INITIATIVE FOR CLIMATE ACTION TRANSPARENCY (ICAT)

PHASE II

National Guidance Document for F-gases (Category 2F) under the IPPU Sector

FIJI

Deliverable title: National Guidance Document for F-gases (Category 2F) under the IPPU Sector

Deliverable B

AUTHOR: Ms. Jeanette Mani & Dr. Francis Mani

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DISCLAIMER

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1.0 Introduction

Many of the industrial processes included in the Industrial Processes and Product Use (IPPU) sector are not relevant to Fiji and, therefore, have not been reported in previous greenhouse gas (GHG) inventories. In the past, carbon dioxide (CO_2) emissions from cement production in Fiji used to be a key category source, but recent years have seen clinker production in Fiji cease, almost eliminating this category source. While there could be some fugitive emissions of sulphur hexafluoride (SF_6) from applications in high-voltage transformers and iron and steel production, these are not considered key category sources.

The implementation of the hydrochlorofluorocarbons (HCFC) Phase-Out Management Plan (HPMP) in 2013, which aims for a 100% reduction in HCFC use by 2030, led to an increase in the use of Hydrofluorocarbons (HFCs) as alternative refrigerants. Hydrofluorocarbons can be used as "drop-in" replacements without significant system modifications. Currently, there is a surge in the use of HFCs with very strong global warming potentials. The National Inventory Report (NIR) for 2023 indicates an approximately 400% increase in HFC consumption since 2016, with very high global warming potentials. The emissions from these gases could significantly impact Fiji's total GHG emissions, necessitating the establishment of a Measurement, Reporting, and Verification (MRV) system for HFC consumption in Fiji. Additionally, with the ratification of the Kigali amendment to the Montreal Protocol, accurate recording of HFC consumption and emissions is crucial, along with a system to evaluate the reduction targets committed to under the Kigali amendment.

2.0 Product Uses as Ozone Depleting Substances Substitutes (Category 2F)

Hydrofluorocarbons and, to a very limited extent, perfluorocarbons (PFCs), serve as alternatives to ozone-depleting substances (ODS) being phased out under the Montreal Protocol e.g., chloro-fluro-carbons or (CFCs). The 2006 IPCC Guidelines outline the following areas of HFCs and PFCs use:

- Refrigeration and air conditioning
- Fire suppression and explosion protection
- Aerosols
- Solvent cleaning
- Foam blowing

- Other applications such as in sterilisation of equipment, for tobacco expansion applications, and as solvents in the manufacture of adhesives, coating and inks.

2.1 Refrigeration and Air Conditioning (Category 2.F.1)

In the ICAT Phase II project, Fiji primarily focuses on HFC gases used in refrigeration and air conditioning equipment. These fall under category 2.F.1, which is further divided into two subcategories: 2.F.1.a for Refrigeration and Stationary Air Conditioning, and 2.F.1.b for mobile air conditioning. The table below lists the common HFCs used in these types of equipment with their associated Global Warming Potential (GWP). In this report IPCC Assessment Report IV (AR4) is used, however from 2025 any reporting for the Paris Agreement from 2025 will use AR5 GWP.

Table 1: Lists of various HFCs and their Global Warming Potential (GWP) and atmospheric lifetime.

Chemical	**AR4 Global Warming Potential** 100 yr time horizon (for reporting in the BUR until the end of 2024)	**AR5 Global Warming Potential** 100 yr time horizon (for reporting under the Paris Agreement from 2025)	**Atmospheric Lifetime** (yr)
HFC-23	14800	12400	270
HFC-32	675	677	4.9
HFC-125	3500	3170	29
HFC-134a	1430	1300	14
HFC-143a	4470	4800	52
HFC-152a	124	138	1.4
HFC-227ea	3220	3350	34.2
HFC-236fa	9810	8060	240

(Source: https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf)

The 2006 IPCC Guidelines for refrigeration and air conditioning category is further divided into 6 major sub-applications as such:

- **Domestic (Household) Refrigeration:** This category includes refrigeration systems used in homes.

- **Commercial Refrigeration:** Encompassing various types of equipment, from vending machines to centralized refrigeration systems in supermarkets.
- **Industrial Processes:** This category involves chillers, cold storage, and industrial heat pumps used in the food, petrochemical, and other industries.
- **Transport Refrigeration:** Refers to equipment and systems used in refrigerated trucks, containers, reefers, and wagons.
- **Stationary Air Conditioning:** Includes air-to-air systems, heat pumps, and chillers for building and residential applications.
- **Mobile Air-Conditioning Systems:** Used in passenger cars, truck cabins, buses, and trains.

3.0 Guidance on methodology for estimating emissions of HFCs in Fiji

There are two methodological approaches, emission factor and mass balance, available for estimating emissions from HFC use in refrigeration equipment. Both approaches can also be applied under Tier 1 and Tier 2 methods, the latter is based on the availability of data disaggregation by sub-applications.

Table 2: Overview of data requirements for different tiers and approaches

	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 [country-specific or globally/regionally derived] • Emission factors by sub-application [country-specific or default]	• 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 (emission estimation at an aggregated level)	• Data on chemical sales by application [country-specific or globally/regionally derived] • Emission factors by application [country-specific or (composite)default]	• 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]

(source: Table 7.2, Chapte 7, Vol 3, 2006 IPCC Guidelines for National Greenhouse Gas Inventories)

In Fiji's current scenario, HFC consumption is a key category source. Therefore, following the decision tree below (**Figure 1**), it is recommended that country-specific Activity Data (AD) disaggregated at the sub-application level should be obtained to apply the Tier 2 method. Although HFC emissions from RAC is a key category source in Fiji, in the absence of disaggregated data at the sub-application level and country-specific composite emission factors, the Tier 1a/b method is the methodological approach used for the national scenario prior to 2020. Since 2021, the amount of HFC gases imported into the country by sub-application level is available, and it is highly recommended that Tier 2b could be adopted for Fiji. The HFC data imported into equipment is not captured in the correct format. It is recommended that the national ODS unit be trained in recording data to enable F-gas emissions, particularly from "bank emissions." The data is not digitized and does not record the amount of gases. Although some expert judgment could be applied, a more comprehensive template design for capturing data will enhance transparency in recording the activity data for the Tier 2b category.

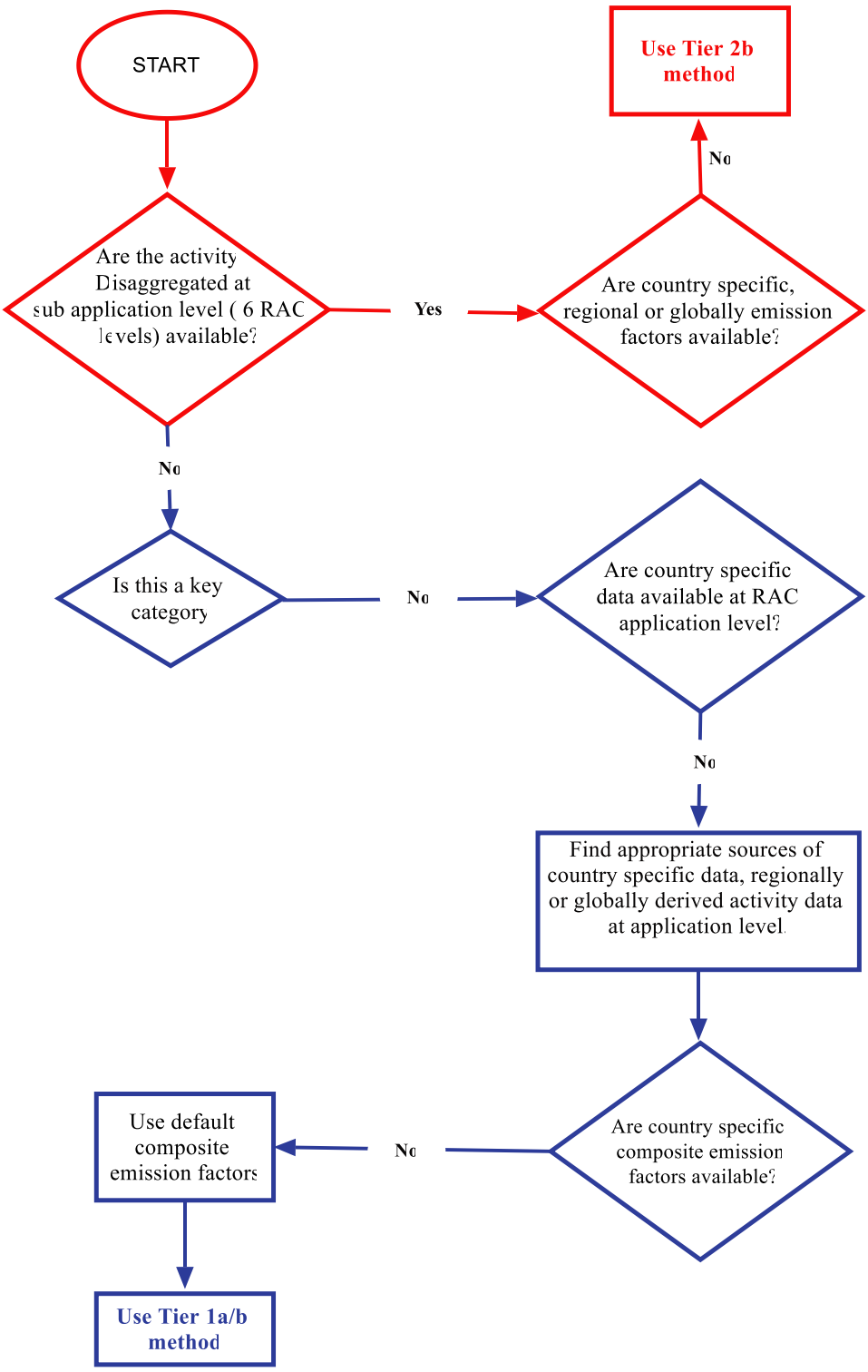

Figure 1: Fiji-specific decision tree for estimating HFC emissions from RAC applications. The red colour indicates that Tier 2B could be used for the years 2021 onwards, while the blue colour denotes that the Tier 1 a/b hybrid method could be used for years prior to 2021. (Adapted from Figure 7.6, Chapter 7, Vol 3. 2006 IPCC Guidelines for National Greenhouse Gas Inventories.)

Currently, as a signatory to the Montreal Protocol, Fiji is required to report consumption data only to the ozone secretariat. This calculation equates to:

Consumption = Production + Import – Export

HFCs stored in equipment, such as refrigeration and air conditioning systems, can emit these gases into the atmosphere throughout the entire life cycle of the equipment, which can be as long as 30 years, contributing to anthropogenic climate change. These emissions are considered delayed emissions and may occur gradually or predominantly during the end-of-life phase of the equipment. In the context of GHG inventories, it is essential to account for HFC consumption data and emissions from the "bank" (i.e., HFCs accumulated within the country in equipment), as illustrated in **Figure 2** below.

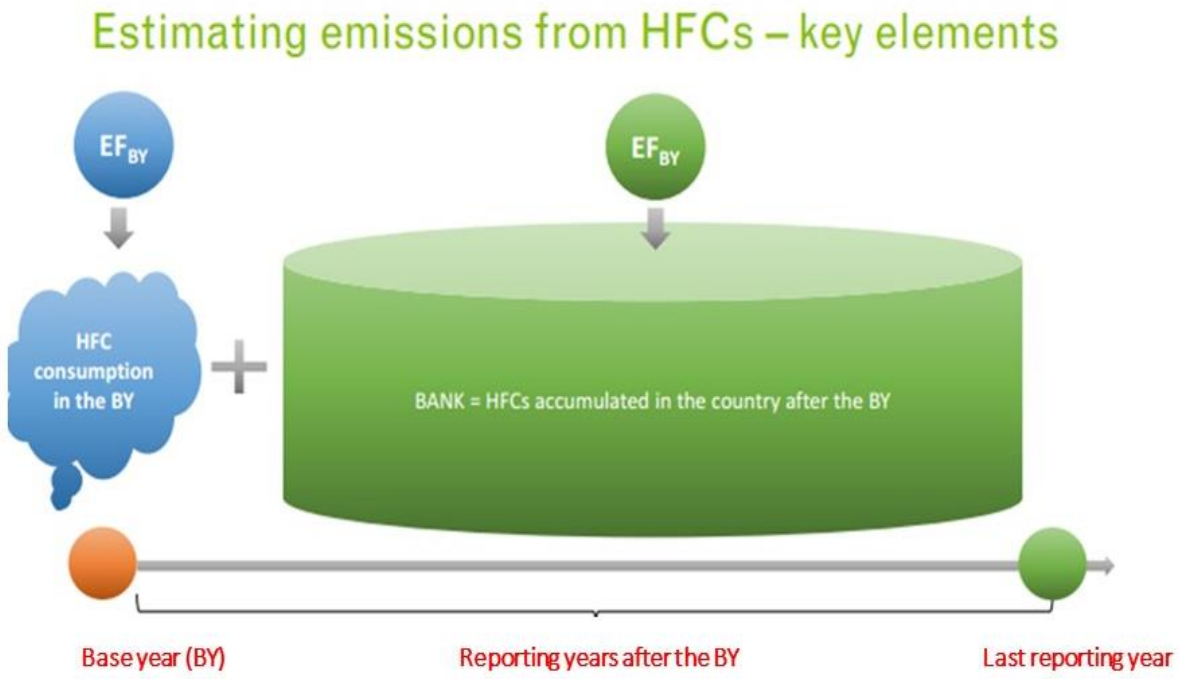

Figure 2: Visualizing the Process of Estimating Emissions from HFCs

3.1 Tier 1a: Emission-factor approach at the application level

In Tier 1a, the annual consumption data for a chemical is established. This data is then multiplied by the composite emission factor for the application. The net consumption is computed using equation 7.1, as given in Chapter 7 of Volume 3 of the IPPC 2006 guidelines.

EQUATION 7.1
CALCULATION OF NET CONSUMPTION OF A CHEMICAL IN A SPECIFIC APPLICATION

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

Once consumption is calculated, the HFC emissions are computed as follows:

EQUATION 7.2A
CALCULATION OF EMISSIONS OF A CHEMICAL FROM A SPECIFIC APPLICATION

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

Even in simple Tier 1 methods, there is only partial emissions from the consumption of a particular chemical agent and to estimate total emissions then emissions from any potential development of banks as described in above section need to be considered. In Tier 1 the emissions from the equipment banks are considered, although data is not disaggregated at sub-application levels. The emissions from banks in Tier 1 can be estimated using relatively straightforward algorithms and assumptions (See Table 4 below). Also to estimate emissions from the equipment bank, average lifetime of equipment and average emission factor for all equipment under RAC or known as composite EF is also considered in Equation 7.2B from chapter 7, Vol 3 of 2006 IPCC Guidelines (GLs). A similar approach is taken for Tier 2a methodology but here the data is disaggregated at sub-application level and therefore sub-application/equipment specific emission factor and lifetime is taken into account and emissions are calculated separately for each sub application and then summed at the end (Chapter7, Vol 3, 2006 IPCC GLs)

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

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

3.2 Tier 1b – Mass-balance approach at the application level

The mass balance approach estimates emissions from assembly, operation, and disposal without relying on emission factors. Instead, it utilizes measured consumption (i.e., sales) of each chemical in the country or facility under consideration. This method is generally limited to ODS substitutes contained in pressurized systems, which is the case for refrigeration and air conditioning equipment. The general equation is as follows:

EQUATION 7.3
GENERAL MASS BALANCE EQUATION FOR TIER 1b

Emissions = Annual Sales of New Chemical – (Total Charge of New Equipment – Original Total Charge of Retiring Equipment)

Generally, a hybrid approach (Tier 1a/b) is commonly adopted for aggregated activity data. A simplified worksheet has been developed for this purpose, and we will discuss it in the next section.

3.3 Guidance on the use of Spreadsheet for Tier 1 a/b – Category Code 2F1

Vol 3 of 2006 IPCC Guideline (https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html) contains Annex 1 titled Worksheets. Under worksheets click the first worksheet titled "*Calculation Example for 2F1(MS-Excel)*9*" and this will lead to an excel sheet called V3_An1_calculation_example_for_2F1.

This automated sheet allows you to input the current year, and it also calculates emissions from the bank starting from the year when the chemical or HFC was introduced in the country.

3.3.1 Data Requirements:

Information on domestic production, import, and export of chemicals (agents) for the reporting year. In Fiji's case, we do not produce these gases domestically, so production is zero. However, we export some of these refrigerants to other Pacific Island countries (PICs), and this export data needs to be accounted for. The import data for these chemicals and the exported quantities can be sourced from the Department of Environment (DoE) and verified by the Fiji Revenue and Customs Service (FRCS). All data should be reported in tonnes.

Note that in the case of blends, the relative proportions of different amounts of HFCs present should be considered and estimated for separately.

Table 3: This table shows the percentage composition of different HFCs in six refrigerant blends (R-404A, R-407C, R-410A, R-417A, R-449A and R-507C).

HFC or blend	HFC-23	HFC-32	HFC-125	HFC-143a	HFC-134a
R-404A	0.00%	0.00%	44.00%	52.00%	4%
R-407C	0.00%	23.00%	25.00%	0.00%	52.00%
R-410A	0.00%	50.00%	50.00%	0.00%	0.00%
R-427A	0.00%	15.00%	25.00%	10.00%	50.00%

R-449A	0.00%	24.30%	24.70%	0.00%	25.70%
R-507C	0.00%	0.00%	50.00%	50.00%	0.00%

Regrigerant Blend Calculation Example

Suppose that in a particular year, 100 kg of R410A was imported into the country. From the table provided above, we can see that the chemical composition of R410A consists of 50% HFC-32 and 50% HFC-125.

Therefore, the individual masses (in kg) are as follows:

HFC-32 mass (in kg) = 0.50 x 100 kg = 50 kg

HFC-125 mass (in kg) = 0.50 x 100 kg = 50 kg

Remember to convert these masses from kg to tonnes by dividing by 1000.

Parameters needed to apply Tier 1 a/b include:

- **Year of Introduction**: Obtain this information from the ODS unit within the Department of Environment.
- **Growth Rate in Sales**: Typically assumed to be linear across the assessment period, often derived from increases in the number of households or GDP (commonly taken as 2.5%).
- **Assumed Equipment Lifetime**: For household equipment, the IPCC default is 15 years.
- **Remaining Agent in Retired Equipment**: If unknown, it can be set at 0 (default factor is 15%).
- **Destruction of Agent in Retired Equipment**: Often negligible within the country, but sometimes agents are sent back to Australia for destruction (addressed in the export section).
- **Release of Agent from Retired Equipment**: If unknown, the IPCC default factor is 25%.

3.4 Tier 2a Emission Factor Approach

The emissions for each of the six sub-applications of refrigeration can be calculated separately for any given year, denoted as *t*. This calculation involves using **Equation 7.10** from Volume 3 of the IPCC 2006 guidelines. It's important to note that all quantities in this context are expressed in kilograms (kg), and the calculation must be performed for each type of HFC used in the six different sub-applications.

EQUATION 7.10
SUMMARY OF SOURCES OF EMISSIONS

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

Where;

- **$E_{containers,t}$ =** Emissions related to the management of refrigerant containers, calculated using Equation 7.11 (Chapter 7, Vol 3, IPCC 2006 GLs).

EQUATION 7.11
SOURCES OF EMISSIONS FROM MANAGEMENT OF CONTAINERS

$$E_{containers,t} = RM_t \bullet \frac{c}{100}$$

Where:

$E_{containers,t}$ = emissions from all HFC containers in year *t*, kg

RM_t = HFC market for new equipment and servicing of all refrigeration application in year *t*, kg

c = emission factor of HFC container management of the current refrigerant market, percent

- **$E_{charge,t}$:** Emissions related to refrigerant charging, including connection and disconnection of the refrigerant container and new equipment. This can be calculated using Equation 7.12 (Chapter 7, Vol 3, IPCC 2006 GLs).

EQUATION 7.12
SOURCES OF EMISSIONS WHEN CHARGING NEW EQUIPMENT

$$E_{charge,t} = M_t \bullet \frac{k}{100}$$

Where:

$E_{charge,t}$ = emissions during system manufacture/assembly in year *t*, kg

M_t = amount of HFC charged into new equipment in year *t* (per sub-application), kg

k = emission factor of assembly losses of the HFC charged into new equipment (per sub-application), percent

- **$E_{lifetime,t}$:** Annual emissions from the banks of refrigerants associated with the six sub-applications during operation (fugitive emissions and ruptures) and servicing. You can calculate this using Equation 7.13 and leak rates from Table 7.9 ((Chapter 7, Vol 3, IPCC 2006 GLs).

EQUATION 7.13
SOURCES OF EMISSIONS DURING EQUIPMENT LIFETIME

$$E_{lifetime,\,t} = B_t \bullet \frac{x}{100}$$

Where:

$E_{lifetime,\,t}$ = amount of HFC emitted during system operation in year *t*, kg

B_t = amount of HFC banked in existing systems in year *t* (per sub-application), kg

x = annual emission rate (i.e., emission factor) of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing, percent

- **$E_{end\text{-}of\text{-}life,\,t}$:** Emissions at system disposal, calculated using Equation 7.14 (Chapter 7, Vol 3, IPCC 2006 GLs).

EQUATION 7.14
EMISSIONS AT SYSTEM END-OF-LIFE

$$E_{end-of-life,\,t} = M_{t-d} \bullet \frac{p}{100} \bullet \left(1 - \frac{\eta_{rec,\,d}}{100}\right)$$

Where:

$E_{end\text{-}of\text{-}life,\,t}$ = amount of HFC emitted at system disposal in year *t*, kg

M_{t-d} = amount of HFC initially charged into new systems installed in year (*t-d*), kg

p = residual charge of HFC in equipment being disposed of expressed in percentage of full charge, percent

$\eta_{rec,d}$ = recovery efficiency at disposal, which is the ratio of recovered HFC referred to the HFC contained in the system, percent

3.4.1 Data Requirements for Tier 2A

The data requirements for Tier 2A is similar to Tier 1 except that in Tier 2 data is for a specific equipment or application type with its specific emission rate and equipment average lifetime. In tier 1 emission rate and equipment lifetime is averaged data for all equipment/applications under RAC as data is not disaggregated. The data requirements are as follows:

- Number of equipment units or products in each sub-application.
- Year of introduction.
- HFC chemical used in each sub-application.

- Average chemical charge of each equipment or product type.
- The average lifetime of each equipment/product type.
- Emission rates for each sub-application (country-specific or regional/global).
- Recycling, disposal, and repurposing parameters.

3.5 Tier 2b Mass-Balance Approach

The Tier 2b mass-balance approach relies on knowledge of the annual sales of refrigerant, refrigerant destruction, and any changes in equipment stock (such as new equipment sales and decommissioned equipment) on a sub-application basis. It does not require absolute knowledge of equipment stocks or emission factors related to each refrigeration and air conditioning sub-application.

Tier 2b emissions can be calculated as follows:

EQUATION 7.9
DETERMINATION OF REFRIGERANT EMISSIONS BY MASS BALANCE

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

Where:

Annual sales of new refrigerant = (Imported bulk chemical – exported bulk chemical + chemical contained in Factory Factory -Charged imported equipment)

Total Charge of New Equipment

= Chemical to Charge Domestically Manufactured Equipment that is not Factory - Charged

+ Chemical to Charge Domestically Manufactured Equipment that is Factory - Charged

+ Chemical to Charge Imported Equipment that is not Factory Charged - Charged

+ Chemical Contained in Factory - Charged Imported Equipment

-Chemical Contained in Factory - Charged Exported Equipment

Total Charge of Retired Equipment

= Chemical to Charge Domestically Manufactured Equipment that is not Factory -- Charged

+ Chemical to Charge Domestically Manufactured Equipment that is Factory-- Charged

+ Chemical to Charge Imported Equipment that is not Factory - Charged

+ Chemical Contained in Factory - Charged Imported Equipment

-Chemical Contained in Factory - Charged Exported Equipment

4.0 Estimating Emissions of F-gases from Refrigeration and Air Conditioning (Category 2.F1.)

The emissions of HFCs from the RAC sector in Fiji were estimated using the Tier 1a/b approach of the IPCC 2006 GLs. To compile the inventory of F-gases from RAC a four step process needs to be followed as depicted in **Figure 3** and thoroughly explained in **Table 4.**

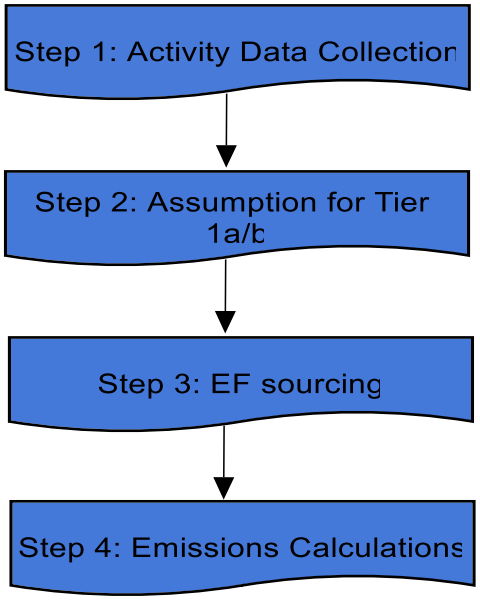

Figure 3: A flowchart outlining steps for HFC emissions calculations for the years 2005 to 2023.

Table 4: Details of requirements and description of each step in calculating HFC emissions from RAC.

Steps	Requirements/Descriptions
1. Activity Data Collection	For Tier 1a/b methodology, you need to compute the chemical sales data of different chemical agent or HFCs. ***Activity Data Required***: Amount (Mass in kilograms of individual HFCs or blends) imported, exported in bulk and in equipment (See data flow diagram below) and the year of introduction of chemical agent in Fiji. **Institution Responsible**: Department of Environment in Ministry of Environment and Climate Change is responsible for activity data compilation.

	Data Request needs to be sent by Director of CCD to Director of DoE timely before the GHG reporting cycle.
2. Assumptions for Tier 1a/b methodology	The following assumptions are made to sue Tier 1 a/b methodology to estimate HFC emissions for Fiji: • Servicing of equipment containing the refrigerant does not commence until 3 years after the equipment is installed. • In a mature market two thirds of the sales of refrigerants is used for servicing and one third is used to charge the new equipment. • The average equipment lifetime is 15 years. • The complete transition to a new refrigerant technology will take place over a 10 year period. • The growth rate in new sales of equipment is assumed to be zero (default) • The percentage of gas destroyed at the End-of-Life is also assumed to be zero.
3. Emission Factor sourcing	The default emission factor (EF) of 15% annually across the whole RAC application area is used. This default emission factor is the weighted average of all default EF for all sub-applications listed in Table 7.9, Chapter 7 of Vol 3, IPCC 2006 Guidelines.
4. Emissions calculations	Once the activity data is received then the following is done to estimate emissions: • If the imports and exports of blends are provided then using Table 7.8 of Vol. 3 IPCC 2006 Guidelines, the individual composition of HFC should be calculated. • The data should be converted into Tonnes by simply dividing the mass in kilograms by one thousand. • Tier 1a/b excel worksheet labelled "Calculation Example for 2F1" in Annex 1 of Vol 3 IPPU, 2006 IPCC GLs should be used. • The yellow cells should be filled and the "Data" tab of the worksheet for following cells (See **Figure 4**): - Name of Country - Current year - Production in current year (is always 0 as no chemical agent is produced in Fiji.) - Imports in current year in Tonnes. - Exports in current year in Tonnes - Year of introduction - Growth Rate in new equipment sales - Assumed equipment lifetime(years) - Emission factor from installed base - Data (Import and exports in tonnes) for different HFCs for previous years should be filled as well. • In the "Calc" tab of the worksheet you can use the Dropdown list to choose the individual HFC and it will show emission in

	the current year in Tonnes and and will back calculate the emissions from the year of calculations (See Below **Figure 5**).

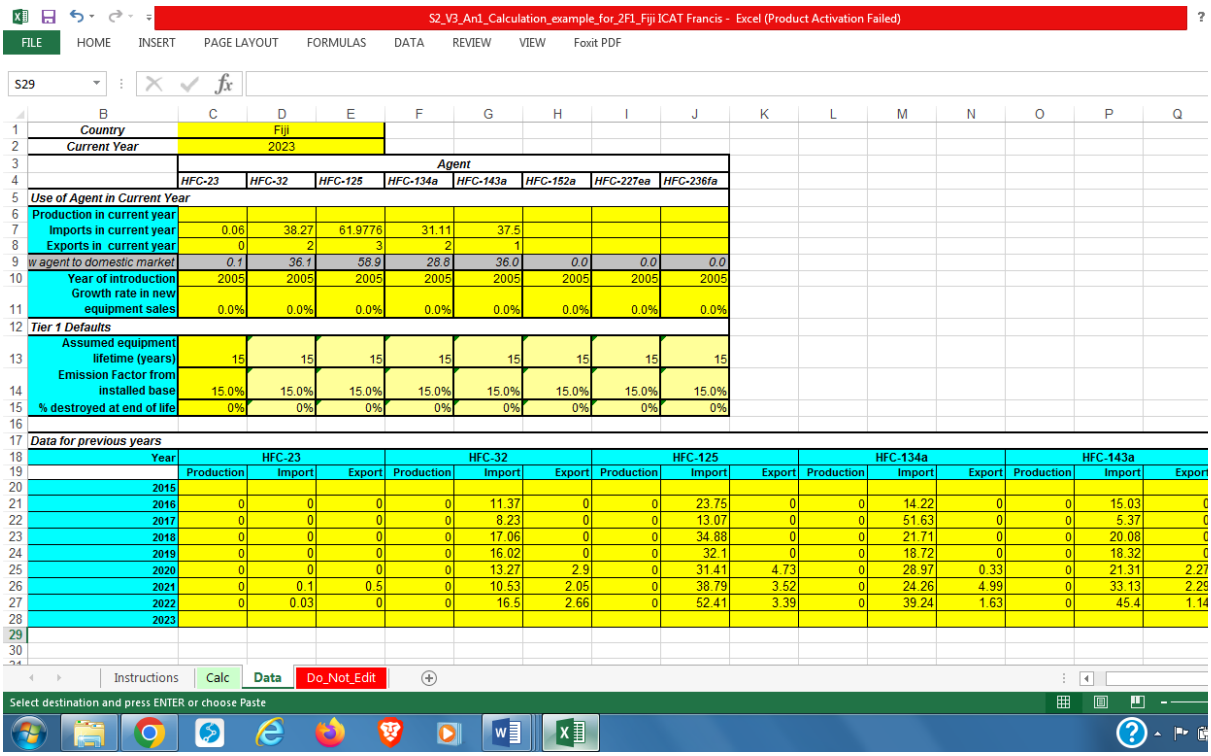

Figure 4: A screenshot of the "Data" tab of the IPCC worksheet.

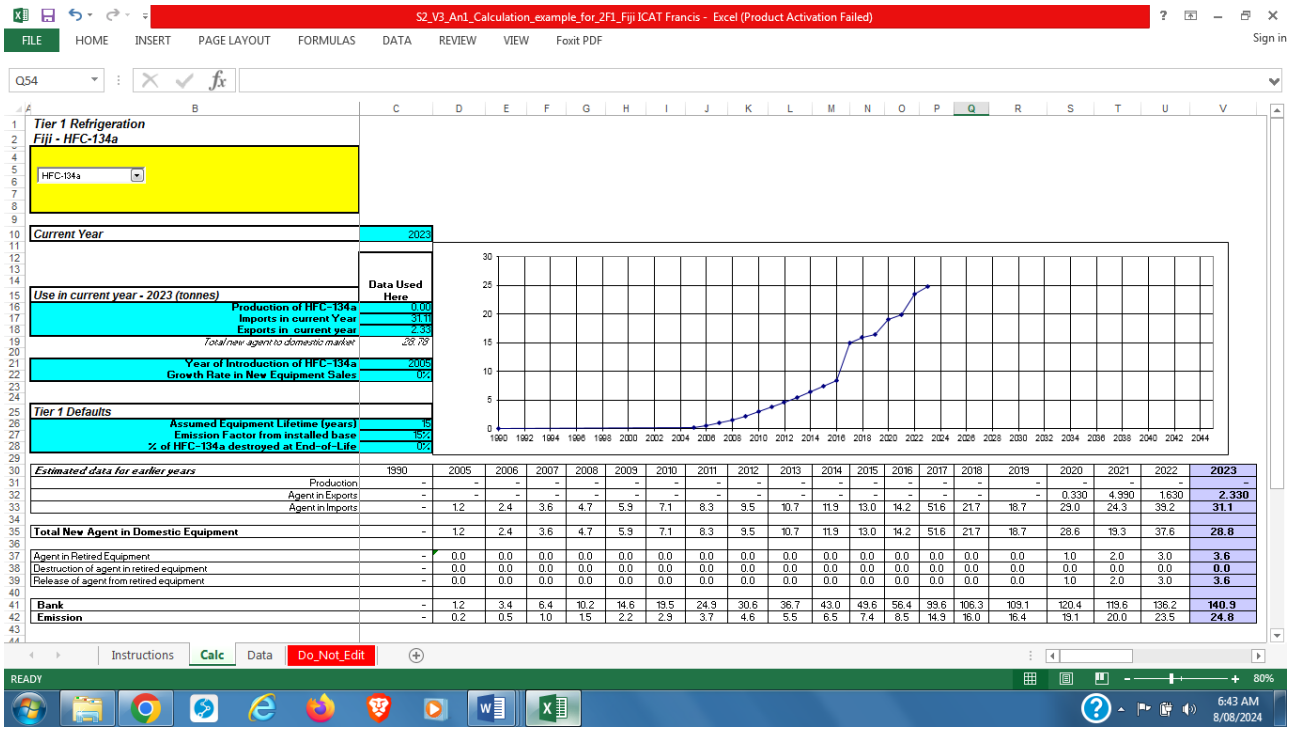

Figure 5: A screenshot of the "Calc" tab of the IPCC worksheet for HFC-134a as the selected gas.

For Fiji's scenarios and in consultation with the stakeholders, the following assumptions, based on the Tier 1 defaults, were used:

- The year of introduction is 2005.
- The growth rate in new equipment sales is 0%.
- The emission factor from the installed base is 15%.
- The percentage of gas destroyed at the end of life is 0%.

The growth rate in new equipment sales is taken as 0% as no data is available and therefore a default of 0% is applied. This is a very conservative approach but maybe other approaches such as growth in population rate or GDP could also be used to ascertain the growth rate in new equipment sales. The same assumptions were used in the Fiji National Inventory Report, except that the percentage of gas destroyed at the end of life was 15%. During stakeholder consultations, it was realized that no gas recovery was done at the end of the equipment's life. Therefore, expert judgment was applied, assuming that all the gas contained in the equipment at the end of its life was emitted into the atmosphere. This further justifies why a 0% factor was used in this report.

4.1 Activity Data

The equipment data is not disaggregated into six sub-applications, and information on chemicals stored in new equipment is only available starting from 2021. Unfortunately, this data is not digitized and it exists in hard copy format as import permits. However, it is possible to estimate emissions from 2021 onwards using Tier 2b. This estimation would rely on equipment data, annual sales data, and assumptions about equipment decommissioning in specific years (although no data is currently available for this).

The emissions calculated using Tier 1a/b can be updated in the future using Tier 2b if accurate and electronic equipment data becomes available.

Currently, the AD used for estimating HFC emissions is based on the total amount of blends and HFCs imported into the country from 2016 to 2023 (see **Error! Reference source not found.**). The consumption data provided by the national ODS unit, MECC, was used to calculate emissions. Consumption is defined as:

Consumption = Production + Import – Export

For Fiji, where there is no local production of these gases, production is considered zero. Export is negligible and typically involves bulk gas exports to other PICs or sales to foreign fishing vessels.

Table 5: Activity data used to estimate HFC emissions from refrigeration and air conditioning in metric tonnes.

	HFC-134a		HFC-23		HFC-32		HFC-125a		HFC-143a	
	Import	**Export**	**Import**	**Export**	**Import**	**Export**	**Import**	**Export**	**Import**	**Export**
2016	14.22	0	0	0	11.37	0	23.75	0	15.03	0
2017	51.63	0	0	0	8.23	0	13.07	0	5.37	0
2018	21.71	0	0	0	17.06	0	34.88	0	20.08	0
2019	18.72	0	0	0	16.02	0	32.1	0	18.32	0
2020	28.97	0.33	0	0	13.27	2.9	31.41	4.73	21.31	2.27
2021	24.26	4.99	0.1	0.5	10.53	2.05	38.79	3.52	33.13	2.29
2022	39.24	1.63	0.03	0	16.5	2.66	52.41	3.39	45.4	1.14
2023	31.11	2.33	0.06	0	38.27	2.205	61.98	3.05	37.5	1.49

As explained earlier to estimate total emissions, emissions from equipment bank needs to considered togather with emissions from consumption. The emissions from bank are estimated

using the assumptions given in Table 4 and data requirements such as the year of introduction of the chemical agent, growth rate in the sales of new equipment and the average lifetime of the equipment.

4.2 Emission trends in HFCs from the RAC sector:

The results from the Tier 1a/b hybrid model show the emission trends of individual HFCs (HFC-125, HFC-134a, HFC-143a, HFC-23, and HFC-32) in Fiji (see **Figure 6**). Notably, HFC-125 and HFC-143a emissions are increasing at an alarming rate compared to other HFCs. In 2023, HFC-125 recorded the highest emission of 35.5 tonnes, followed by HFC-134a (24.8 tonnes), HFC-143a (24.6 tonnes), HFC-32 (16 tonnes), and finally, HFC-23 (0.01 tonnes).

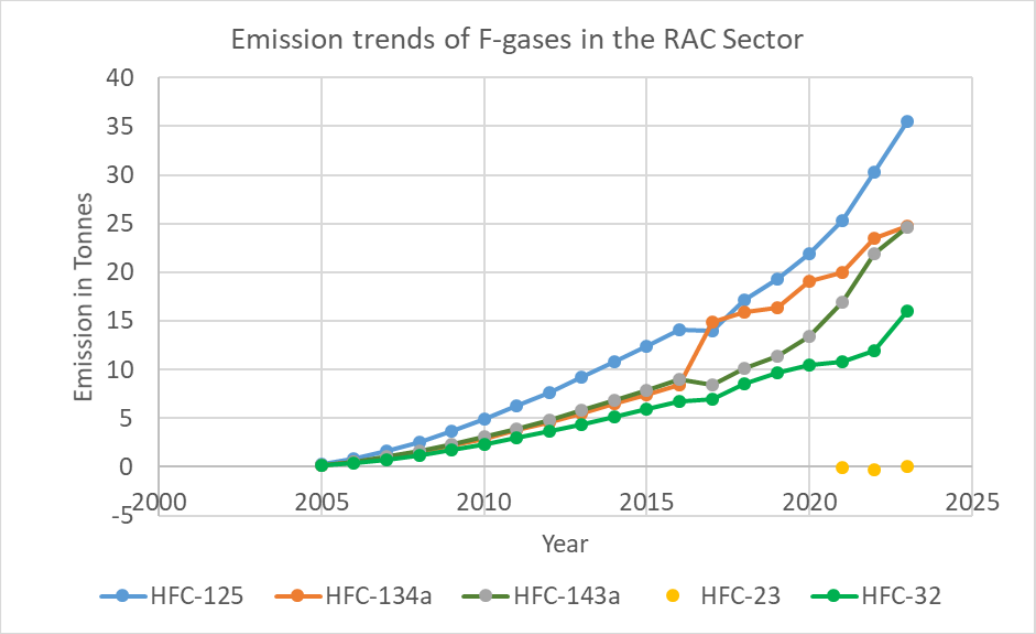

Figure 6: Emission trends of different HFCs in Fiji from the RAC sector from 2005 – 2023.

The emission trends shown in **Error! Reference source not found.7** were then converted to CO_2 equivalent using the GWP from AR4 of the individual HFC gases stated in **Table 1**.

Table 6: Summary of GHG emissions from HFC use in refrigeration and air conditioning in Fiji (Gg CO_2 eq) using Tier 1a/b methodology.

Year	Total Gg CO_2 eq	NIR[1] values
2005	2.23	NE[2]
2006	6.35	NE
2007	12.09	NE
2008	19.19	NE
2009	27.46	NE
2010	36.71	NE
2011	46.81	NE
2012	57.62	NE
2013	69.04	49.86
2014	80.97	59.48
2015	93.34	74.42
2016	106.09	89.33
2017	112.55	104.29
2018	133.82	117.62
2019	148.52	130.78
2020	170.95	NE
2021	199.34	NE
2022	240.85	NE
2023	280.63	NE

The CO_2 equivalent emissions for each year were summed and are summarized in **Figure 6**. The emissions were converted to gigagrams (Gg) by dividing the emissions in tonnes by one thousand.

It should be noted that the discrepancy between emissions recorded in the NIR and in this report is due to the varying assumptions used in the calculation, particularly the percentage of gas destroyed at the end of the equipment's life. In any case, this is a very conservative approach, as the growth rate in sales of new equipment is taken as zero by default. However, there could be an increase in equipment sales. The discrepancy observed between the 2019 emission value calculated here and the NIR is about 14%.

Figure 7 illustrates the graphical representation of GHG emissions data from **Error! Reference source not found.6**. It is noteworthy that since 2017, there has been a change in

[1] National Inventory Report 1, Biennial Update Report (BUR) 1
(Source: https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/07213546_Fiji-BUR1-1-Fiji_GHG%20NIR%202023_Final.pdf)
[2] NE = Not estimated

the gradient in the emission rate, and since 2017, the emission rate has grown exponentially. Notably, there has been a change in the gradient in the emission rate since 2017, and it has been growing exponentially. This is attributed to detailed consumption data available from 2016, and the emissions correlate positively with the increase in consumption of HFC-125 and HFC-143a, which also have higher GWPs compared to HFC-134a and HFC-32.

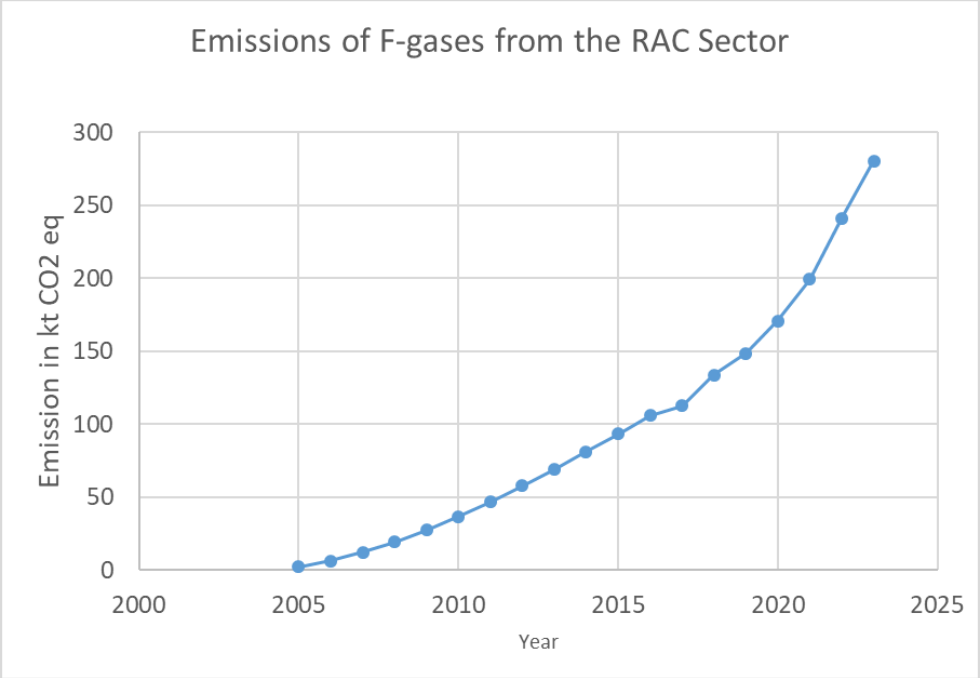

Figure 7: Exponential Growth in HFC Emissions from the RAC Sector (2000-2025)

5.0 Institutional Arrangements and Data Flow

5.1 Institutional Arrangement

The arrangement for the collection, compilation, and estimation of emissions for Refrigeration and Air Conditioning (category 2.F.1) under Product Uses from fluorinated substitutes for ODS substances can be facilitated through Fiji's Climate Change Act 2021(**Figure 8**).

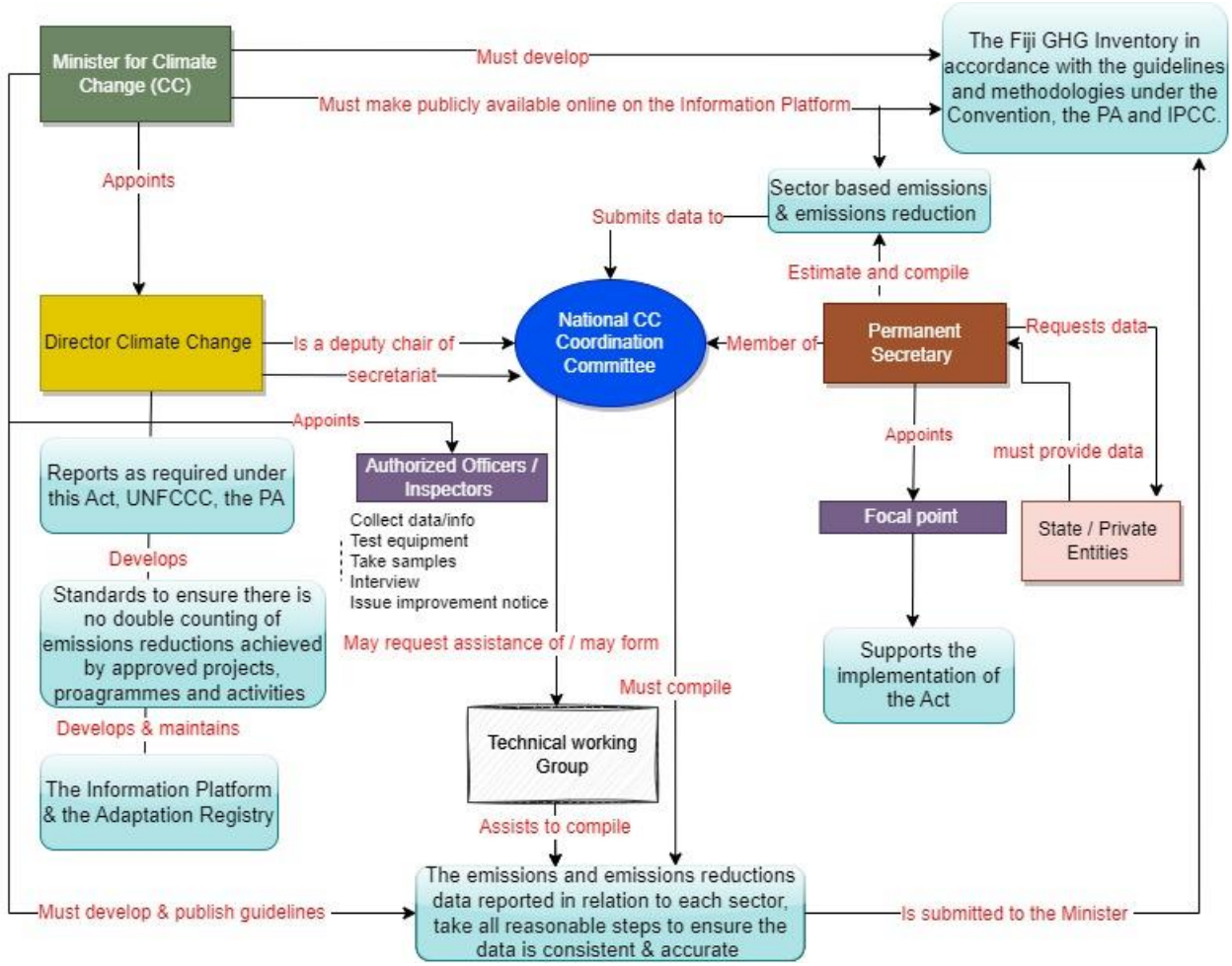

Figure 8: Institutional Arrangement and Governance structure as established in Fiji's Climate Change Act 2021.

The CCD is responsible for executing, coordinating, and implementing the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. This entity is overseen by the Director of Climate Change appointed under the Climate Change Act 2021. The roles of the Director of Climate Change include preparing necessary reports, compiling emissions data, ensuring data accuracy, and supporting the Fiji Government in addressing climate change risks through national policy.

The Climate Change Act 2021 establishes the framework for the sector-based collection of data and information needed to estimate emissions and emissions reduction data for the National GHG Inventory. The sector responsibilities thus fall on the respective Permanent Secretaries (PSs) to biennially estimate, and compile data related to emissions and emissions reduction activities from within their portfolio and submit this information to the National Climate

Change Co-ordination Committee (NCCCC) which is a body comprised of PSs, with the function of coordinating and implementing all climate change initiatives in the country.

Compiling data and reporting on the category Refrigeration and Air Conditioning (2F1) under Product uses as substitutes for ODSs as per the CCA may fall under the purview of the ODS Unit of the Ministry of Environment and Climate Change. The Department focuses on refrigeration and air-conditioning (for both land and marine applications) and the fumigation industry for quarantine and pre-shipment. It grants permits to companies for sale and servicing air conditioning and refrigeration. Licensing for permits is done annually for the import and export of gases. The Department thus has the data available on the amount of HFCs and blends imported in Fiji and is monitored through the permitting system for HFCs. Data on imported appliances with HFCs (bulk gases) is only available from 2020 onwards on the onset of ratifying the Kigali Amendment. The institutional arrangement for GHG inventory for category 2F1 is given in **Figure 9** below.

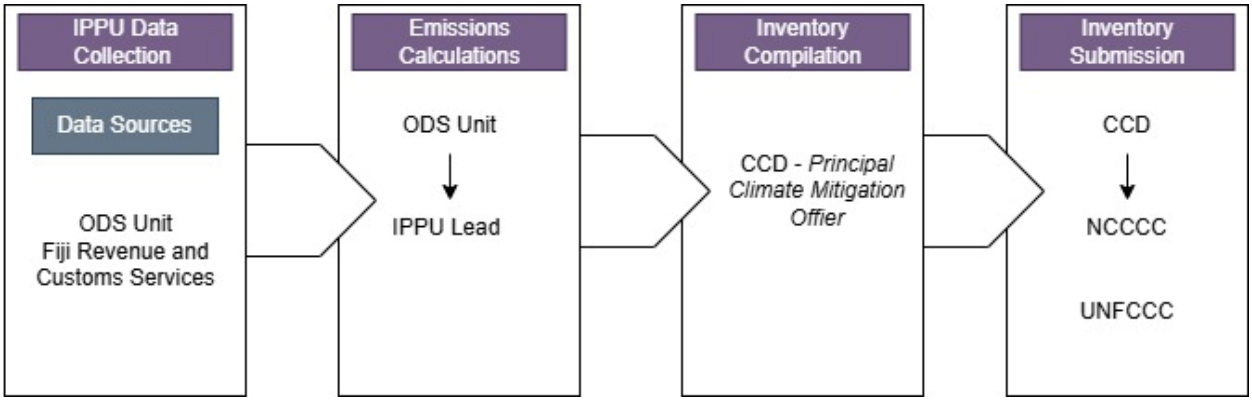

Figure 9: Institutional arrangement chart for GHG inventory submission for 2F1 category.

5.1.1 Roles and responsibilities

Table 7: Responsibilities of Inventory Coordinator and IPPU Sector Lead

Inventory Coordinator – *Principal Climate Mitigation Officer*:	- A clear understanding of their role in producing the IPPU GHG estimates for the inventory. - Collaborate with the National Inventory Coordinator to manage the IPPU sector budget and develop an IPPU sector-specific work plan and schedule that coincides with the overall National Inventory Schedule. - Develop and implement an IPPU sector-specific plan for archiving all relevant information and materials, in coordination with the archiving coordinator. - Oversee the establishment of arrangements between IPPU sector data collectors and data suppliers.

	- Convene the IPPU sector working group to review calculations and perform initial Quality Assurance/Quality Control (QA/QC). - Coordinate the response to comments received from QA (external) reviews of the IPPU sector GHG estimates and update the inventory if necessary. - Review the final IPPU sector GHG estimates and the narrative describing the assumptions, methodologies, and results.
IPPU Sector Lead *The IPPU sector lead as per the CCA is the national ODS unit. A consultant or an existing member of staff may assume the role of the IPPU sector lead working in close coordination with the ODS unit and its data providers.*	The IPPU Sector Lead should understand: - The expected and required deliverables and timeline for the submission of each deliverable, - The IPCC Guidelines for this sector, include default methods, data sources, basic QA/QC, uncertainty assessment, and reporting procedures. - Review the Consultative Group of Experts (CGE) materials related to the IPPU sector. - Review the IPPU section of the IPCC Guidelines to understand the default methods, data sources, basic QA/QC, uncertainty assessment, and reporting procedures. - Review the IPPU section of the previous National GHG Inventory and other reports relevant to national GHG estimates for this sector. Reviewing the IPPU section from other country's GHG inventory reports can also be informative. - Understand which categories in the IPPU sector were identified as key categories in the previous inventory. - Consider potential improvements identified in the previous inventory for this sector. - Determine the most appropriate IPCC methodology to be used to estimate GHGs for each category in accordance with decision trees. - Oversee choice and/or development of emission factors. - Document all data collection arrangements, methodologies, and assumptions, including the use of expert judgment. - Oversee the development of the uncertainty analysis for the IPPU sector. - Identify any improvements needed for subsequent inventories, related to AD, emission factors, methodologies, or other components of developing the estimates. Document these improvements.

5.2 Data Flow Diagram for Activity Data for F- gases

Figure 10 below depicts the data flow diagram for ADAD collection, compilation, and quality assurance/quality control (QA/QC) checks carried out by the national ODS unit, FRCS, and third-party verifiers. The process begins with permit applications submitted by registered importers of bulk HFCs into the country and equipment importers. The permit includes the following yearly AD:

- Types or blends of F-gases and their amounts imported/exported in bulk (measured in kilograms).
- Types and amounts of F-gases in imported equipment.
- Equipment quantities and models.

- Recovered or destroyed gases.

Registered importers also provide annual sales and purchase records, which should include AD for bulk imports (in cylinders), exports, and recovered or destroyed gases. It's important to note that records from registered importers may not always contain information on recovered or destroyed gases. The recovery of gases is typically performed by technical officers within the ODS unit, and this data should be compiled by either the Technical Officer (TO) or Environment Officer (EO) within the ODS unit.

Once the permit is approved and all data is recorded, the next step involves physical inspection of equipment and cylinders upon arrival at the point of entry by customs officers and ODS unit personnel. The consignment is checked against the permit, and custom entries are made. Goods are then released to the importers. If any gases are imported without a permit or if banned ODS (such as CFCs) are detected, an entry for recovered gases is also recorded. Similarly, when gases in cylinders or equipment are exported from Fiji to other PICs, custom entries are made.

The TO or EO compiles a report on the export, import, and recovered/destroyed gases, which is submitted to the Principal Environmental Officer (PEO) within the ODS unit. The PEO verifies the report by reconciling it with the custom entries. If any data discrepancies or uncertainties arise, records are verified with individual importers. Instances of double custom entries or missing entries are addressed, ensuring correct Harmonized System (HS) codes as per the Customs Tariff Classification.

Once all AD is verified by the PEO, it is archived and undergoes third-party verification by implementing partners such as UNDP and UNEP. These partners primarily check consumption data, and any discrepancies found are referred back to the PEO for verification. If consumption data is accurately recorded, it is submitted through an online portal to the ozone secretariat.

For inventory purposes, the Climate Change Division (CCD) must send a data request to the Director of Environment, who approves the release of extracted data from the archive. The CCD then provides AD to inventory compilers for estimating emissions using either Tier 1a/b or Tier 2b methods.

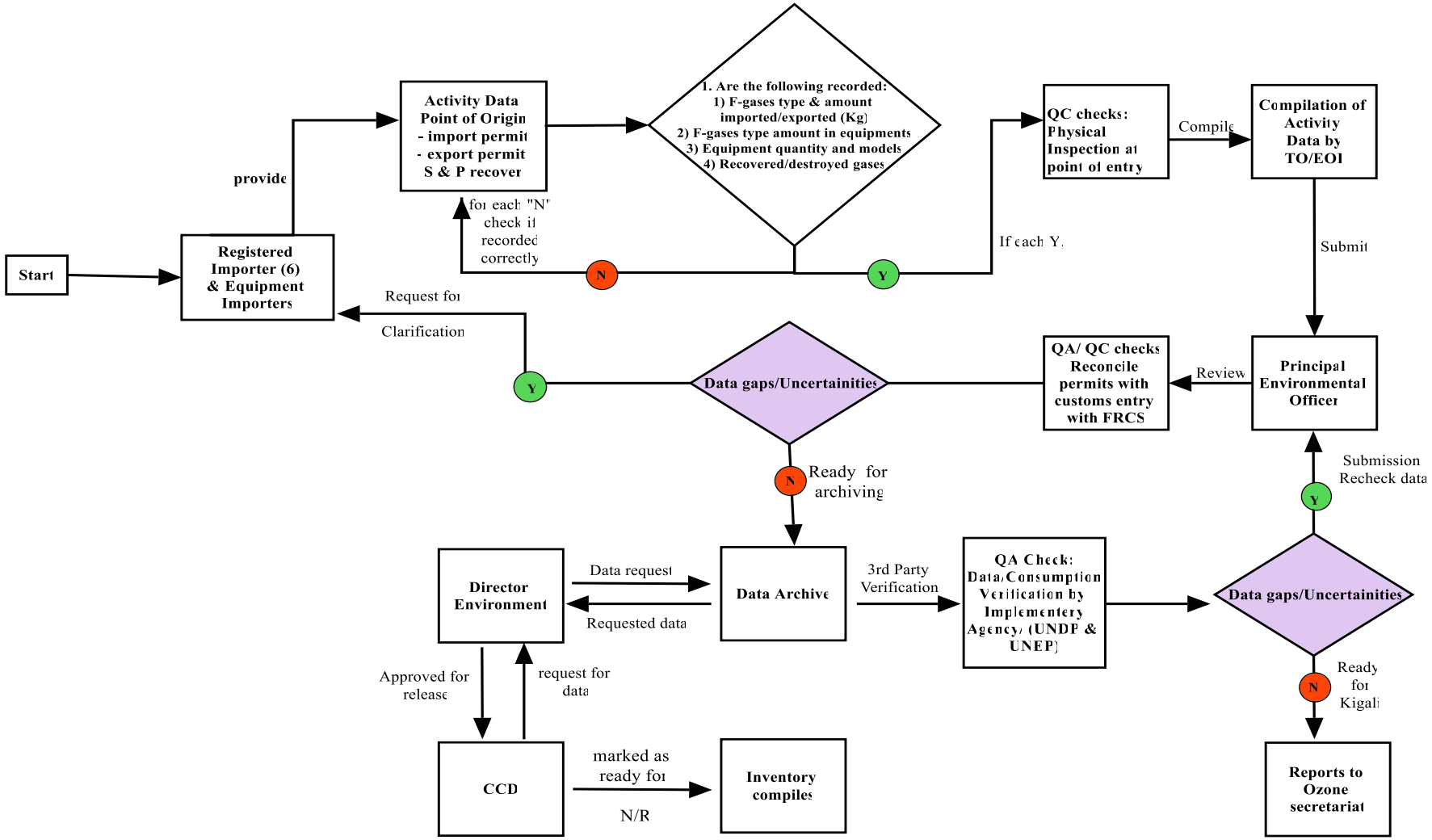

Figure 10: Data flow diagram for activity data for estimating emissions of HFC gases from category 2F1.

6.0 The Kigali Amendment to the Montreal Protocol: HFC Phase-down

The parties to the Montreal Protocol on substances that deplete the ozone layer reached an agreement at their 28th Meeting of the Parties on 15 October 2016 in Kigali, Rwanda to phase down HFCs known as Kigali amendment to Montreal Protocol. It is a legally binding agreement between the signatory parties to limit the use of HFCs under protocol that could mitigate global emissions of up to 105 billion tonnes of carbon dioxide equivalent of GHG and could potentially reduce 0.5°C of global temperature rise by 2100.

Fiji ratified the Kigali amendment on 16 Jun 2020 and committed to phasing down HFCs by 80% by 2045. Fiji is in Group 1 under Article 5 (A5) Countries HFC phasedown schedule (Developing Countries).

6.1 Baseline Calculation for Kigali amendment

The calculation for baseline for Kigali amendement consists of two componenets:

- The average annual HFC quantity consumed (or produced) during a 3-year baseline period (2020 – 2022)
- A proportion of the baseline for the control of HCFCs under the Montreal Protocol (This component is required because A5 countries are only in the early stages of HCFC phase-out). The HCFC component bolsters a country's HFC baseline to allow for growth. It does not change any obligations countries have regarding HCFCs. Since Fiji is classified under Group 1 in A5, 65% of the HCFC baseline (See **Table 8**) is factored into the baseline calculation.

In summary, the formula for calculating the baseline (or starting point for consumption of HFC) for Group 1 A5 countries is:

Baseline = Average HFC consumption for the period 2020–22 + 65% of the hydrochlorofluorocarbon (HCFC) baseline.

6.2 Steps for Calculating Fiji's Kigali Baseline

Step 1: Estimating 65% of the HCFC baseline consumption.

Fiji's Baseline Survey for HCFC was done in 2009-2010. The Original Fiji's baseline for HCFCs was established at 152.83 kt HCFCs. This was later revised through Decision XXIX/15 in 2015 with the revised amount of 104.18MT (5.73 ODP tonnes). The baseline was reduced from 152.83t to 104.18t with the removal of 48.65t for the ODS supply of Foreign Flagged Fishing Vessels (FFFV). According to the government of Fiji, the two ODS subject to the HCFC baseline are HCFC-22 (R22) and HCFC-142b (Freon-142b or R142b). According toArticle 7, the baseline reporting for HCFC was 104.18 MT but the data provided by the DoEDoE sums up to 104.09 MT and the shortfall of 0.09 MT could not be accounted for. Taking into account the GWPs from AR4 for the two HCFCs (R22 and HCFC-142b), the baseline was calculated to be 188.73 kt CO_2 equivalent. These baselines values reported here and are shown in the Table 8 in highlighted yellow cell.

Table 8: Estimating 65% of HCFC baseline consumption in kt CO_2 eq

HCFC	*2015*	*2016*	*2017*	*2018*	*2019*	*Baseline*	*GWP*	*Baseline*	
			Metric tonnes (t)					**tonnes (t) CO_2e**	**kt CO_2e**
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I = G * H**	**J = I/1000**
HCFC-22 (R22)	70.03	74.43	67.6	75.23	83.91	103.44	1810	187,226.40	187.23
HCFC-142b	0.32	0.09	0	0.05	0.05	0.65	2310	1,501.50	1.50
Totals						104.09		188,727.90	188.73

Step 2: Calculating the HFC consumption for the years 2020 – 2022

The verified HFC consumption data (= import - export) should be obtained, which then should be converted into the mass (kg) of individual HFC gas using the composition data. Then, using the GWPs of these individual gases, the consumption data is expressed as CO_2 equivalent (See **Error! Reference source not found.**). Finally, the average for the 3-year consumption is calculated and used in the

baseline calculation. The average HFC consumption for 2020 – 2022 was calculated to be 318.18 kt of CO_2 equivalent.

Table 9: Illustrates the step-by-step calculation of Fiji HFC consumption for 2020 – 2022 in CO_2 eq and the calculation of average HFC consumption used in Baseline calculation.

HFC component = average (HFC consumption in 2020–22)			
	Consumption (import- export) in Fiji, kg		
HFC or blend	***2020***	***2021***	***2022***
HFC-134A	25881.2	15990.2	33646.4
HFC-23	0	500	30
R-32	347.3	-400	2992.5
R-404A	30640	56015.1	76507.1
R-407C	2938	1988.2	1627.2
R-410A	18705.4	16565.2	20938.9
R-427A	0	904	0
R-449A	0	0	227
R-507C	6220	3271.2	8949.6
	Recalculated to individual gases (kg)		
	2020	***2021***	***2022***
HFC-23	0.00	500.00	30.00
HFC-32	10,375.74	8,475.49	13,891.37
HFC-125	26,678.80	35,287.89	49,070.24
HFC-143a	19,042.80	30,853.85	44,258.49
HFC-134a	28,634.56	19,716.67	37,611.17
	HFCs Recalculated to tonnes CO_2 eq		
	2020	***2021***	***2022***
HFC-23	0.00	7,400.00	444.00
HFC-32	7,003.62	5,720.95	9,376.67
HFC-125	93,375.80	123,507.63	171,745.85
HFC-143a	85,121.32	137,916.72	197,835.46
HFC-134a	40,947.42	28,194.84	53,783.97
Total 2020-22	**226,448.16**	**295,340.14**	**432,741.95**
Average 2020-22 HFC Consumption	**318,176.75**		

Step 3: Add 65% of the HCFC baseline (Step 1) and average HFC consumption for (2020 – 2022)

Total HFC baseline = Average(HFC consumption in 2020–22) + 65% HCFC baseline	
Baseline (kt CO_2e)	**= (318.18 + 0.65 *188.73) = 440.85**

Hence the baseline for Kigali amendementis calculated to be **440.85 kt CO_2 eq**.

6.3 HFC Phase-down Schedule Calculation for Fiji

Fiji as a Group 1 A5 country is required to reduce HFC consumption in step-wise manner to total of 80% by 2045. It is anticipated that 2024 the consumption of HFC will be limited or "freezed" to the baseline consumption of 441 kt CO_2 eq and then will follow the step-wise reduction as shown in **Table 10** below.

Table 10: Fiji HFC phase-down schedule.

Reduction Steps Freeze	2024	
Step 1	2029	10%
Step 2	2035	30%
Step 3	2040	50%
Step 4	2045	80%

To calculate the phase down calculations it is imperative to know the baseline or the starting point and then using the schedule given in **Table 10**, calculations can be done to know the reductions in kt of CO_2 eq. **Table 11** shows a detailed calculation for thephase down calculation starting with a baseline HFC consumption of 441 kt of CO_2 eq.

Table 11: Detailed phase-down schedule calculation for Fiji Kigali Amendment.

Step 1	10% reduction by 2029
Calculation elements	**Results**
Baseline (kt CO_2 eq)	441
1st reduction step	10%
Amount of HFCs reduced	44
Amount of HFCs after the reduction	397
Step 2	30% reduction by 2035
Calculation elements	**Results**
Baseline (kt CO_2e)	441
1st reduction step	30%
Amount of HFCs reduced	132
Amount of HFCs after the reduction	309
Step 3	50% reduction by 2040
Calculation elements	**Results**
Baseline (kt CO_2 eq)	441
1st reduction step	50%
Amount of HFCs reduced	220
Amount of HFCs after the reduction	220
Step 4	80% reduction by 2045
Calculation elements	**Results**
Baseline (kt CO_2 eq)	441
1st reduction step	80%
Amount of HFCs reduced	353
Amount of HFCs after the reduction	88

It is shown that HFC consumption is on freeze at 441 kt CO_2 eq, then decreses by 10% to 397 kt of CO_2 eq in 2029 amd then follows a stepwise decrease by 30% in 2035 and 50% by 2040 and then finally decreases by 80% to 88 kt CO_2 eq by 2045 (See **Figure 11**).

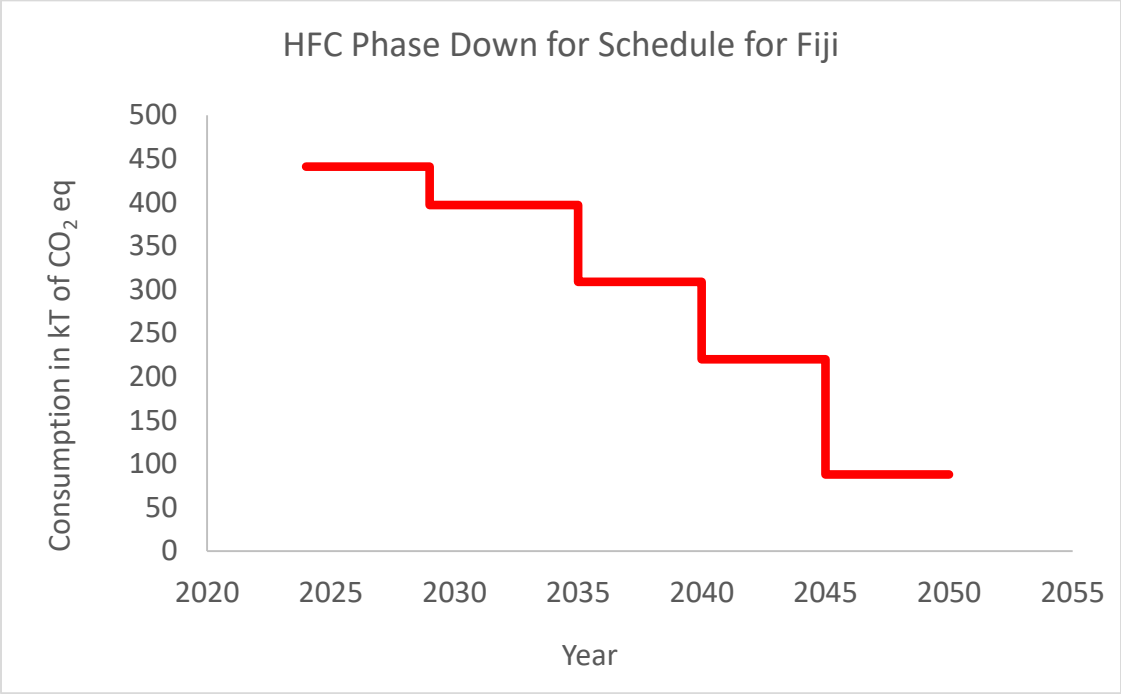

Figure 11: An illustration of stepped reduction in Hydrofluorocarbon consumption for Fiji over time.

7.0 Recommendations

The following recommendations are made for GHG inventory compilation for F-gases from refrigeration and air conditioning applications (Category 2F1):

- Emission estimations could be improved by using Tier 2 methodology if the AD (import and export data) is disaggregated by sub-applications. There is data now available on imports of gases or chemical agents in equipment. However, the bulk gases used in the servicing of these sub-applications is not known. There is a need to set-up a system whereby the licensed importers keep a detailed sales and purchase record as per sub-applications and equipment brought into the country with the initial charge being noted.
- The equipment imported with HFC needs to be classified accurately into the six sub-applications correctly.
- It is recommended to survey refrigeration and air conditioning equipment (number of air conditioning and refrigeration equipment introduced into the market, the refrigerant used and their initial refrigerant charge, percentage of initial charge of the retiring equipment and the

lifetime of the equipment) which will allow estimating F-gas emissions from this category using a Tier 2b methodology with more country specific factors.

- Currently, there is no regulation or law regarding the recovery of F-gases from retiring equipment that will be subjected to high-temperature destruction. It is assumed that the remaining gas in old household equipment is vented into the atmosphere at the end of the life of the equipment. This suggests a need for regulation reform thatwill regulate all gases to be collected before disposal of these household equipment in landfills. The implementation of such regulations will also allow better estimation of the charge remaining in retiring equipment.
- The Harmonized System (HS) codes as per the Customs Tariff Classification need to be well defined to avoid any ambiguity in data recording as this serves an important role in the QC of data. It is also recommended to collect further information from the FRCS on the import data of refrigeration and air conditioning units to clarify descriptions such as “other” and “parts” to properly allocate them to the sub-application categories in the 2006 IPCC Guidelines.
- There is data on equipment imported into the country containing HFC or its blends since 2021, however, the data is not in the electronic format but rather in the form of permit letters issued to the importers. It is strongly recommended that the data be classified into different sub-applications and needs to be digitised so that data can be retrieved with ease for GHG compilation. There needs to be a good database management system for ODS substitutes within the National ODS unit.
- There is no data available on the mobile sub-application and it is recommended that this should be recorded in future as well as there is a high influx of air-conditioned vehicles imported into the country which could contribute to a sizeable market demand for servicing of this sub-application.