane	HC-600: 4	4



TYPICAL PRE-CHARGE AMOUNTS

Mobile AC (all R134a)							
Cars	Vans	Pickup	Lorry	Trucks	Cranes	Forklifts	Excavators
0.6	0.6	0.6	0.6	0.9	1	0.6	1
Domestic refrigeration							
R134a	R404a						
0.13	0.18						
Commercial refrigeration							
R134a	R404a	R507	R23				
0.32	1.15	1.15	0.1				
Residential and Commercial ACs							
R410a	R407C	R417A	R134a	R32			
2.08	5.56	3.13	3.13	4.51			
Industrial refrigeration							
R134a	R404a	R407	R410	R507C	R23	R438	
4	26	26	26	26	4	4	
Transport							
R134a	R404a						
0.28	6.5						



EMISSION ESTIMATION

- To estimate emissions, the most accurate way would be to collect blend agents and chemical use from the sector. However, this would be a difficult data to collect.
- Import data should be used. Import data needs to be broken down to application and sub-application level. It also needs to be segregated to which industries they are used in.
- One blend type might be used in several sectors.
- For example, R-134a is used in many sectors (almost all sectors). But how much of the imported amount is used by the sectors needs to be determined by a survey. Similarly, R-507a is used in commercial refrigeration and industrial refrigeration. But from the imported amount, how much is used in these sectors must be estimated.



EMISSION ESTIMATION (USING TIER 1)

- Disaggregated level of information is not available, a hybrid approach of Tier 1 (Tier 1 a/b) could be undertaken according to the IPCC guidelines
- The following data would be minimally required:
 - Sales of a specific refrigerant in the year to be reported
 - Year of introduction of the refrigerant
 - Growth rate in sales of new equipment (usually assumed linear across the period of assessment)
 - Assumed percentage of new equipment imported
 - Import/export data of chemical agent (in tonnes)
- The following assumptions are made.



EMISSION ESTIMATION (USING TIER 1)

- The following assumptions are made.
- Refrigerant-containing systems operate for 3 years after installation before any service is performed.
- Refrigerant banks experience an annual emission rate of 15% across the entire refrigeration and air conditioning sector
- The average lifetime of refrigeration and air conditioning equipment is assumed to be 15 years, which is estimated as a weighted average across all sub-applications.
- A 10-year time frame is required for a complete transition to a new refrigerant technology. For a single chemical in a single country, this assumption is believed to be valid based on past experience.



EMISSION ESTIMATION (USING TIER 1)

- For Tier 1 the following IPCC interface could be used. Columns for data entry are the first 3 columns.

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

2006 IPCC Categories

1 - Energy

2 - Industrial Processes and Product Use

2.A - Mineral Industry

2.B - Chemical Industry

2.C - Metal Industry

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

2.E - Electronics Industry

2.F - Product Uses as Substitutes for Ozone Depleting Subst

2.F.1 - Refrigeration and Air Conditioning

2.F.1.a - Refrigeration and Stationary Air Conditioning

2.F.1.b - Mobile Air Conditioning

2.F.2 - Foam Blowing Agents

2.F.3 - Fire Protection

2.F.4 - Aerosols

2.F.5 - Solvents

2.F.6 - Other Applications (please specify)

2.G - Other Product Manufacture and Use

2.G.1 - Electrical Equipment

2.G.1.a - Manufacture of Electrical Equipment

2.G.1.b - Use of Electrical Equipment

2.G.1.c - Disposal of Electrical Equipment

2.G.2 - SF6 and PFCs from Other Product Uses

2.G.2.a - Military Applications

2.G.2.b - Accelerators

2.G.2.c - Other (please specify)

2.G.3 - N2O from Product Uses

2.G.3.a - Medical Applications

2.G.3.b - Propellant for pressure and aerosol product

2.G.3.c - Other (Please specify)

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: R-404A (HFC-125/HFC-143a/HFC-134a (44.0/52.0/4.0)) Emissions

Data

Subdivision: Domestic Refrigeration

Gas: R-404A (HFC-125/HFC-143a/HFC-134a (44.0/52.0/4.0))

Chemical's Data

Year: 2006

GR (%): 1

d (years): 15

EF (%): 15

X (%): 0

I. Total Chemical Agent Inputs (across the time series) (ΣD)

II. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t))

III. Total Chemical Agent Emissions (across the time series) (ΣE)

IV. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (ΣF)

Equation 7.2B

Year	Agent production (tonnes)	Agent export (tonnes)	Agent import (tonnes)	Total new agent to domestic market (tonnes)	Retired in equipment at end-of-life (tonnes)	Destruction of agent in retired equipment (tonnes)	Release of agent from retired equipment (tonnes)	Bank (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)	Information for UNFCCC CRT				
t	$\Delta \nabla$	P	Exp	Imp	$D = P - \text{Exp} + \text{Imp}$	$R = [L(t-d) - (L(t-d)) * EF/100] - [S_{\text{needed}} - S_{\text{done}}](t-d)$	$F = R * (X/100)$	$G = R - F$	$\text{Bank} = \text{Bank}(t-1) + D - R - I$	$I = IF(M * EF/100 > \Sigma D - \Sigma R - \Sigma I); M * EF/100; \Sigma D - \Sigma R - \Sigma I$	$E = G + I$	$EE = E / 1000$	Agent for servicing (tonnes) $K = IF(D > I) (t-1) - M(t-d+1) * EF/100; I (t-1) - M(t-d+1) * EF/100; D$	Agent in new equipment installed in year t $L = D - K$	Agent in all equipment installed in service (tonnes) $M = \Sigma (L(t, -(d-1)))$	
2019					0	0	0	0	0	0	0	0	0	0	0	0
2020					0	0	0	0	0	0	0	0	0	0	0	0
2021					0	0	0	0	0	0	0	0	0	0	0	0

EMISSION ESTIMATION (USING TIER 1)

- Addition of subdivision and gases

Sheet: HFC-134a (CH₂FCF₃) Emissions

Data

Subdivision: Unspecified Gas: HFC-134a (CH₂FCF₃) Chemical's Data IY: 2006 GR (%) 1 d (years)

I. Total Chemical Agent... (from the time series) (EF)

II. Total Chemical Agent...

III. Total Chemical Agent...

IV. Total Chemical Agent...

Country/Territory: Maldives

Category: 2.F.1.a - Refrigeration and Stationary Air Conditioning

Subdivision: Unspecified

Gas: HFC-134a (CH₂FCF₃)

Data

Year of Introduction (IY): 2006

Growth Rate in New Equipment Sales (GR): 1.00%

Assumed Equipment Lifetime (years) (d): 15

Emission Factor from installed base (EF): 15.00%

% of Gas Destroyed at End of Life (X): 0.00%

Save Close

Year	Agent production (tonnes)	Emissions from installed equipment (tonnes)	Total Emissions (tonnes)	Total Emissions (Gg)
2020		0	0	0
2021		0	0	0
2022		0	0	0
2023		0	0	0

Time Series

HFC-134a (CH₂FCF₃)

EMISSION ESTIMATION (USING TIER 2A)

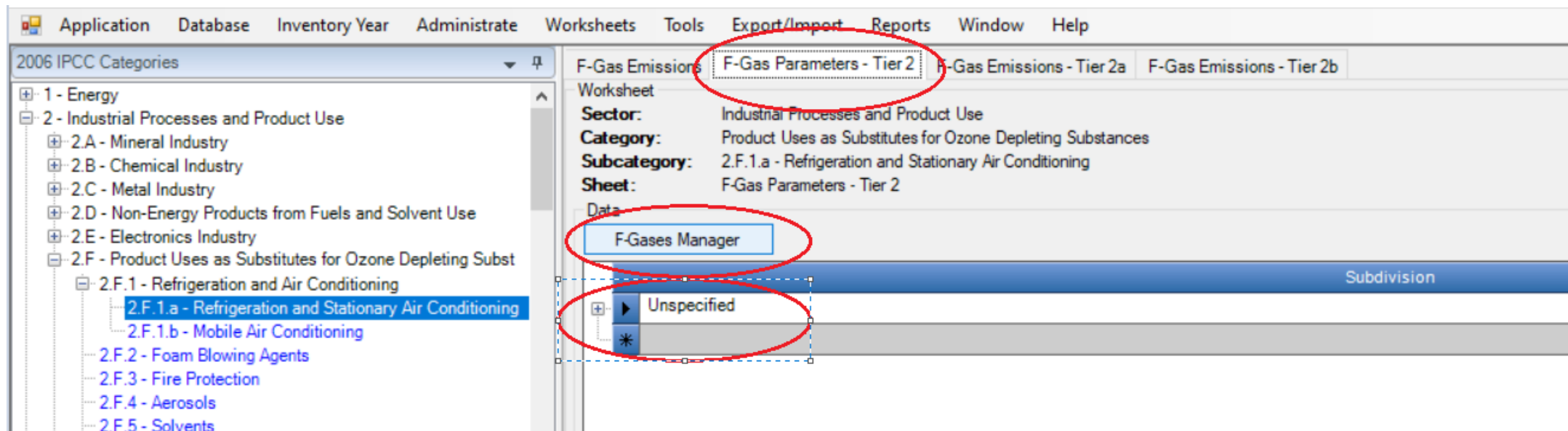
Addition The Tier 2a method takes the following into account.

- Incorporates the scheduled elimination or gradual reduction of CFCs and HCFCs according to Montreal Protocol timelines and applicable national or regional regulatory frameworks, enabling the determination of appropriate refrigerant selections across all applications.
- It specifies the typical refrigerant charge (the amount of refrigerant used in a system) and the equipment lifetime for each sub-application. This information helps estimate refrigerant demand and emissions over time, tailored to specific uses like commercial refrigeration, industrial cooling, or residential air conditioning.
- It establishes emission factors for different stages of a refrigerant's lifecycle:
 - Refrigerant charge: Emissions during initial filling of the system.
 - During operation: Emissions from leaks or normal system operation.
 - At servicing: Emissions during maintenance, repairs, or refilling.
 - At end-of-life: Emissions when equipment is decommissioned or disposed of.



EMISSION ESTIMATION (USING TIER 2A)

- Tier 2 data entry needs to set up the sub-application level and F-Gases.



EMISSION ESTIMATION (USING TIER 2A)

- Management of blends and F-gases to prepare for use of Tier 2

F-Gases Manager - 2.F.1.a

Chemicals and Blends - applicability at IPCC Category level

Chemical group			
HFCs			
	Chemical	Formula	Consumed and/or Exported at category level
HFCs listed in Table 7.1	HFC-23	CHF3	<input checked="" type="checkbox"/>
	HFC-32	CH2F2	<input checked="" type="checkbox"/>
	HFC-125	CHF2CF3	<input checked="" type="checkbox"/>
	HFC-134a	CH2FCF3	<input checked="" type="checkbox"/>
	HFC-152a	CH3CHF2	<input checked="" type="checkbox"/>
	HFC-143a	CH3CF3	<input checked="" type="checkbox"/>
Chemical group			
PFCs			
SF6			
NF3			
Ethers and Halogenated Ethers			
Other GHGs			
Blends			
	Chemical	Formula	Consumed and/or Exported at category level
Blends referenced in section 7.5.1 of the 2006 GL	R-410A	HFC-32/HFC-125 (50.0/50.0)	<input checked="" type="checkbox"/>
	R-404A	HFC-125/HFC-143a/HFC-134a (44.0/52.0/4.0)	<input checked="" type="checkbox"/>
	R-407C	HFC-32/HFC-125/HFC-134a (23.0/25.0/52.0)	<input checked="" type="checkbox"/>
	R-507A	HFC-125/HFC-143a (50.0/50.0)	<input checked="" type="checkbox"/>
Other blends	R-401A	HCFC-22/HFC-152a/HCFC-124 (53.0/13.0/34.0)	<input checked="" type="checkbox"/>
	R-417A	HFC-125/HFC-134a/HC-600 (46.6/50.0/3.4)	<input checked="" type="checkbox"/>
User-defined blends	R-438A	HFC-32/HFC-125/HFC-134a/HC-600a/HC601a (8.5/4...	<input checked="" type="checkbox"/>

Chemicals at country level

Blends at country level

Close

EMISSION ESTIMATION (USING TIER 2A)

- Default factors to create the sub-divisions

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 2021

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

Data

F-Gases Manager

Subdivision					
Domestic Refrigeration					
Sub-application					
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	$12 \leq d \leq 20$	$0.2 \leq k \leq 1$	$0.1 \leq x \leq 0.5$	$0 < \eta_{rec,d} < 70$	$0 < p < 80$
Stand-alone Commercial Applications	$10 \leq d \leq 15$	$0.5 \leq k \leq 3$	$1 \leq x \leq 15$	$0 < \eta_{rec,d} < 70$	$0 < p < 80$
Medium & Large Commercial Refrigeration	$7 \leq d \leq 15$	$0.5 \leq k \leq 3$	$10 \leq x \leq 35$	$0 < \eta_{rec,d} < 70$	$50 < p < 100$
Transport Refrigeration	$6 \leq d \leq 9$	$0.2 \leq k \leq 1$	$15 \leq x \leq 50$	$0 < \eta_{rec,d} < 70$	$0 < p < 50$
Industrial Refrigeration including Food Processing and Cold Storage	$15 \leq d \leq 30$	$0.5 \leq k \leq 3$	$7 \leq x \leq 25$	$0 < \eta_{rec,d} < 90$	$50 < p < 100$
Chillers	$15 \leq d \leq 30$	$0.2 \leq k \leq 1$	$2 \leq x \leq 15$	$0 < \eta_{rec,d} < 95$	$80 < p < 100$
Residential and Commercial A/C, including Heat Pumps	$10 \leq d \leq 20$	$0.2 \leq k \leq 1$	$1 \leq x \leq 10$	$0 < \eta_{rec,d} < 80$	$0 < p < 80$



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EMISSION ESTIMATION (USING TIER 2A)

- Data entry to Tier 2a. If available data should be entered to C,D,E,F,G

Worksheet: F-Gas Emissions, F-Gas Parameters - Tier 2, F-Gas Emissions - Tier 2a, F-Gas Emissions - Tier 2b

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

Data
 Subdivision: Refrigeration
 Sub-application: Domestic Refrigeration
 Gas: HFC-134a (CH₂FCF₃)

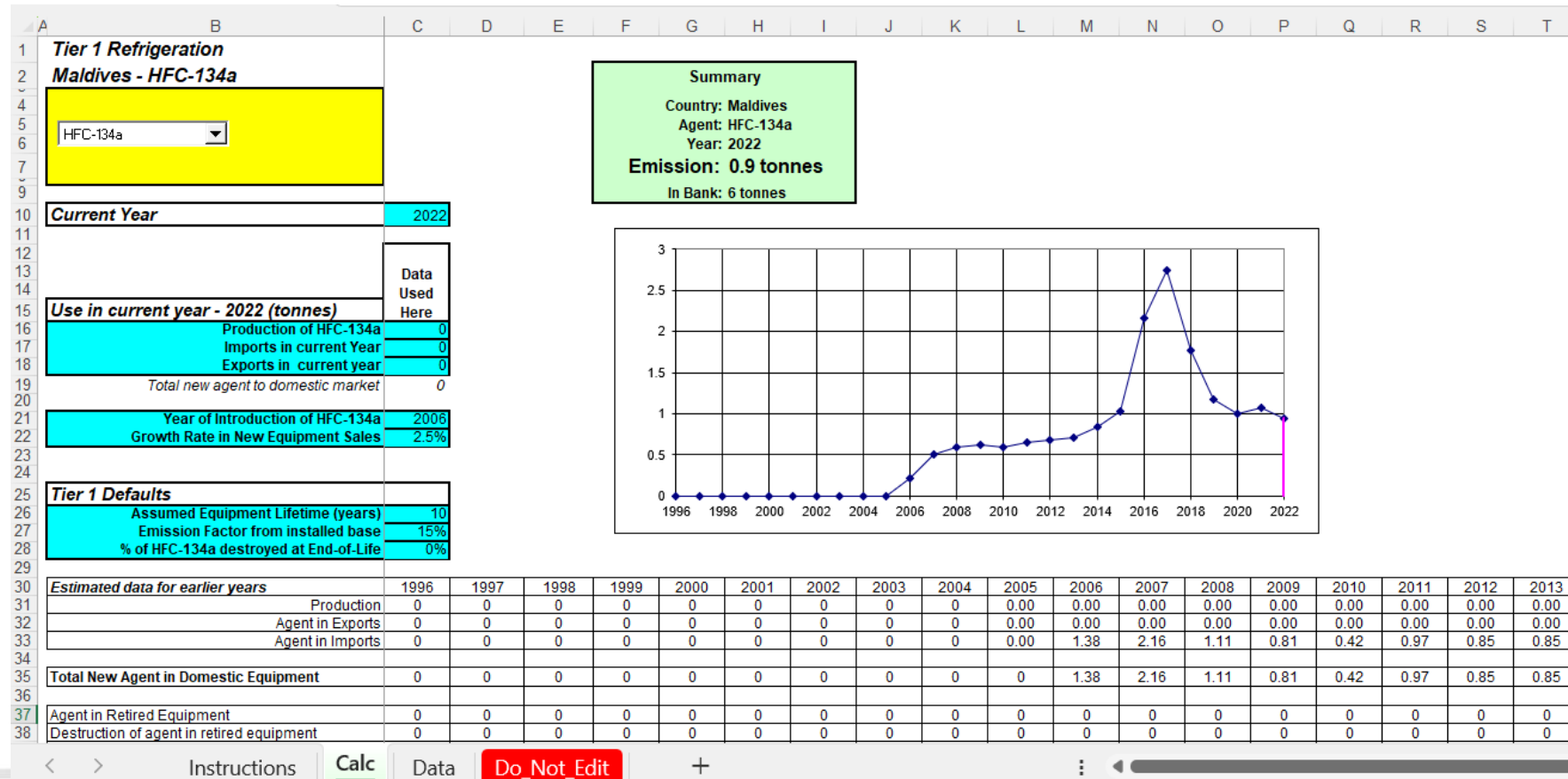
Intro Year: 2006
 EFc [%]: 15
 EFk [%]: 1
 p [%]: 80
 D [%]: 0
 η(rec.d) [%]: 0

I. Total Chemical Agent Inputs (across the time series) (ΣF + ΣH) 0
 II. Total Chemical Agent in new equipment exported (across the time series) (ΣG) 0
 III. Total Chemical Agent in equipment in use (last year of the time series) (Bank(t)) 0
 IV. Total Chemical Agent Emissions (across the time series) (ΣV) 0
 V. Total Chemical Agent Recovered/Destroyed/Exported from equipment at end-of-life (across the time series) (ΣQ + ΣS + ΣT) 0

Year	Amount in the bank on January 1st of year t (kg)	Domestically Manufactured Chemical in year t (kg)	Imported in bulk in year t (kg)	Exported in bulk in year t (kg)	Contained in factory-charged imported equipment in year t	Contained in factory-charged Exported new -equipment in year t	Domestic Sales of new & recovered chemical (in bulk) in year t (kg)	Emitted by containers management (during transfer from bulk to small, kg)	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 new equipment consumed in year t (kg)
t	Bank(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
2006	0						0	0	0	0	0	0
2007	0						0	0	0	0	0	0
2008	0						0	0	0	0	0	0

USE OF EXCEL TOOL BY IPCC

- IPCC provides two excel sheets (1 for tier 1 and other for Tier 2) to calculate the emissions.
- Tier 1 approach



USE OF EXCEL TOOL BY IPCC

- Tier 2 approach

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1																					
2	Country			Country XX																	
3	Equipment type (sub-application)			Mobile Air Conditioning																	
4	Chemical or blend			HFC-134a																	
5	Current Year			2022																	
6	Year of Introduction			2006																	
7																					
8																					
9																					
10																					
11																					
12																					
13																					
14																					
15																					
16																					
17																					
18																					



QUALITY CONTROL & QUALITY ASSURANCE

- When applying the Tier 2 method, QA/QC involves comparing the annual national HFC refrigerant market data, declared by manufacturers or distributors, with the HFC refrigerant needs derived from the inventory calculations
- Detailed accounting, distinguishing between refrigerants used for various purposes—such as new system charging, servicing, or those lost during handling.
- Survey needs to be conducted to understand the use of chemicals by various sectors, the type of equipment, their service histories to identify re-charging and leakage rate
- Customs import data could be compared with licenses issued for the chemicals to ensure the right type and amount of chemicals imported
- Results from similar studies to identify emissions should be used to compare the results if similar methodologies and assumptions are used.
- It is also important to have a 3rd party independent and expert review on the findings.

