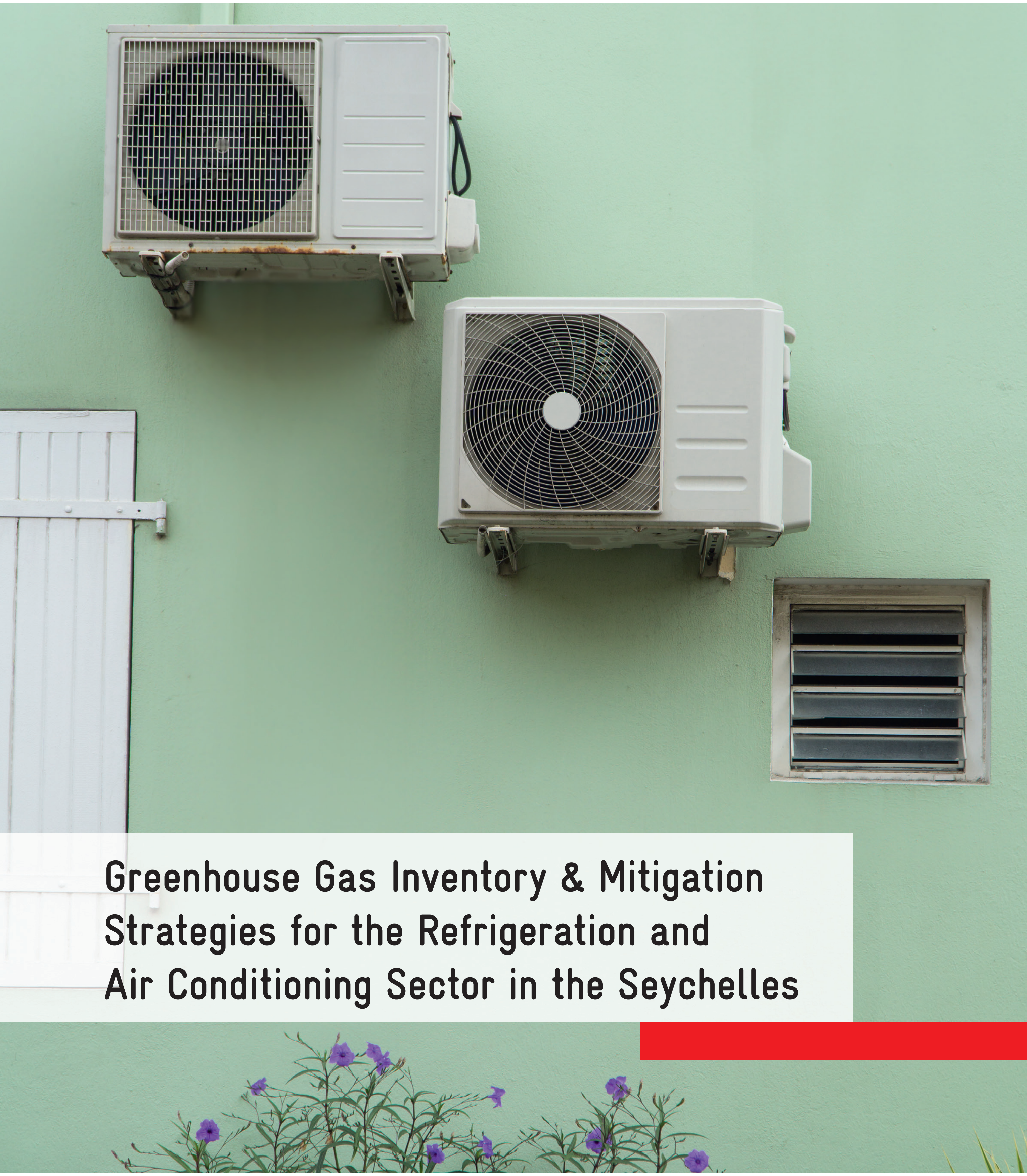

Greenhouse Gas Inventory & Mitigation Strategies for the Refrigeration and Air Conditioning Sector in the Seychelles

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

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LIST OF ABBREVIATIONS

AC	Air conditioner
BAU	Business-as-Usual
BAT	Best Available Technologies
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CAGR	Compound Annual Growth Rate
CDD	Cooling Degree Days
CFC	Chlorofluorocarbons
EE	Energy Efficiency
EER	Energy Efficiency Ratio
EE S&L	Energy Efficiency Standards & Labelling
F-GAS	Fluorinated gas
GCI	Green Cooling Initiative
GDP	Gross Domestic Product
GEF	Grid Emission Factor
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GWP	Global warming potential
HC	Hydrocarbon
HCFC	Hydrochlorofluorocarbon
HEAT	Habitat, Energy Application and Technology GmbH
HFC	Hydrofluorocarbon
HFO	Unsaturated HFC or Hydrofluoroolefin
HPMP	HCFC Phase-out Management Plan
HVAC	Heating, Ventilation and Air Conditioning
IEA	International Energy Agency
IKI	International Climate Initiative
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
MAC	Mobile Air Conditioning
MEECC	Former ‚Ministry of Environment, Energy and Climate Change', now referred to as Ministry of Agriculture, Climate Change & Environment
MEPS	Minimum Energy Performance Standard
MIT	Mitigation scenario
MLF	Multilateral Fund of the Montreal Protocol
MRV	Measurement, Reporting and Verification
NAMA	Nationally Appropriate Mitigation Action

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NDC	Nationally Determined Contributions
NOU	National Ozone Unit
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substances
QCR	Qualification, Certification and Registration
RAC	Refrigeration and Air Conditioning
SEER	Seasonal Energy Efficiency Ratio
SRC	Seychelles Revenue Commission
TAMCC	T.A. Marryshow Community College
TPMP	Terminal Phase-Out Management Plan
UAC	Unitary Air Conditioning
UNFCCC	United Nations Framework Convention on Climate Change
VRF/VRV	Variable Refrigerant Flow/Variable Refrigerant Volume flow

ACKNOWLEDGEMENTS


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On behalf of the National Ozone Unit (NOU) of the Ministry of Agriculture, Climate Change & Environment of the Republic of Seychelles, this report is the result of a comprehensive data collection and assessment process that has been carried out between April and October 2019 within the 'Green Cooling Initiative II' project. The project is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) under the International Climate Initiative (IKI) instrument.

It supports the development of a greenhouse gas (GHG) mitigation strategy in the refrigeration and air conditioning (RAC) sector as part of the Seychelles' Nationally Determined Contributions (NDCs), including establishing parameters for increased energy efficiency in RAC technology, finding solutions for greener RAC technologies and fostering their marketability and uptake by local distributors and end-users.

The GHG inventory provides a detailed profile of GHG emissions resulting from refrigeration and air conditioning in the Seychelles and supports the further development of emission reduction measures in the RAC sector supplementing the Seychelles' climate targets. It also serves as a basis for further planning of the Seychelles' NDCs and hydrofluorocarbon (HFC) phase-down schedules in contribution to the Montreal Protocol's Kigali Amendment.

We would like to express our gratitude for the support of all the institutions, companies and other stakeholders in the Seychelles. We specially thank Ms. Inese Chang-Waye, the senior ozone officer of the National Ozone Unit at the Ministry of Agriculture, Climate Change & Environment of the Seychelles, the Seychelles Licensing Authority and the National Bureau of Statistics for providing data for the report.

SUMMARY

Summary of key findings

Over the last few years there has been constant growth in the Seychelles' RAC industry. The growing population, wealth and temperatures have led to an increased demand for air conditioning and refrigeration solutions. A key driver for the cooling demand is the tourism sector of the Seychelles, providing air-conditioned rooms and storage space for refrigerated goods.

» The findings of the report suggest, that in 2017, the RAC sector was responsible for 0.32 Mt CO_2eq of GHG emissions. This means that the RAC sector's share in overall energy-related emissions lies at approximately 33% of Seychelles' overall indicated GHG emissions of 0.968 Mt CO_2eq in 2017 (European Commission, 2018).

» Following the current trend and taking into account the global development scenario, the predicted 2–2.5 °C global temperature rise until the year 2100 (IPCC, 2014), the need for air conditioning, the use of air conditioners and refrigeration and thus, the annual emissions in the Seychelles' RAC sector are expected to rise to around 0.48 Mt CO_2eq in the year 2050 (see Figure 1).

» Under ambitious mitigation measures with the transition to low global warming potential (GWP) refrigerants and energy-efficient RAC appliances, emissions could be reduced compared to the business-as-usual (BAU) scenario. The adoption of best available technology (BAT) and the design of targeted policy measures could keep projected GHG emissions below 0.35 Mt CO_2eq in 2050 (see Figure 2, page 12). Further mitigation could be achieved through shifting the energy supply to power the RAC appliances from fossil fuel to renewable energy sources.

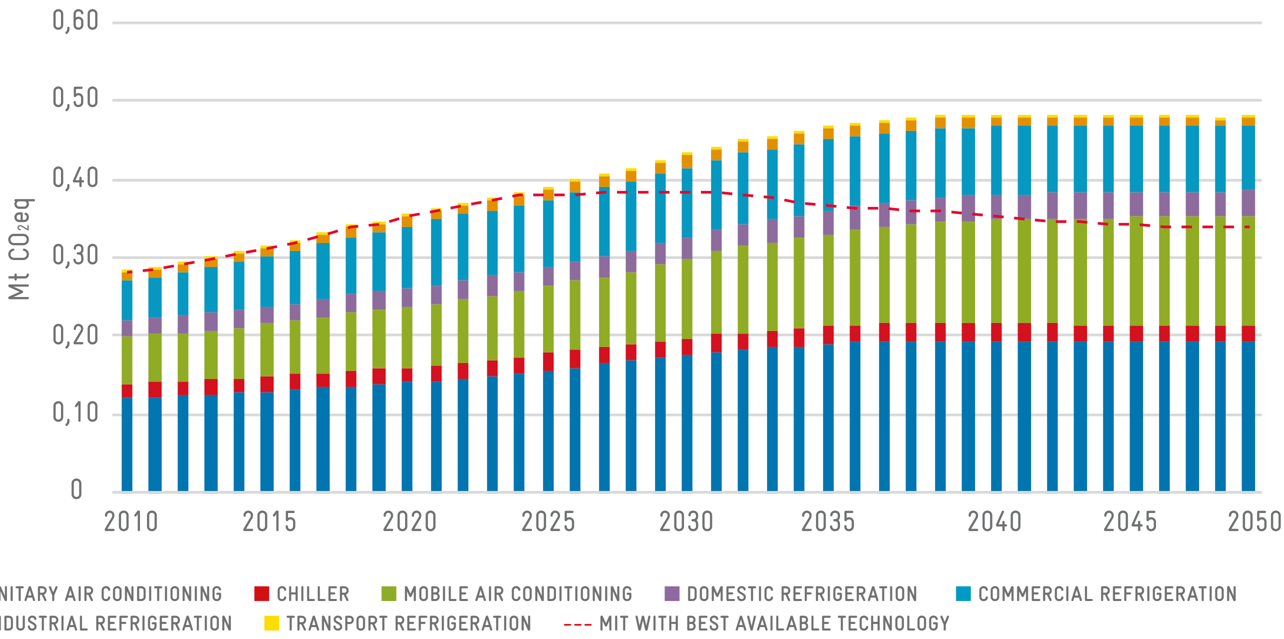


FIGURE 1: BAU SCENARIOS BY SUBSECTORS UNDER THE KIGALI AMENDMENT AND THE BAT SCENARIO

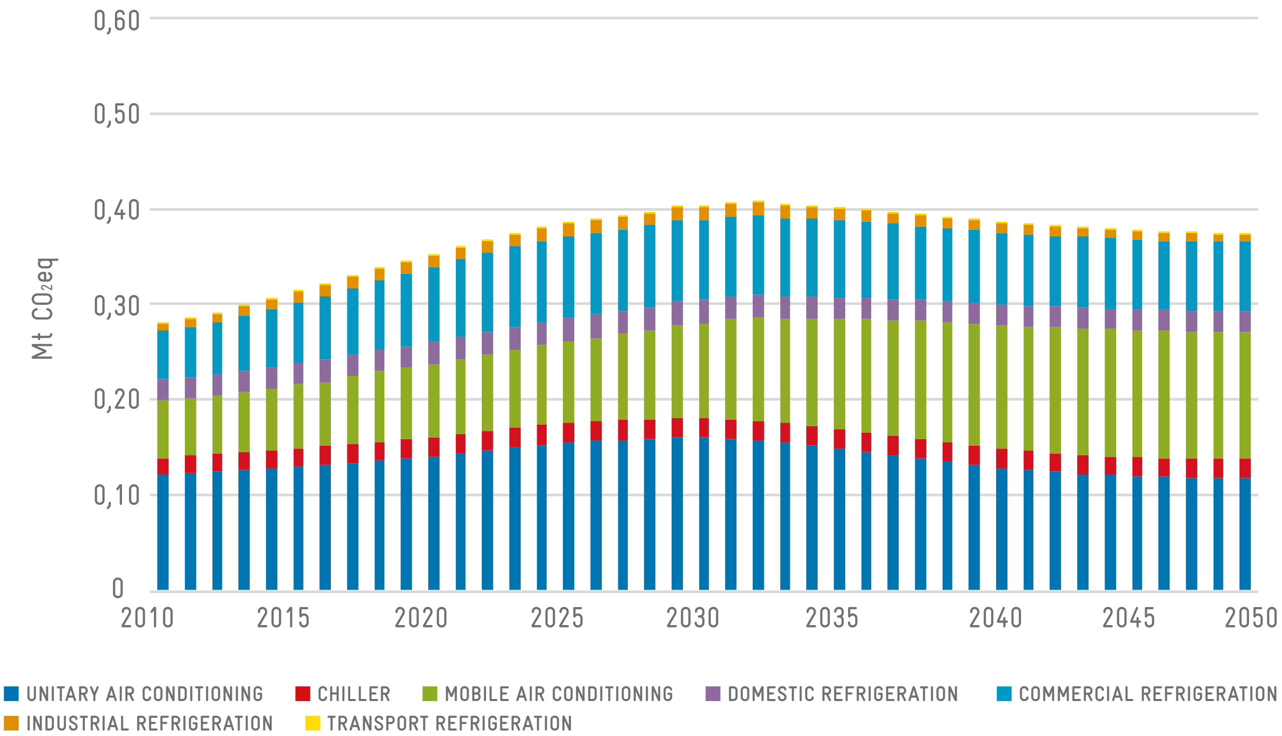
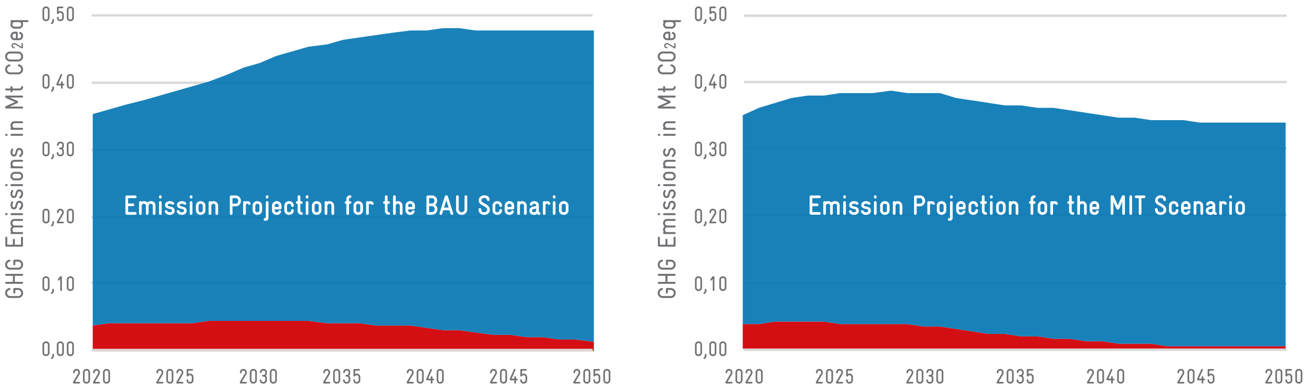


FIGURE 2: MITIGATION (MIT) SCENARIO APPLYING THE BAT IN THE SEYCHELLES

The source of emissions from the RAC sector originates to a large extent from indirect emissions. Figure 3 describes the projection of total indirect and direct emissions from the RAC sector in the BAU, the MIT and the National Cooling Strategy (NCS) scenario.



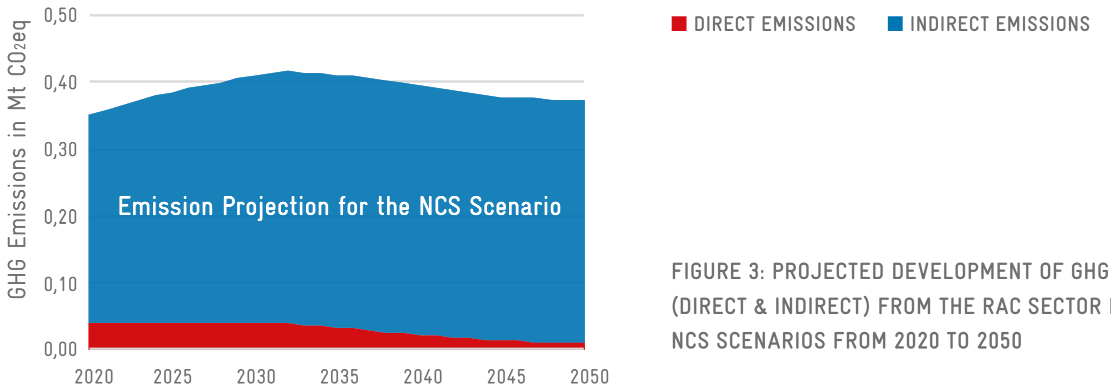


FIGURE 3: PROJECTED DEVELOPMENT OF GHG EMISSION SOURCES (DIRECT & INDIRECT) FROM THE RAC SECTOR IN THE BAU, MIT AND NCS SCENARIOS FROM 2020 TO 2050

A significant proportion of the GHG mitigation potential is based on the transitioning from highly climate-damaging hydrochlorofluorocarbons (HCFC) and hydrofluorocarbons (HFC) to alternatives with a low-GWP ahead of the HFC phase-down schedule stipulated in the Kigali Amendment to the Montreal Protocol (Clark and Wagner, 2016). Figure 4 shows the RAC-related HFC consumption under the BAU scenario, the "freeze" in consumption and reduction steps under the Kigali Amendment and the incorporation of these steps into the BAU-Kigali scenario.

Also shown is the National Cooling Strategy (NCS) scenario developed for the Seychelles and the consumption according to a more ambitious mitigation (MIT) scenario, which assumes the application of the BAT and the use of very-low-GWP natural refrigerants.

Refrigerant consumption and refrigerant emissions in this inventory report are calculated using the same data and model.

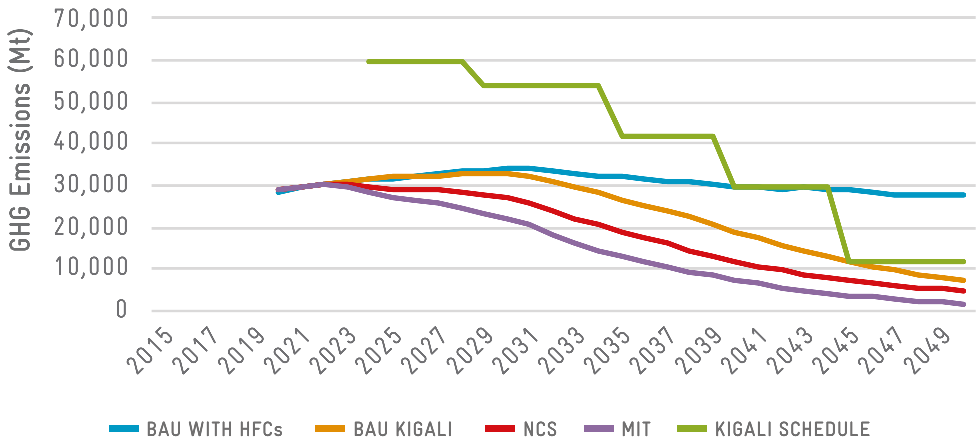


FIGURE 4: HFC CONSUMPTION IN THE BAU AND MIT SCENARIOS

Furthermore, the transition to low-GWP refrigerants can also cause other benefits besides the abatement of GHG emissions. Such co-benefits are energy and costs savings through improved energy efficiency (EE) and the creation of employment when climate-friendly and energy-efficient appliances are installed and maintained through qualified local technicians. These technicians need to be properly trained in the handling of low-GWP refrigerants during the transition phase. The Reduction of energy use also contributes to the Seychelles' national energy security.

The RAC GHG inventory is the first of its kind in the Seychelles. As no data on RAC emissions in the country has been established prior to the compilation of this RAC emission inventory, they are so far not included in the Seychelles' National Determined Contributions (NDCs) to the Paris Agreement. With the information provided by this inventory, the Seychelles will have a more robust RAC sector emissions estimate as a basis for mitigation planning and action as part of the Seychelles' NDCs. This RAC GHG inventory shows direct emissions, which are refrigerant related, and indirect emissions, which are energy use related. Direct and indirect emissions describe total GHG emissions of the RAC sector.

The RAC GHG inventory highlights unitary air conditioning (UAC) and commercial refrigeration as the two subsectors with the most significant emission share and mitigation potential. The emissions of the domestic refrigeration subsector are slightly smaller. The NCS provides specific recommendations and suggests timelines for steps to take towards a more environmentally friendly RAC sector.

The NCS targets the three key subsectors commercial refrigeration, unitary air conditioning and domestic refrigeration. The implementation of the NCS includes the following elements:

1) Introduction of ambitious Minimal Energy Performance Standards (MEPS) and labels to increase energy efficiency of RAC appliances

2) Introduction of a tax scheme to facilitate the transition to low-GWP refrigerants

3) Development of a Qualification, Certification & Registration (QCR) scheme to increase education and skills of RAC technicians

4) Establishment of a Measurement, Reporting and Verification (MRV) system for tracking and enforcement of policy measures

Each of the elements of the NCS includes specific actions for the key subsectors. The implementation of the strategies on the specified subsectors can lead to an emission reduction of 10% in 2030. With the ratification of the Kigali Amendment of the Montreal Protocol the Seychelles committed to reduce their HFC consumption by 10% from 2029 as an A5 Group 1 country (UNEP, 2016).

The implementation of the NCS will support achieving the NDC and the Paris Agreement in the Seychelles and possibly allow achieving the transition to low GWP refrigerants ahead of reduction steps required under the Kigali Amendment. The NCS requires a continuous review and update to assure the adoption of BAT and achievement of the low-carbon pathway.

1 INTRODUCTION

1.1 PROJECT FRAMEWORK AND BENEFITS OF RAC SECTOR INVENTORY

This greenhouse gas (GHG) inventory was compiled within the project activities of the "Green Cooling Initiative II". This project was commissioned to the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH for implementation by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) under the International Climate Initiative (IKI). The project aims to develop a GHG mitigation strategy in the RAC sector as part of the Seychelles' Nationally Determined Contributions, including establishing parameters for increased energy efficiency in RAC technology, finding solutions for greener RAC technologies and fostering their marketability and local manufacturing.

The project partner in the Seychelles is the Ministry of Agriculture, Climate Change & Environment, particularly the National Ozone Unit (NOU).

The purpose of this inventory is to get an overview of the current state of GHG emissions of the RAC sector on the Seychelles. The report intends to provide information on the following topics:

» Business-as-Usual GHG emissions resulting from refrigerant and energy consumption of the RAC sector;

» potential market penetration of energy-efficient appliances using refrigerants with low global warming potential (GWP);

» potential to mitigate GHG emissions caused by refrigerant use and energy consumption in the RAC sector and its subsectors;

» BAU-Kigali scenario, where the reduction steps of the Kigali Amendment are incorporated;

» NCS: National Cooling Strategy scenario designed particularly for the Seychelles;

» Mitigation (MIT) scenario with the adoption of BAT and policies.

This report describes the RAC appliances currently available in the Seychelles' market, their energy consumption, the refrigerants used and the respective GHG emissions. RAC technologies currently deployed are compared with international best practice technologies in order to determine the related emissions mitigation potential. Future trends in each of the RAC subsectors are analysed with respect to both BAU and MIT scenarios.

The RAC GHG inventory is based on an estimation of the stock, i.e. the number of equipment in use in different RAC subsectors, as well as average technical parameters for the different appliances for the calculation of their direct (refrigerant-related) and indirect (energy consumption) GHG emissions. The stock model for the RAC GHG inventory provides the starting point for planning GHG emission reduction activities.

This RAC GHG inventory report provides the following information:

» sales and stock per subsector as well as growth rates per subsector;

» technical data on systems, which determines their GHG emissions such as average energy efficiency, refrigerant distribution and leakage rates;

» GHG emissions on a RAC unit basis;

» GHG emissions for the whole RAC sector including the distribution between direct and indirect emissions;

» future projections of RAC-related GHG emissions;

» mitigation scenarios based on the introduction of technical low-GWP alternatives.

The collected information serves the following purposes:

» to identify key subsectors with the **highest GHG emissions** as well as the **highest emission reduction potential** based on available technologies;

» to use the inventory data for reporting HFC-related GHG emissions and mitigation efforts as part of the UNFCCC **reporting including the National Communication, the biennial update reports and the NDCs**. The projections show how GHG emissions will develop in the future. The sectoral RAC mitigation plans can serve as a basis for mitigation efforts as part of the Seychelles' NDC and mitigation targets;

» to provide planning tools for mitigation action, such as the formulation of **Minimum Energy Performance Standards (MEPS)** and labelling or bans on refrigerants with high-GWP;

» to give an indication of the impact of **legislation** on stakeholders in different subsectors;

» to form the basis for a **Measurement, Reporting and Verification (MRV) system** or a product database;

» to support the development of project proposals with the aim of reducing GHG emissions in the RAC sector, such as **Nationally Appropriate Mitigation Actions (NAMAs)**.

1.2 COUNTRY BACKGROUND AND DEMAND DRIVERS FOR REFRIGERATION AND AIR CONDITIONING

The Republic of Seychelles is an island country located in the Indian Ocean and topographically related to the African continent. It consists of about 115 islands, the so-called Inner and Outer Islands. The Inner Islands cover approximately 266 km^2. They are the most densely populated regions and include the capital Victoria on Mahé Island (Figure 5). The Outer Islands are mostly small, consisting of granite and coral type bedrock. The vegetation is composed of mainly endemic, tropical rainforest. The climate is driven by monsoon with two distinct phases while the precipitation is high with 2,880 and 3,550 mm depending on the elevation. The mean annual temperature amounts to around 26°C (see Figure 6).

FIGURE 5: MAP OF THE SEYCHELLES (SOURCE: WIKIMEDIA COMMONS)

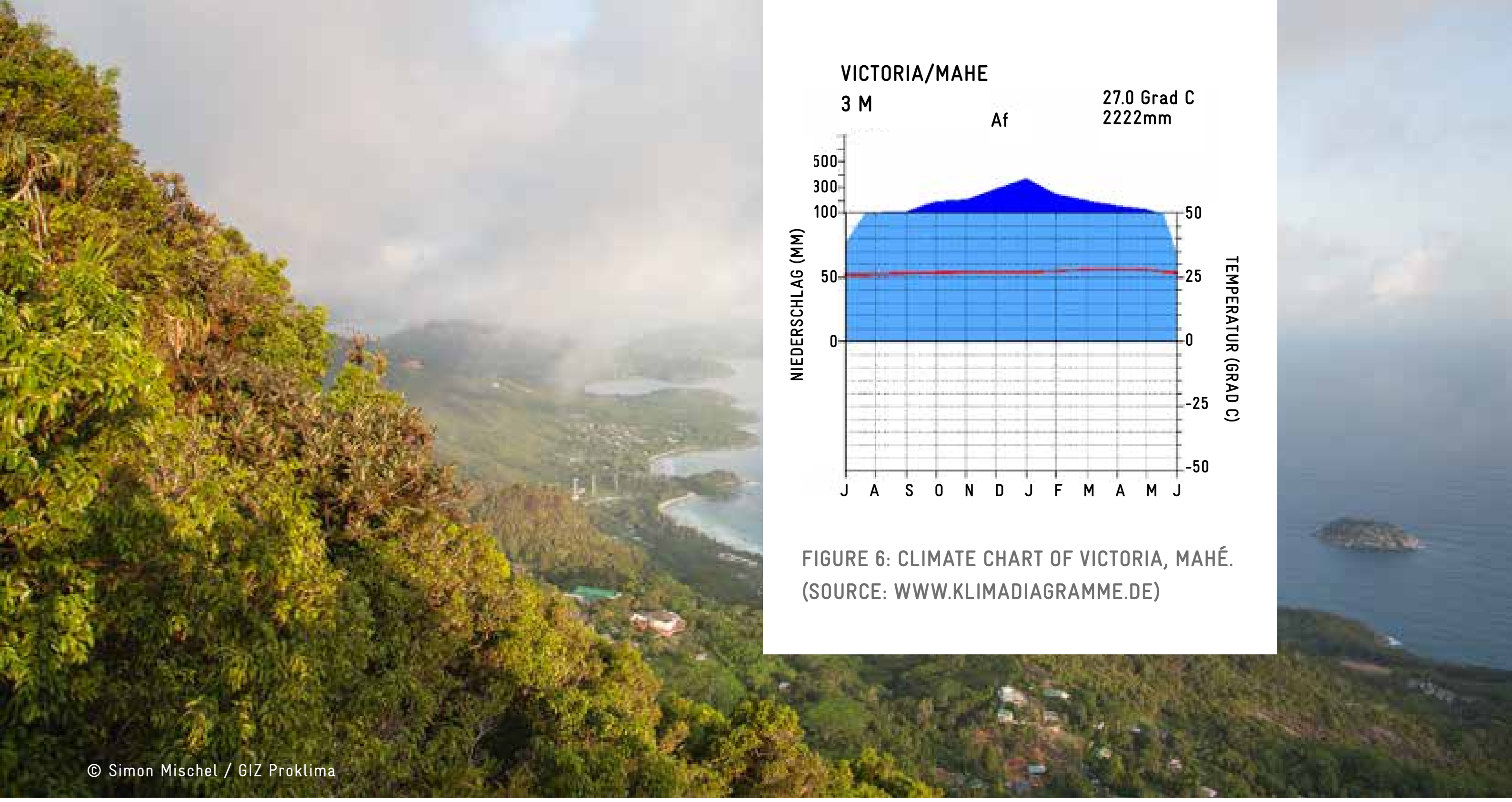


FIGURE 6: CLIMATE CHART OF VICTORIA, MAHÉ. (SOURCE: WWW.KLIMADIAGRAMME.DE)

Due to the high temperatures throughout the year, the Seychelles have an enormous demand for cooling technologies. They count an average of 240 cooling degree days (CDDs) per year (base temperature assumed of 21°C). However, this number is expected to increase with rising temperatures under the climate reference scenarios (Hasegawa et al., 2016). This particularly concerns the need for air conditioning and refrigeration of perishable goods.

Private and commercial air conditioning systems are in great demand, especially for hotels, restaurants and apartments. Tourism represents the main reason for this development as it plays a key role in the Seychelles economy. Over 361,800 visitors were counted in 2018 (World Bank, 2019). Fishery is the second most important sector, contributing 20% to the GDP and employing 17% of the population (World Bank, 2017). Consumable and frozen fish is the main export product. Therefore, refrigeration devices maintaining cold chains and freezing such goods represent a major part of Seychelles industrial RAC sector (World Bank, 2017).

Table 1 (page 18) shows current and future demand drivers for refrigeration and air conditioning such as a growing population, an increasing number of households and an expanding economy.

Between 2013 and 2017 a population growth of 1.6% was recorded. However, this growth is estimated to slow down to about 0.7% between 2017 and 2030 and to 0.2% by 2050.

The number of households rose by 2.8% between 2013 and 2017. This development is related to the growing number of tourist establishments and large hotels, which increased by 7.7% during the same period, as well as the number of guesthouses (6.6%) and the self-catering establishments (7.1%). The amount of newly registered private cars rose by approximately 10.3%, indicating a growth of the mobile air conditioning (MAC) subsector (National Bureau of Statistics, 2018). Moreover, table 1 shows an GDP increase of 2.9% between 2013 and 2017. Further sources report a GDP growth by 2.6% in 2018 (Compound Annual Growth Rate; CAGR) and by 2.9% during the last 5 years (World Bank, 2020). The proportion of the population living in urban areas was 56.7% in 2018 and is expected to rise to about 70% in 2050 (United Nations, 2020). All these factors lead to a significant increase in cooling demand.

TABLE 1: STATISTICAL DATA AND CALCULATED CAGR OF KEY RAC GROWTH DRIVERS.

YEAR/PERIOD	2013 (IF NOT OTHER-WISE STATED)	2018	CAGR 2013-17 IN %	CAGR TO 2030 IN %	CAGR TO 2050 IN %
POPULATION	89,900	95,800	1.6	0.7	0.2
HOUSEHOLDS	24.770*	30.846	2.8	1.2	0.15
GDP P. CAPITA IN USD	81.156	94.207	2.9		
LARGE HOTELS	29	39	7.7	3.4	0.42
GUEST HOUSES	90	116	6.6	2.9	0.36
BUNGALOWS	294	495	7.1	3.1	0.4
NEW PRIVATE VEHICLES REGISTERED	1.006	1.487	10.3	4.5	0.56

*** Data from 2010; Source: National Bureau of Statistics, 2018**

1.3 ENERGY IMPORT AND CONSUMPTION

Nearly all the energy consumed in the Seychelles is currently based on imported fossil fuels. The Seychelles electricity generation had an installed capacity of 88,000 kW, with diesel- or fossil-fuel-based generation dominating the energy production. These sources generate 91% of the total energy used in the Seychelles (Central Intelligence Agency, 2020). The remaining percentage of energy stems from renewable sources, whereby wind farms are the most widely used renewable energy source in the Seychelles. Some large hotels have their own diesel generators. The total electricity generated from imported fossil-fuel-based energy sources accounted to an equivalent of 420.8 million kWh in 2017 (National Bureau of Statistics, 2018). In 2015, 36 kt of oil were used to generate electricity (UNEP, 2017). Therefore, the Seychelles are almost completely dependent on fossil fuels to meet national energy needs. Imports of energy sources are dominated by gas oil (diesel) as shown in Figure 7.

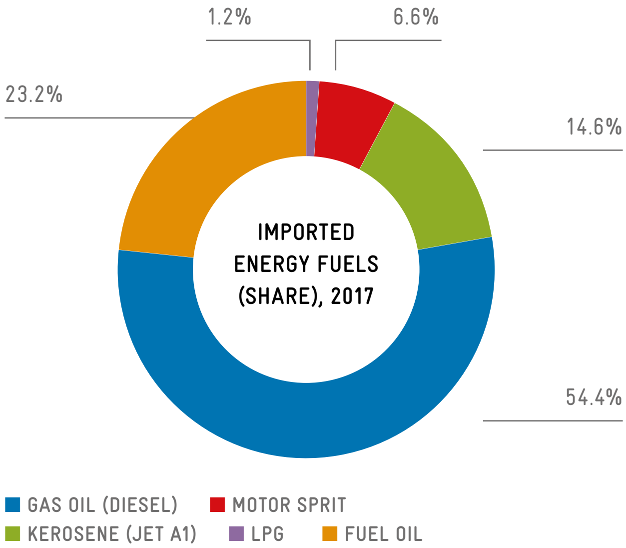


FIGURE 7: IMPORT OF ENERGY SOURCES IN 2017.
(SOURCE: NATIONAL BUREAU OF STATISTICS, 2018)

The largest consumer of electricity in the Seychelles is the commercial and industry sector (55.8%), followed by the domestic sector (31.4%). The remaining energy is consumed by the government (12.4%) and to a small extent by street lighting (0.3%), see Figure 8.

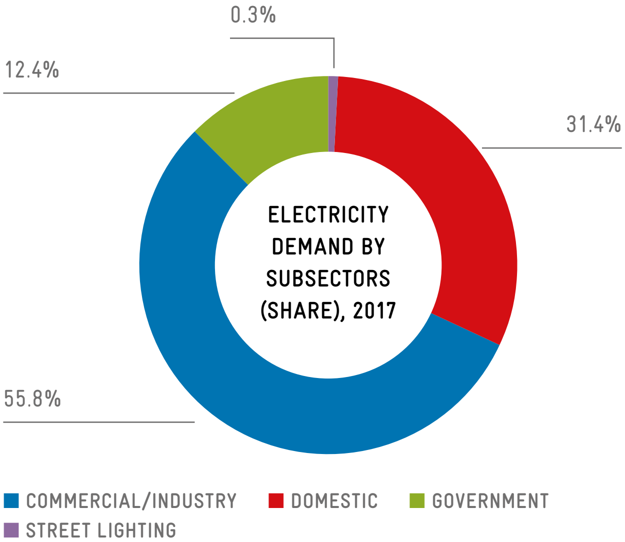


FIGURE 8: ELECTRICITY CONSUMED IN THE SEYCHELLES IN 2017. (SOURCE: NATIONAL BUREAU OF STATISTICS, 2018)

1.4 CLIMATE AND F-GAS POLICY

A robust regulatory framework is required for the implementation of most changes towards environmentally friendlier technology alternatives in the RAC sector. The Seychelles signed the Montreal Protocol on Substances that Deplete the Ozone Layer and ratified it in January 1993. The Seychelles have since been compliant with the Montreal Protocol.

Policies targeting the RAC sector are currently driven by the HCFC Phase-Out Management Plan (HPMP). The Government of the Seychelles issued the Environmental Protection Act supporting the HCFC phase-out. A ban on imports of HCFCs is active since 2018.

The current NDC includes an economy-wide reduction of GHG emissions by 122.5 kt CO_2eq (21.4%) in 2025 and estimated 188 kt CO_2eq in 2030 (29.0%) relative to projected BAU emissions as outlined in the NDC. Whilst the NDC states this as an economy-wide target, the RAC sector or its subsectors are not yet explicitly mentioned. Nevertheless, the Ministry of Agriculture, Climate Change & Environment, is currently preparing an inclusion of the RAC sector into the NDCs of the Seychelles.

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Table 2 provides an overview of the Seychelles' key institutions from private and public domains relevant for the climate and energy conservation policy in the RAC sector as well as key non-state institutions and stakeholders.

TABLE 2: OVERVIEW OF INSTITUTIONS RELEVANT FOR THE RAC SECTOR AND THEIR CONTRIBUTION TO THE SURVEY

INSTITUTION/DEPARTMENT	DUTIES/FUNCTIONS/RESPONSIBILITIES RELATED TO THIS REPORT
MINISTRY OF AGRICULTURE, CLIMATE CHANGE & ENVIRONMENT (MEECC)	• Protection, preservation and improvement of the environment • Environmental and energy regulation and laws • Drafting and implementing climate policies coordination including national GHG emissions reporting and NDC preparation
THE SEYCHELLES' NATIONAL OZONE UNIT (NOU) AT MEECC	• Implementation of the Montreal Protocol • The phase-out of hydrochlorofluorocarbon (HCFC) • Phase-down of hydrofluorocarbons (HFC) under the Kigali Amendment to the Montreal Protocol
CUSTOMS DIVISION AT SEYCHELLES REVENUE COMMISSION (SRC)	• Import control of regulated substances under the Montreal Protocol (HCFCs and HFCs under the Kigali Amendment) • Reporting of the amounts of imported gases • Reporting on imported appliances containing controlled substances
SEYCHELLES LICENSING AUTHORITY (SLA)	• Provided information on the retail shops and the number of registered motorised vehicles
NATIONAL BUREAU OF STATISTICS (NBS)	• Provided statistical data
SEYCHELLES PLANNING AUTHORITY (SPA)	• Reporting of statistical household data
SEYCHELLES ENERGY COMMISSION (SEC)	• Regulatory agency for EE of RAC appliances; works closely with MEECC

2 METHODOLOGICAL APPROACH

The RAC GHG inventory covers GHG emissions from the RAC sector based on a stock model covering the major subsectors and their appliances. The current and future stock is derived from past sales figures, while past growth trends and dynamics help to forecast future stock projections. The emissions are calculated for each subsector and appliance type based on critical technical parameters determining direct and indirect emissions.

The inventory covers the following elements:

» For each of the subsectors and their respective appliance types (Table 3), an inventory of past and future unit sales and stock data was established, data availability was presumed.

» For each appliance type, the past, current and future energy and refrigerant use and their respective emissions were estimated.

» Future trends of RAC subsectors were analysed both with respect to BAU and MIT scenarios.

» Currently deployed RAC technologies were compared to international best-practice technologies for their potential to mitigate GHG emissions on a single-unit basis.

» The calculated mitigation potential of the RAC sector of the Seychelles using the 2006 guidelines of the Intergovernmental Panel on Climate Change (IPCC) for calculating emissions based on specific activity data (here, the number of appliance units).

TABLE 3: RAC SUBSECTORS AND RELATED SYSTEMS COVERED BY THIS INVENTORY

SUBSECTOR	SYSTEMS
UNITARY AIR CONDITIONING	• Split residential air conditioners • Duct split residential air conditioners • Rooftop ducted • Multi-splits and VRF/VRVs
CHILLERS	• Air conditioning chillers
MOBILE AIR CONDITIONING	• Car air conditioning
DOMESTIC REFRIGERATION	• Domestic refrigerators
COMMERCIAL REFRIGERATION	• Stand-alone equipment • Condensing units • Centralised systems (for supermarkets)
INDUSTRIAL REFRIGERATION	• Industrial condensing units • Centralised systems
TRANSPORT REFRIGERATION	• Refrigerated trucks

The RAC subsectors and all appliances covered by the inventory are categorised according to key subsectors as outlined in the RAC NAMA Handbook, Module 1: Inventory (GIZ, 2014a) and further illustrated in Annex 8.2.

As outlined in the methodology section below, the inventory is based on actual emissions gathered at the unit or appliance level as opposed to inventories based on the bulk refrigerant consumption across different sectors. The latter approach is usually applied for estimating emissions as part of ozone depleting substances (ODS) alternative surveys. Future projections have been included, mostly using growth rates based on surveys carried out, feedback from the first stakeholder workshop in June 2019 and information provided by sectoral experts.

2.1 GHG EMISSION CALCULATION

The methodology adopted for the report draws on the concepts outlined by GIZ (2014a), IPCC (2006) and on the IPCC Tier 2 methodology from 2006. To be noted, the word 'system' is used interchangeably in this report with the words 'appliance', 'equipment' or 'unit'.

While alternative refrigerant inventories, such as ODS alternative surveys are typically based on the Tier 1 methodology, this inventory is based on the IPCC Tier 2 methodology to cover not only refrigerant related emissions and their mitigation options but also GHG emissions from the energy use and their mitigation option. In addition, the Tier 2 methodology allows for the calculation of GHG mitigation actions (such as NAMAs) in relevant RAC subsectors and future NDC mitigation actions. As Tier 2 inventories are based on unit appliances, an MRV system of mitigation efforts can be established based at the unit level.

Tier 1 and Tier 2 methodologies have the following basic differences[1]:

» Tier 1: emissions are calculated on the basis of an aggregated sectoral level (GIZ, 2014a; IPCC, 2006).

» Tier 2: emissions are calculated built on a disaggregated unit-based level (GIZ, 2014a; IPCC, 2006).

The difference between the Tier 1 and Tier 2 methodology are further illustrated in Figure 9.

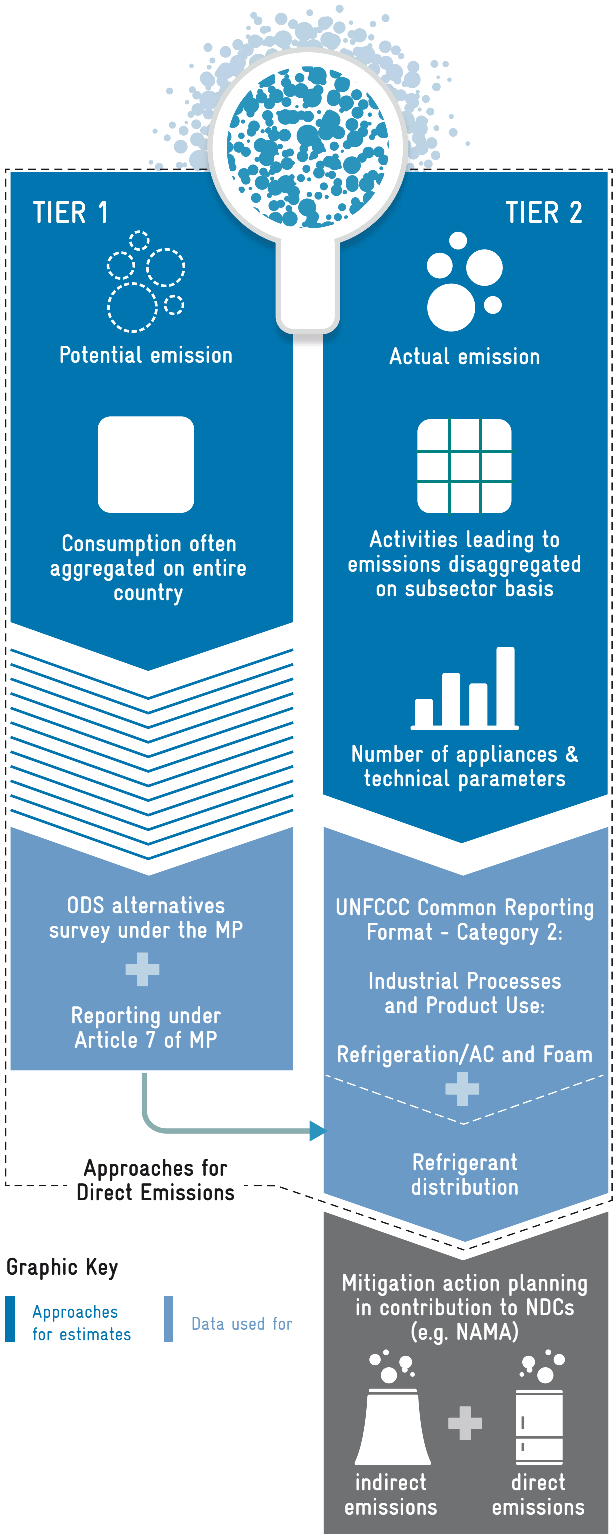

FIGURE 9: APPROACHES FOR GHG EMISSION ESTIMATES RELEVANT TO THE RAC&F SECTOR (SOURCE: GIZ, 2016)

1 Please note that sector and application are used in the context of this report, where IPCC 2006 methodology refers to sector as application and application as sub-application.

The Tier 2 methodology used in this report accounts for direct and indirect emissions at the unit level – as illustrated in Figure 10 – for the stock of appliances in use, their manufacturing and disposal emissions. Indirect emissions result from electricity generation for cooling, considering the annual electricity consumption and Seychelles' grid emission factor (GEF). Direct emissions include refrigerant emissions from leakage of refrigerant gases during manufacture, servicing, operation and disposal of cooling appliances. The Tier 2 methodology goes beyond the Tier 1 approach, which only focuses on the demand and use of refrigerants. The Tier 1 approach does not include indirect emissions from the energy use of appliances.

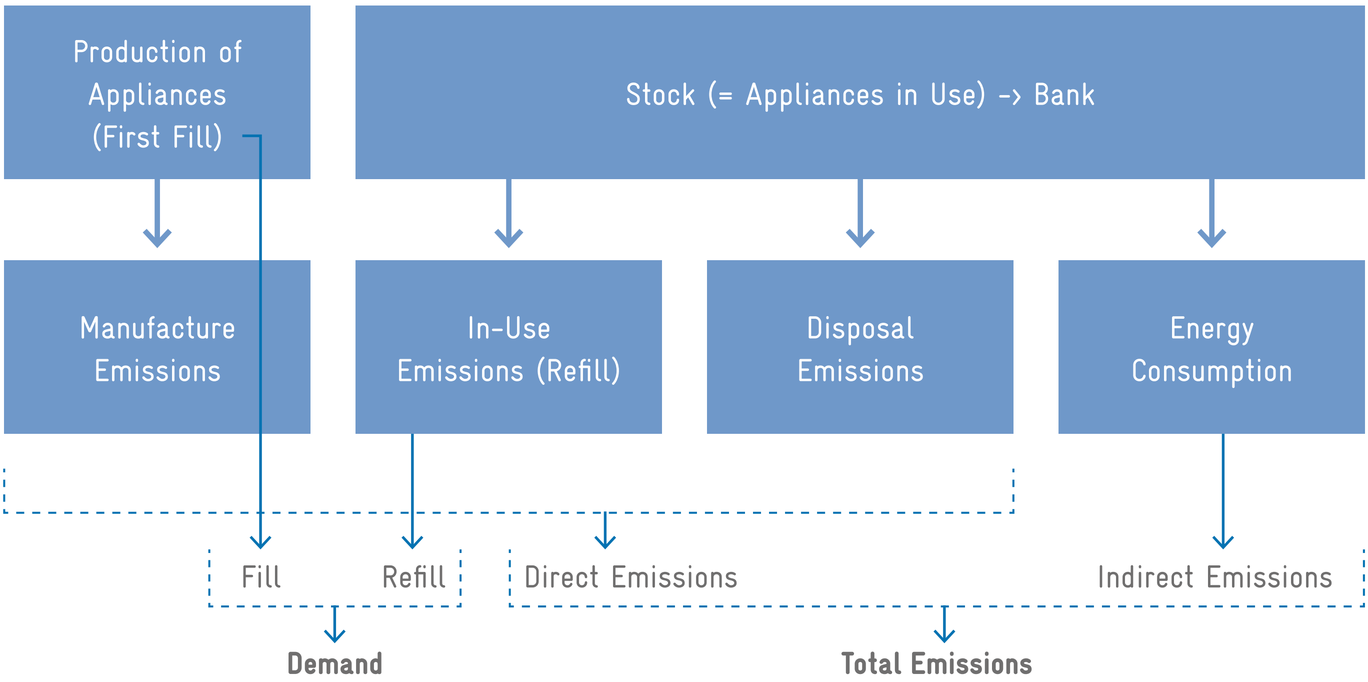

FIGURE 10: OVERVIEW OF RAC REFRIGERANT DEMAND VERSUS RAC TOTAL EMISSIONS. (SOURCE: GIZ, 2014A)

Refrigerant consumption is accounted for at all stages during the product life of the equipment:

» refrigerants that are filled into newly manufactured products

» refrigerants in operating systems (average annual stocks)

» refrigerants remaining in products at decommissioning and end-of-life

The data collection process serves to obtain all relevant input information, both on direct and indirect emissions specific to each subsector and appliance type. The detailed data collection process for obtaining the information is explained in the following sub-chapter.

2.2 DATA COLLECTION PROCESS

The following steps were taken to form the inventory:

Step 1. National kick-off workshop with relevant stakeholders

Step 2. Preparation of questionnaires and list of stakeholders for all subsectors. Detailed questionnaires were prepared for distributors and servicing providers in the AC and domestic refrigeration subsectors

Step 3. Distribution of questionnaires to stakeholders

Step 4. Face-to-face interviews with stakeholders to explain the required data

Step 5. Primary data was received through questionnaires. Secondary data was obtained through stakeholders sharing reports, documents and data.

Step 6. Verification of preliminary data during a national inventory workshop in Victoria

Step 7. Launch of a detailed household, hospital and public building survey

Step 8. Gathering of expert knowledge for the mobile AC and transport refrigeration subsectors

Step 9. Revision of data gathered through the questionnaires and the survey

Step 10. Modelling of the BAU and the MIT emission scenarios

Step 11. Design of the NCS scenario

The data for this inventory was collected from primary and secondary sources. Primary sources include direct information from companies and technicians installing and servicing RAC appliances as well as end-users. The obtained secondary data includes available sectoral and market data from government sources and published reports.

The following activities were carried out to obtain information:

» **Primary data** was obtained from distributors and re-sellers of UAC and domestic refrigeration equipment. The primary data was used to collect information on appliance sales and stock data and technical data for their electricity and refrigerant consumption. The distributors and resellers were directly contacted and questionnaires were sent out. The data initially provided by installers and service companies was sparse and incomplete. The obtained information was verified and complemented with direct visits, interviews with technicians and service companies (see Annex 8.2).

» **Secondary data** was obtained among others from the Customs Division at the Seychelles Revenue Commission, the Seychelles Licensing Authority and the National Bureau of Statistics. Local data was reviewed in line with international default data and expert knowledge obtained from other countries' RAC GHG inventories carried out amongst others in Indonesia, the Philippines, Thailand, Vietnam and Iran.

» **Survey data** from end-users of RAC appliances was gathered to verify the data obtained from distributors and re-sellers and to complement missing data. The survey covered representative sample sizes from key end-users of RAC appliances as shown in Table 4 below.

TABLE 4: SURVEYED END-USERS AND SAMPLE SIZE

	SAMPLE SIZE	TOTAL
HOUSEHOLDS	93	30,846
RETAILERS	52	2,102
HOTELS	14	40
GUESTHOUSES	6	123
SELF-CATERING ESTABLISHMENTS	33	495
HOSPITALS AND HEALTH CENTRES	14	25

There are 40 refrigerated trucks registered in the Seychelles, all are included in this inventory. The number of chillers installed in the Seychelles were estimated to be 45 units, based on expert knowledge.

The following challenges were encountered during data collection for this inventory from primary data resources:

» Reluctance to provide any information (in a few cases) or willingness to provide only partial information due to the confidentiality policy of the companies.

» Difficulties with filling out questionnaires; questionnaires had to be explained during personal visits to obtain the information.

» Customs data on imported equipment could be collected, but it also contained spare parts. Expert knowledge was needed to review and sort out the obtained raw data.

» Despite multiple feedback loops, the attribution of collected equipment data to the appliance groups defined in the inventory categories was sometimes difficult.

2.3 MODELLING PARAMETERS

For the analysis of this inventory, the modelling parameters were based on data as shown in Table 5. Where data was sufficient and plausible, the data was taken from primary data. In other cases, where such data was not sufficient or plausible, secondary or statistical data was applied (values are marked in Table 5 with an asterisk). The appliance lifetime assumed for the future stock projection was based on the surveyed stock data, past sales and the obtained market information.

TABLE 5: MODELLING PARAMETERS FOR THE BAU SCENARIO

EQUIPMENT TYPE	AVERAGE COOLING CAPACITY (KW)	AVERAGE REALISTIC LIFETIME (BASED ON STOCK) [YEARS]	MAIN REFRIGER-ANTS	INITIAL CHARGE [KG]	EER (2019)	LEAKAGE RATE PER YEAR [%]
SPLIT RESIDENTIAL AC	3.4	10	R410A, R22	0.7	3.0	12.0
DUCT SPLIT RESIDENTIAL AC	9.2	10	R410A	2.6	3.3	15.0
ROOFTOP DUCTED	43	10*	R407C	24.3	2.9	10.0*
MULTI-SPLITS, VRF/ VRVS	36	10	R410A, R22, R417	11.7	3.1	4.4
AIR CONDITIONING CHILLERS	454	12	R410A, R717, R134a	123.3	3.5	5.0
CAR AIR CONDITIONING	5*	15*	R134a	0.68	1.7	20.0*
DOMESTIC REFRIGERATION	0.2*	12	R134a, R600a	0.11	2.3	12.0
STAND-ALONE EQUIPMENT	3.5	10	R134a, R600a	0.58	2.6	
CONDENSING UNITS	6.2	10	R404A, R410A, R134a	4	2.7	30.0*
CENTRALISED SYSTEMS FOR SUPERMARKETS	334.1	10	R410A	70	3.5	38.0*
INDUSTRIAL CONDENSING UNITS	16.5	10	R404A, R507	5*	2.7	10.0
REFRIGERATED TRUCKS/TRAILERS	4	15*	R404A	2.5	2.5	25.0*

Note: "*" data are default data[2]

2 Default data refers to values obtained from international reference data (e.g. IPCC, 2006; EU, 2011; GCI database 2013-2014) and own estimates by the authors based on their work in various countries.


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The grid emission factor (GEF) is a measure of CO_2 emission intensity per unit of electricity generation in the grid system. In the presented study a GEF of 0.679 t CO_2/MWh was used, consistent with the INDC report submitted by the Seychelles in 2015 (Republic of Seychelles, 2015). As there are no future predictions of a potential GEF which can be incorporated in the model, the data presented in this report uses the same constant GEF for the BAU and the MIT scenario. Lowering the GEF, in line with the ambition to transit from fossil fuels to renewable energy-based electricity, would result in lower projected GHG emissions possibly as part of both the BAU and MIT scenarios.

The assumed future growth rates for the different sub-sectors were based on past sales data of the different subsectors as well as past and assumed future growth trends of key future growth drivers as shown in Table 1. The resulting future growth rates are presented in Table 6.

TABLE 6: GROWTH RATES AND ASSUMED FUTURE GROWTH RATES OF THE DIFFERENT SUBSECTORS IN THE SEYCHELLES

SUBSECTORS	2013-2017	2018-2030	2031-2045 (2050)
UNITARY AIR CONDITIONING	5.2%	2.3%	0.30%
CHILLERS	1.6%	0.7%	0.09%
MOBILE AIR CONDITIONING	10.3%	4.5%	0.56%
DOMESTIC REFRIGERATION	5.2%	2.3%	0.30%
COMMERCIAL REFRIGERATION	1.6%	0.7%	0.09%
INDUSTRIAL REFRIGERATION	1.6%	0.7%	0.09%
TRANSPORT REFRIGERATION	1.6%	0.7%	0.09%

The initial energy efficiency ratio (EER) values of all equipment types were calculated from primary data collection and assumed to increase based on increments of 10 years as shown in Table 33 in the Annex. Within the BAU the EER increases more slowly than in the MIT scenario.

For the refrigerant emissions, the Kigali Amendment schedule is applied within the BAU and MIT scenarios by modelling the HFC consumption reduction steps. The MIT scenario assumes a faster transition to low-GWP refrigerants.

3 GREEN HOUSE GAS EMISSIONS: BUSINESS-AS-USUAL VS. MITIGATION SCENARIO

3.1 CURRENT GHG EMISSIONS OF THE SEYCHELLES' RAC SECTOR

The current GHG emissions in the RAC sector of the Seychelles were estimated applying the methodology described in Chapter 2. The resulting estimated total GHG emissions for the RAC sector in 2017 are 0.32 Mt CO_2eq.

As illustrated in Figure 11a, 41% of the total emissions are related to the UAC subsector. The second largest emitter is the mobile air conditioning subsector with 22%, closely followed by the commercial refrigeration subsector (21%).

As illustrated in Figure 11b, about 0.03 Mt CO_2eq or about 10% of the total emissions in the RAC sector in the Seychelles resulted from direct, refrigerant-related GHG emissions. 34% of the direct emissions were emitted by the UAC subsector. Another subsector with large direct emissions was the commercial refrigeration subsector with 25% of the total direct emissions.

Figure 11c shows that about 0.29 Mt CO_2eq were coupled to indirect, energy-related GHG emissions, corresponding to 90% of the estimated overall emissions of the RAC sectors. The UAC subsector was the largest contributor with a share of 42% to indirect emissions; followed by the mobile AC subsector (23%) and the commercial refrigeration subsector (20%).

The Seychelles' domestic refrigerator market is saturated, with statistically two refrigerators per household. Nevertheless, this number might be biased as many domestic refrigerators are installed in the hotel and guesthouse business. The allocation of household ACs is similarly complex as these units are also widely distributed in hotels. Based on the surveyed data we estimate that about 57% of the households own an AC.

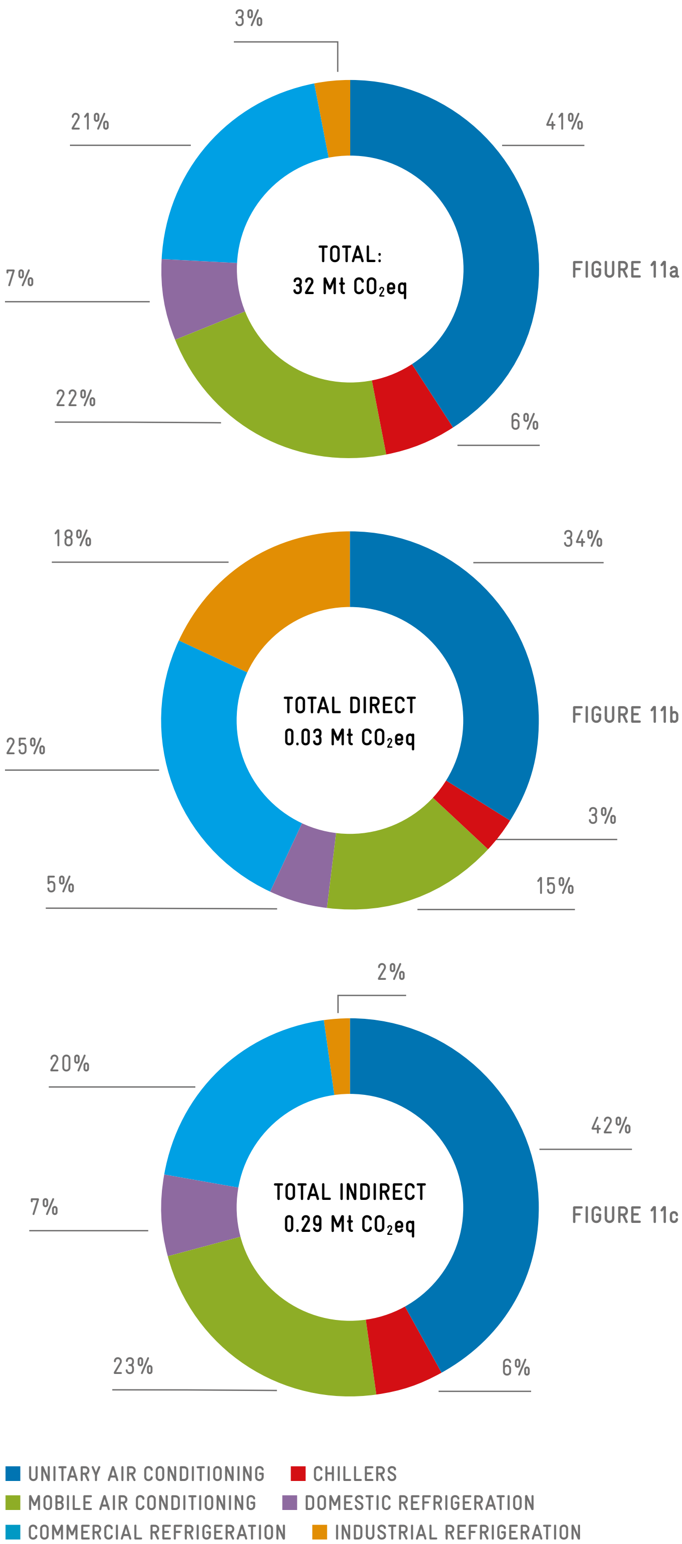

FIGURE 11: ESTIMATED GHG EMISSIONS FOR THE SEYCHELLES RAC SECTOR BY SUBSECTORS IN 2017

3.2 BUSINESS-AS-USUAL VERSUS MITIGATION SCENARIO

It is estimated that with the growing wealth per capita and other factors like growing urbanisation and increasing ambient temperatures, the GHG emissions in the Seychelles' RAC sector are expected to grow from 0.32 Mt CO_2eq in 2017 to 0.43 Mt CO_2eq by 2030 in the BAU scenario as shown in Figure 12. The total emissions in 2050 are estimated with 0.48 Mt CO_2eq.

With ambitious mitigation measures to support the transition to low-GWP refrigerants and energy-efficient RAC appliances, emissions could be reduced compared to the business-as-usual (BAU) scenario as displayed in Figure 13. The adoption of BAT and the design of targeted policy measures could keep projected GHG emissions below 0.35 Mt CO_2eq in 2050. Further mitigation could be achieved through shifting the energy supply to power the RAC appliances from fossil fuel to renewable energy sources.

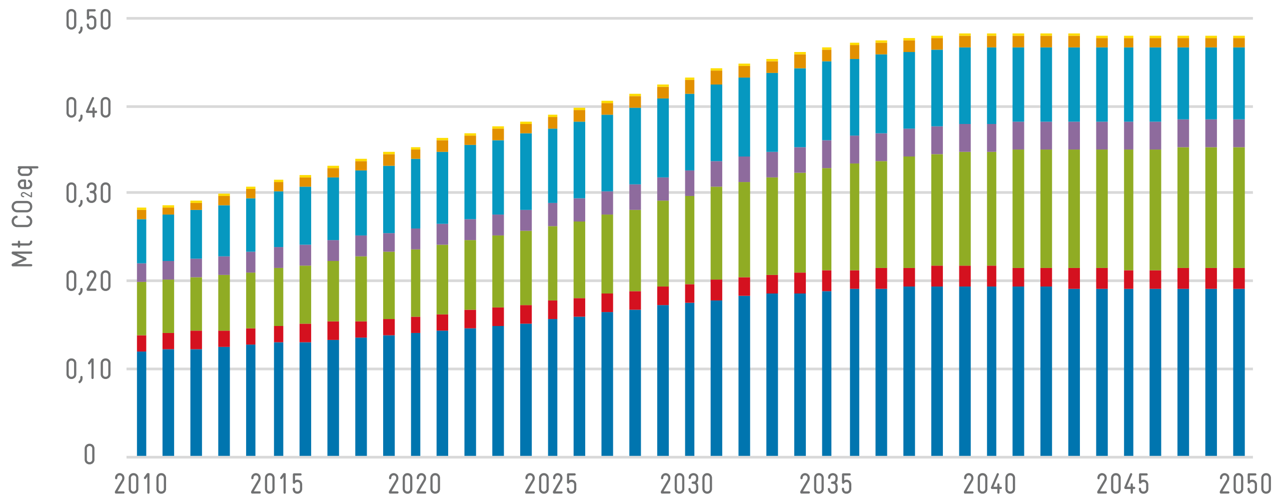

FIGURE 12: PROJECTED BAU GHG EMISSIONS IN THE RAC SECTOR INCLUDING REGULATIONS UNDER THE KIGALI AMENDMENT TO THE MONTREAL PROTOCOL FOR THE YEARS 2010-2050

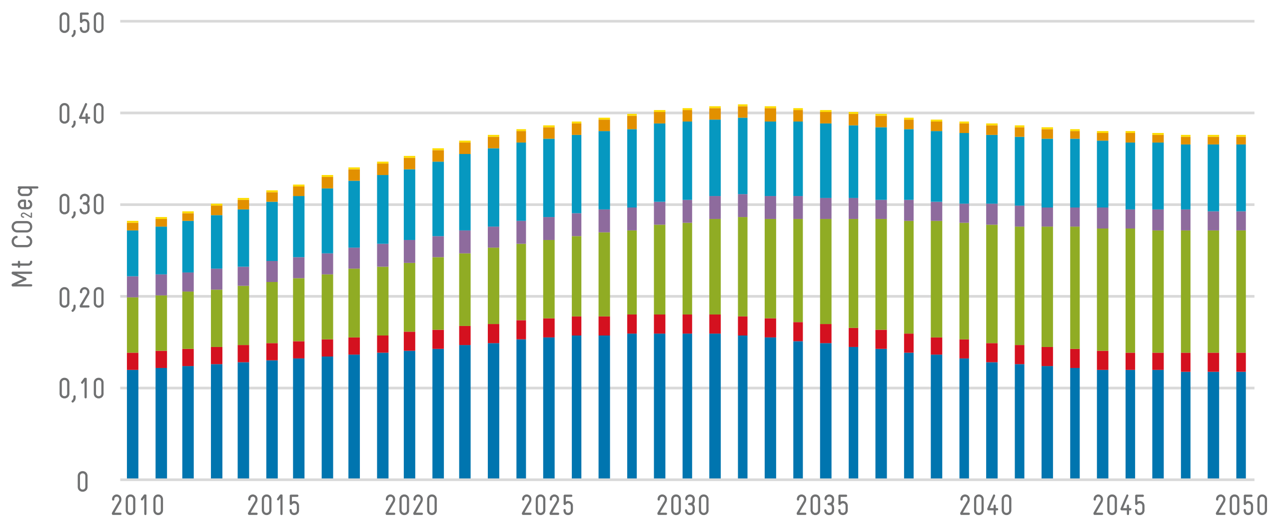

FIGURE 13: PROJECTED MIT GHG EMISSIONS IN THE RAC SECTOR INCLUDING REGULATIONS UNDER THE KIGALI AMENDMENT TO THE MONTREAL PROTOCOL FOR THE YEARS 2010-2050

UNITARY AIR CONDITIONING | CHILLER | MOBILE AIR CONDITIONING | DOMESTIC REFRIGERATION | COMMERCIAL REFRIGERATION | INDUSTRIAL REFRIGERATION | TRANSPORT REFRIGERATION

A large GHG mitigation potential lies in transitioning from highly climate-damaging HCFCs and HFCs to alternatives with low-GWP in a more timely manner, i.e. ahead of the current HFC phase-down schedule stipulated in the Kigali Amendment to the Montreal Protocol (Clark and Wagner, 2016).

With the Kigali Amendment, which the Seychelles have ratified on the 20th of August 2019, the consumption of HFCs will be regulated and reduced in the future. Figure 14 shows the RAC related HFC consumption under the BAU scenario (turquoise line), the assumed consumption freeze and reduction steps under the Kigali Amendment (green line) on the basis of the baseline for the Seychelles as well as the reduction steps incorporated into a BAU-Kigali scenario (orange line). The possible consumption under the mitigation scenario (MIT; purple line) applying best available technologies is presented with the purple curve. Total BAU consumption will peak in 2030, when the appliance stock growth slowly reaches saturation and more low-GWP refrigerants will be used.

Under the Kigali Amendment, the baseline for the consumption is calculated as an average for the years 2020 to 2022 plus 65% of the HCFC baseline. For the Seychelles, as part of the A5 Group 1, the first reduction step will take place in 2029 with a reduction to 90% of the baseline and successive reduction to 70% of the baseline in 2035, 50% in 2040 and 20% in 2045 as illustrated in Figure 14 (green line).

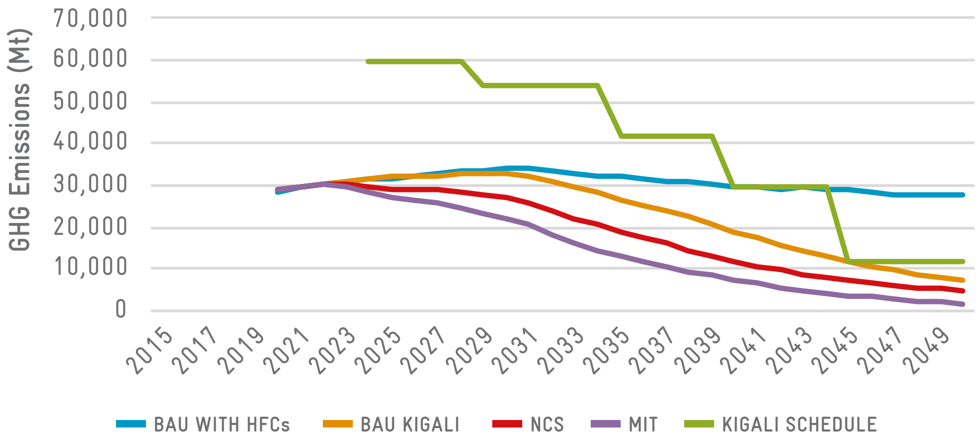

FIGURE 14: BAU (TURQUOISE), THE BAU-KIGALI SCENARIO (ORANGE) WITH THE REDUCTION STEPS UNDER THE KIGALI AMENDMENT (GREEN) AND THE MIT SCENARIO (PURPLE) WITH THE BEST AVAILABLE TECHNOLOGY. THE NCS SCENARIO (RED LINE) DESCRIBES THE MITIGATION SCENARIO BASED ON CONCRETE MEASURES DESIGNED FOR THE SEYCHELLES, WHICH ARE FURTHER ELABORATED ON IN CHAPTER 5

4 EQUIPMENT-BASED RESULTS & TECHNOLOGY GAP ANALYSIS

This chapter shows for each subsector the development of the historic sales, the projected stock numbers until 2050 as well the type of technology currently deployed, and, alternative low GWP technologies. These data form the basis for a detailed analysis of the BAT. Based on the BAT scenario a MIT scenario is developed, and the Kigali Amendment obligations are shown.

To provide information on the BAT on the global market, the units installed in the Seychelles and the BAT were compared. Results are presented as part of the tables in the following sub-chapters. The results of this comparison are fed into the modelling analysis resulting in the MIT scenario.

The data on RAC appliances in use, the stock of appliances, was obtained in two different ways. First, the RAC appliances currently in use were obtained by applying the stock model, calculated amongst others from past sales data of distributors and resellers as well as import data from customs. Second, the RAC appliances currently in use were obtained by surveying key end-users. Table 7 compares the obtained appliance number results from the model and the units in use in the country for the year 2017.

TABLE 7: COMPARISON OF SURVEYED AND CALCULATED STOCK DATA

SECTOR	ESTIMATED STOCK UNITS ON THE SEYCHELLES (SURVEY WITHIN THIS RAC INVENTORY, 2017)	CALCULATED STOCK BASED ON SALES IN THE MODEL (2017)
UNITARY AIR CONDITIONING (SPLIT AC)	32,402	33,006
CHILLERS	45	46
DOMESTIC REFRIGERATION	60,255	60,547
COMMERCIAL REFRIGERATION (STAND-ALONE)	12,192	12,226
MOBILE AC	20,970	20,295
REFRIGERATED TRUCKS	40	40
INDUSTRIAL REFRIGERATION - CONDENSING UNITS - CENTRALISED UNITS	 47 12	 62 14

The end-user survey resulted in an estimation of refrigerators, freezers and room ACs currently in use from key end-users including households, hotels, guest houses and self-catering establishments, retailers (i.e. small shops, minimarkets and supermarkets) and cars equipped with air conditioning as shown in Table 8. The Seychelles Licensing Authority reports of about 30,000 cars registered in the Seychelles. An estimated number of 20,970 of these cars (~70%) are equipped with air conditioning systems in various sizes.

TABLE 8: SURVEY RESULTS AND CALCULATION OF TOTAL NUMBERS OF UNITS

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	MARKET PENETRATION POTENTIAL FOR ALTERNATIVE SYSTEM		
				CURRENT	2030	2040
SELF-CONTAINED AC	Refrigerant	R410A	Low GWP <10	<5%	50%	60%
	Energy efficiency	3.2	>3.7			
DUCTLESS SPLIT	Refrigerant	R410A, R32	Low GWP <10	<5%	50%	70%
	Energy efficiency	3.4	>5			
DUCTED SPLIT	Refrigerant	R410A, R407C	Low GWP <10, Low GWP with secondary fluid	<5%	40%	80%
	Energy efficiency	3.4	>3.65			
MULTI-SPLIT	Refrigerant	R410A, R407C	Low GWP <10 or low GWP with ducted split	<5%	30%	70%
	Energy efficiency	3.3	>4.4			

In the following subchapter the sales and stock developments as well as key assumptions for alternative, low-GWP systems is analysed for each subsector.

4.1 UNITARY AIR CONDITIONING SALES AND STOCK DATA

There is no local production of AC equipment on the Seychelles. All equipment is imported by local distributors. Unfortunately, only a few distributors responded to the questionnaires. Therefore, the data obtained through importers and distributors was low. The data was supplemented by using import and customs data from the Customs Division at Seychelles Revenue Commission (SRC) reporting the imported numbers by equipment type.

The obtained import data was not evenly distributed throughout the years resulting in a scattered sample. For better modelling, the annual import data was evenly redistributed across the review period, leaving the overall number of imported units in the review period unchanged. Based on these results, the stock data was calculated as shown in Figure 15. The numbers of imported UACs provided and calculated from the Customs Division at SRC are shown in Table 9.

The largest share of UAC units are split ACs. This is the most common type of AC units found on the Seychelles. They are easy to install in already existing buildings and are affordable for most households. Approximately 57% of households were estimated to have a split AC unit installed. In addition, hotels regularly use split ACs for cooling their rooms. Findings showed that, on average, one hotel had approximately 97 split ACs units installed.

TABLE 9: UAC UNITS IMPORTED (2014 TO 2018) IN THE SEYCHELLES

SALES	2014	2015	2016	2017	2018
SPLIT RESIDENTIAL AIR CONDITIONERS	2904	3241	1969	5736	3871
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	17	18	19	20	30
ROOFTOP DUCTED	6	6	6	6	7
MULTI-SPLITS	38	18	0	7	46

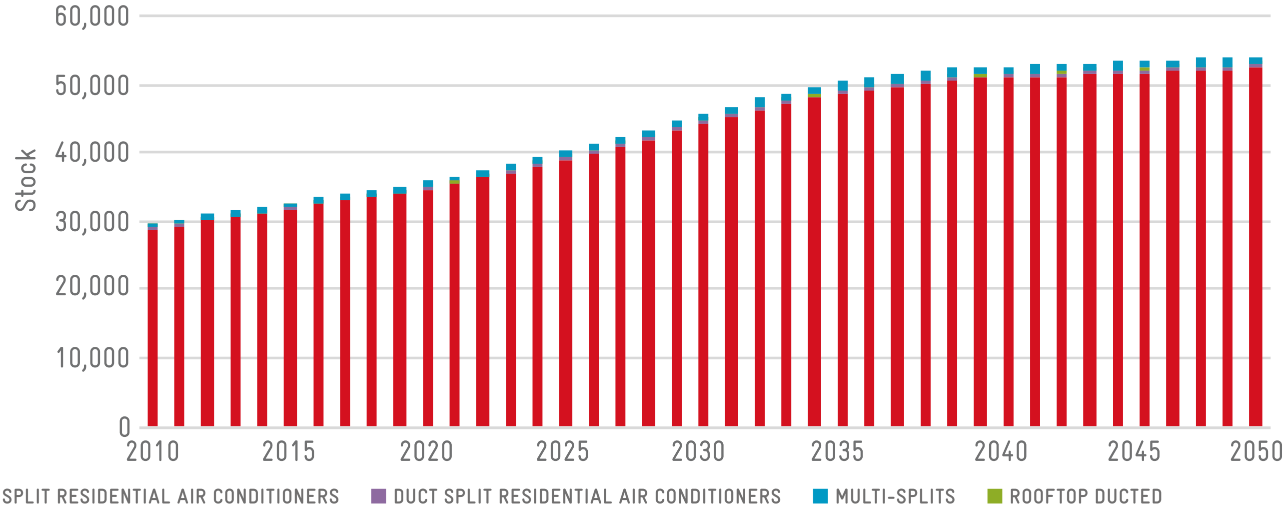

FIGURE 15: STOCK UAC UNITS (2010 TO 2050) IN THE SEYCHELLES

TABLE 10: IMPORTED UAC APPLIANCES

SALES	2014	2015	2016	2017	2018
SPLIT RESIDENTIAL AIR CONDITIONERS	2,904	3,241	1,969	5,736	3,871
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	17	18	19	20	30
ROOFTOP DUCTED	5	6	6	6	7
MULTI-SPLITS AND VRF/VRVS	38	18	0	7	46

Source: Customs Division at Seychelles Revenue Commission

Due to the high ambient temperature conditions in the Seychelles, hydrocarbons (HCs) as natural refrigerants can be used effectively for most UAC systems, especially for split AC and ductless split systems. Split AC units utilising the hydrocarbon refrigerant R290 are already available and in production in India and China. China has completed the conversion of several production lines from R22 to R290 as part of their HCFC Phase-out Management Plan (HPMP). Efforts to assess the risks and establish standards and best practices of using HCs in larger charge systems are underway. Combining aspects such as air mixing rates and leak position, together with additional safety measures (i.e. compressor shut-off in case of leakage) can lead to considerably higher recommended charge sizes and thus, better cooling capacities.

TABLE 11: CURRENT AND BEST PRACTICE RAC APPLIANCES IN THE UAC SUBSECTOR (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
SPLIT AIR CONDITIONERS	Refrigerant	R22, R410A	R290	<5%	50%	70%
	Equipment energy efficiency	3.0	>3.7 (SEER>6.8)			
DUCTED AIR CONDITIONING SYSTEMS	Refrigerant	R410A, R407C	R290 (+liquid secondary)	<5%	40%	80%
	Energy efficiency	3.3	>3.5			
MULTI-SPLITS, VRF/VRVS	Refrigerant	R410A, R417	R32	<5%	30%	70%
	Equipment energy efficiency	3.1	>3.5 (3.6)			

4.2 AIR CONDITIONING CHILLER STOCK DATA

Stationary AC and refrigeration chiller systems are used for residential, commercial and industrial cooling. Generally, chillers are installed in a machinery room or outdoors, making it easier to deal with safety issues related to toxicity and flammability of low-GWP refrigerants. Data was acquired via the questionnaires and site visits. No customer data was obtainable for this subsector. The modelled data is displayed in Figure 16.

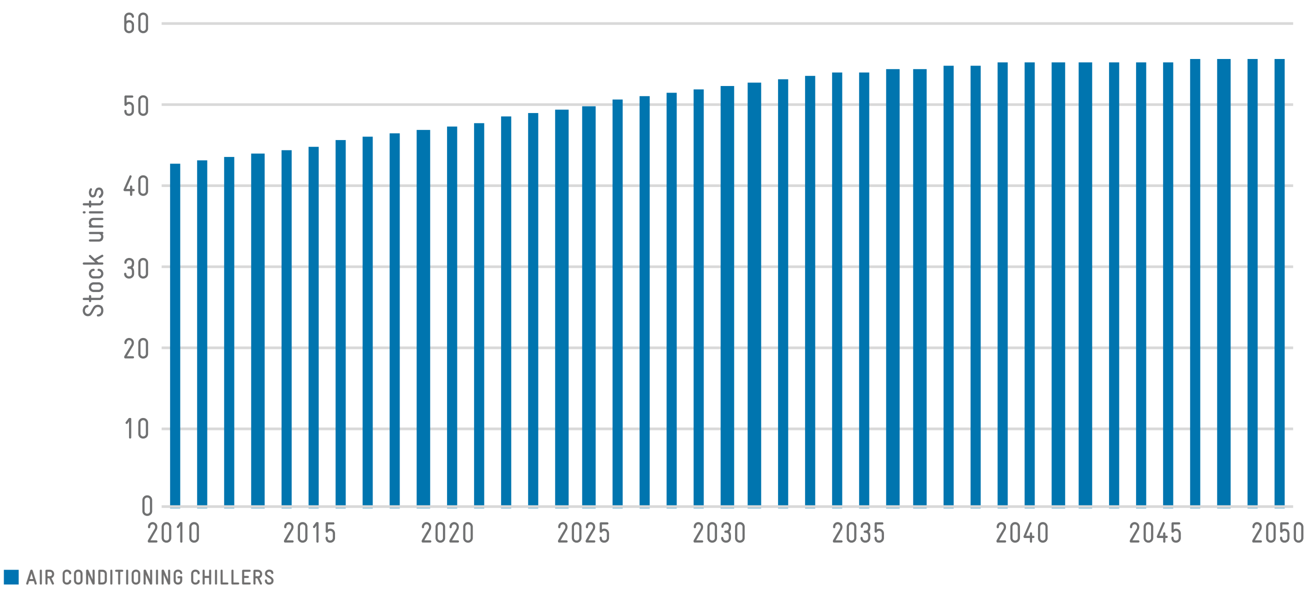

FIGURE 16: ESTIMATED NUMBER OF STOCK UNITS OF AC CHILLERS AND EXPECTED GROWTH OF THE SUBSECTOR (2010 TO 2050) IN THE SEYCHELLES

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For hot ambient conditions, both HC refrigerants, such as R290 and R1270 as well as R717 are very energy-efficient. Chiller systems using those refrigerants show EE properties often superior compared to HFC-based systems. Driven by the requirements of the EU F-gas Regulation, the number of manufacturers producing R290 chillers in Europe and other regions has increased. In Europe, HC chillers have been manufactured and safely operated for many years. Also, first large systems with up to 1 MW have been produced. R717 chillers have been manufactured, installed and operated worldwide for decades, mainly for large scale industrial refrigeration systems. R717 systems are very cost competitive for large applications, both regarding upfront and operating costs. Due to the EU F-gas Regulation, R290 and R717 chillers are increasingly used for AC purposes in Europe. In combination with screw compressors, very high energy efficiencies can be achieved with R290 and R717 chiller systems, particularly in high ambient temperature environments. While R717 chillers are mostly used for very large cooling capacities, hydrocarbon chiller systems can be used for cooling capacities starting from 10 kW.

A comparison of the current and best practice technology is presented in Table 12. The current RAC chillers in the Seychelles mainly operate with high-GWP HFC refrigerants R134a and R410A. It is worth mentioning, however, that some already use R717.

R717 is toxic, whereas HCs are flammable. Therefore, technical skills are required for the installation, operation and maintenance of the systems. Due to technical skill requirements, R717 systems are mainly used for applications with cooling capacities over 500 kW.

TABLE 12: CURRENT AND BEST PRACTICE RAC CHILLERS (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
AC CHILLERS	Refrigerant	R134a, R410A	R290, R1270, R717	<5%	30%	70%
	Equipment EE	3.5	> 4			

4.3 MOBILE AIR CONDITIONING SALES AND STOCK DATA

Mobile AC systems can be categorised into two types:

» mobile AC systems used in passenger vehicles

» transport AC systems used in other vehicles (i.e. trucks, trains, airplanes and buses)

The data from the mobile air conditioning subsector for car air conditioning from 2013 to 2017 was reported by the National Bureau of Statistics in the report "Seychelles in Figures 2018" (Table 13, page 36). Based on this data, the growth rate was calculated as the CAGR (Chapter 1.2, Table 1). There was no data obtainable on sales either via customs or from questionnaires. The modelled data is shown in Figure 17. The total number of cars was obtained by the Seychelles Licensing Authority.

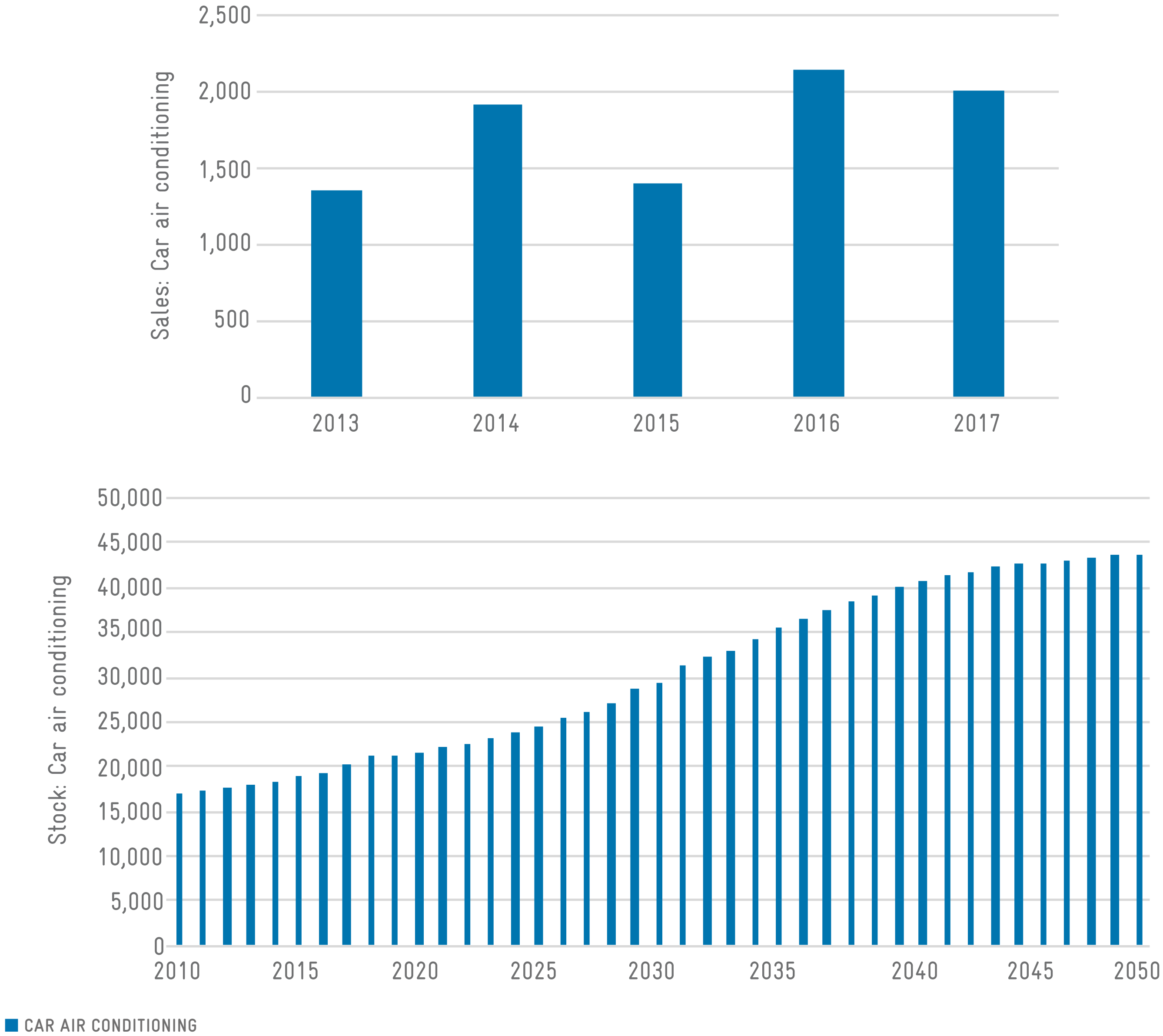

FIGURE 17: MOBILE AC UNIT SALES NUMBERS FROM 2013 TO 2017 (TOP) AND STOCK UNITS (2010 TO 2050, BOTTOM) FOR THE MOBILE AC SUBSECTOR IN THE SEYCHELLES

TABLE 13: NEWLY REGISTERED CARS WITH MOBILE AC FOR THE YEARS 2013-2017 AS GATHERED FROM SECONDARY DATA

	2013	2014	2015	2016	2017
CAR AIR CONDITIONING	1,342	1,912	1,396	2,130	2,005

Currently installed mobile AC systems in the Seychelles use mostly R134a as a refrigerant. Alternative systems with HFO-1234yf and R744 have been developed in Europe. HCs are not yet considered a viable refrigerant option by car manufacturers, due to flammability concerns. Nevertheless, HCs can be an option for electric vehicles with hermetically sealed refrigerant systems. Systems using R744 are available for large vehicles, i.e. buses and trains. The most energy-efficient and environmentally sound solution in the passenger car category would be using hermetically sealed refrigerant systems in electric cars (Table 14).

TABLE 14: CURRENT AND BEST PRACTICE MOBILE AC UNITS (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
CAR AC	Refrigerant	R134a	HFOs, HC for hermitically sealed refrigerant systems	<5%	30%	60%
	Equipment EE	1.66	no data			
TRANSPORT AC	Refrigerant	R134a	R744	none	5%	15%
	Equipment EE	No data	no data			

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4.4 TRANSPORT REFRIGERATION STOCK DATA

The Seychelles Licensing Authority reported 40 refrigerated trucks in the Seychelles. Through the survey, information on the refrigerant and charge size of the cooling systems of the trucks were obtained. The modelled stock is shown in Figure 18.

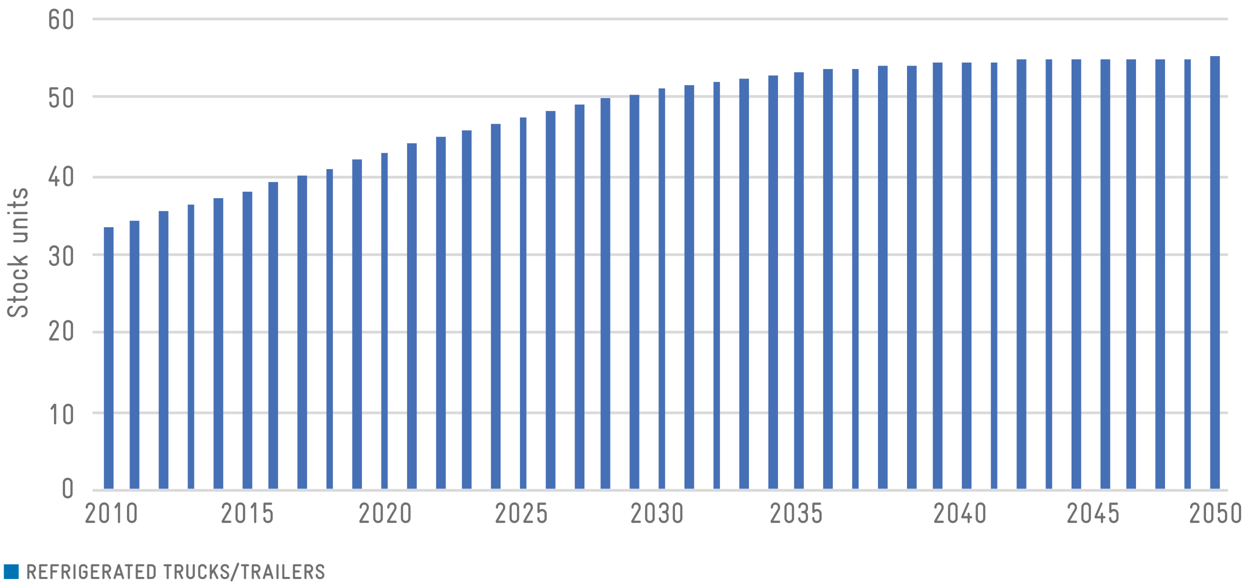

FIGURE 18: ESTIMATED STOCK UNITS (2010 TO 2050) OF THE TRANSPORT REFRIGERATION SECTOR IN THE SEYCHELLES.

Hydrocarbon refrigeration systems for the transport refrigeration subsector are not widely available. However, R290 systems are currently being developed and tested for suitability and applicability. This technology will be relevant for the Seychelles, considering the satisfactory performance of HCs in climatic conditions like those in the Seychelles. It would allow the Seychelles to avoid direct emissions in the transport refrigeration sector and save fuel for powering the systems.

A change from the current R407C systems to a low-GWP alternative (i.e. R290) in the transport refrigeration sector is forecasted to have a significantly improved market potential (Table 15).

TABLE 15: CURRENT AND BEST PRACTICE TRANSPORT REFRIGERATION UNITS (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
REFRIGERATED TRUCKS/TRAILERS	Refrigerant	R407C	R290, R744	none	5%	80%
	Equipment energy efficiency	no data	no data			

4.5 DOMESTIC REFRIGERATION SALES AND STOCK DATA

The data for the domestic refrigeration sector was derived from the household survey and from questionnaires. About 71% of all households were found to have a combined refrigerator/freezer unit. 55% of households reported to have a refrigerator and 51% reported to have a freezer. The refrigerators for the hotels were also reported as domestic refrigerators unless they were specifically classified as commercial refrigeration units.

Furthermore, the obtained customs data was distributed over the review period without changing the overall number of imports during the review period. The total stock units are shown in Figure 19. The growth of this sector was based on the growth of the number of households. The reported lifetime (8 years) of the domestic refrigerator appliances were adjusted to more realistic values (12 years; Chapter 2.3, Table 5) to bring the reported import numbers in line with the surveyed data and a consistent modelling of the future refrigerator stock (see Figure 19).

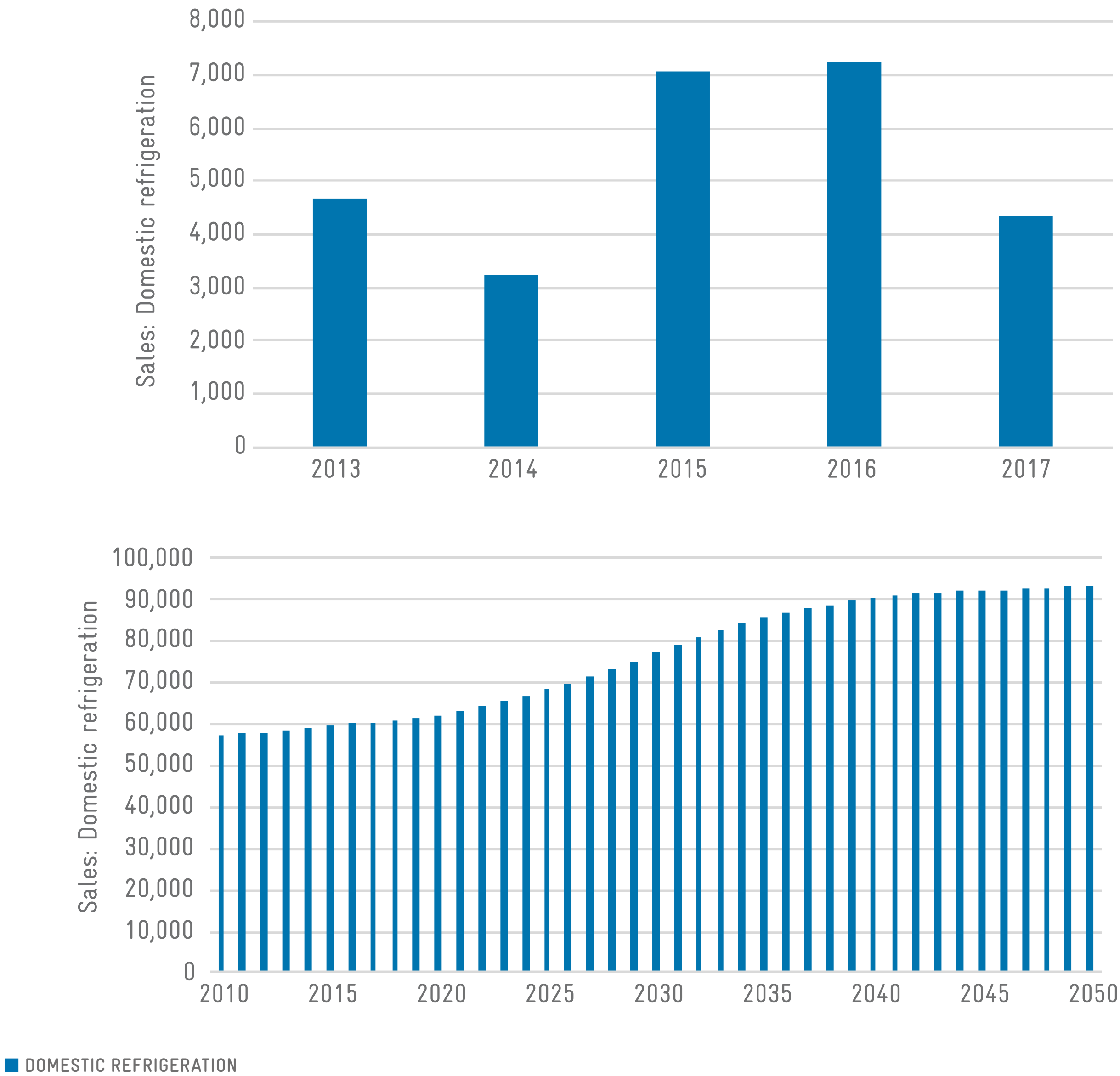

FIGURE 19: DOMESTIC REFRIGERATION UNITS IMPORTED (CUSTOMS DATA, 2014 TO 2018, TOP) AND STOCK (2010-2050, BOTTOM) IN THE SEYCHELLES

Domestic refrigerators using HC R600a as a refrigerant are state-of-the-art in Europe and Asia (Table 16). Efficiency improvements are driven by MEPS and labelling. In Europe, the rating A+++ is the highest category and fridges below A rating are banned from the market.

The Seychelles currently do not have their own labelling system and are using the European rating system as an indicator for a unit's energy efficiency rating.

TABLE 16: CURRENT AND BEST PRACTICE STAND-ALONE AND CONDENSING UNITS (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
DOMESTIC REFRIGERATION	Refrigerant	R600a, R134a	R600a	N/A	95%	95%
	Equipment EE	>300 kWh/year	139 kWh/year			

4.6 COMMERCIAL REFRIGERATION SALES AND STOCK DATA

The number of new units per year were based on raw data obtained by the customs office (Table 17, page 41). The data was restated over the period to obtain a meaningful and realistic distribution. The overall number of imports did not change, only the year of distribution was modified. The smoothened data allowed to calculate the number of units representing the stock on the Seychelles. The number of retailers were obtained from the Seychelles Licensing Authority. The survey included the analysis of 52 shops and minimarkets out of 2,102 active retailers in total, to get a better understanding of the average number of units installed in the stores in the Seychelles (Figure 20+21). Most of the units were stand-alone units and freezers, all of which were combined in the stock of the commercial subsector. There was an estimate of 980 condensing units operating on the Seychelles, mostly cold-stores or larger display refrigeration units in supermarkets. Centralised systems for supermarkets were only found to a minor extent. The projection parameters for the commercial subsector were derived via the questionnaires and the survey conducted for this inventory.

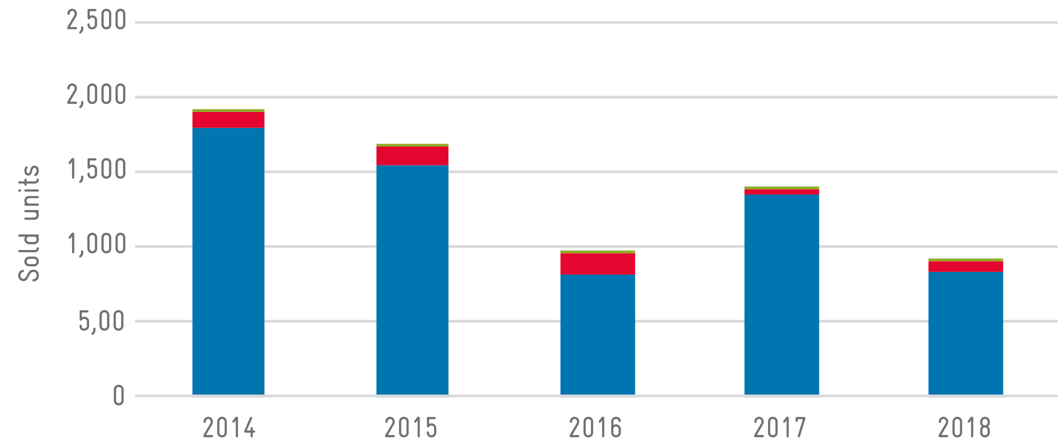

FIGURE 20: IMPORTED UNITS (CUSTOMS DATA, 2010 TO 2015) FOR THE COMMERCIAL REFRIGERATION SUBSECTOR FOR THE SEYCHELLES

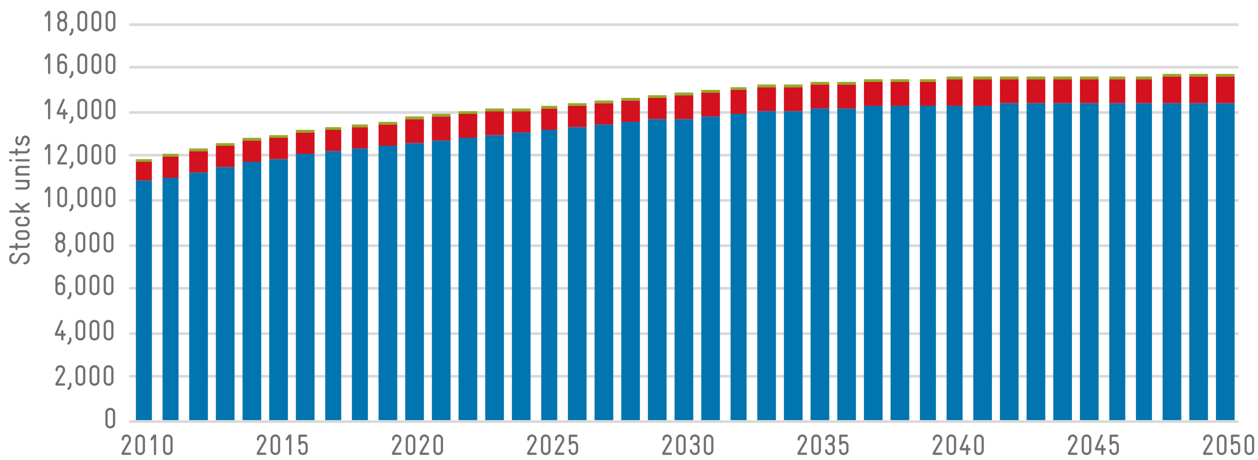

FIGURE 21: STOCK DATA (2010-2050) FOR THE COMMERCIAL REFRIGERATION SUBSECTOR FOR THE SEYCHELLES

STAND-ALONE EQUIPMENT CONDENSING UNITS CENTRALISED SYSTEMS FOR SUPERMARKETS

TABLE 17: IMPORT DATA FOR THE COMMERCIAL REFRIGERATION SECTOR IN THE SEYCHELLES

	2014	2015	2016	2017	2018
STAND-ALONE EQUIPMENT	1,794	1,543	817	1,352	837
CONDENSING UNITS	108	138	145	45	63
CENTRALIZED SYSTEMS FOR SUPERMARKETS	7	7	8	8	8

As a result of efforts to lower F-gas consumption, particularly by the EU F-gas Regulation, alternative refrigerants are increasingly used in RAC appliances in the commercial refrigeration subsector in Europe. In the stand-alone equipment category (i.e. bottle coolers, ice coolers and display cases with a length up to 3.75m), appliances using HC refrigerants have reached significant market shares. In the Seychelles, import of such HC appliances is planned for 2020 as an initial trial.

Commercial refrigeration systems in supermarkets can also be upscaled, combining multiple stand-alone units, which release their condensation heat into a water circuit. Condensing units that use HC refrigerants are also available. Currently, the updated draft of the IEC standard 60335-2-89[3] suggests that the charge size can be increased from 150g to 500g HC refrigerant, allowing an even broader application. The use of R600a and R290 instead of the currently available R134a and R410A is estimated to result in EE gains of over 10% (Table 18).

TABLE 18: CURRENT AND BEST PRACTICE STAND-ALONE AND CONDENSING UNITS (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
STAND-ALONE EQUIPMENT	Refrigerant	R134a	R290	<5%	85%	85%
	Equipment EE	2.6	>3.5			
CONDENSING UNITS	Refrigerant	R410A	R290 (+ liquid secondary)	none	40%	60%
	Equipment EE	2.8	>3.5			
CENTRALISED SYSTEMS FOR SUPERMARKETS	Refrigerant	R134a	R290 (+ liquid sec. for medium temperature and CO_2 cascade for low temperature)	none	20%	80%
	Equipment EE	3.15	>3.5			

3 IEC (International Electrotechnical Commission) 60335-2-89: Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor

4.7 INDUSTRIAL REFRIGERATION STOCK DATA

The number of units in the industrial refrigeration sector were derived from questionnaires. Additional information was gathered through interviews with distributors. The modelled stock is shown in Figure 22. Most of industrial refrigeration applications are used in the fishery industry for the operation of cold stores (condensing units) and for the production of ice in ice plants (centralised systems or ice machines).

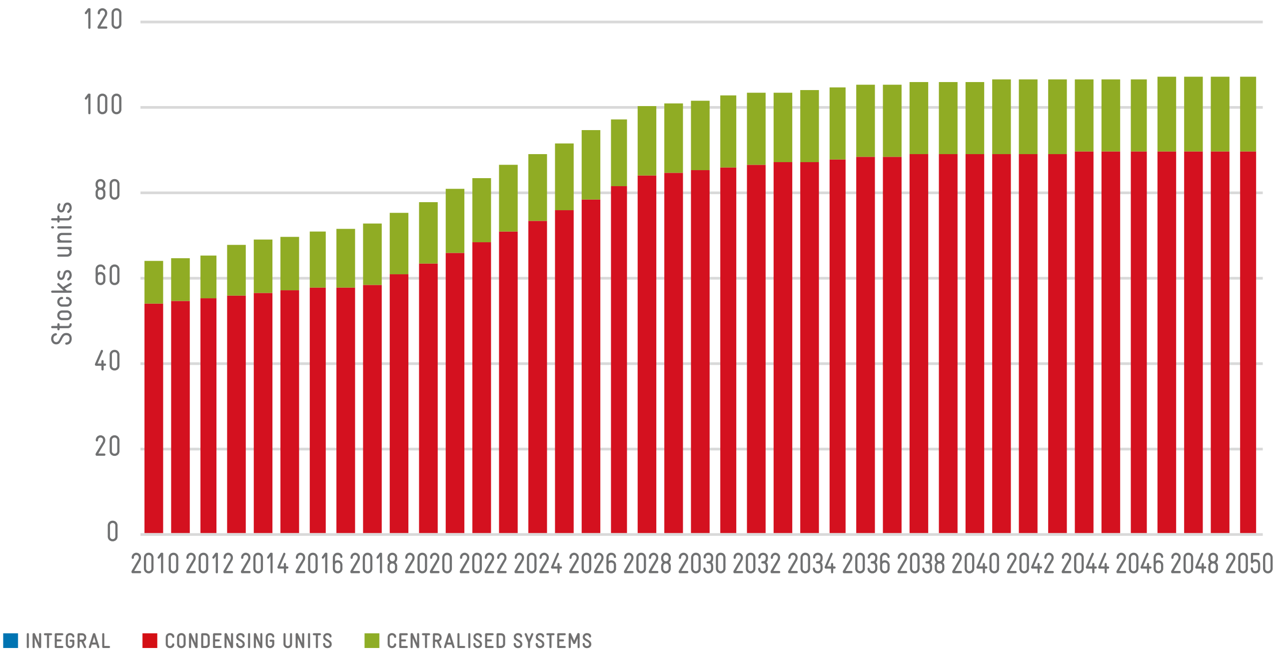

FIGURE 22: PROJECTED STOCK UNITS (2010 TO 2050) IN THE INDUSTRIAL REFRIGERATION SUBSECTOR

As illustrated in Table 19, low-GWP refrigerant alternatives are available worldwide for industrial refrigeration applications.

TABLE 19: CURRENT AND BEST PRACTICE INDUSTRIAL REFRIGERATION UNITS (SOURCE: GCI / HEAT ANALYSIS)

		CURRENT TECHNOLOGY	BEST PRACTICE TECHNOLOGY	POTENTIAL MARKET PENETRATION FOR ALTERNATIVE SYSTEMS		
				CURRENT	2030	2040
CONDENSING UNITS	Refrigerant	R404A, R507c	R290 (+liquid secondary	<5%	40%	60%
	Equipment EE	<2.7	>3.5			
PROCESS CHILLERS	Refrigerant	R404A	R717, R290	<5%	40%	60%
	Equipment EE	<2.5	>4			

R717 chillers have been manufactured, installed and operated worldwide for decades, with the main focus on large-scale industrial refrigeration systems. In combination with screw compressors, very high energy efficiencies can be achieved with both R290 and R717 chiller systems, particularly in high ambient temperature environments. As for the large systems, R717 systems are very cost-competitive, both with regard to upfront and operating costs. Industrial process chillers are in the state-of-the-art condition in many countries. Current industrial applications e.g. mainly in cold stores operate with HFC R134a and R410A, which has a high GWP. With the adaptation of alternative technologies with low-GWP refrigerants (R290 or R717), energy efficiency improvements in the range of 10-20% are to be expected.

As R717 is toxic and hydrocarbons are flammable, particular consideration and technical skills are required for the installation, operation and maintenance of the systems.

Due to the technical skill requirements, R717 systems are mainly used for applications with a cooling capacity over 500 kW. For large systems, R717 systems are very cost competitive, when regarding upfront and operating costs. Hydrocarbon chiller systems are fully suitable for systems from 10 – 500 kW, or even higher kW, if skilled installation and servicing personnel is available.

5 NATIONAL COOLING STRATEGY FOR THE RAC SECTOR IN THE SEYCHELLES ANALYSIS

The National Cooling Strategy (NCS) is a planning instrument, translating the findings of the RAC inventory into strategies and milestones to increase the market share of green cooling technologies to mitigate GHG emissions in the RAC sector. In the Seychelles, the RAC sector currently causes GHG emissions of 0.32 Mt CO_2eq (2017) based on the data obtained through the RAC inventory.

With the RAC inventory, a sound database of RAC equipment in use, its distribution in the subsectors and expected growth has been established. Figure 23 shows the subsector distribution and the projected development until 2050 under BAU conditions (already incorporating the Kigali Amendment reduction steps).

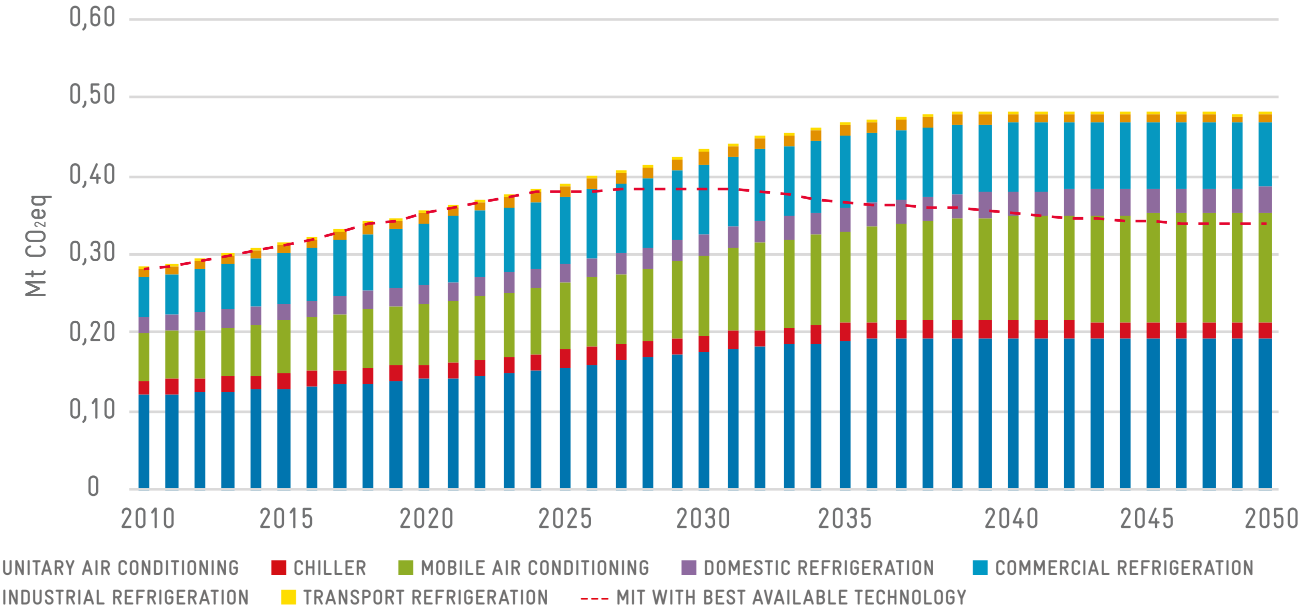

FIGURE 23: BAU SCENARIO BY SUBSECTORS UNDER THE KIGALI AMENDMENT AND MIT SCENARIO WITH BAT APPLIED (TOTAL GHG EMISSIONS)

Considering the growth of the sector, the projections suggest that without any actions taken, the emissions from the RAC sector will rise to up to 0.48 Mt CO_2eq by 2050. The mitigation potential based on introduced BAT amounts to a cumulative 2.45 Mt CO_2eq from 2017 to 2050.

Three key subsectors (Figure 24) were identified based on their emission mitigation potential and the availability of alternatives. UAC and commercial refrigeration are the two largest subsectors. The emissions of the domestic refrigeration subsector are slightly smaller, but green technology alternatives are readily available. The equipment currently obtainable on the market is assessed regarding their EE, cooling capacity and refrigerant employed. These features are compared to internationally available BAT options.

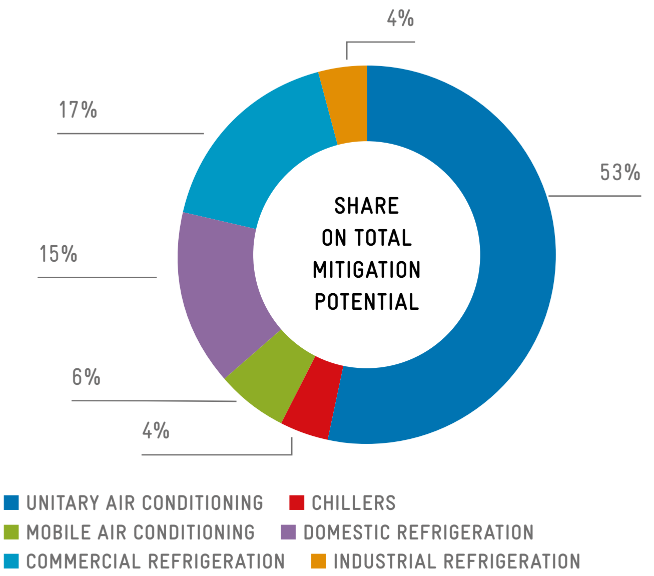

FIGURE 24: SHARE OF TOTAL MITIGATION POTENTIAL OF THE RAC SUBSECTORS FROM 2017 TO 2050 WITH THE ADOPTION OF BAT

Most apparent is the low market penetration of highly-EE home appliances such as fridges and split ACs. Inverter technology, having very favorable part-load efficiencies is not very common but is emerging in the market of the Seychelles, encouraged by the VAT exemption provided by the Seychelles Energy Commission for RAC equipment meeting MEPS established under an energy efficiency bill (Ministry of Finance, Trade and Economic Planning, 2017).

The HCFC phase-out mandated by the Montreal Protocol is further supported by the voluntary MEPS for appliances like RAC equipment as well as the recently approved amendment to the existing ODS regulations, allowing for differential tariffs being placed on refrigerants with high-GWP. These initiatives, if coupled with standardised technician trainings as well as incentives for end users, will provide the basis for a significant shift in the sector towards a low-carbon pathway.

The strategies presented in this chapter target the main barriers hindering the uptake of highly efficient, low-GWP RAC appliances:

1) The absence of market guidance and/or incentives for investment in energy-efficient products

2) Standardised technician training regarding maximisation of energy efficiency and safe-handling and installation of flammable and/or toxic refrigerants is not available

3) Lack of a standardised MRV system

4) Lack of public awareness of climate-friendly refrigerant alternatives

Since parts of the NCS might be conditional to obtain access to international funding, an additional barrier is the absence of a sector monitoring system. Means to monitor the impact of policy changes and other projects are not only necessary for internationally funded projects, but also very helpful for national policy decisions.

A crucial point for the successful implementation of any measure is enough ownership within the respective ministry. It is the task of the ministry to entrust responsible bodies with the implementation and enforcement of agreed measures.

Four strategies are suggested, each with a bundle of actions, targeting the four identified main barriers addressed above. For each strategy, specific measures targeting the key subsectors or the whole sector as cross-cutting issue are outlined. Table 20 (page 46) provides a summary.

TABLE 20: GHG MITIGATION STRATEGIES BASED ON VARIOUS RAC SECTOR INTERVENTIONS

STRATEGY	MEASURES	TARGET SECTOR
1) INCREASING ENERGY EFFICIENCY IN THE RAC SECTOR		
• Make energy use transparent • Inform end-users about life-cycle costs • Ban inefficient products from the market • Provide incentives to accelerate market uptake	• Set of mandatory MEPS • Established labelling requirements • An appropriate authority is the designated institution to enforce, monitor & up-date regulations regarding MEPS & labelling (i.e. Seychelles Energy Commission) • Public procurement purchases equipment based on MEPS & labelling standards, least life-cycle costs and low-GWP (natural) refrigerants where possible • A scheme for returning old appliances to be properly disassembled and recycled is in place • Grant scheme for to balance upfront investment costs of equipment with lower life-cycle costs is available	• UAC: single splits • Commercial stand-alone units • Domestic refrigeration
2) FACILITATE TRANSITION TO LOW-GWP REFRIGERANTS		
• Market mechanisms to facilitate low-GWP refrigerant uptake	• An environmental levy scheme based on the GWP content of imported refrigerants • Ban on high-GWP refrigerants for refrigeration systems where low-GWP alternatives are available • Adoption of ISO 5149 with amendments to allow for higher charge sizes for HC refrigerants	• All key subsectors
3) ENSURING PROPER INSTALLATION AND SERVICING TO MAINTAIN SAFETY AND ENERGY EFFICIENCY		
• Ensure skills of technicians working with RAC appliances & systems, including flammable/ toxic refrigerants • Adopt appropriate safety standards	• TVET curricula on RAC cover the safe use of natural refrigerants • Establishment of compulsory certification scheme • Set-up of registry for certified technicians • Adoption of international safety standards	• Cross-cutting issue; applies to all subsectors
3) ESTABLISHMENT OF A MEASUREMENT, REPORTING & VERIFICATION SYSTEM		
• Set-up of data base of RAC equipment sales to monitor the effects of other measures and provide metrics for any bankable project	• Introduction of detailed import data base including parameters such as model capacity, EER, refrigerant and initial charge	• All sectors (start with the key subsectors)

5.1 STRATEGY 1: INCREASING ENERGY EFFICIENCY IN THE RAC SECTOR

The aim of **Strategy 1** is to improve EE in smaller RAC appliances in the short-term and larger systems in the medium-term. The following actions are suggested initially for UACs, domestic and stand-alone commercial refrigeration equipment:

» introduction and enforcement of mandatory MEPS and labels, including the continuous review and updating of the level of standards, the market surveillance and enforcement on infringements;

» tax reduction for top-labelled products with natural, low-GWP refrigerants and their inclusion on eligibility lists for green public procurement;

» green public procurement with highly efficient and climate-friendly RAC appliances.

The Seychelles have initiated the process of establishing MEPS on a voluntary basis specifically for AC units which are likely to be formally included into regulations under the proposed new energy efficiency bill of the Seychelles Energy Commission[4]. MEPS could be set up and a labelling scheme could be developed. These defined and applied MEPS and labels could be reviewed within specific, pre-defined time intervals to verify their relevance. Through this review process, more ambitious MEPS and labels could be defined, which replace the existing MEPS and labels and to achieve highest EE standards. Depending on investment costs and energy prices, the breakeven point between inefficient units with low investment costs and high operation costs and efficient units with higher investment costs and lower operation costs is a guide to a suitable level of a MEPS. European Union's (EU) Ecodesign requirements can be taken as guiding example but need to be reviewed for suitability for the Seychelles' context.

The following tasks need to be fulfilled for a labelling scheme to work reliably:

» clearly defined and delimited product groups targeted by the labelling scheme;

» standard measurement and calculation method for labelling metric (i.e. Energy Efficiency Ratio (EER), Seasonal Energy Efficiency Ratio (SEER) or Energy Efficiency Index (EEI) depending on product group); label format and the format of required product information sheets are to be defined

» independent verification of the stated energy parameters and the resulting label class; responsibilities within the governing authorities are to be defined and sufficient funds provided for sufficient random testing;

» an enforcing body should be defined for enforcement of violations or fraud.

It is recommended to start with product groups which are easy to specify such as smaller appliances like split ACs, domestic refrigerators and commercial stand-alone units. The highest impact can be expected where unit numbers are high or high growth rates are expected. This is the case for both domestic refrigerators and split ACs. Currently, MEPS have been established only for ACs while Seychelles Energy Commission is considering developing suitable MEPS also for the refrigeration sector which should be encouraged and supported.

Unlike the EU Ecodesign requirements for MEPS which couples EE with the GWP of the refrigerant, the current MEPS being implemented by the Seychelles only considers the rated EE of the AC unit against its cooling capacity (Btu) (Table 21).

TABLE 21: CURRENT MEPS FOR ACS IN THE SEYCHELLES

SIZE/CAPACITY	MINIMUM EER (OUTPUT POWER IS EXPRESSED IN KW)
UP TO 12000 BTU/H (UP TO 3.52 KW)	3.1
12001 TO 24000 BTU/H (3.52 – 7.03 KW)	3.0
>24000 BTU/H	4.2

4 Source: http://www.seychellesnewsagency.com/articles/10688/Pro-environment+legislation+in+Seychelles+will+demand+energy+efficient+appliances+and+buildings

The MEPS levels could be successively reviewed and strengthened within pre-defined intervals. Since the average BAU units are reported to have an EER of 3.0, the NCS scenario was plotted with the following steps as described in Figure 25.

Non-inverter type (EER >= 3.5) in 2025 →	Non-inverter type (EER >= 3.5) in 2025
Inverter type (EER >= 5.0) in 2025 →	Inverter type (EER >= 6.0) in 2025
Non-inverter type (all EER) in 2035 →	Inverter type (EER >= 7.0) in 2035

FIGURE 25: EER AND TECHNOLOGY CHANGES FOR UAC APPLIANCES WITHIN THE NCS SCENARIO

Labelling classes can also be established according to the EU energy labelling regulation for ACs (EU, 2011). The manufacturer or importer should provide a predefined product information sheet with all relevant calculation parameters. The completed sheet should then be presented to the regulatory authority. If the product meets the minimum requirements for energy efficiency, it is placed on the market. The production information sheets also serve as a basis for issuing the product's label. Through the integration of the product information into a central product database and web-interfaces, end-users could also receive details on the energy efficiency of the appliances.

For split ACs, the EU Ecodesign requirements define a Seasonal Energy Efficiency Ratio (SEER) as benchmark metric. The SEER includes part-load efficiencies and represents the overall EE over a whole cooling season rather than at design conditions as the EER does. SEERs are also defined in other countries (i.e. China, India, USA) each using their own temperature profile and slightly different calculation methods. The EU calculation method also includes energy consumption during stand-by and off-modes. By including part-load efficiencies, units employing inverter technology are favoured, as those are most efficient during part-load conditions. Therefore, within a medium timeframe, the introduction of a SEER is recommended to adequately reflect the efficiency gains achieved by inverter technology and provide an incentive for the uptake. Similarly, the labelling framework is recommended to set classes for SEER in the medium term. However, it should use the same metrics as the MEPS.

It is recommended that the voluntary MEPS become mandatory latest by 2025 with an EER of 3.5 and EER >= 3.8 for non-inverter type ACs. For 2025, the introduction of a SEER-based MEPS system is recommended. Since the average BAU split AC unit is reported to have an EER of 3.0, the NCS scenario was set with the steps described in Table 20.

For domestic refrigerators, the metric used in the EU Ecodesign requirements is the Energy Efficiency Index (EEI), which is the ratio between the energy consumption of the tested appliance and a standard appliance. The lower the EEI, the higher the EE. The calculation method provides for several climate categories and could therefore be easily transferred to the Seychelles. The EU Ecodesign requirement is currently an EEI of 42 or lower for compression-type refrigerators. To set the MEPS for Seychelles, a LCC assessment is recommended. The energy consumption of the domestic refrigeration sub-sector is estimated at about 518 kWh/year in 2020. The NCS scenario uses MEPS resulting in an average annual energy consumption of 507 kWh/year in 2025 and 450 kWh/year in 2030. See Table 22 (page 49) for more details. Labelling classes can also be established following the EU regulation on energy labelling of household refrigeration appliances (EU, 2010).

TABLE 22: ENERGY CONSUMPTION IN KWH/YEAR FOR THE DOMESTIC REFRIGERATION SUBSECTOR

YEAR	BAU	NCS	MIT
2020	518	518	518
2025	515	507	491
2030	510	450	362

For stand-alone units, the EU Ecodesign requirements are pending. The benchmark metric will be the same as for domestic refrigerators. Since stand-alone units are usually not bought by the public at large, a labelling scheme might not be necessary for an informed purchase-decision. Though, MEPS and a defined product information sheet containing all relevant technical parameters are recommended. The average stand-alone unit is assumed to have an annual energy consumption of 3483 kWh/year. The NCS scenario uses MEPS resulting in an average annual energy consumption of 3444 kWh/year in 2025 and 3192 kWh/year in 2030 (Table 23).

TABLE 23: ENERGY CONSUMPTION IN KWH/YEAR FOR STAND-ALONE UNITS, WHICH ARE MOSTLY USED FOR COMMERCIAL REFRIGERATION

YEAR	BAU	NCS	MIT
2020	3,483	3,483	3,483
2025	3,468	3,444	3,350
2030	3,432	3,192	2,731

Larger appliances are not as easily categorised as they usually consist of more parts and are often customised to the building where they are being installed. Nevertheless, EU Ecodesign requirements are formulated for "professional refrigerated storage cabinets" including condensing units and process chiller. Once experience with establishing MEPS for the product groups described above is gathered, larger appliances can be included.

The Seychelles are still working through the process of adopting suitable MEPS and labelling for refrigeration equipment being imported. In the interim, the Seychelles rely on existing EE labels of other country's or region's official energy efficiency standards and labelling programmes (EE S&L). Since the Seychelles have a variety of appliances being imported from different parts of the world, the following table (Table 23) provides the approved scale for different types of EE S&L.

TABLE 24: ENERGY EFFICIENCY LABELLING SYSTEMS AND THE SUGGESTED ELIGIBILITY OF RESPECTIVE CLASSES FOR IMPORT INTO THE SEYCHELLES

NUMBER OF ENERGY EFFICIENCY CLASSES OR CATEGORIES	ELIGIBLE CLASSES OR CATEGORIES
4 or less bars or stars	The best energy efficiency class or category only
5 bars or stars	Best 2 classes or categories
6 bars or stars	Best 2 classes or categories
7 bars or stars	Best 3 classes or categories
8 or more bars or stars	Best 3 classes or categories

This effort of establishing the minimum energy labelling requirements for imported refrigeration equipment is a good start on part of a country having the serious intention of controlling the type of equipment entering its shores. The suggestions provided above could help the country refine and improve their MEPS and labelling.

Import taxes depending on EE can provide an incentive for green appliances and adds to balancing the higher investment costs for energy-efficient products. Once a labelling scheme is introduced, import taxes can be graded accordingly. The Seychelles are currently looking to implement such a system based on VAT exemptions for equipment meeting the MEPS established for RAC equipment as well as an environmental levy scheme associated with the GWP of the refrigerant contained in RAC appliances. Both these measures, when implemented, should create a market shift towards Green Cooling technologies.

Green public procurement can add to the uptake of energy-efficient units, as it sets a role model and provides a clear signal to the market that highly efficient units are wanted.

Additional measures to enhance the market uptake of energy-efficient units could be a new-for-old scheme to support replacing old, inefficient appliances with new, efficient units. Similarly, a grant scheme could be rolled out to support lower-income households to balance the investment costs for highly efficient units.

Potential national Partners for Strategy 1:
Establishing MEPS and labelling scheme including testing facility:

» National Bureau of Standards

» Seychelles Energy Commission

» Ministry of Agriculture, Climate Change & Environment

Fiscal initiatives:

» Ministry of Finance, Trade Investment and Economic Planning

» Seychelles Energy Commission

» National Tender Board (i.e. on the issue of green public procurement)

5.2 STRATEGY 2: FACILITATE TRANSITION TO LOW-GWP REFRIGERANTS

Strategy 2 targets the selection of refrigerants used in RAC equipment. Despite the Kigali Amendment giving an expiry date to the wide-spread use of HFCs, the presently employed refrigerants are still predominantly HFCs. It requires a strong political signal to the market to shift towards low-GWP refrigerants. The best practice example is the EU Regulation on fluorinated greenhouse gases (EU F-gas Regulation; EU, 2014), setting a strict quota system to reduce the use of HFCs to 21% of its 2014 baseline level until 2030. Additionally, the EU F-gas Regulation bans the use of refrigerants above a certain GWP threshold (i.e. GWP 150 for domestic & commercial refrigerators).

Banning the use of high-GWP refrigerants in selected RAC applications would provide a strong statement to the local market. The product group with a well-established low-GWP alternative is domestic refrigeration. Banning the sale of domestic refrigerators using refrigerants with a GWP above 150 might not result in a high emission reduction but shows importers that HFCs are no longer favoured (Table 25, page 51). Similarly, self-contained ACs, single-split ACs and commercial stand-alone units could be targeted. Since the EU F-gas Regulation targets the same product groups, the market will have developed enough alternatives. The following dates are suggested and implemented in the NCS scenario for bans on high-GWP refrigerants.

TABLE 25: PROHIBITION YEARS FOR SELECTED PRODUCT GROUPS UNDER THE EU F-GAS REGULATION AND SUGGESTED YEARS FOR THE SEYCHELLES.

PRODUCT GROUP	GWP THRESHOLD	YEAR OF PROHIBITION IN THE EU	SUGGESTED YEAR OF PROHIBITION IN THE SEYCHELLES
SPLIT ACS (BELOW 3 KG CHARGE)	750	2025	2025
DOMESTIC REFRIGERATION	150	2015	2025
COMMERCIAL STAND-ALONE UNITS	2,500	2020	2020
	150	2022	2030

Potential national partners for Strategy 2:
For successful regulatory controls i.e. bans

» Seychelles Energy Commission together with the Ministry of Agriculture, Climate Change & Environment are the prime force behind the initiatives on EE and climate

» Ministry of Finance, Trade Investment and Economic Planning

The Seychelles introduced a levy scheme for the import of refrigerants based on their GWP. See details in Table 26 and compare the GWP of the refrigerants used in the Seychelles in Table 26. Refrigerants with no ODP and a GWP below 100 will be exempt from environmental levies. The higher the GWP, the higher the environmental levy, following the 'polluter pays' principle.

TABLE 26: LEVY SCHEME FOR REFRIGERANTS BASED ON THEIR GWP VALUE

LEVY	REFRIGERANT GWP
NO LEVY	≤ 100
5% LEVY	100 – 2,000
8% LEVY	2,000 – 3,000
10% LEVY	≥ 3,000

TABLE 27: GWP OF REFRIGERANTS CURRENTLY USED IN THE SEYCHELLES

REFRIGERANT	TYPE OF SUBSTANCE	GWP (IPCC AR4)
R744	NR	0
R717	NR	1
R290	HC	3
R600A	HC	3
HFO1234YF	HFO	4
R32	HFC	675
R134A	HFC	1,430
R22	HCFC	1,810
R410A	HFC	2,087
R407C	HFC	2,107
R417A	HFC	2,346
R404A	HFC	3,921
R507	HFC	3,985

5.3 STRATEGY 3: ENSURING PROPER INSTALLATION AND SERVICING

Strategy 3 aims at establishing a formalised training and certification scheme for RAC technicians according to the European standard EN 13313. Accordingly, skills of graduating and graduated technicians should be improved to ensure proper handling of RAC appliances and systems during design, installation, servicing and disassembly. Concerns regarding the inclusion of the informal sector have been voiced by the vocational training schools. A lack of demonstration projects and training equipment using natural refrigerants makes practical training difficult.

Being able to proof a certain skill level also to international technology suppliers is crucial for gaining market access to technologies using flammable (HCs) and/or toxic (ammonia) refrigerants. In addition, skill is equally required to maintain high EE throughout the lifetime of the equipment. In absence of national safety standards, international standards could be adopted.

While new alternatives are environmentally safe, there are several technical challenges to overcome. For example, the use of flammable substances for refrigeration, as is the case with HCs, requires a different safety concept and control than for substances classified as 'not flammable'. Public safety is a key concern when introducing new alternatives. Even though knowing that the introduction of such alternatives in products and installations in Europe achieves, without compromise, the same level of safety as with HFCs. The introduction of new, often more complex, technologies, requires new skills, know-how and quality control. Conformity of process, product, or service with required good practice and standards can be enforced with certification, regulation and market incentives. Companies, as well as technicians need to conform with good practice and standards. Finally, the safety of the product or installed equipment needs to be verified.

Training builds capacity of personnel. However, critical aspects of the impact of personnel on public or environmental safety need to be assessed through third party verification.

In other words, the introduction of new alternatives will also depend on the availability of qualification and verification systems and intermediaries that enable certification of conformity of relevant processes, products and services. Therefore, the objective is to establish a framework for RAC technologies at various levels through policy action, private sector cooperation and code of practice and commercial services and requirements that enable overall monitoring of the quality of products, services and processes.

Qualification, Certification and Registration (QCR) schemes need to ensure that personnel in public and private sector is trained in fulfilling relevant technical standards and that requirements are enabled to qualify for examination and certification. For certificates to be reputable and accepted worldwide (i.e. by suppliers of parts and equipment), accreditation of third-party certification bodies (although not always mandatory) is strongly recommended.

Accreditation is validating the appropriateness of the structure and governance of the certifying body, the characteristics of the certification programme, the information required to be available to applicants, and the recertification initiatives of the certifying body.

Furthermore, accreditation is facilitating acceptance of the certification bodies and their certification schemes and mutual recognition of personnel competences and services on national and international levels.

A staged training and certification process is recommended, including:

1. **Qualification:** Education, experience and knowledge are the basis for evaluating the qualification level of trainees. An entry exam helps to tailor training courses to the needs of the trainee.
2. **Training:** Courses can be conducted by any institution with demonstrated experience in the field. They can be supported by standardised curricula.
3. **Training certificate for successful participation:** Training institutes will certify successful completion of the training. However, this is in general not considered enough when liability issues are involved.
4. **Application for certification:** With proven entry qualification, third-party examination can be applied for. A diversified structure is needed to allow all levels of proficiency to acquire certified competence.
5. **Examination by third-party:** Internationally or nationally accredited training institutes will issue a certificate based on locally adapted international standards for certification.
6. **Registration:** After certification, the certified person needs to be registered by a national body.

An example for skill levels defined by EN 13313 in its Annex A:

a) Basic Appreciation (BA) Category I

» Recognises importance of Skill to business and society, and relevance to own job;

» Interprets information on the Skill for own tasks;

» Knows where to obtain professional help in the Skill.

b) Working Knowledge (WK) Category II

» Assesses and diagnoses issues in the Skill;

» Provides reasoned challenges to specialists in the Skill;

» Supervises or directly works with practitioners of the Skill.

c) Fully Operational (FO) Category III

» Performs all normal activities in the Skill;

» Resolves problems and makes improvement in the Skill;

» Applies and adapts best practice in the Skill to local conditions.

d) Leading Edge (LE) Category IV

» Able to create major innovations in the Skill;

» Creates best practice in the Skill; Acts as a recognised reference point for the Skill.

Potential national partners for Strategy 3 are:

» Seychelles Institute of Technology (SIT) Seychelles Qualification Authority, Ministry of Education and Human Resource Development

5.4 STRATEGY 4: ESTABLISHMENT OF A MEASUREMENT, REPORTING & VERIFICATION SYSTEM

The focus of **Strategy 4** is to develop a MRV system in order to track the effects of adopted policy measures. It is also aimed to collect activity data of the RAC sector to be integrated into the GHG inventory process. For a detailed knowledge of equipment in use, it is important to know what is sold in the country. For a country heavily relying on imports such as Seychelles, it might be enough to closely monitor imports and exports of equipment. Best practice is a data base of sold RAC equipment including selected technical parameters such as cooling capacity, EE metric, labelling class (if applicable), initial charge and contained refrigerant.

Setting up such a comprehensive data base requires an institutional framework, defining reporting obligations for all market participants. Nevertheless, it is a powerful information source, once established.

It is recommended to start with a product group such as domestic refrigerators or smaller ACs, where technical parameters are either already defined by labelling requirements or are easy to define. Collection of sales numbers can be done through customs data, including the count of re-export. However, the assumption that all units that are imported are also sold right away, needs to be verified. If feasible, reporting obligations are best to be established at a level where double counting can be avoided and all units sold are recorded.

Potential national partners for Strategy 4:

» Seychelles Energy Commission

» Ministry of Agriculture, Climate Change & Environment

» Customs Division, Seychelles Revenue Commission

» Industry

Table 28 depicts the overall milestones suggested to implement the National Cooling Strategy to achieve the projected GHG mitigation potential of the RAC sector in the Seychelles. The table summarises the proposed mitigation measures for the different subsectors. The measures build upon each other and describe a ratcheting up of level of ambition or complexity from 2025 to 2035.

TABLE 28: MILESTONES FOR SUBSECTOR SPECIFIC SECTOR STRATEGY ACTIONS

	STRATEGY	2025	2030	2035
SPLIT AC	1	MEPS: Non-Inverter EER>=3.5 Inverter EER>=5 Labelling scheme is operational Establish SEER metric for MEPS	Strengthen MEPS: Non-Inverter EER>=3.8 Inverter EER>=6 Phase-out of Non-Inverter technology almost achieved	Replace EER metric with SEER metric Review MEPS (Non-Inverter EER>= 4.1 Inverter SEER>= 7)
	2		Ban units with charge sizes below 3 kg using refrigerants with GWP above 750	
	4	Data base recording sales incl. technical parameters is functional	Review functionality and coverage of data base	
LARGER UAC SYSTEMS	1	Incentive for high EE Established guidelines for Green Public procurement of AC equipment	MEPS apply	Review MEPS
	2	Incentive for low-GWP refrigerant Choice of refrigerant included in guidelines for Green Public procurement of AC equipment		
	3	Service and end-of-life emissions are decreasing due to better training	Annual service Emission factor = 5%, End-of-life emission factor = 50%	

	STRATEGY	2025	2030	2035
DOMESTIC REFRIGERATION	1	MEPS: EEI equivalent to annual energy use = 518 kWh Labelling scheme is operational	Strengthen MEPS: EEI equivalent to annual energy use = 420 kWh	Review MEPS: EEI equivalent to annual energy use = 370 kWh
	2	Ban units using refrigerants with GWP above 150		
	4	Data base recording sales incl. technical parameters is functional	Review functionality and coverage of database	
COMMERCIAL STAND-ALONE UNITS	1	MEPS: EEI equivalent to annual energy use = 3,482 kWh Labelling scheme is operational	Strengthen MEPS: EEI equivalent to annual energy use = 2,974 kWh	Review MEPS: EEI equivalent to annual energy use = 2,741 kWh
	2	Ban units using refrigerants with GWP above 2,500	Ban units using refrigerants with GWP above 150	
	4		Data base recording sales incl. technical parameters is functional	Review functionality and coverage of database
COMMERCIAL CONDENSING UNITS	1	Incentive for investing in high EE is established	MEPS are defined and apply	Review MEPS
	2	Incentive for investment in low-GWP refrigerant is established		
	3	Service and end-of-life emissions are decreasing due to better training	Annual service emission factor = 10%, end-of-life emission factor = 50%	
GENERAL RAC SECTOR	3	Established training and certification system according to international standard is functioning Enough training equipment is available	Make certification according to EN 13313 (or a comparable standard) compulsory	
	4	Define working plan setting a time plan for subsector coverage Define linkages to GHG reporting	Data base for refrigerators and small UAC is up and running	More product groups are included in data base

5.5 POTENTIAL MITIGATION EFFECTS

The implementation of the strategies on the specified subsectors can lead to an estimated total GHG emission reduction of 12% in 2030. The implementation of the mitigation strategy will result in 25% lower emissions than BAU in 2050 (Figure 26). The largest share of emission reduction stems from the UAC subsector, followed by the commercial and domestic refrigeration subsectors (Figure 28). The remaining emissions can be mitigated through the transition to renewable energies.

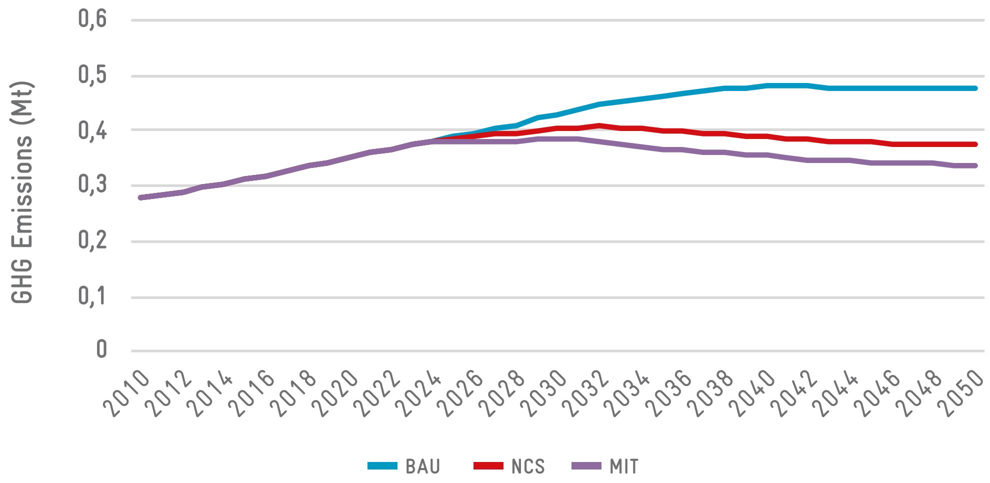

FIGURE 26: TOTAL GHG EMISSIONS FROM THE RAC SECTOR UNDER THE BAU, MIT AND NCS SCENARIO

The mitigation potential seems more prominent for the reduction of indirect emissions through introduction of energy-efficient appliances as shown in Figure 27. When comparing the mitigation potential for cumulative emissions for 2020-2050, however, direct emissions could be reduced by 16%, indirect emissions by 11%. These findings demonstrate the importance of shifting to green cooling appliances running on both natural refrigerants and being more energy-efficient to mitigate total GHG emissions from the RAC sector in the Seychelles. In absolute figures, indirect emissions are suggested to be reduced by 1.4 Mt CO_2eq, direct emissions by 0.15 Mt CO_2eq from 2020 up to 2050 in the NCS scenario.

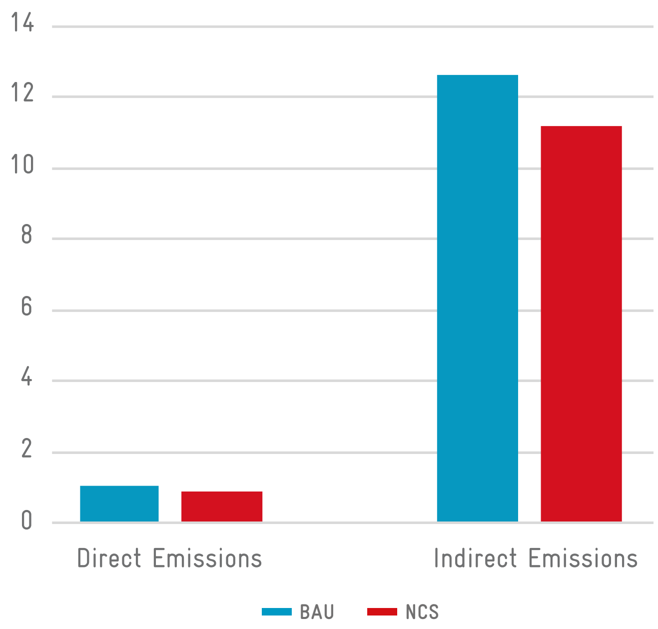

FIGURE 27: PROJECTED CUMULATIVE GHG EMISSIONS FROM 2020 TO 2050 IN THE BAU AND THE NCS SCENARIO SHOWING THE MITIGATION POTENTIAL OF THE NCS SCENARIO

Additional 58% of emission reduction to the BAU-Kigali scenario could be achieved with the decarbonisation of grid electricity. Remaining direct emissions could be further reduced by mandated leak checks and further development of alternative technologies and standards enabling the use of low-GWP refrigerants in all applications. The use of HFCs in the mobile AC sub-sector is difficult to reduce on a national level. The international automobile industry needs to agree on a common alternative (Figure 28).

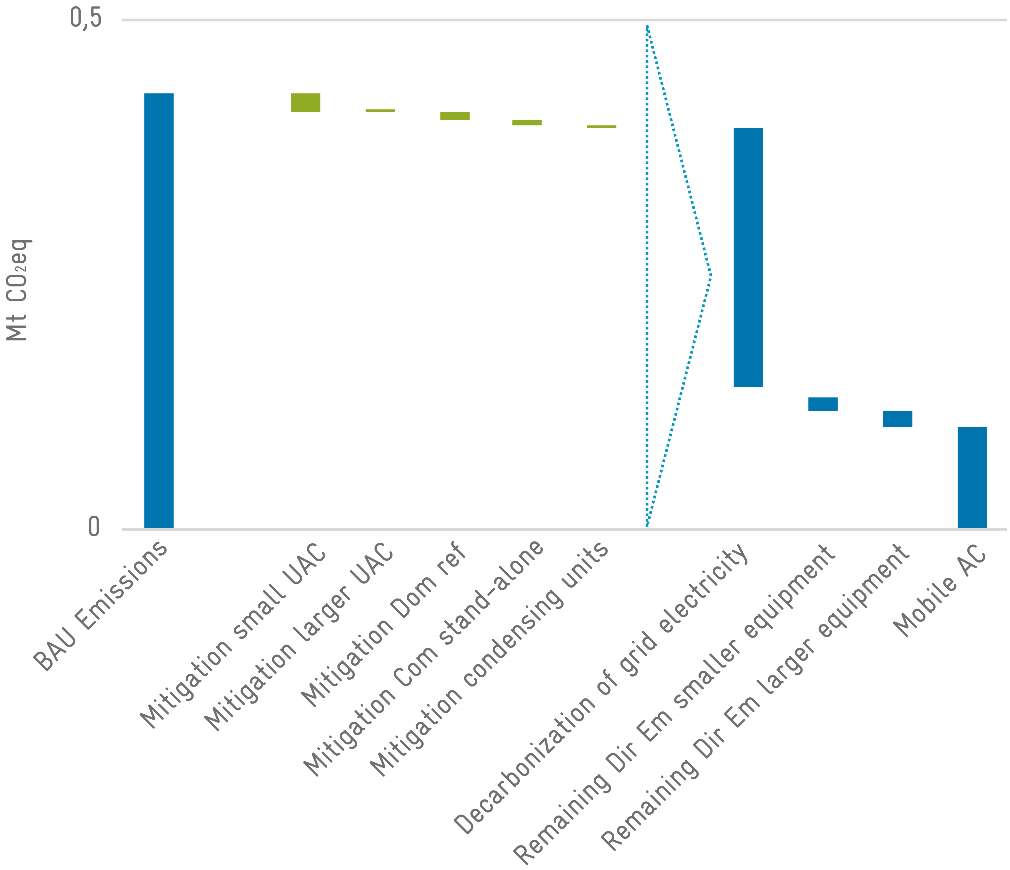

FIGURE 28: REDUCTION EFFECTS OF STRATEGIC ACTION ON SUBSECTORS AND REMAINING EMISSIONS IN 2030

6 CONCLUSIONS

With the information provided by this inventory, the Seychelles will have a more robust RAC sector emissions estimate as a basis for mitigation planning and action as part of the Seychelles' NDCs.

A key driver for the cooling demand is the tourism sector of the Seychelles, providing air-conditioned rooms and storage space for refrigerated goods. The three subsectors with the highest contribution to the emissions of the RAC sector are the unitary air conditioning subsector, the commercial and domestic refrigeration subsectors. Those subsectors also show the highest mitigation potential[5]. Regulatory measures combined with the transition towards energy-efficient appliance with low GWP refrigerants can achieve substantial emission reduction and contribute to the Seychelles' overall GHG reduction targets. Further mitigation could be achieved through shifting the energy supply to power the RAC appliances from fossil fuel to renewable energy sources.

A significant proportion of the GHG mitigation potential is based on the transitioning from highly climate-damaging hydrochlorofluorocarbons (HCFC) and hydrofluorocarbons (HFC) to alternatives with a low-GWP ahead of the HFC phase-down schedule stipulated in the Kigali Amendment to the Montreal Protocol. The transition to low-GWP refrigerants can also cause further benefits such as energy and costs savings through improved energy efficiency (EE) and the creation of employment by using climate-friendly and energy-efficient ACs installed and maintained by trained and qualified local technicians. These technicians will need to be trained in the handling of low-GWP refrigerants during the transition phase.

Four strategies for the reduction of direct and indirect emissions are outlined:

1) Introduction of Minimal Energy Performance Standards (MEPS) to increase energy efficiency of RAC appliances

2) Introduction of a tax scheme to facilitate the transition to low-GWP refrigerants

3) Development of a Qualification, Certification & Registration (QCR) scheme to increase education and skills of RAC technicians

4) Establishment of a Measurement, Reporting and Verification (MRV) system for tracking and enforcement of policy measures

Each strategy includes specific actions for the key subsectors. The implementation of the strategies on the specified subsectors can lead to an emission reduction of 12% in 2030 ahead of any HFC reduction steps required under the Kigali Amendment.

In its efforts to address the issue of GHG emissions, the Seychelles are already in the process of adopting several initiatives such as Minimum Energy Performance Standards (MEPS) and labelling including an environmental levy system for high-GWP refrigerants. These initial policy steps require a continuous review and update to assure moving to a low-carbon pathway and the adoption of BAT.

5 to be noted that mitigation potential in the mobile AC sector had not been considered here due to limited intervention potential.


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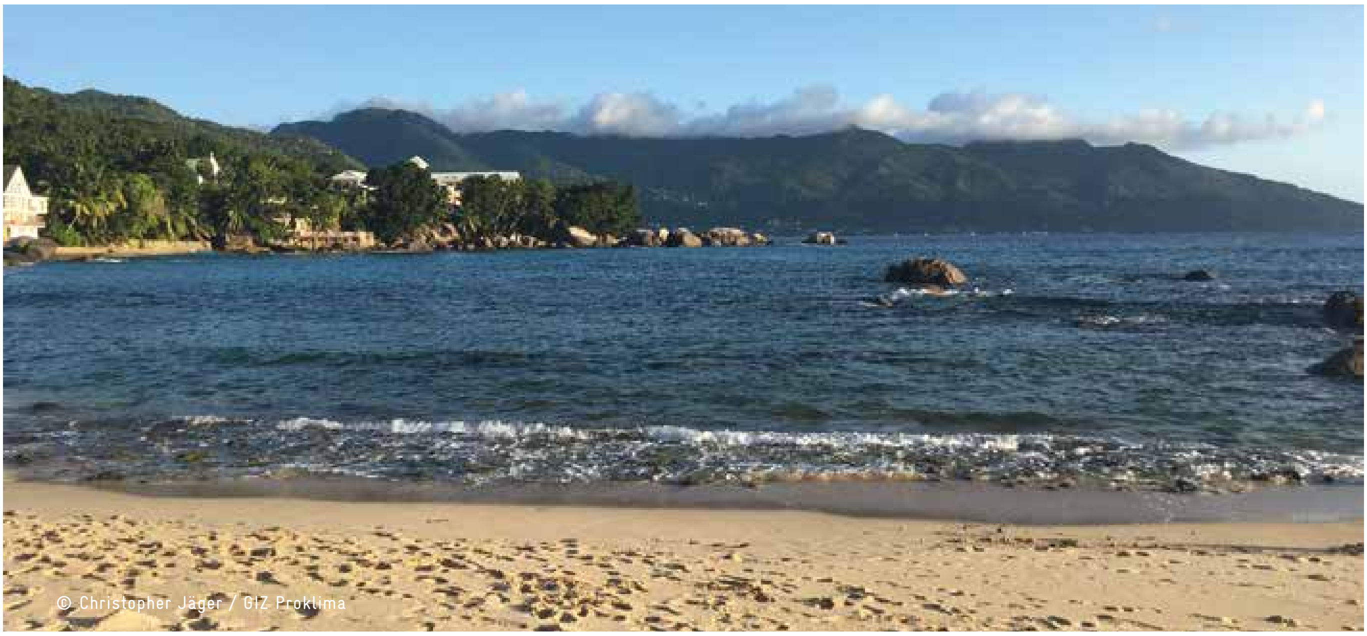
8 ANNEX

8.1 RUNTIME

TABLE 29: RUNTIME HOURS, COMPARING REPORTED AND MODELLING VALUES

	MODEL VALUES [HOURS/YR.]	SURVEYED VALUES [HOURS/YR.]
SPLIT ACS	4,339	4,358
DUCTED SPLIT	6,250	6,220
ROOFTOP DUCTED	4,876	NA
MULTI-SPLITS, VRF/VRVS	8,155	8,124
AC CHILLER	6,241	6,226
MOBILE AC	1,852	NA
DOMESTIC REFRIGERATION	6,553	6,570
STAND-ALONE COMMERCIAL	2,877	2,920
CONDENSING UNITS	3,839	3,821
CENTRALISED SYSTEMS FOR SUPERMARKETS	8,715	8,736
INDUSTRIAL CONDENSING UNITS	6,588	6,570
TRANSPORT REFRIGERATION	2,925	2,920



8.2 CONTACTED COMPANIES VIA QUESTIONNAIRES OF UNITARY AIR CONDITIONING AND DOMESTIC REFRIGERATION SUBSECTORS

TABLE 30: LIST OF CONTACTED COMPANIES

COMPANY NAME	CONTACTED VIA EMAIL	CONTACTED VIA PHONE	VISITED	QUESTIONNAIRE RECEIVED
ABHAYE VALABHJI PTY LTD	yes	yes	yes	no
ALLIED BUILDERS (SEYCHELLES) LTD	yes	yes	no	no
APEX HOTEL SUPPLIES LIMITED	yes	yes	no	no
AQUARIUS SHIPPING	yes	yes	no	no
ARC DISTRIBUTION PTY LTD	yes	yes	yes	no
AUTO SPEED JAPANESE COMMERCIAL TRUCKS	yes	yes	no	no
BERJAYA BEAU VALLON BAY BEACH RESORT	yes	yes	yes	yes
BODCO	yes	yes	no	no
CELLULAR SERVICES (PTY) LIMITED	yes	yes	yes	no
COOLING PLUS (SEYCHELLES) LTD	yes	yes	yes	yes
COOLTECH	yes	yes	no	no
DENIS ISLAND DEVELOPMENT COMPANY (P	yes	yes	no	no
DESROCHES ISLAND LODGE LIMITED	yes	yes	no	yes
DIY (SEYCHELLES)LTD ALFRED FOURCROY	yes	yes	no	no
EDEN ISLAND DEV COMPANY (SEY) LTD	yes	yes	no	no
EXECUTIVE CARS	yes	yes	no	no
FISHTEC	yes	yes	no	no
FORD	yes	yes	no	no
GLOBAL SUPPLY CENTER (PTY) LIMITED	yes	yes	yes	no
H.I.S ENTERPRISE (PTY) LTD	yes	yes	no	no
HENRI FRAISE FILS & CIE RENAULT	yes	yes	no	no
HILTON (SEYCHELLES) NORTHOLME HOTEL	yes	yes	no	no
HILTON SEYCHELLES LABRIZ RESORT/SPA	yes	yes	yes	yes
HUNT DELTEL AND COMPANY LIMITED	yes	yes	no	no
ISLAND DEVELOPMENT COMPANY LTD	yes	yes	yes	no
ISLAND MOTORS COMPANY LIMITED	yes	yes	no	no
ISPC SEYCHELLES (PTY) LTD	yes	yes	yes	no

COMPANY NAME	CONTACTED VIA EMAIL	CONTACTED VIA PHONE	VISITED	QUESTIONNAIRE RECEIVED
JL AIR CONDITIONING & REFRIGERATION	yes	yes	no	no
KANNU'S SHOPPING CENTRE PTY LTD	yes	yes	yes	no
KIM KOOM & COMPANY (PTY) LTD	yes	yes	no	no
KOT MEYER (PRASLIN)	yes	yes	no	no
LAXMANBHAI AND COMPANY (SEYCHELLES)	yes	yes	no	no
LE REFUGE DU PECHEUR LTD	yes	yes	no	no
LIFESTYLE CO PTY LTD	yes	yes	no	no
MACHINERY & EQUIPMENT LTD	yes	yes	yes	yes
MAHE BUILDERS COMPANY LIMITED	yes	yes	no	no
MEJ ELECTRICALS (PTY) LTD	yes	yes	no	no
NISSAN	yes	yes	no	no
NORTH ISLAND COMPANY	yes	yes	yes	yes
OCEANA FISHERIES COMPANY (PROPRIETA	yes	yes	no	no
PILLAY R GROUP	yes	yes	no	no
PMC AUTO HYUNDAI	yes	yes	no	no
PMC SPARES LTD	yes	yes	no	no
PORT LAUNAY RESORT LTD	yes	yes	no	no
PROVIDENCE SUPPLIES (PTY) LIMITED	yes	yes	no	no
REFRIGERATION SYSTEMS (SEYCHELLES)	yes	yes	yes	yes
REY & LENFERNA LTD	yes	yes	no	no
ROSEBELLE FARM(JEAN-PIERRE MORIN)	yes	yes	no	no
SANKEN OVERSEAS (SEYCHELLES) LIMITE	yes	yes	no	no
SEA HARVEST	yes	yes	no	no
SEYBREW	yes	yes	no	no
SHREEJI CONSTRUCTION (PTY)LTD	yes	yes	no	no
SKYCHEF LTD	yes	yes	yes	yes
TOUCH ELECTRONIX (PTY) LTD	yes	yes	yes	no
UCPS	yes	yes	no	no
UNIQUE REFRIGERATION (PTY) LTD	yes	yes	no	no
VISALLY TRADE CENTRE PTY LTD	yes	yes	no	no

8.3 SUBSECTOR DEFINITIONS

TABLE 31: OVERVIEW OF AIR CONDITIONING SUBSECTORS

RAC SUB-SECTOR	PRODUCT GROUP	DESCRIPTION
UNITARY AIR CONDITIONING	Split residential and commercial (duct-less)	• The systems consist of two elements: (1) the condenser unit containing the compressor mounted outside the room and (2) the indoor unit (evaporator) supplying cooled air to the room. • Residential units: applied in private households • Commercial units: applied in offices or other commercial buildings • This product group refers to "single" split systems, i.e., one indoor unit is connected to one outdoor unit.
	Ducted split, residential and commercial	• Systems consist of an outdoor unit (condenser) containing the compressor which is connected to an indoor unit (evaporator) to blow cooled air through a pre-installed duct system. • Residential units are mainly used in domestic context • Commercial units: applied in offices or other commercial buildings • Ducted splits are mainly used to cool multiple rooms in larger buildings (incl. houses).
	Rooftop ducted	• Single refrigerating system mounted on the roof of a building from where ducting leads to the interior of the building and cool air is blown through.
	Multi-split, VRF/VRV	• Multi-splits: like ductless single-split systems (residential/commercial single splits, see above), although usually up to 5 indoor units can be connected to one outdoor unit. • VRF/VRV (variable refrigerant flow/volume) systems: Type of multi-split system where a 2-digit number of indoor units can be connected to one outdoor unit. Used in mid-size office buildings and commercial facilities.
CHILLERS, AIR-CONDITIONING	Chillers (AC)	• AC chillers usually function by using a liquid for cooling (usually water) in a conventional refrigeration cycle. This water is then distributed to cooling – and sometimes heating – coils within the building. • AC chillers are mainly applied for commercial and light industrial purposes.
MOBILE AIR CONDITIONING	Small: Passenger cars, light commercial vehicle, Pick-up, SUV Large: Busses, Trains, etc.	• Air conditioning in all types of vehicles, such as passenger cars, trucks or buses. Mainly a single evaporator system is used.
DOMESTIC REFRIGERATION	Refrigerator/freezer	• The subsector includes the combination of refrigerators and freezers as well as single household refrigerators and freezers

RAC SUB-SECTOR	PRODUCT GROUP	DESCRIPTION
COMMERCIAL REFRIGERATION	Stand-alone	• "plug-in" units built into one housing (self-contained refrigeration systems) • Examples: vending machines, ice cream freezers and beverage coolers
	Condensing unit	• These refrigerating systems are often used in small shops such as bakeries, butcheries or small supermarkets. • The "condensing unit" holds one to two compressors, the condenser and a receiver and is usually connected via piping to small commercial equipment located in the sales area, e.g., cooling equipment such as display cases or cold rooms. The unit usually comes pre-assembled.
	Centralised systems (for supermarkets)	• Used in larger supermarkets (sales are greater than 400 square meters). • Operates with a pack of several parallel working compressors located in a separate machinery room. This pack is connected to separately installed condensers outside the building. • The system is assembled on-site.
INDUSTRIAL REFRIGERATION	Stand-alone (integral) unit	• "plug-in" units built into one housing (self-contained refrigeration systems) • Examples: industrial ice-makers
	Condensing unit	• The 'condensing unit' holds one to two compressors, the condenser and a receiver and is usually connected via piping to small commercial equipment located in the sales area, e.g. cooling equipment such as display cases or cold rooms. The unit usually comes pre-assembled. Example: cold storage facilities
	Centralised systems	• Operates with a pack of several parallel working compressors located in a separate machinery room. This pack is connected to separately installed condensers outside the building. The system is assembled on-site
TRANSPORT REFRIGERATION	Trailer, van, truck	• Covers refrigeration equipment that is required during the transportation of goods on roads by trucks and trailers (but also by trains, ships or in airborne containers). • Per road vehicle, usually one refrigeration unit is installed.

8.4 APPLIED MODELLING PARAMETERS AND RESULTS OF MODEL CALCULATIONS

TABLE 32: REFRIGERANT DISTRIBUTION FOR BUSINESS-AS-USUAL (BAU) SCENARIO UNDER THE KIGALI AMENDMENT

SUBSECTOR	REFRIGERANT	2010	2017	2020	2030	2040	2050
SELF-CONTAINED AIR CONDITIONERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SELF-CONTAINED AIR CONDITIONERS	R22	72.00%	41.70%	0.00%	0.00%	0.00%	0.00%
SELF-CONTAINED AIR CONDITIONERS	R290	0.00%	0.38%	5.00%	20.00%	85.00%	85.00%
SELF-CONTAINED AIR CONDITIONERS	R407C	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%
SELF-CONTAINED AIR CONDITIONERS	R410A	28.00%	57.50%	75.00%	40.00%	0.00%	0.00%
SELF-CONTAINED AIR CONDITIONERS	R32	0.00%	0.00%	20.00%	40.00%	15.00%	15.00%
SELF-CONTAINED AIR CONDITIONERS	R417	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%
SELF-CONTAINED AIR CONDITIONERS	R507	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
SELF-CONTAINED AIR CONDITIONERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R290	0.00%	0.00%	0.00%	0.00%	70.00%	80.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R407C	3.00%	4.00%	5.00%	10.00%	0.00%	0.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R410A	97.00%	96.00%	95.00%	90.00%	30.00%	20.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R32	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
COMMERCIAL DUCTED SPLITS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ROOFTOP DUCTED	R290	0.00%	0.00%	0.00%	0.00%	50.00%	60.00%
ROOFTOP DUCTED	R407C	100.00%	100.00%	100.00%	100.00%	20.00%	0.00%
ROOFTOP DUCTED	R410A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ROOFTOP DUCTED	R32	0.00%	0.00%	0.00%	0.00%	30.00%	40.00%
MULTI-SPLITS	R22	60.00%	10.40%	0.00%	0.00%	0.00%	0.00%
MULTI-SPLITS	R410A	35.00%	61.10%	60.00%	60.00%	20.00%	15.00%
MULTI-SPLITS	R32	0.00%	0.00%	0.00%	0.00%	70.00%	80.00%
MULTI-SPLITS	R417	5.00%	28.50%	40.00%	40.00%	10.00%	5.00%

SUBSECTOR	REFRIGERANT	2010	2017	2020	2030	2040	2050
AIR CONDITIONING CHILLERS	R134a	40.00%	10.00%	10.00%	0.00%	0.00%	0.00%
AIR CONDITIONING CHILLERS	R290	0.00%	0.00%	0.00%	10.00%	50.00%	80.00%
AIR CONDITIONING CHILLERS	R407C	0.00%	5.00%	5.00%	5.00%	0.00%	0.00%
AIR CONDITIONING CHILLERS	R410A	40.00%	45.00%	45.00%	45.00%	5.00%	0.00%
AIR CONDITIONING CHILLERS	R717	20.00%	40.00%	40.00%	40.00%	25.00%	10.00%
AIR CONDITIONING CHILLERS	HFO 1234yf	0.00%	0.00%	0.00%	0.00%	20.00%	10.00%
PROCESS CHILLERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PROCESS CHILLERS	R404A	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%
PROCESS CHILLERS	R407C	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%
CAR AIR CONDITIONING	R134a	100.00%	100.00%	100.00%	50.00%	30.00%	0.00%
CAR AIR CONDITIONING	HFO 1234yf	0.00%	0.00%	0.00%	50.00%	70.00%	100.00%
CAR AIR CONDITIONING	R12	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LARGE VEHICLE AIR CONDITIONING	R134a	100.00%	98.00%	95.00%	90.00%	75.00%	75.00%
LARGE VEHICLE AIR CONDITIONING	HFO 1234yf	0.00%	2.00%	5.00%	10.00%	25.00%	25.00%
DOMESTIC REFRIGERATION	R134a	100.00%	85.20%	78.00%	55.00%	20.00%	0.00%
DOMESTIC REFRIGERATION	R600a	0.00%	14.00%	20.00%	40.00%	65.00%	80.00%
DOMESTIC REFRIGERATION	R717	0.00%	0.80%	2.00%	5.00%	15.00%	20.00%
DOMESTIC REFRIGERATION	R12	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R22	20.00%	3.00%	0.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R134a	80.00%	73.00%	70.00%	60.00%	20.00%	10.00%
STAND-ALONE EQUIPMENT	R290	0.00%	4.00%	6.00%	10.00%	30.00%	40.00%
STAND-ALONE EQUIPMENT	R404A	0.00%	4.00%	3.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R410A	0.00%	4.00%	3.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R600a	0.00%	10.00%	14.00%	25.00%	45.00%	45.00%
STAND-ALONE EQUIPMENT	R744	0.00%	2.00%	4.00%	5.00%	5.00%	5.00%
CONDENSING UNITS	R134a	40.00%	11.00%	11.00%	11.00%	0.00%	0.00%
CONDENSING UNITS	R290	0.00%	0.00%	0.00%	0.00%	70.00%	80.00%

SUBSECTOR	REFRIGERANT	2010	2017	2020	2030	2040	2050
CONDENSING UNITS	R404A	50.00%	71.00%	71.00%	71.00%	30.00%	20.00%
CONDENSING UNITS	R407C	10.00%	18.00%	18.00%	18.00%	0.00%	0.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	R290	0.00%	0.00%	0.00%	0.00%	70.00%	80.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	R410A	100.00%	100.00%	100.00%	100.00%	20.00%	10.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	HFO 1234yf	0.00%	0.00%	0.00%	0.00%	10.00%	10.00%
INTEGRAL	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
INTEGRAL	R134a	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
INTEGRAL	R290	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
INTEGRAL	R32	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	R22	80.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	R290	0.00%	0.00%	0.00%	0.00%	40.00%	70.00%
ICONDENSING UNITS	R404A	10.00%	70.00%	70.00%	60.00%	30.00%	5.00%
ICONDENSING UNITS	R410A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	R744	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	HFO 1234yf	0.00%	0.00%	0.00%	0.00%	10.00%	15.00%
ICONDENSING UNITS	R507	10.00%	30.00%	30.00%	40.00%	20.00%	10.00%
CENTRALISED SYSTEMS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CENTRALISED SYSTEMS	R134a	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CENTRALISED SYSTEMS	R290	0.00%	0.00%	0.00%	0.00%	30.00%	60.00%
CENTRALISED SYSTEMS	R404A	100.00%	100.00%	100.00%	100.00%	50.00%	20.00%
CENTRALISED SYSTEMS	HFO 1234yf	0.00%	0.00%	0.00%	0.00%	20.00%	20.00%
REFRIGERATED TRUCKS/TRAILERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
REFRIGERATED TRUCKS/TRAILERS	R290	0.00%	0.00%	0.00%	0.00%	50.00%	80.00%
REFRIGERATED TRUCKS/TRAILERS	R404A	100.00%	100.00%	100.00%	100.00%	50.00%	20.00%

TABLE 33: REFRIGERANT DISTRIBUTION IN THE MITIGATION (MIT) SCENARIO APPLYING THE BEST AVAILABLE TECHNOLOGY (BAT)

SUBSECTOR	REFRIGERANT	2010	2017	2020	2030	2040	2050
SELF-CONTAINED AIR CONDITIONERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R22	72.00%	41.70%	0.00%	0.00%	0.00%	0.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R290	0.00%	0.38%	5.00%	70.00%	90.00%	100.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R407C	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R410A	28.00%	57.50%	75.00%	0.00%	0.00%	0.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R32	0.00%	0.00%	20.00%	30.00%	10.00%	0.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R417	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%
SPLIT RESIDENTIAL AIR CONDITIONERS	R507	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
SPLIT COMMERCIAL AIR CONDITIONERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R290	0.00%	0.00%	0.00%	30.00%	75.00%	90.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R407C	3.00%	4.00%	5.00%	10.00%	0.00%	0.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R410A	97.00%	96.00%	95.00%	60.00%	25.00%	10.00%
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	R32	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
COMMERCIAL DUCTED SPLITS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ROOFTOP DUCTED	R290	0.00%	0.00%	0.00%	30.00%	60.00%	70.00%
ROOFTOP DUCTED	R407C	100.00%	100.00%	100.00%	70.00%	0.00%	0.00%
ROOFTOP DUCTED	R410A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ROOFTOP DUCTED	R32	0.00%	0.00%	0.00%	0.00%	40.00%	30.00%
MULTI-SPLITS	R22	60.00%	10.40%	0.00%	0.00%	0.00%	0.00%
MULTI-SPLITS	R410A	35.00%	61.10%	60.00%	30.00%	15.00%	10.00%
MULTI-SPLITS	R32	0.00%	0.00%	0.00%	45.00%	80.00%	85.00%
MULTI-SPLITS	R417	5.00%	28.50%	40.00%	25.00%	5.00%	5.00%
AIR CONDITIONING CHILLERS	R134a	40.00%	10.00%	10.00%	0.00%	0.00%	0.00%
AIR CONDITIONING CHILLERS	R290	0.00%	0.00%	0.00%	30.00%	80.00%	80.00%
AIR CONDITIONING CHILLERS	R407C	0.00%	5.00%	5.00%	0.00%	0.00%	0.00%

SUBSECTOR	REFRIGERANT	2010	2017	2020	2030	2040	2050
AIR CONDITIONING CHILLERS	R410A	40.00%	45.00%	45.00%	30.00%	0.00%	0.00%
AIR CONDITIONING CHILLERS	R717	20.00%	40.00%	40.00%	30.00%	10.00%	10.00%
AIR CONDITIONING CHILLERS	HFO 1234yf	0.00%	0.00%	0.00%	10.00%	10.00%	10.00%
PROCESS CHILLERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PROCESS CHILLERS	R404A	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%
PROCESS CHILLERS	R407C	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%
CAR AIR CONDITIONING	R134a	100.00%	100.00%	100.00%	50.00%	20.00%	0.00%
CAR AIR CONDITIONING	HFO 1234yf	0.00%	0.00%	0.00%	50.00%	80.00%	100.00%
CAR AIR CONDITIONING	R12	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LARGE VEHICLE AIR CONDITIONING	R134a	100.00%	98.00%	95.00%	90.00%	75.00%	75.00%
LARGE VEHICLE AIR CONDITIONING	HFO 1234yf	0.00%	2.00%	5.00%	10.00%	25.00%	25.00%
DOMESTIC REFRIGERATION	R134a	100.00%	85.20%	78.00%	0.00%	0.00%	0.00%
DOMESTIC REFRIGERATION	R600a	0.00%	14.00%	20.00%	95.00%	85.00%	80.00%
DOMESTIC REFRIGERATION	R717	0.00%	0.80%	2.00%	5.00%	15.00%	20.00%
DOMESTIC REFRIGERATION	R12	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R22	20.00%	3.00%	0.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R134a	80.00%	73.00%	70.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R290	0.00%	4.00%	6.00%	40.00%	50.00%	45.00%
STAND-ALONE EQUIPMENT	R404A	0.00%	4.00%	3.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R410A	0.00%	4.00%	3.00%	0.00%	0.00%	0.00%
STAND-ALONE EQUIPMENT	R600a	0.00%	10.00%	14.00%	55.00%	45.00%	45.00%
STAND-ALONE EQUIPMENT	R744	0.00%	2.00%	4.00%	5.00%	5.00%	10.00%
CONDENSING UNITS	R134a	40.00%	11.00%	11.00%	5.00%	0.00%	0.00%
CONDENSING UNITS	R290	0.00%	0.00%	0.00%	50.00%	70.00%	80.00%
CONDENSING UNITS	R404A	50.00%	71.00%	71.00%	40.00%	30.00%	20.00%
CONDENSING UNITS	R407C	10.00%	18.00%	18.00%	10.00%	0.00%	0.00%

SUBSECTOR	REFRIGERANT	2010	2017	2020	2030	2040	2050
CENTRALISED SYSTEMS FOR SUPERMARKETS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	R290	0.00%	0.00%	0.00%	30.00%	80.00%	80.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	R410A	100.00%	100.00%	100.00%	70.00%	10.00%	10.00%
CENTRALISED SYSTEMS FOR SUPERMARKETS	HFO 1234yf	0.00%	0.00%	0.00%	0.00%	10.00%	10.00%
INTEGRAL	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
INTEGRAL	R134a	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
INTEGRAL	R290	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
INTEGRAL	R32	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	R22	80.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	R290	0.00%	0.00%	0.00%	20.00%	70.00%	70.00%
ICONDENSING UNITS	R404A	10.00%	70.00%	70.00%	40.00%	5.00%	5.00%
ICONDENSING UNITS	R410A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	R744	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ICONDENSING UNITS	HFO 1234yf	0.00%	0.00%	0.00%	10.00%	10.00%	15.00%
ICONDENSING UNITS	R507	10.00%	30.00%	30.00%	30.00%	15.00%	10.00%
CENTRALISED SYSTEMS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CENTRALISED SYSTEMS	R134a	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CENTRALISED SYSTEMS	R290	0.00%	0.00%	0.00%	20.00%	60.00%	60.00%
CENTRALISED SYSTEMS	R404A	100.00%	100.00%	100.00%	60.00%	20.00%	20.00%
CENTRALISED SYSTEMS	HFO 1234yf	0.00%	0.00%	0.00%	20.00%	20.00%	20.00%
REFRIGERATED TRUCKS/ TRAILERS	R22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
REFRIGERATED TRUCKS/ TRAILERS	R290	0.00%	0.00%	0.00%	30.00%	80.00%	80.00%
REFRIGERATED TRUCKS/ TRAILERS	R404A	100.00%	100.00%	100.00%	70.00%	20.00%	20.00%

TABLE 34: EER DISTRIBUTION IN THE BAU SCENARIO

	2017	2020	2025	2030	2035	2040	2050
SPLIT RESIDENTIAL AIR CONDITIONERS	3.01	3.01	3.07	3.07	3.07	3.07	3.07
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	3.30	3.30	3.36	3.36	3.39	3.39	3.39
ROOFTOP DUCTED	2.86	2.86	2.92	2.97	3.03	3.03	3.15
MULTI-SPLITS	3.20	3.20	3.28	3.28	3.32	3.32	3.36
AIR CONDITIONING CHILLERS	3.50	3.50	3.56	3.56	3.59	3.59	3.62
CAR AIR CONDITIONING	1.66	1.66	1.74	1.74	1.76	1.76	1.76
DOMESTIC REFRIGERATION	2.28	2.28	2.34	2.34	2.41	2.41	2.41
STAND-ALONE EQUIPMENT	2.60	2.60	2.66	2.66	2.72	2.72	2.66
CONDENSING UNITS	2.80	2.80	2.85	2.85	2.91	2.91	2.93
CENTRALISED SYSTEMS FOR SUPERMARKETS	3.15	3.15	3.19	3.19	3.22	3.22	3.26
CONDENSING UNITS	2.82	2.82	2.82	2.82	2.82	2.82	2.82
CENTRALISED SYSTEMS	3.10	3.10	3.13	3.13	3.15	3.16	3.19
REFRIGERATED TRUCKS/TRAILERS	2.30	2.30	2.34	2.34	2.34	2.34	2.34
CONDENSING UNITS	9	12	9	9	9	9	9
CENTRALISED SYSTEMS FOR SUPERMARKETS	0	0	0	0	0	0	0
INTEGRAL	1	1	1	1	1	1	1
CONDENSING UNITS	1	2	1	1	1	1	1
CENTRALISED SYSTEMS	0	0	0	0	0	0	0
REFRIGERATED TRUCKS/TRAILERS	1	1	1	1	1	1	1

TABLE 35: EER DISTRIBUTION IN THE NCS SCENARIO

	2017	2020	2025	2030	2035	2040	2050
SPLIT RESIDENTIAL AIR CONDITIONERS	3.01	3.01	3.59	3.87	6.36	7.00	7.00
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	3.30	3.30	3.42	3.42	3.42	3.45	3.54
ROOFTOP DUCTED	2.86	2.86	2.97	3.03	3.09	3.15	3.27
MULTI-SPLITS	3.20	3.20	3.36	3.40	3.44	3.48	3.56
AIR CONDITIONING CHILLERS	3.50	3.50	3.72	3.90	3.92	3.94	3.96
CAR AIR CONDITIONING	1.66	1.66	1.74	1.76	1.79	1.79	1.82
DOMESTIC REFRIGERATION	2.28	2.28	2.90	3.32	3.35	3.35	3.41
STAND-ALONE EQUIPMENT	2.60	2.60	2.90	3.35	3.38	3.44	3.56
CONDENSING UNITS	2.80	2.80	2.91	2.93	2.96	3.01	3.17
CENTRALISED SYSTEMS FOR SUPERMARKETS	3.15	3.15	3.22	3.26	3.29	3.33	3.43
CONDENSING UNITS	2.82	2.82	3.03	3.06	3.09	3.15	3.36
CENTRALISED SYSTEMS	3.01	3.01	3.14	3.17	3.19	3.21	3.35
REFRIGERATED TRUCKS/TRAILERS	2.30	2.30	3.34	2.36	2.38	2.40	2.46
CONDENSING UNITS	9	12	9	9	9	9	9
CENTRALISED SYSTEMS FOR SUPERMARKETS	0	0	0	0	0	0	0
INTEGRAL	1	1	1	1	1	1	1
CONDENSING UNITS	1	2	1	1	1	1	1
CENTRALISED SYSTEMS	0	0	0	0	0	0	0
REFRIGERATED TRUCKS/TRAILERS	1	1	1	1	1	1	1

TABLE 36: EER DISTRIBUTION IN THE MIT SCENARIO USING BAT

	2017	2020	2025	2030	2035	2040	2050
SPLIT RESIDENTIAL AIR CONDITIONERS	3.01	3.01	4.10	4.68	6.20	7.11	7.33
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	3.30	3.30	3.48	3.54	3.68	3.76	3.84
ROOFTOP DUCTED	2.86	2.86	3.17	3.22	3.33	3.40	3.40
MULTI-SPLITS	3.20	3.20	3.44	3.52	3.68	3.76	3.84
AIR CONDITIONING CHILLERS	3.50	3.50	3.72	3.90	3.92	3.94	3.96
CAR AIR CONDITIONING	1.66	1.66	1.80	1.83	1.83	1.89	1.89
DOMESTIC REFRIGERATION	2.28	2.28	5.22	6.06	6.06	6.06	6.06
STAND-ALONE EQUIPMENT	2.60	2.60	3.94	3.99	4.05	4.17	4.98
CONDENSING UNITS	2.80	2.80	3.20	3.24	3.27	3.41	3.47
CENTRALISED SYSTEMS FOR SUPERMARKETS	3.15	3.15	3.29	3.40	3.43	3.50	3.66
CONDENSING UNITS	2.82	2.82	3.36	3.40	3.43	3.50	3.74
CENTRALISED SYSTEMS	3.01	3.01	3.44	3.53	3.53	3.68	3.71
REFRIGERATED TRUCKS/TRAILERS	2.30	2.30	2.34	2.42	2.42	2.46	2.59
CONDENSING UNITS	9	12	9	9	9	9	9
CENTRALISED SYSTEMS FOR SUPERMARKETS	0	0	0	0	0	0	0
INTEGRAL	1	1	1	1	1	1	1
CONDENSING UNITS	1	2	1	1	1	1	1
CENTRALISED SYSTEMS	0	0	0	0	0	0	0
REFRIGERATED TRUCKS/TRAILERS	1	1	1	1	1	1	1

TABLE 37: CALCULATED STOCK OF RAC APPLIANCES

EQUIPMENT TYPE	2010	2017	2020	2025	2030	2035	2040	2045	2050
SPLIT RESIDENTIAL AIR CONDITIONERS	28,823	33,006	34,750	38,996	44,414	48,731	50,907	51,675	52,455
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	177	189	216	295	369	404	422	429	435
ROOFTOP DUCTED	7	22	34	52	67	78	85	90	93
MULTI-SPLITS	833	847	864	953	1,085	1,191	1,244	1,263	1,282
AIR CONDITIONING CHILLERS	43	46	47	50	53	54	55	55	56
CAR AIR CONDITIONING	17,124	20,295	21,688	24,590	29,370	35,432	39,930	42,561	43,766
DOMESTIC REFRIGERATION	57,230	60,547	62,369	68,522	77,351	85,655	90,460	92,266	93,658
STAND-ALONE EQUIPMENT	10,845	12,226	12,634	13,166	13,721	14,120	14,312	14,377	14,441
CONDENSING UNITS	857	965	996	1,035	1,077	1,108	1,123	1,128	1,133
CENTRALISED SYSTEMS FOR SUPERMARKETS	28	54	67	75	78	80	81	82	82
CONDENSING UNITS	54	58	63	76	85	88	89	89	90
CENTRALISED SYSTEMS	10	14	15	16	16	17	17	17	17
REFRIGERATED TRUCKS/ TRAILERS	34	40	43	48	51	53	54	55	55
CONDENSING UNITS	9	9	12	9	9	9	9	9	9
CENTRALISED SYSTEMS FOR SUPERMARKETS	0	0	0	0	0	0	0	0	0
INTEGRAL	1	1	1	1	1	1	1	1	1
CONDENSING UNITS	1	1	2	1	1	1	1	1	1
CENTRALISED SYSTEMS	0	0	0	0	0	0	0	0	0
REFRIGERATED TRUCKS/TRAILERS	1	1	1	1	1	1	1	1	1

TABLE 38: CALCULATED SALES OF RAC APPLIANCES

EQUIPMENT TYPE	2010	2015	2020	2025	2030	2035	2040	2045	2050
SPLIT RESIDENTIAL AIR CONDITIONERS	0	0	0	0	0	0	0	0	0
DUCT SPLIT RESIDENTIAL AIR CONDITIONERS	3,209	3,509	4,001	4,483	5,022	5,098	5,175	5,253	5,332
ROOFTOP DUCTED	0	0	0	0	0	0	0	0	0
MULTI-SPLITS	19	20	33	37	42	42	43	44	44
AIR CONDITIONING CHILLERS	0	0	0	0	0	0	0	0	0
CAR AIR CONDITIONING	1	6	7	8	9	9	10	10	10
DOMESTIC REFRIGERATION	84	86	98	110	123	125	126	128	130
STAND-ALONE EQUIPMENT	4	4	4	4	5	5	5	5	5
CONDENSING UNITS	0	0	0	0	0	0	0	0	0
CENTRALISED SYSTEMS FOR SUPERMARKETS	1,283	1,396	1,653	2,059	3,243	2,678	2,754	3,482	2,923
CONDENSING UNITS	0	0	0	0	0	0	0	0	0
CENTRALISED SYSTEMS	5,021	5,236	5,971	6,690	7,495	7,608	7,723	7,840	7,958
REFRIGERATED TRUCKS/ TRAILERS	1,207	1,256	1,336	1,362	1,432	1,417	1,445	1,430	1,458
CONDENSING UNITS	95	99	105	106	113	111	114	112	115
CENTRALISED SYSTEMS FOR SUPERMARKETS	3	7	8	8	8	8	8	8	8
INTEGRAL	0	0	0	0	0	0	0	0	0
CONDENSING UNITS	6	6	8	9	9	9	9	9	9
CENTRALISED SYSTEMS	1	2	2	2	2	2	2	2	2
REFRIGERATED TRUCKS/TRAILERS	3	3	3	4	4	4	4	4	4

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