Government of Barbados

Ministry of Environment and National Beautification

National Ozone Depleting Substances (ODS) and Hydrofluorocarbon (HFC) Management Programme

BARBADOS NATIONAL COOLING STRATEGY

FOR THE REFRIGERATION AND AIR CONDITIONING (RAC) SECTOR

2022

Acknowledgements

The Barbados National Cooling Strategy (NCS) is a product of the collaborative effort of the National Ozone Depleting Substances (ODS) and Hydrofluorocarbon (HFC) Management Programme of the Ministry of Environment and National Beautification (MENB) and the Caribbean Cooling Initiative (CCOOL) led United Nation's Environment Programme (UNEP) - United for Efficiency (U4E) team, with contributions provided by key stakeholders from governmental and non-governmental organisations during consultations, meetings and the document development and review stage.

Accordingly, the MENB recognises and thanks the Ministry of Energy and Business Development (MEB), the Ministry of Tourism and International Transport (MTI), Department of Commerce and Consumer Affairs (DCCA), Barbados National Standards Institution (BNSI), Samuel Jackman Prescod Institute of Technology (SJPI), Ministry of Housing, Lands and Maintenance Development (MHLMD), Fisheries Division, Ministry of Maritime Affairs and the Blue Economy (MMABE), Refrigeration and Air Conditioning (RAC) Association of Barbados, Barbados Hotel and Tourism Association (BHTA), Barbados Renewable Energy Association (BREA), Barbados Chamber of Commerce and Industry (BCCI) and Dr. Hugh Sealy, Special Advisor to the MENB, for their input into the development of the Barbados NCS.

CCOOL was launched in 2018 with funding from the Clean Cooling Collaborative. Under U4E's overall project management, the Basel Agency for Sustainable Energy (BASE) and Lawrence Berkeley National Laboratory (LBNL) provided expert support on financial mechanisms and policy analysis. Regional coordination and local stakeholder consultations were supported by UNEP's Caribbean Sub-Regional Office in Jamaica.

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Acronyms

BHTA	Barbados Hotel and Tourism Association
BCCI	Barbados Chamber of Commerce and Industry
BNSI	Barbados National Standards Institution
BOE	Barrel of Oil Equivalent
BREA	Barbados Renewable Energy Association
CARICOM	Caribbean Community
CCREE	Caribbean Centre for Renewable Energy and Energy Efficiency
CDB	Caribbean Development Bank
CCOOL	Caribbean Cooling Initiative
CHENACT	Caribbean Hotel Energy Efficiency and Renewable Energy Action Programme
CHTA	Caribbean Hotel and Tourism Association
CO_2	Carbon Dioxide
CREEBC	CARICOM Regional Energy Efficiency Building Code
CROSQ	Caribbean Regional Organization for Standards and Quality
CTO	Caribbean Tourism Organization
EE	Energy Efficiency
ESCO	Energy Service Company
FTC	Fair Trading Commission
HACCP	Hazard Analysis and Critical Control Points
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HPMP	Hydrochlorofluorocarbon Phase out Management Plan
IDB	Inter-American Development Bank
IPCC	Inter-Governmental Panel on Climate Change

MEES	Minimum Energy Efficiency Standard
MENB	Ministry of Environment and National Beautification
MEPs	Minimum Energy Performance Standard
MEBD	Ministry of Energy and Business Development
MTWW	Ministry of Transport Works and Water Resources
MTI	Ministry of Tourism and International Transport
MVE	Monitoring Verification and Evaluation
NCS	National Cooling Strategy
RACAB	Refrigeration and Air-conditioning Association of Barbados
U4E	United for Efficiency

Executive Summary

Barbados and other Caribbean countries have been proactive in pursuing a variety of energy and environment activities over the years. Various governments, tourism and commercial industries have expressed a strong need for further transformation using renewable energy and energy efficiency solutions to fully address their sustainable development ambitions. Although large capital investments are needed to convert the energy sector from its over-reliance on fossil-fuels to renewables and energy-intensive business practices, there are viable near-term opportunities that can deliver significant improvement with relatively modest investments. "Cooling", which ranges from refrigeration for food, medicine and industrial applications to space cooling for thermal comfort in buildings and transportation, should be a priority. Amidst the existential threat of severe weather, Barbados needs to maintain the health and well-being of its people and economy in a manner that is resilient, cost-effective, timely and impactful. In recognition of the massive strategic opportunities in this domain, the Government of Barbados (alongside counterparts from Saint Lucia, the Bahamas, Jamaica and the Dominican Republic) joined UNEP United for Efficiency in launching the Caribbean Cooling Initiative (CCOOL).

The first step in CCOOL entailed a review of priority subsets of the cooling sector in Barbados, with a focus on stationary refrigeration and space cooling given the outsized importance of these applications and ability to make near-term, impactful interventions. CCOOL then developed recommendations to mitigate much of the waste of electricity and the impacts of refrigerant gasses through a range of voluntary and regulatory approaches. The findings are compiled into this National Cooling Strategy. It includes input from a wide cross-section of the country, including government officials, tourism stakeholders, technology providers, financial institutions, and civil society organizations. A combination of best practice policies, programmes, awareness-raising, and capacity building should be marshalled to change the landscape toward widespread implementation in Barbados, leveraging the best home-grown ideas alongside proven approaches that have taken root in proactive markets around the world.

Objectives of the NCS:

- Assess the cooling sectors, technologies, relevant policies, and stakeholders
- Reduce the electricity waste and peak electricity demand from cooling-related activities
- Enable greater comfort and productivity for buildings occupants by ensuring energy efficient and climate-friendly cooling services

- Advance national economic development priorities in line with the Barbados Growth and Development Strategy and the Barbados Energy Policy 2019- 2030
- Mitigate pollution and greenhouse gas emissions in support of the country's Nationally Determined Contribution to the Paris Climate Agreement
- Contribute to the measures taken by the National Ozone Depleting Substances (ODS) and Hydrofluorocarbon (HFC) Programme in the refrigerant transition in compliance with the Kigali Amendment to the Montreal Protocol.
- Strengthen the technical skills of cooling professionals, government officials and other relevant stakeholders and raise awareness of civil society.

Challenges and Opportunities Related to Cooling:

While cooling is a critical element for the sustainability and development of the economy it is also an environmental threat unless it is properly managed. It is required to ensure Government buildings, homes, offices, and cars are comfortable; industrial processes run safely and efficiently while ensuring societies have preserved foods and medications for consumption. However, one of the major challenges associated with refrigeration and air-conditioning (RAC) sectors (cooling sector) is its contribution to Greenhouse gas emissions (GHGs) both directly and indirectly. Without effective mitigation, cooling may account for almost 20% of global greenhouse gas (GHG) emissions by 2050 (Peters, 2018)[1].

The direct impact of cooling on the environment is due to the refrigerant emissions and relates to the global warming potential (GWP) of the refrigerant used, the refrigerant charge in the equipment and the leakage rates (annual, and during maintenance and decommissioning) of the equipment. The cooling technology used for RAC mainly utilizes synthetic refrigerants that can either deplete the ozone layer or have a high-GWP. Hydrofluorocarbon (HFC) refrigerants were introduced to replace their ozone-depleting counterparts but are greenhouse gases that can have a high-GWP. High GWP refrigerants can contribute to the increases in temperature currently experienced worldwide, and thus, the demand for cooling also increases.

The indirect impact of cooling technologies on GHGs is associated with the CO_2 emissions resulting from the use of fossil fuels to generate electricity for powering RAC equipment. Many cooling technologies, such as typical air conditioners and refrigerating appliances, require vast amounts of

[1] https://www.birmingham.ac.uk/Documents/college-eps/energy/Publications/2018

electricity and refrigerant gases to operate. Electricity that is wasted due to equipment that is inefficient or improperly designed, installed, or maintained has a profound impact on the electricity grid. With high electricity prices and reliance on imported fossil fuels, residents and businesses suffer from expensive power bills, utilities struggle to meet peak energy demand, governments are saddled with increasing dependence on imported energy (with prices that fluctuate), and pollution and greenhouse gas emissions are exacerbated.

However, opportunities exist to reverse these challenges through the use of more sustainable, low-GWP cooling, reducing waste in the demand, enhancing the phase-out and phase down targets under the Montreal Protocol and the enforcement of the regulations to promote energy efficient RAC technologies, buildings and operational practices.

Linking Existing Policies and Initiatives

The NCS seeks to integrate all relevant national, regional and international policies and initiatives to develop strategic recommendations to meet the nation's cooling needs in a sustainable and cost-effect manner. Barbados has taken a proactive and ambitious approach to reducing its emissions by introducing concrete mitigation actions to decarbonise the electricity grid, introducing initiatives to improve energy efficiency, and introducing measures to address emissions from various sectors. Policies, plans and programmes have been developed to guide and coordinate the national implementation approach, for example the country's Green Economy Scoping Study, The Sustainable Development Policy, The National Energy Policy 2019-2030, the Growth and Development Strategy, The National Ozone Depleting Substances (ODS) and Hydrofluorocarbon (HFC) Management Programme, The Hydrochlorofluorocarbon (HCFC) Phase-out Management Plan (HPMP), Roofs to Reefs Programme (R2RP) and the Nationally Determined Contribution (NDC) among others.

Regional standards such as the 2018 CARICOM Regional Energy Efficiency Building Code (CREEBC) and the three (3) Energy efficiency standards for air-conditioners, refrigerators and lighting which were approved in May 2019 by CARICOM, have been incorporated into the recommendations and the NCS provides further interlinkages for the country to progress in the achievement of the Kigali Amendment to the Montreal Protocol, The Paris Agreement on Climate Change and the Sustainable Development Goals (SDGs).

Barbados Energy Sector and Cooling Applications Market

Barbados is located in the Windward part of the Caribbean's archipelago and has a tropical, oceanic climate with hot and humid conditions. The average temperature is 26.8°C with higher temperatures in the summer. The usual humidity levels play an important role in the human comfort levels as high

humidity levels reduce the evaporation rate of perspiration, the natural mechanism for cooling the body. Therefore, creating a more oppressive thermal sensation than in dryer climates.

As the population continues to grow and temperatures increase in the summer months, the country is seeing an increase in demand for air conditioners, and refrigerators remain a staple appliance in homes and many businesses. Many refrigerators and air conditioners which are most affordable to purchase are inefficient and therefore cost much more to operate (in terms of electricity bills) than competing models. With new energy labels coming into effect, purchasers can make more informed decisions than ever before so that they select a product that suits their needs and their pockets over time.

Refrigerators and ACs are among the highest energy consuming products using nearly 20% of global electricity[2]. Fuel inputs for electricity generation in Barbados are predominantly fossil fuels (~92%) therefore electricity consumed by the Refrigeration and Air Conditioner (RAC) sector contributes indirectly to the country's GHG emissions. The RAC sector in Barbados can be divided into seven main applications: Refrigeration and Cold Chain, Industrial Refrigeration, Commercial Refrigeration, Commercial Air conditioning, Domestic Refrigeration, Stationary Air conditioning, and Mobile Air Conditioning (MAC). The four most common refrigerants gases present in the local RAC market are HCFC-22, R-410A, R-404A and R-134a.

Recommended Implementation Strategies:

There are numerous approaches and opportunities to address cooling demand through energy conservation, energy efficiency, and alternative refrigerants and refrigerant technologies with lower global warming potentials (GWPs). The Barbados NCS recommends the implementation of strategies which include:

1. Refrigeration and Air Conditioning Sector Market Assessment
2. Building Energy Codes and High-Performance Building Design to Reduce Cooling Demand
3. Implementation of Public Procurement Measures
4. Cold-Chain Enhancements
5. Education, Training and Capacity Building
6. Development and Implementation of Demonstration Projects for the RAC sector
7. Awareness Raising and Communications

2 U4E (2017). Policy Guide Series – Energy-Efficient and Climate-Friendly Air Conditioners. https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-air-conditioners/ & Policy Guide Series – Energy-Efficient and Climate-Friendly Refrigerators. https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-climate-friendly-refrigerators/

8. Alternative Cooling Technologies and Solutions
9. Enhanced Refrigerator and AC Requirements to Unlock Additional Energy Savings and GHG Reductions
10. Market Monitoring, Verification and Enforcement (MVE)
11. Funding and Financial Mechanisms
12. NDC Enhancement
13. Refrigerant Management (HCFC Phase-out and HFC Phase-Down)
14. Recovery, Recycling, Reclamation and Waste Management (Transport, Storage and Disposal of Refrigerants and RAC Equipment)
15. Reinforce Regional Collaboration

Recommendations are presented as a basis for additional actions. Implementation of the NCS would greatly accelerate the transition to climate friendly and energy efficient solutions, enabling a more viable and cost-effective pathway for continued prosperity and growth while minimizing adverse trade-offs from cooling.

Collaboration among the various stakeholders in the public and private sector is fundamental to achieve an effective implementation of the Barbados NCS as it will permit a better understanding of the drivers, challenges and opportunities in advancing these measures.

1. Introduction

1.1. Country Profile

Barbados, the most easterly of the Caribbean islands, is located at 13° 4' North Latitude and 59° 37' West Longitude. With a land area of 166 mi^2 (430km^2), the island enjoys 92 km of coastline, a tropical oceanic climate with an average temperature of 27°C, and distinct dry and wet seasons. The wet season coincides with the north Atlantic hurricane season that occurs from June 1st to November 30th and during which time, the island may be exposed to extreme weather events which are likely to occur during this period. The resident population is estimated to be 270,995[3]. The Gross Domestic Product (GDP) (nominal) per capita is US$16, 082[4]. Barbados is a high-income service economy that is driven largely by the real estate sector, the accommodation and food services industries as well as the wholesale and retail sectors[5]. The Tourism industry is the most significant contributor to the country's foreign exchange earnings.

With respect to social development, Barbados is ranked at 58 in the High category of the United Nations Human Development Index Ranking (2020)[6]. As a Small Island Developing State (SIDS), Barbados remains committed to environmental protection and sustainable development nationally, regionally and globally. To this end, the government of Barbados continues to develop and implement a number of national policies, plans, programmes and activities geared toward conserving the local environment and supporting the health and social, economic and cultural development of the people of Barbados while meeting obligations under regional and international treaties. Barbados is Party to the Treaty of Chaguaramas which established the Caribbean Community and the Common Market (CARICOM), as well as several international Multilateral Environmental Agreements (MEAs) including the Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol), The Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC) among others.

1.2. Why Cooling matters

Cooling can be defined as the action or process of removing heat to lower temperature. Cooling can occur either through natural or mechanical processes or via a combination of the two to achieve the

[3]Barbados Statistical Services Department, May 27, 2021
[4]https://stats.gov.bb/international-indices/
[5] Barbados Economic and Social report, Ministry of Economic Affairs and Investment, 2018
[6] https://stats.gov.bb/international-indices/

desired outcome in human comfort, transport, technology, public spaces, the storage and transport of food and other perishable products (e.g. blood, flowers) (i.e. cold chain), health, science and research and refrigeration. Ultimately, RAC are crucial technologies to maintaining our modern way of life.

1.2.1. Thermal Comfort - Space Cooling

Historically, the traditional design of buildings in Barbados achieved comfortable thermal conditions in the absence of electricity. With the advent of electricity and air conditioning systems, modern architecture evolved to include mechanical cooling built-in as a major component of the design to solve the issue of achieving thermal comfort. This circumstance can sometimes lead to the prioritisation of construction aesthetic design and cost requirements above energy and cooling issues.

Addressing thermal comfort is essential in stationary applications (e.g. offices, showrooms, classrooms, stores, data centres, offices, hotels, factories and residences etc.) as well as in mobile applications for the transportation sector (e.g. vehicle air conditioning). The space cooling share of total buildings electricity at global scale is approximately 18% and its share of global electricity is expected to increase from 10% to 16% by 2050[7]. Extreme heat and humidity can adversely impact health and performance, the ability to manufacture products and conduct research, capacity to perform medical procedures that require precise conditions etc. and make even the simplest of tasks difficult. Moreover, healthcare, manufacturing, and science-related sectors that rely on such facilities are cornerstones of diversified economies. Although the trade winds blow directly across Barbados, the demand for cooling in the country, particularly domestic/residential air conditioning (i.e. air conditioning split systems) is increasing and is expected to continue to rise. Moreover, as the tourism industry and the commercial and manufacturing sectors that depend heavily on RAC continue to expand, the demand for cooling in these areas is also expected to significantly increase.

It is important to consider that even though Air Conditioning has provided significant space cooling benefits, over the years, this technology has unfortunately contributed to the energy and environmental crisis. However, this challenge presents significant opportunities to support the shift in thinking as it relates to building design and importantly improve the selection, installation,

[7] IEA (2018) Future of Cooling Report.
https://webstore.iea.org/download/direct/1036?fileName=The_Future_of_Cooling.pdf

commissioning, operation and maintenance of AC units that are best suited to the climatic conditions and applications in Barbados.

A comprehensive approach to building design that utilises a combination of old passive cooling techniques and new green designs and technologies such as reducing heating loads (e.g. through shading, application of reflective coatings, natural ventilation, optimal building orientation etc.) and optimising operations (e.g. ideal space temperature, utilising ozone and climate friendly refrigerants and energy efficient equipment), in addition to leveraging behavioural changes (e.g. shifting away from formal ties and jackets) are practical measures that can be used to minimise the negative energy and environmental impacts caused by thermal comfort.

While it is recognised that improved building design can significantly increase thermal comfort and reduce or even avoid the energy demand for space cooling. This issue is already adequately addressed through *inter alia* the Town and Country Planning Act *Cap 240*, Health Services Act *Cap 44* and the Health Services (Building) Regulations, 1969 and the Barbados National Building Code. These legislative, regulatory and policy frameworks are enforced by the Town and Country Development Planning Office (TCDPO); the Building Development Control Section of the Environmental Protection Department (EPD), Ministry of Environment and National Beautification (MENB); the Barbados National Standards Institution (BNSI) and the Barbados Building Standards Authority respectively. Consequently, the subject of building design is not covered in detail in this document, instead the focus will be on addressing cooling through mechanical processes i.e. Refrigeration and Air Conditioning (RAC).

1.2.2. Refrigeration and the Cold Chain

The core element of the cold chain that is familiar to consumers is refrigerating appliances. Residential and commercial refrigerators and freezers are ubiquitous in Barbados. Refrigeration systems use up to 10% of the world's electricity[8] and the impact of this electricity use varies by sector for example,

[8] Accelerating the Global Adoption of Climate-friendly and Energy Efficient Refrigerators https://united4efficiency.org/wp-content/uploads/2017/11/U4E-RefrigerationGuide-201801-Final-R1-1.pdf.

refrigeration accounts for the lion's share of a supermarket's total electricity consumption and is estimated to represent about 3% - 4% of the total sales price of a refrigerated food or drink item.[9]

According to the Birmingham Energy Institute, "90% of the world's fish stocks are fully or over-exploited, and wastage of fish and sea food in the supply chains of developing countries averages around 30%."[10] Although Barbados has some sophisticated infrastructure and sustainable fisheries practices, the estimated figure of wastage in this important sector as a result of an inadequate cold chain is therefore illustrative of the need to continue to ensure that spoilage and waste are minimised in this sector.

Approximately, 30% of global food production is lost to spoilage, which in turn reduces the income of smallholder farmers by at least 15%.[11] Although there is currently no specific data for the country this data can be indicative and applied to the Barbadian context to develop precautionary measures. Food-borne illnesses, due in part from insufficient refrigeration during transport and/or storage, can cause illness or death from food poisoning. The cold chain is also imperative for preserving the visual and sensory aspects of food. For chilled foods, quality and safety are reliant on the food being maintained at a sufficiently low temperature throughout its shelf life to prevent growth of bacterial pathogens and to minimise growth of spoilage microbes. Chilling minimises moisture transport and maintains flavour, colour and texture.

1.3. The Covid-19 Pandemic and Refrigeration and Air Conditioning (RAC)

Barbados recorded its first Covid-19 cases in March 2020. Since then, the government has been implementing a number of policy and legislative measures to control the spread of the virus and manage the health, social and economic impacts caused by the Covid-19 pandemic. .

At the sector level, specific RAC technical measures were recommended to combat the spread of Covid-19. International guidance recommending that a well-maintained and operated AC system could reduce the spread of COVID-19 in indoor spaces by increasing the rate of air exchange, reducing

[9] Irrek (2013). Policy options for ecodesign and labelling of commercial refrigeration. Available: http://www.eceee.org/ecodesign/products/ commercial_refrigerators_freezers/Wuppertal_presentation_ 23April2010.
[10] University of Birmingham – Birmingham Energy Institute. *Clean Cold and the Global Goals*. Page 28. Available at: https://www.birmingham.ac.uk/Documents/college-eps/energy/Publications/Clean-Cold-and-the-Global-Goals.pdf
[11] University of Birmingham – Birmingham Energy Institute Pages 5 - 6

air recirculation, and increasing the amount of outdoor air that was introduced into a space was taken into consideration at the local technical level. In this regard, a number of measures were promoted including: utilising settings that recirculated the air, use of filters with the appropriate Minimum Efficiency Reporting Values (MERV), and the routine inspection, maintenance and cleaning of HVAC systems in accordance with good RAC practices[12].

The Covid-19 pandemic also drew greater attention to the important role that refrigeration and the cold chain play in supporting food security as well as ensuring vaccine storage, safety and efficacy etc. Effective cold chain management involves ensuring not only that those temperatures needed to maintain perishable commodities and vaccine viability are held constant, but also that adequate technologies are in place to allow stakeholders at various points in vaccine storage, transport and distribution chains to verify stability of required temperatures.

To address the crisis, the Government of Barbados (GoB) successfully sourced some additional international funding to support and complement the government's fiscal stimulus measures aimed at reducing the economic, health, social and financial impacts of COVID-19 in the country. The scale of this current recovery package is unprecedented and while geared specifically toward solving the crisis it also presents an opportunity for the Government to capitalise on synergies with ongoing efforts to transform sectors that rely on RAC and energy.

1.4. Barbados National Cooling Strategy for the Refrigeration and Air Conditioning Sector (NCS)

The Barbados National Cooling Strategy for the Refrigeration and Air Conditioning sector (NCS) is a document developed by the Government of Barbados in partnership with national stakeholders and with the technical support of the Caribbean Cooling initiative, a project of UNEP's United for Efficiency (U4E) programme. The NCS provides and explores the cooling space in Barbados and provides stakeholders with a framework of areas for intervention to support the transition toward climate and ozone-friendly refrigerants and energy efficient cooling technologies, while meeting the growing demands for cooling in a sustainable manner.

[12] WHO (2021). Coronavirus disease (COVID-19): Ventilation and air conditioning. https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-ventilation-and-air-conditioning

The implementation of the NCS is anticipated to directly reduce energy costs for residential and commercial consumers, conserve electricity, mitigate greenhouse gas (GHG) emissions, expand the ozone and climate friendly and energy efficient equipment plant locally and support the Government of Barbados' efforts to meet its national goals as well as the country's regional and international obligations.

1.4.1. NCS Approach

The National Cooling Strategy aims to address the national cooling demand in a more holistic manner that includes capitalising on potential synergies across various sector policies, programmes and stakeholders. The Strategy's approach:

- Identifies the present and future impact of cooling and highlights its scale at the national and global level.
- Couples the transition to low GWP ozone and climate friendly refrigerants with energy efficiency and conservation.
- Collects relevant country and regional data inputs from experts and leverages international market data and research in the domain of cooling for an integrated analysis.
- Recommends policy instruments, interventions and measures informed by global best practices, expert inputs and the country's experience.

1.4.2. Objectives of the NCS

The NCS aims to contribute to addressing the following national objectives:

- Assessing the cooling sectors, technologies, relevant policies and stakeholders
- Reducing the electricity waste and peak electricity demand from cooling-related activities
- Enabling greater comfort and productivity for building occupants by ensuring energy efficient and ozone and climate-friendly cooling services
- Advancing national economic development priorities in line with the Barbados Energy Policy 2019-2030 and relevant growth and development strategies
- Mitigating pollution and greenhouse gas emissions in support of the country's Nationally Determined Contribution (NDC) to the Paris Climate Agreement
- Contributing to the transition to the use of ozone and climate friendly and energy efficient refrigerants and refrigerant technologies in the RAC sector in accordance with national objectives and in support of meeting compliance obligations under the Kigali Amendment to The Montreal Protocol on Substances that deplete the Ozone Layer

- Contributing to building the capacity of all stakeholders in the RAC sector e.g. RAC and MAC technicians, refrigerant and RAC equipment importers and retailers, government officials and other relevant stakeholders and
- Raising awareness of consumers/end-users and the wider public.

2. Linkages with Key National, Regional and International Frameworks

In recent years, Barbados has taken a proactive and ambitious approach to reducing its emissions by introducing concrete mitigation actions to decarbonise the electricity grid, introducing initiatives to improve energy efficiency, and introducing measures to address emissions from various sectors. In this context, a number of policies, plans and programmes have been developed to guide and coordinate the national implementation approach for example, the country's Green Economy Scoping Study, The Sustainable Development Policy, The National Energy Policy 2019-2030, the Growth and Development Strategy, Roofs to Reefs Programme (R2RP) and the Nationally Determined Contribution (NDC).

The impacts of climate change have undoubtedly propelled the pursuit of more energy efficient solutions for the cooling of buildings while simultaneously reducing GHG emissions. To this end, the NCS seeks to integrate considerations of HCFC phase-out, HFC phase down, energy efficiency, mitigation of climate impacts and access to cooling. The NCS has also endorsed recommendations from the Implementation Plan for Barbados' National Energy Policy [13], developed to assist the Government of Barbados with achieving its 2030 vision of becoming 100% fossil fuel free (FFF) by 2030. This plan was commissioned by the Ministry of Energy, Small Business and Entrepreneurship (MESBE), to supplement the Barbados National Energy Policy (BNEP). In particular, reference is made to recommendations #48a "Create an energy efficiency plan as a policy guideline document" and #65c "Develop policy recommendation for cabinet decision").

Barbados is also advancing minimum energy performance standards (MEPS) and energy labels for refrigerators and air conditioners (AC) as part of a broader policy harmonisation and collaborative enforcement effort across CARICOM in CRS57:2018 and CRS59:2019 respectively. Similarly, model green building codes[14] and standards for energy efficiency in buildings[15] have been released which address cooling related aspects. Building on these foundational elements, the NCS identifies gaps and recommends opportunities that should be pursued to transform the market toward more sustainable

13 Implementation Plan for Barbados' National Energy Policy (2019). https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030
14 CARICOM (2019). Regional Energy Efficiency Building Code (CREEBC). https://ccreee.org/document/new-caricom-regional-energy-efficiency-building-code-creebc
15 New energy efficiency standards for buildings in the Caribbeanhttps://ccreee.org/article/new-energy-efficiency-standards-buildings-caribbean

cooling. Refrigerators and ACs are also given additional attention due to the outsized impacts of these products on energy consumption and the environment, as well as the relative ease with which they can be addressed through targeted policies and programmes.

Therefore, the NCS builds on existing national and regional efforts and brings international best practices and expertise to develop strategic recommendations to meet the nation's cooling needs in a sustainable and cost-effect manner. Furthermore, the NCS due to its crosscutting nature provides interlinkages for the country to progress in the achievement of the Kigali Amendment to the Montreal Protocol, The Paris Agreement on Climate Change and the Sustainable Development Goals.

2.1. International Frameworks

Sustainable Development Goals

The Sustainable Development Goals (SDGs) aim to tackle some of the more pressing challenges facing the world today.[16] The 17 Goals interconnect and seek to address climate change impacts, management of fragile natural resources, better health, the eradication of poverty and fostering peaceful and inclusive societies, which in turn reduces inequalities and helps economies prosper. Access to cooling is linked to the achievement of multiple SDGs that are essential to the health and well-being of Barbados, and the planet namely poverty (1), zero hunger (2), good health and well-being (3), affordable and clean energy (7), decent work (8), industry (9), sustainable communities (11), responsible consumption and production (12), and climate action (13)

The United Nations Framework Convention on Climate Change and the Paris Agreement

Barbados ratified the Climate Change Agreement in Paris on the 12th of December 2015. The central aim of the Paris Climate Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C.[17] Additionally, the agreement aims to strengthen the ability of countries to adapt to the impacts of climate change.

The Intergovernmental Panel on Climate Change (IPCC) report from 2018 warns that there are only 12 years for global warming to be kept to a maximum of 1.5 °C, beyond which even half a degree will significantly worsen the risks of drought, floods, extreme heat and poverty for hundreds of millions of people.[18]

[16] About the Sustainable Development Goals https://www.un.org/sustainabledevelopment/sustainable-development-goals/
[17] The Paris Agreement https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[18] An IPCC special report on the impacts of global warming of 1.5 °C http://www.ipcc.ch/report/sr15/

Under the Paris Agreement Barbados as all signatory countries has committed to a variety of measures to reduce national emissions and adapt to the impacts of climate. In the first NDC Barbados intends to "achieve an economy-wide reduction in GHG emissions of 44% compared to its business as usual (BAU) scenario by 2030. In absolute terms, this translates to a reduction of 23% compared with the baseline year, 2008". More specifically in electrical energy efficiency, the NDC states "a 22% reduction in electricity consumption compared to a BAU". According to the U4E Country Savings Assessments, by transitioning to energy-efficient Room Air Conditioners and domestic refrigerators in 2030, a reduction of 100 GWh of electricity use could be achieved. This is equivalent to almost 10% of national electricity use (in 2019).

To reach these ambitious goals, new funding and financing streams (e.g. Green Climate Fund), a new technology framework and an enhanced capacity building framework (e.g. Climate Technology Centre and Network) have been put in place. The Agreement also provides for enhanced transparency through Nationally Determined Contributions that list official actions and/or goals identified by national governments on how they will mitigate and/or adapt to climate change.

The NDC indicates planned measures in this sector that are considered and further developed in the NCS, as the 'Public Sector Energy Efficiency and Conservation Programme', implementation of applicable recommendations through the Caribbean Hotel Energy Efficiency and Renewable Energy Action-Advanced Program (CHENACT), energy efficiency measures in homes and various LED lighting initiatives.

Every 5 years the parties of the Climate Change agreement must update their NDC commitments. At the time of writing Barbados was currently working on the NDC update in which the country will aim to raise its ambition and include cooling related mitigation measures that relate to the transition of energy efficient and ozone and climate friendly refrigerants and refrigerant technologies in alignment with the National Cooling Strategy.

The Ozone Layer Protection Treaties

The Adoption of the Convention in (1985) signified that countries around the world acknowledged that the depletion of the Ozone Layer in the earth's stratosphere was of global concern. The subsequent adoption of the Montreal Protocol in 1987 provided the framework that defined which states would act collectively to phase-out and phase down the production and consumption of Ozone Depleting Substances (ODS) and Hydrofluorocarbons (HFCs) respectively. Though HFCs are not ozone depleting, these chemicals are powerful greenhouse gases (GHGs) that contribute to climate change.

Barbados has been a party to the Vienna Convention for the Protection of the Ozone Layer (VC) and the Montreal Protocol on Substances that Deplete the Ozone Layer (MP) since October 1992.

Presently there are ninety-six (96) chemicals identified for global phase-out and eighteen (18) chemicals identified for global phase-down under the Protocol. In Barbados, these chemicals are primarily used in the RAC sector. Over time, Barbados has deposited instruments of ratification for all the attendant amendments of the Montreal Protocol including the Kigali Amendment which was agreed at the 28th Meeting of the Parties (MOP28) on October 15, 2016 in Kigali Rwanda.

The Kigali Amendment to the Montreal Protocol requires a phase-down in the production and usage of HFCs.[19] (See Figure 1). HFCs are synthetic chemicals that are primarily used in RAC in Barbados, and are powerful greenhouse gases (GHGs) that can be thousands of times more potent than an equivalent molecule of carbon dioxide in trapping heat, a characteristic that can be quantified by their Global Warming Potential (GWP). Barbados ratified the Kigali Amendment to the Montreal Protocol on April 19, 2018. The compliance with the refrigerant transition to low GWP refrigerants under this Amendment will dramatically reduce the direct emissions of GHGs in Barbados and therefore can help to attain the national commitments to the Paris Agreement under the UNFCCC.

2.2.National Frameworks

The National Ozone Depleting Substances (ODS) and Hydrofluorocarbon (HFC) Management Programme

Having signed on to the Convention and Protocol in 1992, Barbados has actively implemented a country programme to achieve and maintain compliance obligations since 1994. The National Ozone Depleting Substances (ODS) and Hydrofluorocarbon (HFC) Management Programme, Ministry of Environment and National Beautification (MENB) (known as the National Ozone Unit (NOU) in the Montreal Protocol sphere) serves as the focal point for the Vienna Convention and the Montreal Protocol.

As part of it' s mandate the National ODS and HFC Management Programme, MENB is responsible for the development coordination and implementation of policies, plans, programmes and activities to ensure phase-out and phase down of ODS and HFCs respectively in accordance with the government of Barbados' obligations under the Montreal Protocol, and to guide the transition towards the use of ozone and climate friendly and energy efficient refrigerants and refrigerant technologies at the national level. To this end, Barbados is expected to phase-out the consumption of HCFCs by January

[19] The Kigali Amendment to the Montreal Protocol: HFC Phase-down
http://multimedia.3m.com/mws/media/1365924O/unep-fact-sheet-kigali-amendment-to-mp.pdf

1, 2030 , establish a freeze in HFC consumption by January 1, 2024; and subsequently phase down HFC consumption to 80% by 2045 as an Article 5 group 1 country (refer to Figure 1). Further, once the phase down is achieved, Barbados will be required to manage the regulatory and administrative frameworks that have been established to support maintenance of Barbados' obligations beyond 2045.

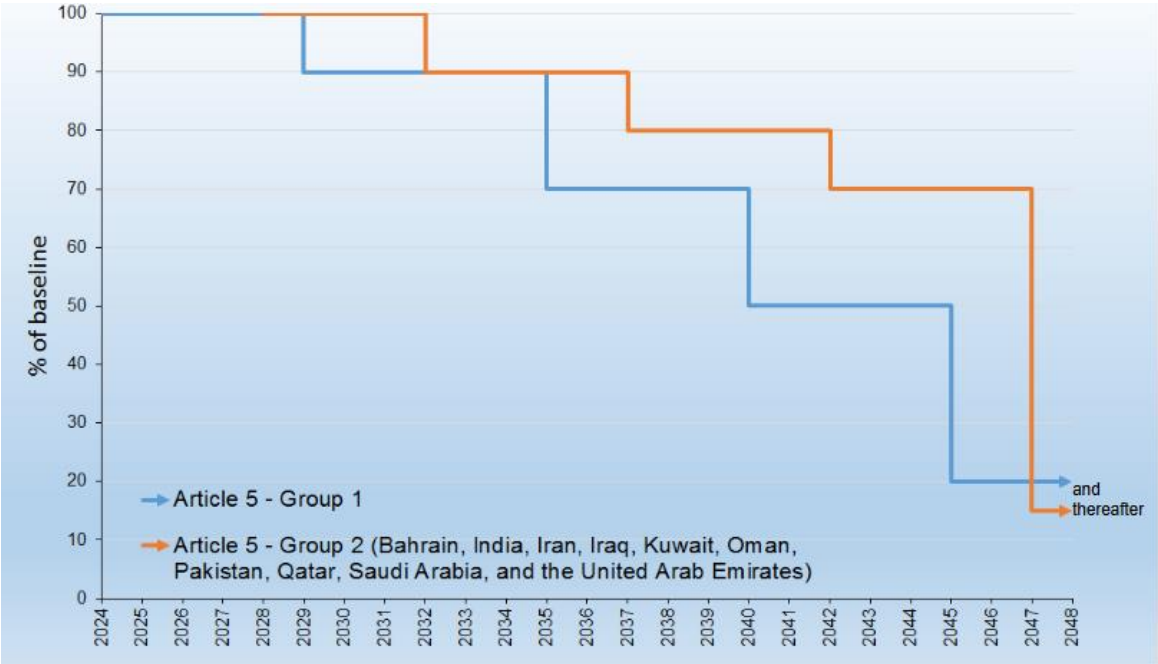

Figure 1: The Kigali Amendment to the Montreal Protocol: HFC Phase-down (OzonAction, 2017)

The Hydrochlorofluorocarbon (HCFC) Phase-out Management Plan (HPMP)

The Hydrochlorofluorocarbon (HCFC) Phase-out Management plan defines the schedule of activities required to be implemented to effect the phase-out of HCFCs by January 1, 2030.

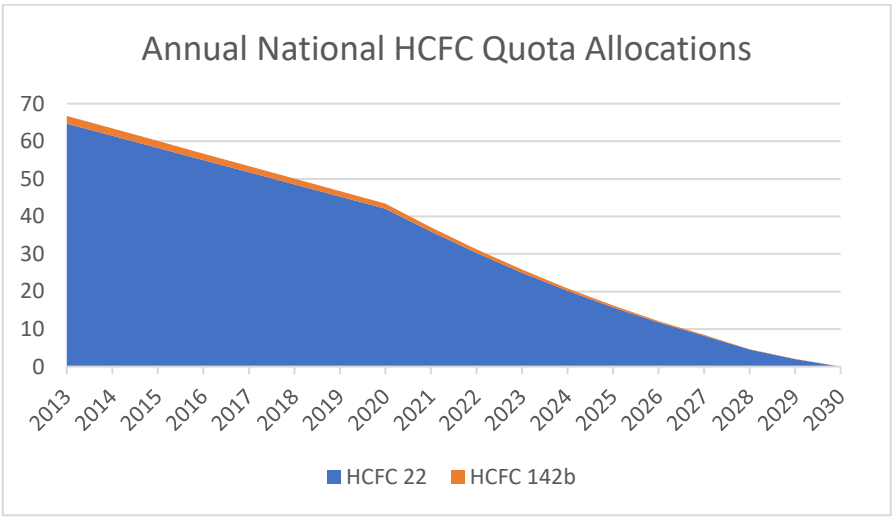

Figure 2: Annual National HCFC Quota Allocations

The implementation of the HPMP is enabling Barbados to meet all of the Montreal Protocol's HCFC control targets using an overarching strategy that is based on: capacity-building; policy, legislation and regulation; education and awareness as well as monitoring and evaluation.

The Capacity Building Component of the HPMP focuses on the provision of recovery and reclamation equipment and other related tools and devices to the Samuel Jackman Prescod Institute of Technology (SJPI), training of technicians, importers and other relevant stakeholders in Good RAC practices and alternative technologies and the handling and storage of refrigerants as well as training of licensing and enforcement officers on Montreal Protocol related matters.

The HPMP Policy, Legislative and Regulatory Framework component is expected to produce a labelling standard, put forward recommendations for measures for the certification and licensing of RAC technicians, investigate the feasibility of introducing incentives for the RAC sector and the banning of importation of RAC equipment and ultimately the development of a policy that will inform the drafting of national legislation to manage the RAC sector.

Under the HPMP, education and awareness raising activities have been expanded beyond coverage of ozone layer destruction and its effects to include a focus on areas such as: technical information, technology transfer, industry transformation and synergistic benefits of adaptation of alternative technologies.

The aim of the monitoring and evaluation component is to further develop the capacity of the NOU, MENB to effectively monitor and evaluate the activities developed and implemented under the HPMP.

Legislation

Domestic regulation of ODS and HFCs is exercised through the Customs (List of Prohibited and Restricted Imports and Exports) Order 2009, Customs (List of Prohibited and Restricted Imports and Exports) (Amendment) Order 2020. The list of items subject to licence under the Miscellaneous Control Act *Cap 329* was also revised to include the eighteen (18) Hydrofluorocarbons (HFCs) that are subject to control under the Montreal Protocol. The Order lists (a) the ODS and HFC chemicals prohibited from import or export, and (b) requires all traders to secure an import or export licence for the ODS and HFCs included on the restricted list. These controls apply equally to trade in bulk ODS and any blended derivatives thereof.

The NOU's experience and success are leveraged in this NCS to identify effective policy interventions that while advancing the phase-out of ODS refrigerants will also phase-out inefficient equipment and when feasible foster a transition to more sustainable alternative technologies at an enhanced rate. With this in mind, the data suggests that the global RAC sector could potentially contribute 0.051

$MtCO_{2eq}$ of direct GHG emissions to the atmosphere and 0.275 $MtCO_{2eq}$ indirect emissions into the atmosphere in 2020[20].

Barbados National Building Code

The Barbados National Building Code Part 13: Conservation of Fuel and Power [BNS-SP1:PART13:2013] stipulates that buildings, which incorporate air conditioning or mechanical ventilation shall meet specific construction requirements for thermal efficiency and follow certain performance criteria. The required criteria consider an efficient envelope which will not require an excessive install capacity of active cooling, energy efficient appliances such as fans, pumps, refrigeration equipment and other components. The code also refers to guaranteeing appropriate means of managing, controlling and monitoring the operation of the equipment and the systems in the building, compliance with a carbon performance index that assesses the contribution to carbon emissions due to Building Services, Design and Operation.

The national code requires that information shall be made available to the building owner regarding the install, building services, the operation and controls required to comply with the stipulated efficiency requirements, referencing the ISO standard 12655:2013.

Considerations in the design and construction are also referenced, thermal insulation that allows the building to achieve a minimum thermal performance when components of the buildings are to be mechanically cooled. Environmental factors in the design of the building are also to be considered such as the orientation of the building, the geometrical shape, surface color, shading and reflections from other structures, materials for the external walls, exterior shading of windows, light colored roof materials, and considerations on air leakage.

The document stipulates that active cooling shall be installed only in areas where it is necessary for human comfort storage, temperature sensitive products or humidity sensitive equipment. It also regulates operation for 24-hour active cooling system only when it's critical and indicates the use of individual temperature controls for each room and timers for higher capacity equipment when on low operation.

In terms of design and equipment selection the code requires a specialist to size the AC equipment to be installed, considering humidity control, location of the unit, reuse of waste or exhaust energy, pressure loss considerations and ensure the insulation of piping and tanks within the system to be

[20] The Green Cooling Initiative, Global greenhouse gas emissions from the RAC sector. https://www.green-cooling-initiative.org/country-data#!total-emissions/all-sectors/absolute

optimized for efficiency. Additional specifications on the type of equipment to be installed to address needs more precisely and fostering better performance were included in the code.

Barbados National Energy Policy

The Barbados National Energy Policy (BNEP) 2019 – 2030 lays out a pathway to achieve the 100% renewable energy and carbon neutral island- state transformational goals by 2030. To achieve this goal, there is an urgent need for the National Energy Task Force to develop a mechanism that will allow for sustainable growth of renewable energy based on predictable and effective price signals to the consumer. The Ministry of Energy and Business Development also indicated its intent to formalise a policy regarding a stable pricing mechanism for renewables at the level of the Cabinet in the foreseeable future.

The BNEP is expected to reduce domestic fossil fuel consumption from 11000 BOE/day to 0 BOE/day. This represents an estimated fossil fuel reduction of 100%. Energy efficiency policy measures for electricity consumption and transportation are expected to result in a reduction in energy consumption of 20% below Business as Usual (BAU) over the planning period.

The BNEP recognise that energy efficiency and energy conservation are fundamental to achieve the national targets on limiting the fuel import bill expenditure. Fostering the penetration of technoclogies that provide more output for less input improves both the economic and environmental benefits.The importance of energy efficiency is stated in Visionary Goal 2 (An energy sector where consumption and production of energy resources occur with the maximum level of efficiency that is feasible). The BNEP recommeds the development of an Energy Efficiency Plan with sub-sections to consider areas of energy management and planning, lighting and exterior energy efficiency activities. The NCS can certainly be linked and leveraged by the future Energy Efficiency policy as a mechanism to better address the energy consumption of the cooling sub-sector.

The BNEP calls for all relevant national entitites in Barbados to work together to improve the effiicency of energy use in the country and established key policy measures. The NCS links and further develops upon a subset of these measures listed below to develop NCS recommendations:

- Establish efficiency standards governing electricity production for utility and distribution-scale operations.
- Develop a maximum useful life and cost/performance ratio of operations for generation equipment.
- Create legislation and regulations to govern movement towards greater energy efficiency in businesses and residences in Barbados.

- Develop an energy conservation education and awareness programme that will promote lifestyle changes among Barbadians with regard to energy consumption.
- Develop sectoral energy efficiency and consumption standards for buildings, and encode them in the Town and Country Planning Act.
- Establish or adopt business standards for the design of energy efficient homes and offices.
- Create energy efficiency standards for appliances and equipment used for residential, commercial and industrial purposes.
- Develop a set of regulations in tandem with all government ministries involved in the energy sector, which identifies a clear and defined process for new applicants in energy efficiency projects.

Roofs to Reefs Programme

The R2R Programme is a national resilience programme that intersects several sectors. The programme was developed to ensure that Barbados' economic plans are developed in a holistic manner in accordance with, and complimentary to the country's Sustainable Development Agenda in order to build a climate resilient economy.[21] The programme directly relates to the Physical Development Plan (PDP) and provides the vehicle through which public investment will be directed. Given the programme's mandate to seek to identify key projects and programmes, assess their costs, and identify and pursue funding opportunities, and coordinate implementation[22] this could potentially be another avenue through which the transformation of the RAC sector could be supported.

Sustainable Development Policy and the Green Economy Scoping Study (GEES)

The Government of Barbados defines the Green Economy as "…an integrated production, distribution, consumption, and waste assimilation system that, at its core, reflects the vulnerability of Barbados' island ecosystems as the basis for natural resource protection policy intervention, business and investment choice, human development programming, and facilitating export market development strategies…"[23]

In 2007, the Government of Barbados commenced the national green economic policy framework based on The National Strategic Plan (NSP) 2006 – 2025, which sets out the Government's main development agenda for that 20-year period ending in 2025. Goal Four in particular of the NSP was

[21] Barbados Government Information Services (2021). 'Roofs To Reefs' Is Barbados' National Resilience Plan https://gisbarbados.gov.bb/blog/roofs-to-reefs-is-barbados-national-resilience-plan/
[22] Barbados 2021 Update of the First NDC
[23] Green Economy Scoping Study, 2014

aimed at "Building a Green Economy: Strengthening the physical infrastructure and preserving the environment." It included the protection, preservation and enhancement of physical infrastructure, environment and scarce resources in the context of advancing the country's social and economic development agenda. It also called for enhancing access to adequate water and energy supplies, a sustainable transportation system, and the development and maintenance of the country's infrastructure.

The Government engaged the United Nations Environment Programme (UNEP) in the establishment of a partnership to support its green economy agenda. The first phase of the partnership involved conducting a Green Economy Scoping Study (GESS). The GESS report recognises the potential of reducing heat loads with passive methods and improving the energy efficiency of the RAC technologies while phasing out ODS as a contributor to a more sustainable economy. Solar and Natural gas air conditioners were highlighted as potential alternative solutions, recommendations that have been further developed in the NCS.

Barbados Tourism Master Plan 2014-2023

Within the Barbados Tourism Master Plan 2014-2023 - Report I: The Master Plan, 2014, high energy costs have been highlighted as having a significant impact on the tourism industry. The document notes that the provision of electricity through Direct Current (DC) operation is more efficient than through Alternating Current (AC), which is primarily used across Barbados and recommended that inefficient air conditioning units and swimming pool pumps in the sector be replaced with energy efficient equipment. It was recognised that by implementing these measures, the sector would benefit from improved energy efficiency, and reduction in operating costs through lower utility bills.[24]

The development and implementation of the NCS directly contributes to achieving the measures related to mainstreaming environmental management within the tourism industry as specified in the Barbados Tourism Master Plan 2014-2023 and The White Paper on the Development of Tourism in Barbados, which states that "Achieving more energy efficiency in the tourism sector is one of the critical success factors".

2.3. Caribbean Community (CARICOM) Standards

The CARICOM Regional Standards for residential refrigerators and ACs, and CARICOM Regional Energy Efficiency Building Code (CREEBC)[25] have been developed over the past several years. Adopting

[24] Barbados Tourism Master Plan 2014-2023 – Report I: The Master Plan, 2014
[25] 2019 CARICOM Regional Energy Efficiency building Code https://codes.iccsafe.org/content/document/1335

common MEPS and labels across the region can reduce trade barriers and unlock economies of scale to make products more affordable, enable more effective market enforcement using proven test procedures, and facilitate the exchange of compliance information.

Even though most Caribbean Community (CARICOM) countries have drafted or approved National Energy Policies[26], a specific schedule for mandatory appliance energy efficiency adoption is unknown at the time of writing. Currently, voluntary energy labels for refrigerators and ACs are CRS57 and CRS59 are available respectively. The CARICOM Regional Organisations for Standards and Quality (CROSQ) released new energy efficiency building standards, in March 2019. The new codes were developed to assist Member States to improve the energy efficiency of buildings and support energy conservation efforts. The 2018 CCREEBC, which will cover both commercial and residential construction, is a joint effort between the CROSQ, the Code Council and ASHRAE.[27] The three (3) Energy efficiency standards for air-conditioners, refrigerators and lighting were approved in May 2019 by CARICOM. These standards will be implemented in Barbados as voluntary standards following approval by the Cabinet and publication in the Official Gazette.

CCOOL aims to build upon such existing efforts to support a comprehensive transition to energy-efficient and climate-friendly cooling solutions. Government officials, tourism stakeholders, technology providers, financial institutions, and civil society organisations worked with UNEP U4E to understand the market in Barbados and explore opportunities for greater ambition. Among the recommendations included in this NCS are additional opportunities targeting room ACs and refrigerating appliances that complement the CARICOM Regional Standards with more stringent energy efficiency levels and refrigerant gas requirements that Barbados can consider in different policy interventions or incentive programmes to unlock deeper energy savings and reductions in greenhouse gas emissions.

[27] 2018 CARICOM Regional Energy Efficiency Building Code h ttps://codes.iccsafe.org/content/document

3. Energy Infrastructure, Supply and Demand

3.1. Overview

According to the National Energy Policy 2019-2030, the demand for energy in Barbados over the last ten years is characterized by a declining trend. The average demand of primary and secondary energy was estimated between 2008 and 2014 at an average of 11,297 Barrels of Oil Equivalent (BOE) per day between 2008 and 2014. In 2008 it peaked at 12,056 barrels of oil equivalent per day (BOPD), while the lowest level of demand was observed in 2014 at 10,132 BOPD.

The declining trend reflects not only the economic challenges that Barbados has been facing but also energy efficiency improvements and the installation of the continuing number of PV systems in residences and businesses across the island. The Government is currently installing PV systems in all public buildings. The sales of electricity for the year 2017 were 944 million kWh[28], representing a marginal increase of 0.04% when compared to 2016. Of the total sales of electricity for 2017 it is estimated that 36.2 million kWh or 3.8% of electricity were sales from renewable energy sources. This represents 3.8% of total sales. The overall increase in electricity sales was largely due to a rise in customer demand with the largest category of users continuing to be the domestic sector. This sector accounted for 34% of total sales or 324 million kWh.

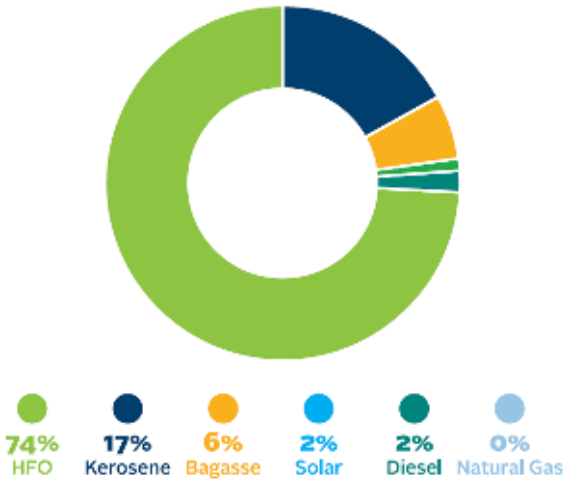

Figure 3. Fuel Inputs for electricity Production[29]

[28] The Barbados Economic Report, Energy Chapter (2017) https://www.energy.gov.bb/web/home/59-bulletin/271-Barbados-economic-report-energy-chapter-2017

[29] National Energy Policy for Barbados (2019) https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030

To reduce energy demand and facilitate the transition to 100% renewable energy generation, energy efficiency policies must be firmly adopted. Energy conservation (avoiding its use in the first place – such as through shutting off equipment when not needed and using natural solutions where practicable in lieu of air conditioning) and energy efficiency (using less energy to achieve the same amount of desired cooling) are the most cost-effective ways of reducing the demand for energy and thereby lowering the cost of transition to 100% renewables.

Over the years, Barbados has sought to maintain an energy sector where energy resources are universally available at reasonable prices. There is virtually 100% access to electricity and gradually, more sustainable forms of energy are being integrated into the energy mix in terms of electricity delivery and other energy services. However, the main fuel for electricity generation remains Bunker "C" heavy fuel oil, which is a major pollutant and high in emissions.

3.2. Key actors

The energy sector in Barbados involves four main actors: The Ministry of Energy, Small Business and Entrepreneurship's Renewable Energy and Energy Conservation Department, the Barbados Light & Power Company (BL&P), the Fair-Trading Commission and The Barbados National Standards Institution (BNSI). The Ministry of Energy, Small Business and Entrepreneurship is tasked with developing energy policy papers. BL&P is a vertically integrated privately owned utility company that is the sole producer of electricity for the national grid. Given the new policies of the Government regarding renewable energy, a change in the structure of the electricity market will need to be addressed.

The Fair-Trading Commission (FTC) regulates public utilities and has a mandate to ensure that all utilities operate efficiently to the extent that rates are kept low. To this end, the Commission is tasked with establishing principles to determine the rates to be charged, is guided by sector policy, and seeks to protect consumers by setting fair and reasonable rates. This mandate is juxtaposed with the requirement to afford utility companies an opportunity to make a reasonable return on their investment. Standards can be used as a tool to support regulations and other policy initiatives.

The Barbados National Standards Institution (BNSI) is a joint undertaking between the Government of Barbados and the private sector. The institution's mandate includes publishing national standards on labelling, building, food, chemicals, textiles, solar energy, liquefied petroleum gas, furniture, and consumer products. In recent years the BNSI in collaboration with partner organisations and stakeholders has bolstered its efforts to encourage the uptake of energy efficient technologies, particularly in the residential sector by introducing energy efficiency labels and standards for major electrical household appliances, lighting equipment and other electrical household products. To this

end, the BNSI implemented the Barbados Energy Labelling Programme as a mechanism to enable consumers to make informed purchase decisions, prevent inefficient equipment from being imported, contribute to energy saving, lower fossil fuel import and use and by extension contribute to environmental protection and climate change mitigation.

In addition, other stakeholders that will be key in the implementation of the National Cooling Strategy are the Ministry of Environment and National Beautification (particularly the ODS and HFC Management Programme/NOU), the Ministry of Finance and Economic affairs (particularly the Customs and Excise Department and the Department of Commerce and Consumer Affairs (DCCA) of the Ministry of energy and Business Development and the Ministry of Education, Technological and Vocational Training [particularly the Samuel Jackman Prescod Institute of Technology (SJPI) and the Barbados Vocational Training Board (BVTB)].

3.3.Electricity End-Uses

The demand for energy in Barbados over the last ten years has been characterised by a declining trend. Electricity consumption over the last decade was distributed over a number of sectors as follows: Domestic – 33%, Commercial – 21%, Public – 16%, Tourism/Hotel – 15%, Industrial – 9% and Other – 6%.

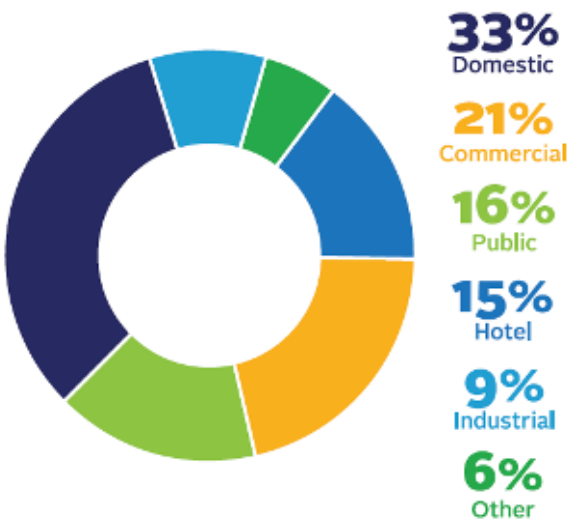

Figure 4: Electricity sales by demand group[30]

[30] Barbados National Energy Policy 2019-2030

Thirty three percent (33%) of the electricity in Barbados is used by households, most of which have refrigerators and a growing number are installing ACs. In addition, the commercial sector accounts for 21% of electricity usage, and this sector includes the Retail sector, Supermarkets, Banking facilities, shopping malls and other subsectors apart from manufacturing and agriculture. Of these, the most energy demanding are the supermarkets and the malls. The public sector accounts for 16% of electricity usage, and ranges from the provision of electricity to operate government buildings, hospitals, schools, military facilities and public markets etc. to the operation of public services e.g. pumping water, streetlights. As the government moves towards reaching its overall energy efficiency goals for the country, work has commenced to implement policies, projects and programmes that are geared toward transforming the public sector's energy usage as the first step.

While hotels account for 15% of the energy usage in the country, this does not include the over 3000 Airbnb listings which are still unregistered and, in most cases, would fall under the domestic market. These listings could possibly account for 10% of electricity usage, and if added to the hotel sector would increase that sector's usage estimate to 25% making tourism the largest user of electricity in Barbados followed by domestic at 23% and the commercial sector 21%. It is also noteworthy that AC and refrigeration account for over 60% of the energy usage in hotels. Therefore, with holistic approaches to reduce thermal loads (e.g. shading, reflective coatings, roofing insulation, and leveraging natural ventilation), improve operations and maintenance, and adopt more efficient cooling equipment and associated controls, there is a significant potential for cost-effective energy savings and a reduced carbon footprint.

The implementation of measures to support the enhanced uptake of ozone and climate friendly and energy efficient refrigerants and RAC equipment is anticipated to have a positive impact on reducing energy demand in at least the four major energy consuming sectors (Domestic, Commercial, Public and Hotel). This would account for approximately 85% of electricity consumption and contribute to increasing the rate at which the government could reach its energy targets. Refer to section *1.2 Why Cooling matters* for more information on the electricity and cooling nexus.

3.4. Energy Efficiency and Energy Conservation

In parallel to pursuing renewable energy solutions, Barbados has advanced efforts in the arena of energy conservation and energy efficiency. Projects have been executed to retrofit incandescent and fluorescent lights with LEDs. Moreover, efforts are ongoing to establish and implement efficiency standards for buildings, refrigerators and ACs.

Achieving Sustainable Energy in Barbados: Energy Dossier[31] is a publication by the Inter-American Development Bank that provides a deep dive into the energy sector in the country. The study describes the energy matrix, production and consumption aspects and presents consumption and capacity projections. In a second section an in-depth analysis is done into the institutional organisation, policies and regulations already established and in development. It provides evidence of the high dependency on fossil fuels, one of the main drivers for the national priorities to three principal objectives in the energy sector: reducing energy costs, achieving greater energy security, and improving environmental sustainability. [32]

As part of the preparation for the Global Environmental Facility's project, *Strategic Platform to Promote Sustainable Energy Technology Innovation, Industrial Development and Entrepreneurship in Barbados*, a market assessment report has been prepared. The study provides a comprehensive analysis of the energy industry, pre-feasibility of sustainable energy technologies and recommendations on areas to focus from a policy and technological perspective. [33]

A regional study by the Caribbean Hotel Energy Efficiency Action (CHENACT) Programme[34] on clean energy policy for hotels (with Barbados as the pilot country), was completed in February 2018. The programme recognized the importance of the tourism sector to the economy, which is also a major consumer of energy and emitter of greenhouse gases. The study provides a summary of the current energy policy that is applicable to hotels in Barbados, and policy and incentive recommendations that are required to encourage clean and efficient use of energy in the hotel sector.

These elements have been integrated in the development of this National Cooling Strategy document to identify potential synergies.

[31] Achieving Sustainable Energy in Barbados: Energy Dossier https://publications.iadb.org/en/publication/12572/achieving-sustainable-energy-barbados-energy-dossier
[32] Achieving Sustainable Energy in Barbados: Energy Dossier
[33] Barbados Sustainable Energy Industry Market Assessment Report https://www.ccreee.org/sites/default/files/project/files/barbados_market_assessment_report_-_final_2018-03-19.pdf

4. RAC Market Overview

As part of its continued effort to utilise a holistic and comprehensive approach to ODS and HFC management the NOU, MENB conducted a national survey to identify the level of consumption (i.e. imports minus exports) of Hydrochlorofluorocarbons (HCFCs) in Barbados over the period 2009-2010. Based on the data compiled, the Government was able to determine that HCFCs were only used as refrigerants in Barbados and was able to calculate a national baseline consumption of 66.74 Mt of HCFCs from which, the country was required to freeze and subsequently reduce importation. Additionally, with stakeholder involvement, the MENB developed the HCFC Phase-out Management Plan (HPMP), which defines the schedule of capacity building, policy and legislative, education and awareness and monitoring, reporting and evaluation activities required to be implemented at the national level to phase-out the consumption of these chemicals by January 1, 2030. A Licensing and Quota System (LQS) to manage HCFCs was established and is administered, monitored and enforced collectively by the NOU, MENB; the Department of Commerce and Consumer Affairs and the Customs and Excise Department.

As the phase-out of HCFCs has progressed and the country has continued to develop, the use and variety of refrigerants and cooling products have correspondingly expanded to include Hydrofluorocarbons (HFCs), natural refrigerants (e.g. Isobutane, ammonia) and Hydrofluoroolefins (HFOS). In 2019 Barbados' consumption survey was expanded to include HFCs and the data confirmed that refrigerants remained the only use for which these controlled chemicals were imported. Additionally, the estimated total import quantity for 2019 was 101.69 MT. The level of percentage increase could not be determined since HFC refrigerant imports were not subject to control under the Montreal Protocol and therefore were not monitored under this framework.

Appliance energy efficiency and energy conservation have been recognized as two of the most cost-effective policy measures in helping countries to meet climate goals, reduce energy use and improve energy security. Reducing energy waste is especially important for CARICOM, since most member states rely heavily on imported fossil fuels for power generation and therefore experience electricity prices ranging from US$0.25 - US$0.45+/kWh. These electricity tariffs—which are among the highest in the world--provide a strong case for energy efficiency standards and labelling, as they greatly reduce operating costs of appliances and generate significant savings for consumers and businesses. In addition, appliance efficiency policies can help Barbados to meet national energy efficiency targets, as well as NDC and other climate commitments.

As the population continues to grow and temperatures increase in the summer months, the country is seeing an increase in the demand for air conditioning products. Some more affordable air conditioning units are on the market which may not be energy efficient or use refrigerants that are ozone friendly. The options for cooling, however, have expanded giving consumers the ability to find a cooling product that suits their needs and their pockets. As part of the CARICOM regional standards development process, a survey was conducted in member states that gathered data on appliances sold in retail stores. This process yielded important findings that helped underpin the minimum energy performance standards and energy labels that were developed. The CHENACT project included in-depth audits of hotels in participating countries which also yielded important insights into the tourism sector. The CCOOL project referenced this information and conducted an additional market assessment to help address some of the information gaps, with an emphasis on room ACs and refrigerating appliances.

Refrigerators and ACs are among the highest energy consuming products using nearly 20% of global electricity[35]. Fuel inputs for electricity generation in Barbados are predominantly fossil fuels (~92%) therefore electricity consumed by the RAC sector contributes indirectly to the country's GHG emissions. The RAC sector in Barbados can be divided into six main applications: Industrial Refrigeration, Commercial Refrigeration, Commercial Air conditioning, Domestic Refrigeration, Stationary Air conditioning, and Mobile Air Conditioning (MAC).[36] The four most common refrigerants gases present in the local RAC market are HCFC-22, R-410A, R-404A and R-134a[3738]. These gases have high Global Warming Potentials (GWP), meaning that one molecule of a gas could be equivalent to the release of 3922 molecules of CO_2 to the atmosphere (in the case of R-404A). Together, the indirect (from electricity use) and direct (refrigerant leaking from RAC equipment) emissions of cooling products can have profound impacts due to their contribution to the GHG concentration in the atmosphere.

[35] U4E (2017). Policy Guide Series – Energy-Efficient and Climate-Friendly Air Conditioners. https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-air-conditioners/ & Policy Guide Series – Energy-Efficient and Climate-Friendly Refrigerators. https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-climate-friendly-refrigerators/
[36] MENB (2012). Barbados HPMP National Survey Report.
[37] Barbados National Ozone Unit (NOU, 2019). Data from the 2019 ODS and HFC Survey
[38] NOU (2017) Ozone Depleting Substances Alternative Survey Report, MENB

According to a global study, over the lifetime of ACs, approximately 75% of the total greenhouse gas emissions are indirect and 25% are direct[39]. For refrigerators, the ratio is approximately 60% indirect and 40% direct. These figures vary, depending on the refrigerant gas that is used, the carbon-intensity of the fuels used for generating electricity, the energy-efficiency of the equipment, the hours of use, and other factors. By 2020, it was projected that 75% of new refrigerators produced globally would use hydrocarbon refrigerants [e.g. isobutane (R600a)] which ozone depletion potentials of zero and negligible global warming potentials.[40] There is a greater variety of refrigerants in use globally for ACs, as these products have a much larger charge size (amount of refrigerant used in the vapour compression system) than refrigerators so issues ranging from flammability and the ability to operate in a broader range of climatic conditions are much more pronounced. This has been the hindrance to many small islands as training of staff is another cost attached to the safe handling of these refrigerants.

Barbados is located in the windward part of the Caribbean's archipelago and has a tropical, oceanic climate with hot and humid conditions. The average temperature is 26.8°C with no drastic changes in either seasonal or daily temperatures, as shown in Figure 5. The usual humidity levels play an important role in the human comfort levels as high humidity levels reduce the evaporation rate of perspiration, the natural mechanism for cooling the body. Therefore, creating a more oppressive thermal sensation than in dryer climates.

[39] US DOE (2016). The Future of Air Conditioning for Buildings. https://www.energy.gov/sites/prod/files/2016/07/f33/The%20Future%20of%20AC%20Report%20-%20Full%20Report_0.pdf#page=31&zoom=90,-304,792

[40] U4E (2016). Climate-Friendly and Energy-Efficient Refrigerators Policy Guidelines. Page 64 https://united4efficiency.org/wp-content/uploads/2017/11/U4E-RefrigerationGuide-201801-Final-R1-1.pdf

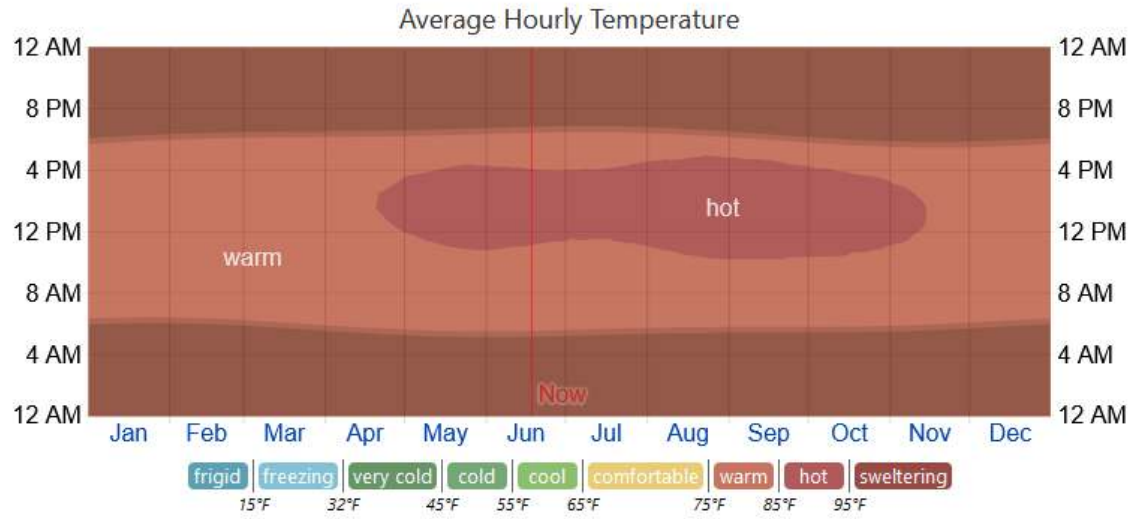

Figure 5. Average Hourly Temperature chart for Bridgetown, Barbados. Source: weatherspark

The Cooling degree day (CDD) is a measurement designed to reflect the demand for energy needed to cool a home or business to a human comfort level. At a base temperature of 21°C Barbados has an average yearly amount of 2376.5 CDD and ranks as the 32nd country on the highest space cooling needs in the world[41].

The World Bank's Climate data models project that the mean annual temperatures in Barbados will likely increase from 0.4°C to 2.1°C by the 2060s. According to UNDP's climate change profile, the frequency of hot days and nights that are considered "hot" in the same model is expected to increase on 27-67% of days by the 2060s, and 36-100% of days by the 2090's. Also, nights that are considered 'hot' for the annual climate of 1970-1999 are projected to occur on 27-66% of nights by the 2060's and 37-99% of nights by the 2090s.

As a relatively small market on the global scale, but with an increasing national demand for RAC equipment, it is important for Barbados to pursue policies, programmes and activities that are in keeping with the positive trends toward the increased uptake of more energy-efficient and ozone and

[41] CDDs extracted from Degeedays.net and calculated for a base temperature of 21C. Ranking from Worldwide Cooling Needs (2011). Available at: http://chartsbin.com/view/1030

climate-friendly cooling equipment as seen in major developed and developing country markets. The quantity of refrigerators and ACs in developing and emerging economies is expected to nearly double to 2 billion by 2030.[42]

According to the U4E Country Savings Assessments model, energy efficiency benefits from residential refrigerators and room air conditioners with the implementation of Minimum Energy Performance Standards in line with U4E Model Regulations can help to reduce over 100 GWh of electricity use, US$ 29 Million and 80 thousand tonnes of CO_2 equivalent in year 10 after their implementation.[43]

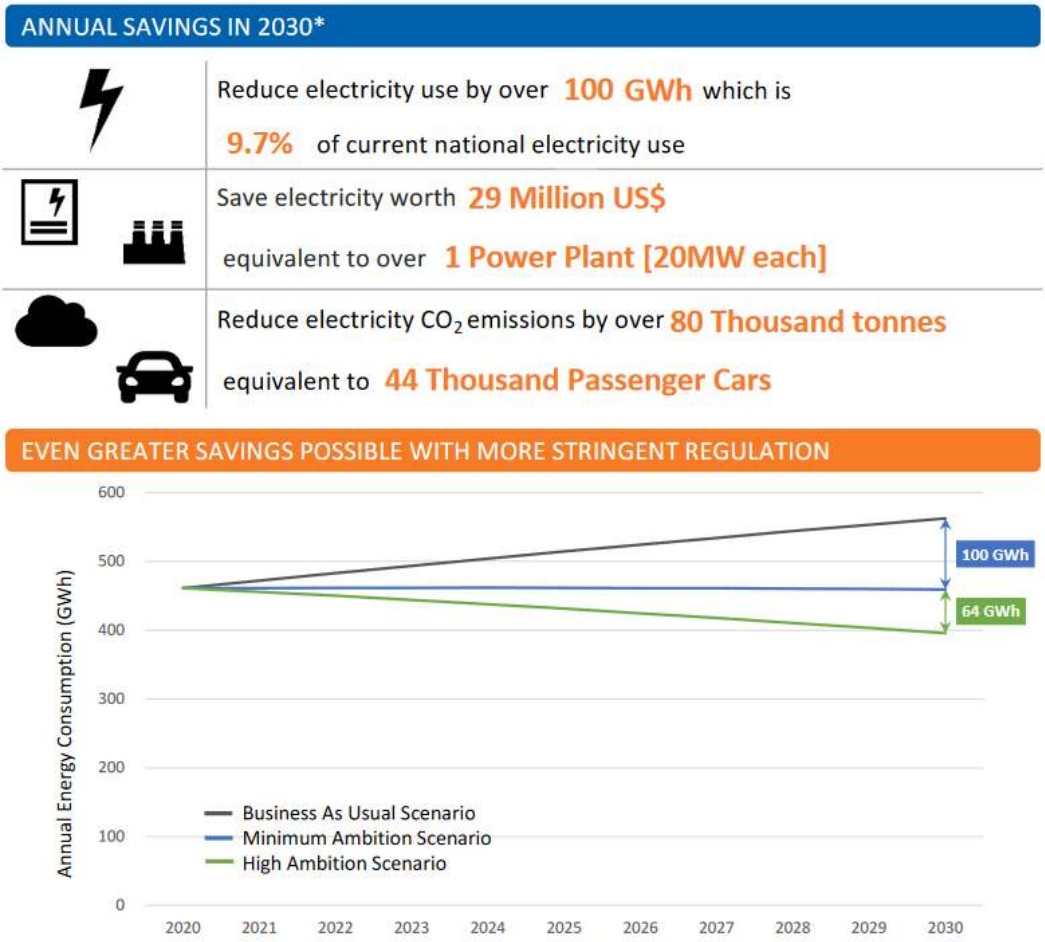

Figure 6. Energy efficiency benefits from residential refrigerators and room air conditioners with the implementation of MEPS as per the U4E Model Regulations.

[42] The Future of Cooling: Opportunities for energy-efficient air conditioning Technology report — May 2018 https://www.iea.org/futureofcooling/

[43] U4E (2020) Country Savings Assessment. https://united4efficiency.org/wp-content/uploads/2020/11/BRB_U4E-Country-Saving-Assessment_Cooling_Oct-20.pdf

Additionally, the U4E model estimates that 6 thousand tonnes of Direct GHG emission can be avoided in 2030 with the adoption of a low-GWP regulation consisted with the U4E Model Regulations guidelines in Annex A: Suggested MEPS and Labelling Requirements for Air Conditioners and Refrigerating Appliances.

4.1. Existing information sources and gaps

The following sources of information that have been made available for the purposes of developing the present strategy contribute to provide a reference of how the RAC market is composed in Barbados.

The Barbados HPMP National Survey report and the Ozone Depleting Substances Alternative Survey Report summarized the findings and analysis of the data gathered from the national survey conducted in 2012 and 2017 respectively to support the preparation of the Hydrochlorofluorocarbon Phase-out Management Plan (HPMP) and to provide an update on the status of ODS alternative refrigerant use across the island. These reports provide a comprehensive analysis of the RAC market in Barbados focused on the consumption of hydrochlorofluorocarbons (HCFCs). However, data specific to equipment performance characteristics such as efficiency, capacity, hours of operation or electricity consumption was out of the scope of the study.

The ODS Alternative Survey Report, 2014 stated that ideally, projections of future consumption of ODS alternatives would be based on bottom-up consumption estimates for the base years (2012-15) extrapolated up to the target year (2030) with growth of equipment stocks driving the calculations. However, the low response rates to the questionnaires issued by the C-COOL project did not allow for a solid baseline for projections to be built.

In view of the greater confidence associated with the data received from importers relative to other stakeholders, future consumption demands were approximated on the basis of the rate of importation growth derived from the dataset. This method has its challenges because imports could vary considerably from consumption in any one year based on the purchase patterns used by importers. However, this variation evens out over time and whereas the four years covered by the historic data

used in this projection may not be the ideal period to allow for this, the confidence in the import data provides a greater measure of comfort than using incomplete data sets. [44]

The Ministry of Energy, Small Business and Entrepreneurship (MESBE) conducted an audit to capture the air conditioning units installed in Government Institutions. A data set of the number of Air Conditioning Units at Government Institutions was produced for the Division of Energy and Telecommunications on December 7, 2015. The audit is an important asset for the Cooling Assessment as it presents information for over 429 units and more than 1823 kW of installed capacity in 39 public sites.

A previous regional assessment collected data from retail stores in several Caribbean countries including Barbados. This data was leveraged for the current assessment which provides a better understanding of the composition of the residential and light commercial RAC market. Additional data gaps were identified for the ACs and refrigerating appliances in the tourism sector which often procures products directly from suppliers rather than from retail stores. Given the outsized demand for cooling by the tourism sector, and its vital importance in the local economy, it was paramount to ensure that this sector was not under-represented. Previous findings from the CHENACT project, and other sources were also referenced to flesh-out details to better understand the market, though data gathering remains a challenge.

Information has been made available by the Barbados Statistical Service (BSS) Department on the imports of ACs and refrigerators into Barbados since 2010. However, it is not broken down by brand, size/capacity or the refrigerant used. There is no differentiation between new or used products and even used equipment e.g. refrigerators imported by returning nationals is included. Establishing measures to record this type of information (see recommendation 5.1) could allow the government to improve knowledge for policy interventions.

Information on cooling equipment apart from the public buildings 2015 audit is relatively scarce in Barbados and other available sources of data such as the imports registered do not provide enough of the information in the required format that is needed for the purposes of this report.

There is not a centralised tracking of energy consumption, refrigerant gasses, capacity on a per product/model basis. Sales data is business sensitive, and in general, there is a fatigue with surveys which rarely result in any changes and a consequent reluctance among target audiences in responding

[44] Ozone Depleting Substances (ODS) Alternative Survey report, 2017

to new surveys. In spite of this challenge, CCOOL was able to glean additional information, though mostly through qualitative responses in discussions held with dozens of stakeholders throughout the country.

As part of a solution to the aforementioned challenges, the UNEP United for Efficiency's (U4E) Stock Model used in the Country Savings Assessments has also been leveraged to estimate the electricity consumption of room air conditioners and household refrigerators in the country, and also, to forecast the impacts of implementing policies that improve the energy efficiency of new household refrigerators.

4.2.Data Gathering Methodology

The CCOOL project carried a market assessment to complement the existing information, it focused on:

- Key stakeholders such as government agencies, hotels and hotel associations, commercial space owners, and refrigerant and RAC equipment retailers who were surveyed to obtain details on their impact in the market,
- Primary technologies existing in the market with a long-term presence, AC systems and refrigerators currently in use,
- Energy efficiency opportunities in various areas,
- Consumer awareness on purchasing options and in energy efficient technologies to enhance their savings potential, and
- Investment perceptions, financing opportunities or lack thereof in current industry practices.

The first approach taken was through market assessment surveys to collect data on air conditioning and refrigeration equipment use in all sectors. A combination of on the ground surveys and the support of national associations as a distribution channel. The regional and national hotel associations served as C-COOL's main intermediaries to distribute the surveys to members. The list was also distributed through the Chamber of Commerce, The Barbados Renewable Energy Association, The Refrigeration and Air-conditioning Association, the Small Business Association, The Manufacturers Association and all other relevant email lists. Efforts were also made to obtain member emails, though this was fraught with sensitivities.

An on-line surveying system was initially used to collate emails/responses after participants responded to the survey. However, the response was very poor hence this method was abandoned in favour of personal visits and calls. Following the inception meetings conducted, a list of possible

survey participants was drawn up. Direct requests were also made to the local project partner for the MENB to assist in sending the questionnaire onward to contacts.

The project also researched and/or targeted other users/suppliers e.g. suppliers, the Customs and Excise department, Chamber of Commerce and other relevant public agencies, who were not members of any association. However, although the responses were limited, some stakeholders did provide information on their use, procurement &/or purchase of cooling equipment. The purpose of the survey was to get a broad picture of the behaviours of these various groups.

4.3. RAC Applications

The local RAC market is classified under six applications (6) as below:

Refrigeration and Cold Chain

The refrigeration sector includes applications in the domestic, commercial, industrial and mobile/transport sub-sectors. These applications support food preservation during transport storage and display, commercial activities such as cooling of beverages, ice manufacturing and industrial processes such as the production of dairy-related products and beer.

Domestic

The domestic sector comprises mainly domestic refrigerators and freezers and the main alternative used in this sector is HFC-134a. There may be is significant potential for increased uptake of the natural refrigerant HC-600a which is ozone and climate friendly and energy efficient. Equipment with HC-600a is already present in the local market and is available in some brands of household refrigerators as well as small display freezers that are used by businesses.

Commercial

The commercial sector includes equipment ranging from small “plug-in” vending machines to display cabinets, food service coolers and large supermarket rack and cold storage systems. The main ODS alternatives used include HFC-134a, and blends such as R-404A, R-407A and R-410A. The US is the largest importer of commercial refrigeration systems for Barbados, followed by China and Mexico. The US market has products in this category with low-GWP refrigerants (e.g., R290 and R600a) which can be an opportunity to make them available in the Barbados market. [45]

[45] U4E (2021). Supporting information on the Model Regulations for Commercial Refrigeration (https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-commercial-refrigeration-equipment/

Industrial

Industrial refrigeration in Barbados includes but is not limited to the production of beer and dairy-related products. There is also ice production to support the fishing industry. The main ODS alternatives used include HFC-134a, and blends such as R-404A, R-407A and R-410A.

Mobile/Transport

There are some refrigeration applications in the transport sector to support distribution of frozen foods such as meats, fish and dairy products. Once again, the main ODS alternatives used include HFC-134a, and refrigerant blends such as R-404A, R-407A and R-410.

Stationary Air Conditioning

Domestic air conditioning applications include the cooling of homes, rooms, small offices and other small spaces that house equipment requiring controlled atmospheric conditions. Commercial and industrial air conditioning involves systems used for cooling large buildings including those that house heat producing equipment (e.g. computers). The gases used may include HFC-134a, R-407C, R-410A, R-507A. It is important to note that R290 is being sold locally, which suggests that there may be R290 AC units installed in the country in addition to those already installed and utilised at the SJPI for training purposes.

Mobile Air Conditioning (MAC)

The MAC sector involves a wide range of vehicles such as cars; SUVs, 4x4s, trucks, larger passenger vehicles such as coaches, buses, maxi taxis and minibuses; and other vehicles used in transportation. The main refrigerant gas used in this MAC sector is HFC-134a. However, in recent years it has been observed by the NOU that some hybrid vehicles as well as electric vehicles e.g. vans donated by the MESBE under the Electric Vehicle (EV) pilot component of the Smart Energy project utilise HFO1234yf. Similarly, these observations have also been confirmed by reports from local MAC technicians.

4.4. Equipment Stock and Projections

The Market Assessment carried out under the Caribbean Cooling Initiative (CCOOL) in 2018 and 2019[46] found that many cooling appliances in Barbados are inefficient when compared to international baselines standards in place in some developed and developing countries. Additionally, the lack of mandatory Energy Efficiency (EE) performance standards for RAC equipment poses a risk that could

[46] Please refer to chapter 5 for details on methodology, results and analysis

result in the "dumping" of inefficient products no longer saleable in developed countries whose policies preclude them, or the import of inefficient equipment still being produced or sold in other developing countries with the same Montreal Protocol phase out and phase-down targets and have more relaxed policies.

Most households in Barbados have a refrigerator, but the majority do not have an AC. About 70% of commercial and public buildings have AC, with a similar percentage in the Accommodation sector (hotels, guest houses apartments etc.) The total value of the imported ACs market in 2018 was estimated to be BB$14 million. While the total value of the import market on refrigerators in 2018 was approximately BB$20 million[47].

Air Conditioning equipment is available in a variety of types, including simple split-systems for a single room to larger variable refrigerant flow systems, as well as solar thermal heating cooling units[48] and building-scale chilled water systems, among others. Wall-mounted mini-split systems have become the most popular selling units in Barbados due to the ease of installation, with non-inverter (fixed speed) systems predominant due to the lower purchase price and the lack of awareness by many purchasers on their potential higher life-time operational cost when compared to a more efficient inverter (variable speed) model. The Barbados HPMP National Survey Report from 2012 provides an estimation of the size of the local market in RAC units for the different sectors mentioned above as shown in Table 1 below.

Table 1. Service Quantity Requirements for HCFC Refrigerants in the Barbados Sector[49]

Application	No of Units	Total Charge of Units requiring servicing (Mt)	Quantity required for re-charge (Mt)	% total HCFC required for servicing
Commercial AC	122,741	110.78	30.39	68.1%
Commercial Refrigeration	504	27.22	13.61	30.5%
Industrial Refrigeration	18	8.19	0.420	0.9%
Residential AC	5,265	4.265	0.213	0.5%

[47] Barbados Imports of Air-conditioning units 2010-2018. Barbados Government Statistical Department
[48] Uses solar thermal heat to drive absorption or adsorption chillers for AC or other cooling purposes, is considered as a very promising technology for reducing the peak loads on power grids, especially in light of more and more AC units being installed and used. (CCREEE, 2019)
[49] National Ozone Unit, MENB 2012. Barbados HPMP National Survey Report

The objective of the study was to quantify the HCFC use across technologies, but the reported units provide a reference of the penetration trends of these technologies. One of the main key trends to highlight is the low penetration of ACs in the residential sector back in 2012. The import data gathered from 2010 to 2018 can shed light on the more recent trends in the national market.

There are no manufacturers of ACs or refrigerators on the island. Therefore, all equipment is imported. Equipment for domestic use is available from the various retail stores and can be purchased cash or using hire purchase terms. Commercial equipment can also be purchased from local retailers/contactors who import on request. Supplies are generally limited and many larger businesses such as hotels, malls, supermarkets etc. import directly from the manufacturers or suppliers.

Environmental conditions in Barbados are extremely hard on appliances, especially on the south and east coasts and many users complain that ACs rarely last more than 2 -3 years. One supplier indicated that they tried marine paint to prevent ACs from rusting while another indicated that they had tried a plastic casing. For this reason, many are continuing to use the cheaper units as the short lifetime will drive their purchase priorities to minimise the upfront cost of the equipment and overlook the operational cost. However, an alternative solution to mitigate this issue based on the interviews conducted, was that ACs with compressors installed behind parapet walls on the roof lasted longer than those that were exposed to the elements.

Domestic refrigerators are the most imported RAC equipment with an approximate number of 10 thousand units per year, they also represent the biggest value spent, as seen in Figure 7 and Figure 8 respectively. Commercial and Domestic Air Conditioners (reflected in Figure 7 and Figure 8 as “Room Air conditioners”) are also the second most imported in terms of units and third in terms of value. This could be a sign of an increase of ownership in the residential sector combined with the growing demand by the commercial sector, in which the hospitality sub-sector is a major player.

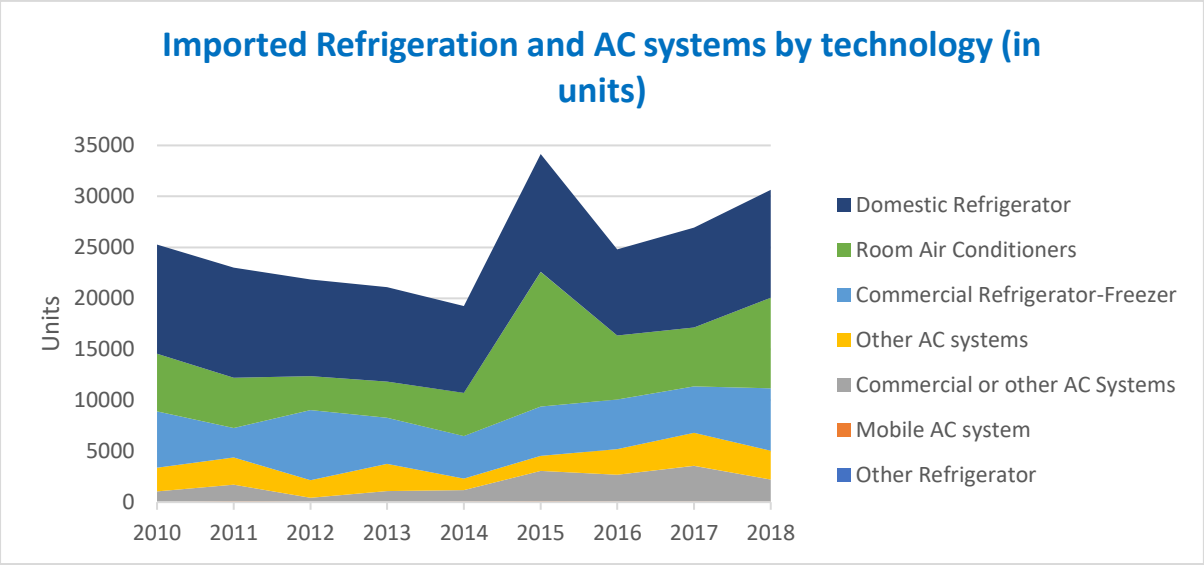

Figure 7. Imported RAC equipment units. Source: Barbados imports data 2018

Commercial refrigeration equipment in most cases have higher capacities than domestic and are more costly due to their complexity and robustness for a more intense use. These are in second place in terms of the import value and generally the hospitality sector, supermarkets and fresh produce suppliers are the main users.

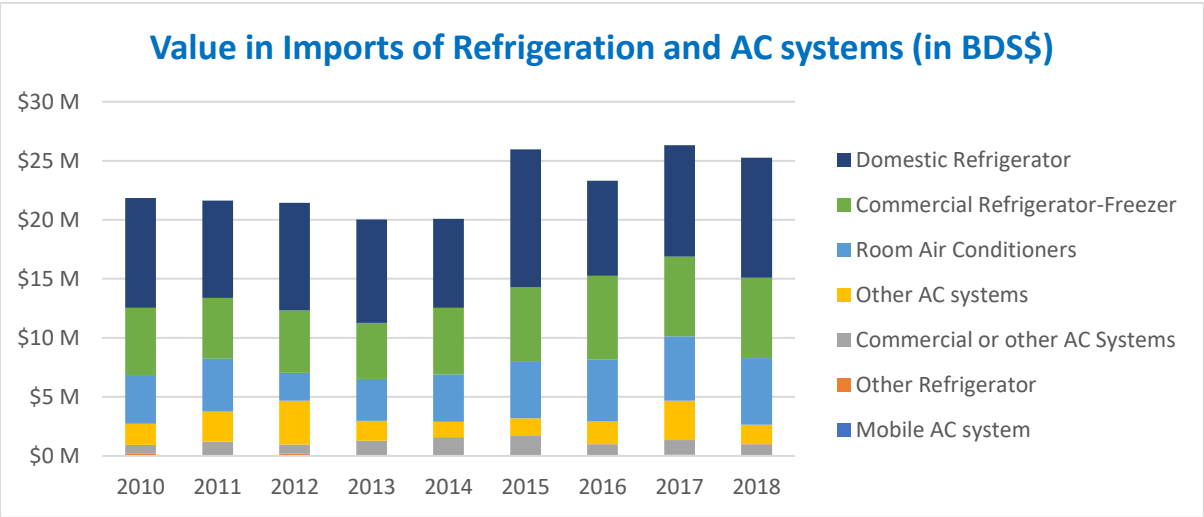

Figure 8. Value of RAC equipment imports by sector. Source: Barbados imports data 2018

4.5. Refrigerant's consumption

The Barbados HPMP National Survey Report presents a sectoral analysis of the demand for HCFC refrigerant. The sectors covered are: Industrial Refrigeration; Commercial Refrigeration; Commercial Air conditioning and Domestic Refrigeration. Results showed that the largest sector in terms of installed units and refrigerant demand is Commercial Air Conditioning which includes the hotels, public buildings and other businesses, as seen in Table 1 before.

The preliminary results of the 2020 ODS and HFC Survey show that the refrigerant imports mix in Barbados is dominated by R-410A followed by R134a. The low GWP and non-ODS refrigerants R-290 and HFC-32 are starting to penetrate the market, which shows market availability (Figure 9).

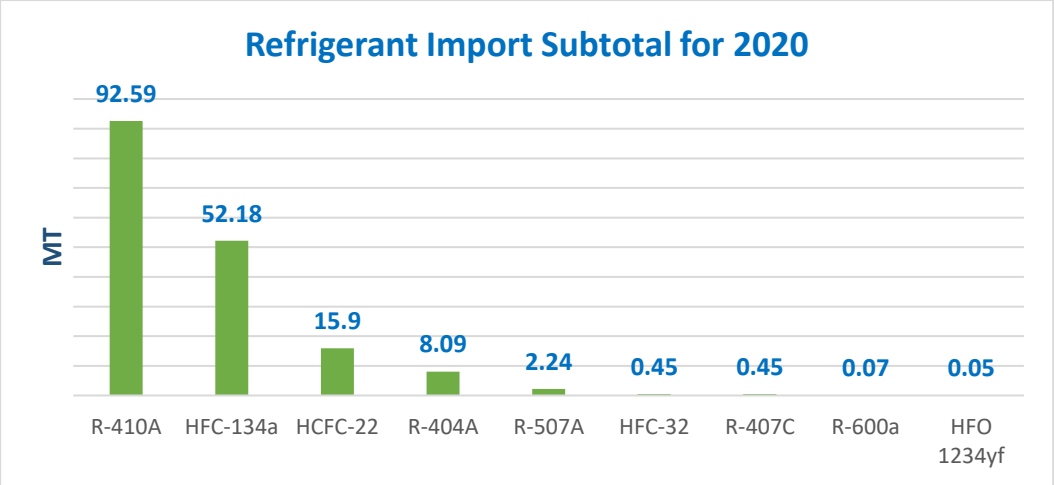

Figure 9. Data from the 2020 ODS and HFC Survey (Ozone Unit)

4.6.Commercial and Tourism Sector Findings

At the time of reporting, some of the larger commercial entities are replacing their A/C and refrigeration units with more energy efficient and ozone friendly options. Illustrative examples include:

- One of the food courts in a large suburban mall is fully air-conditioned by a natural gas chilled water system.
- A major supermarket chain has switched to ozone friendly refrigerant air conditioning and refrigeration systems and incorporated insulated roofing in its new building designs to reduce energy consumption. In July 2019, the organisation announced that it had switched to R-404A refrigerant gas for chillers in all new and refurbished stores and incorporated insulated roofing into its new building designs to decrease energy consumption. While R-404A has a low ozone depleting potential (ODP) it has high global warming potential (GWP). Information received from one supermarket chain on their cooling equipment revealed that R-404A accounts for a very small percentage and is only used the air-based chillers. The refrigerant gas mostly used in AC units is R-410A which has relatively high GWP and low ODP.
- A large regional Retail/Hire Purchase company embarked on a replacement of all inefficient equipment in their stores and buildings, and the company is transitioning

towards renewable energy where possible. They are currently working with IDB Invest to assist with this upgrade.

From the survey results (C-COOL 2018) on the demand side of AC systems i.e. equipment collected mainly in the hospitality sector, a total of 2454 single AC units re installed and have a total of 13367 kW of installed capacity. From these results it appears that commercial AC equipment R22 is still a dominating refrigerant gas in use in Barbados (Figure 10).

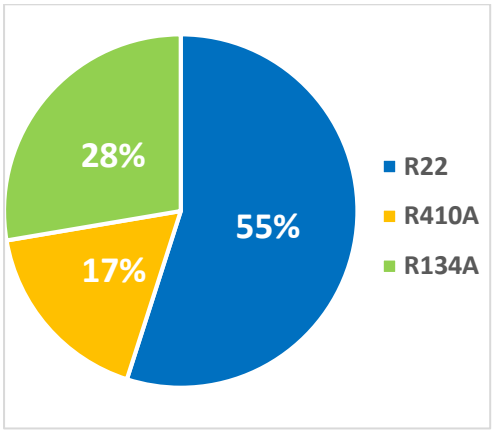

Figure 10. Mini-Split and Multi-Split Refrigerant Mix (C-COOL survey, 2018)

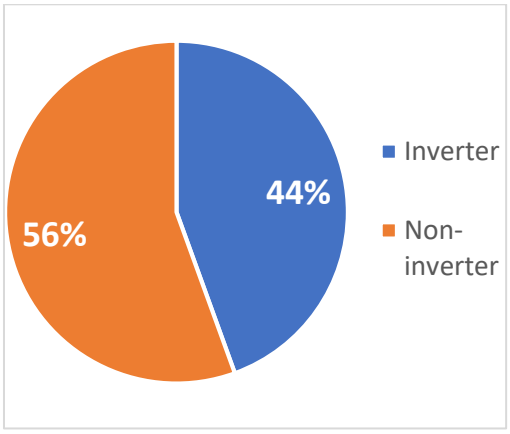

Figure 11: Mini-Split and Multi-Split Inverter share (C-COOL survey, 2018)

The sample analysed also shows that the share of installed AC equipment with variable speed (inverter) and fixed speed inverters is almost equal (Figure 11). This pattern will very likely change toward more variable speed inverter units with the acquisition of higher efficiency equipment and increased sensitisation among consumers.

The tourism sector in Barbados is the largest foreign exchange earner and accounts for 15% of the energy usage in the island. Cooling and refrigeration account for over 61% of the total energy bill of the hotels. The demand for air-conditioning is increasing and guests from the US and Canada require ACs that cool to extremely low temperatures (circa 15 degrees Celsius). The demand for in-room fridges is also increasing and more and more hotels are supplying them.

Hotels have indicated that they are extremely concerned about energy bills and most are very aware that cooling is the major cost. According to the survey results carried in 60 hotels, residences, condos and apartments, (and confirmed by the findings of the CHENACT Project) the portion of electricity usage from ACs in the electric bill is up to 50%. AC use in hotels during the high demand months can easily reach non-stop operation in some cases, as shown in Figure 12. This demand is mildly reduced during lower season months but not considerably.

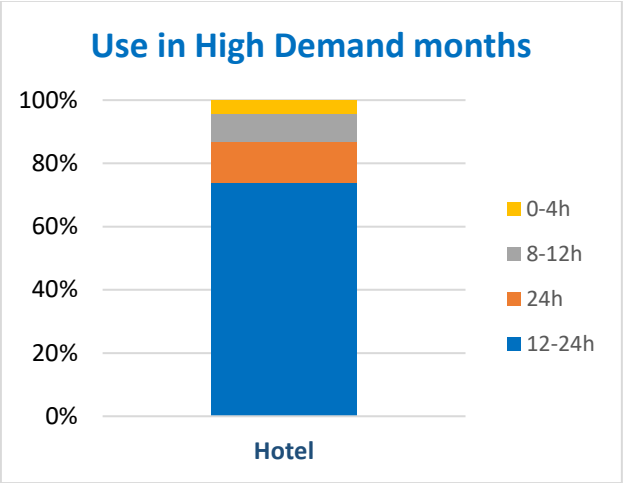

Figure 12: AC time use in Hotels (C-COOL survey, 2018)

Many have installed wireless control systems, i.e. devices which turn off the AC when motion is no longer detected in the room. However, many guests have found ways to circumvent the system and many hoteliers found that their energy bills increased. Many hotels service their ACs as they breakdown, but few have been able to do a complete replacement of systems on the property and consequently never really see the possible savings.

Inefficient AC equipment is often found in the hotels as in many cases the investment priority is only led by the upfront cost and there are no considerations given to efficiency or life cycle. In some cases, the choice of AC is also limited by what is available in the stores or at a supplier. Vendors are not always trained to understand the energy efficiency and life cycle operation costs, therefore their advice to hoteliers will not be in that direction. AC users that have switched over to inverter units are generally pleased with the results. Most report savings in energy usage. However, many have complained that parts are often unavailable and rather than wait for the parts to arrive they are forced to replace the entire unit. According to the data collected, the equipment age distribution shows that the largest capacity AC units installed in hotels is 7 years or older and more than 50% of it is non-inverter technology that is typically considered to be inefficient equipment.

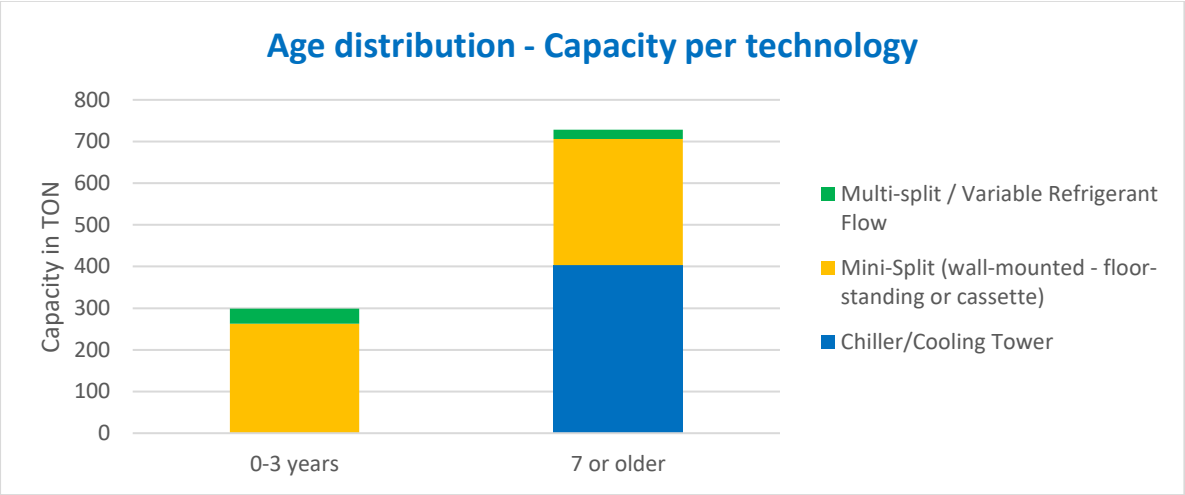

Figure 13: Installed Capacity by Age distribution (C-COOL survey, 2018)

Hoteliers are rarely technical experts in HVAC, and most rely on technicians and suppliers to advise them. Many are unaware about the differences between brands or technologies and usually go with whatever is the lowest price. Many also claim that they are forced to buy whatever is available if they need to replace an AC quickly as the suppliers do not always have their preferred brand. Most are aware of energy conservation benefits and try to encourage guests to maintain an AC setting upwards of 23°and refrigerator settings at "medium" or "normal". Most request guests and staff to turn off the ACs when not in use and to turn off the AC when the doors are open as energy saving measures.

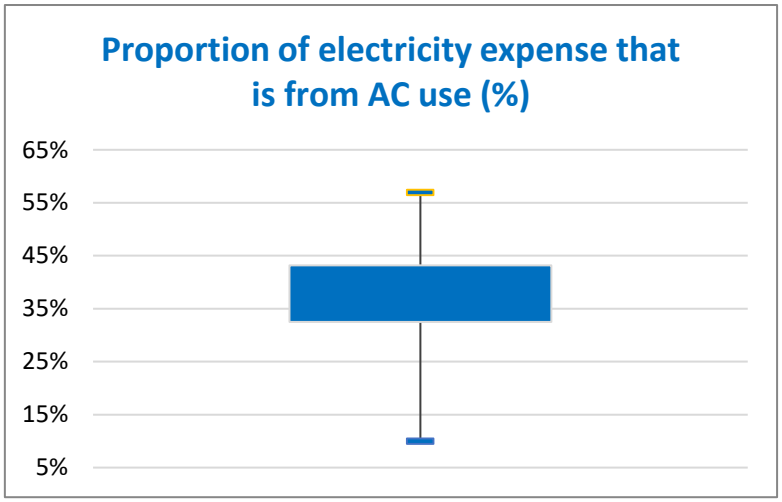

Figure 14. electricity use from ACs (C-COOL survey, 2018)

Due to the lack of knowledge about energy efficiency and appropriate financing mechanisms, for hotels in Barbados, there is a growing interest in Energy Service Companies (ESCOs) type investments or similar where an energy company will retrofit and deduct the re-payments out of the savings on the utility bill. Furthermore, few hotels (or any other businesses) have asset management

programmes where they document their electrical equipment. Consequently, programmes such as CCOOL experience great difficulties in obtaining correct information on the exact number, brand and models etc. of air-conditioning and refrigeration equipment in properties. As a result, it is highly recommended that businesses install Asset Management programmes to the track purchase, performance and replacement of electrical assets.

4.7.Domestic/Residential Findings

Domestic use of air conditioning systems has been increasing. Electricity consumption in Barbados' houses has increased in the last few years. Refrigerators was the largest consumer in 2015 Figure 15. Air conditioners which already had a considerable share continue to penetrate the market. Household ownership of refrigerator appliances has over 90% before the 2000s and by 2010 had increased by 2-3%.[50]

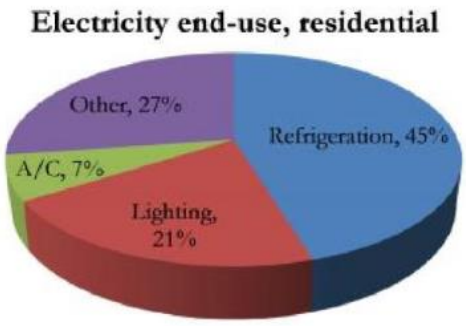

Figure 15. Electricity consumption by end use in the residential sector (2015)[51]

The domestic tourism market is growing and the main area of growth is in the Airbnb market (many of which are classified as "home stays"). There are over 3,000 listings in Barbados and that could account for up to 6,000 rooms most of which may be air conditioned. Appliances offered in the market have broadened, thus providing more options for consumers and wider ranges in price. This in turn has allowed more households to purchase an AC system, bigger refrigerators, or additional units, including dedicated freezers. In many cases the lower price tag products may improve access to

[50] CEPAL (2017). National Energy Efficiency Monitoring report of Barbados.
[51] BREA (2016). Consumer Guide Energy Efficiency

cooling services but in most cases the lowest values product are highly inefficient, and operational costs of the equipment can be a burden for the household income.

The government has launched several efforts to mitigate an uncontrolled increase in electricity demand and peak load by raising awareness on energy efficiency and conservation. Two such examples are the Public Sector Smart Energy Programme (PSSEP) and the Sustainable Energy Investment Programme (Energy Smart Fund) that promoted a shift to LED bulbs with a replacement programme and to energy efficiency appliances through a rebate programme targeting residential consumers.

4.8. Public Sector Findings

Based on the Air Conditioning audit done by MESBE in 2015 the government had installed a total of 429 units distributed in 39 buildings which included schools, Government offices, fire stations, the hospital and post offices.

The total installed capacity was at the time 6.2 million BTU/h or 1823 kW. The average efficiency of these units is 2.91 EER W/W and the maximum available 3.87 ERR W/W please refer to Figure 16 for a more detailed distribution of the efficiency rankings found. Considering a very conservative assumption of 2% efficiency increase per year in consistency with the U4E Country Savings Assessments Business as Usual Scenario[52] and servicing of AC units has remained stable. The average efficiency rate in 2020 can be estimated to be at least 3.22 EER W/W.

[52] U4E (2019) Country Savings Assessments Methodology and Assumptions. https://united4efficiency.org/wp-content/uploads/2019/10/U4E-Country-Savings-Assessments-2019-Methodology-and-Assumptions.pdf

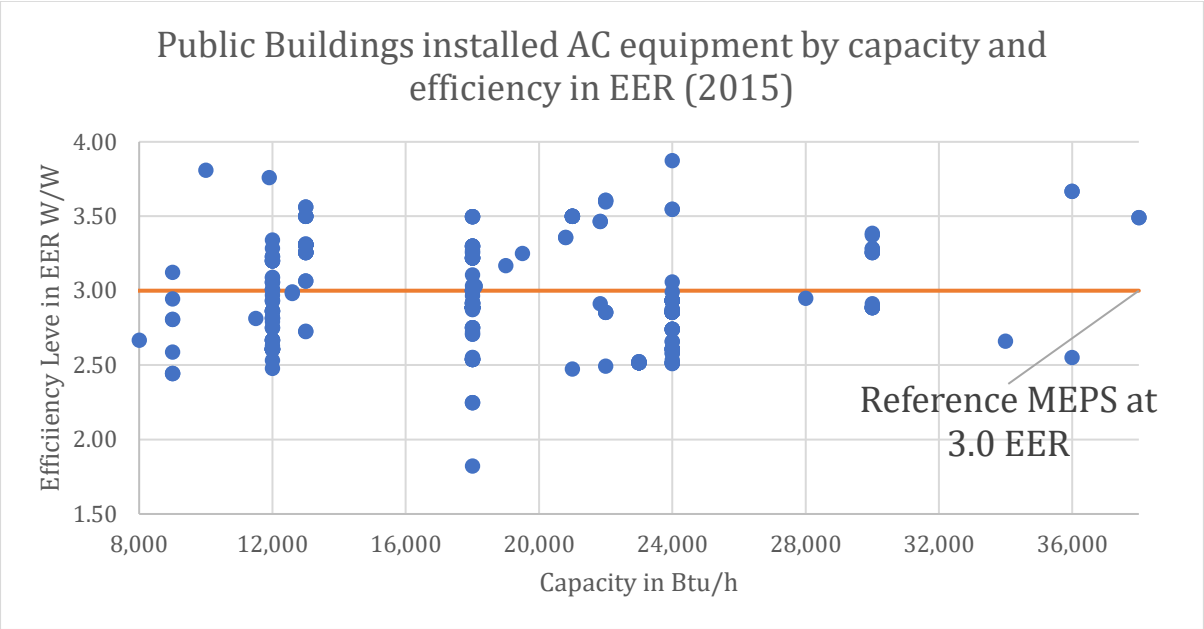

Figure 16. Efficiency in Public Building's AC units

The data showed that the predominant refrigerant in Public Buildings according to the 2015 assessment was R-22. See the figure below.

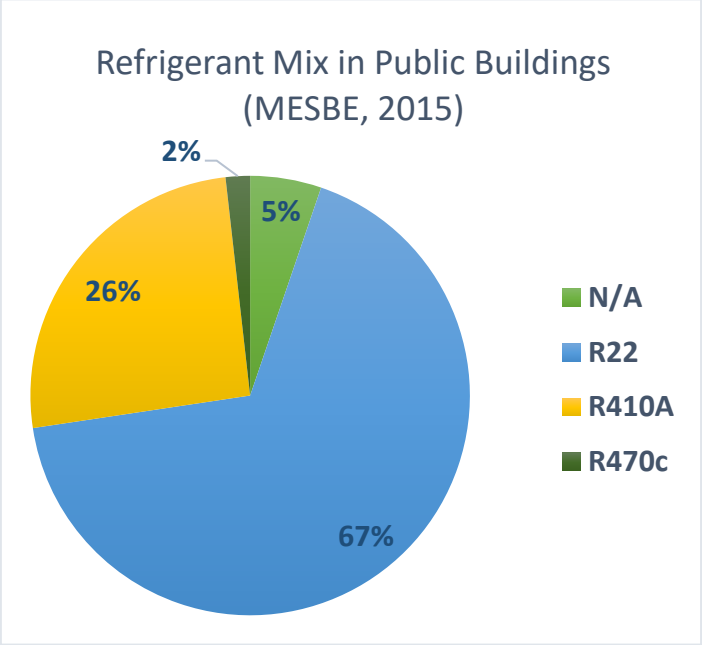

Figure 17. Refrigerants Share in Public Buildings (MESBE 2015)

4.9.Mobile Air Conditioning Sector

The mobile air-conditioning sector involves a range of vehicles such as cars; larger passenger vehicles such as coaches, maxi taxis and minibuses; and a wide range of other vehicles used in transportation. The number of vehicles registered in Barbados increased steadily from 94 thousand in 2007 to 117 thousand by 2017[53]. The growth in this sector is expected to increase the use of mobile air conditioning and the associated refrigerants. The main refrigerant gas used in this MAC sector is HFC-134a and the estimated annual consumption is presented in Table 2 below. However, with the advances made in vehicular AC technology, there is evidence that vehicles carrying HFO1234yf refrigerant are being imported into the island.

Table 2. Estimated Use of ODS Alternative HFC-134a in the MAC Sector (Mt)

Year	2012	2013	2014	2015	TOTAL
HFC-134a Used	9.37	8.79	7.76	6.6	**32.5**

4.10. RAC Equipment Supply Chain and Technology Providers

The RAC sector supply chain in Barbados is managed by the Customs and Excise Department, the Department of Commerce and Consumer Affairs and the NOU, MENB. Barbados does not manufacture refrigerants or RAC equipment presently. Therefore, all refrigerants and RAC equipment used in the country is imported.

On the retail side, importers typically retail the refrigerant and/or RAC equipment on the local market, sell to other retailers, and in some instances to neighbouring islands. Retailers of RAC equipment range from industry-specific suppliers, to the appliance and furniture stores; with no regulation of who can retail the equipment. All ODS and HFCs are subject to control under the Customs (List of Prohibited and Restricted Imports and Exports) Order 2009 and the Customs (List of Prohibited and Restricted Imports and Exports) (Amendment) Order 2020. According to the legislation, CFCs regardless of how they are packaged are listed as prohibited imports and exports. This means that equipment pre-charged with CFC are also prohibited. Under the legislation HCFCs and HFCs are listed as restricted

[53] Knoema (2017). Barbados number of vehicles registered, 2017. https://knoema.com/WHOGSRS2019Jan/global-status-report-on-road-safety-2018?country=1000070&indicator=1001670&frequency=A

imports and exports. Regulation goes a step further for HCFCs due to the national quota system that is in place and is reduced annually.

A well-organized supply chain seeks to match demand with supply and do so with the minimal inventory. Unfortunately, the market in Barbados is not so sophisticated and is too small for a perfect supply chain for example: shipping costs from Miami to Trinidad and Tobago are about 1/3 of what it costs to ship to Barbados although Barbados is geographically closer. The reason for this is that the market in Barbados is considerably smaller than Trinidad and Tobago and Barbados is also 100 miles off the chain of islands thereby costing the shipping companies more to sail to Barbados.

Table 3 refers to the categorisation of the importation of Air-conditioners and Refrigerators into Barbados in 2018. Equipment is broken down by window units, other ACs and parts. There is no breakdown by brand, model capacity etc. Country of origin is captured, however, in the case of Barbados this refers to the country from which the item is shipped and not the country of manufacture. Improving equipment information collection enables the quantity and characteristics of the various types of equipment including efficiency, refrigerant gases used as well as price points to be assessed more accurately. One of the recommendations from the project is that Barbados implements the Project Registration System to assist with this data capture. (See P 35 Annex F)

Table 3. Importation of ACs and Refrigeration into Barbados 2018

	CUSTOMS –A/C Imports	2018
1)	Window Or Wall Type Self-Contained Or Split-System Air Conditioning Machines.	5,640,140
2)	Other Air Conditioning Machines Incorporating A Refrigerating Unit.	642,205
3)	Other Air Conditioning Machines Not Incorporating A Refrigerating Unit.	1,009,265
4)	Part of A/C machines.	7,125,311
5)	Total value of the market	**14,416921**

	CUSTOMS CODE/Refrigeration Imports	2018
1)	Fridges all types	10,166, 902
2)	Freezers all types	6,816,615
3)	Others including heat pumps, compressors etc	1,511,739
4)	Part of Fridges/Freezers	1,772,976
5)	Total value of the market	**20,268,232**

Over 20 local suppliers/dealers and 35 technicians were contacted, by telephone, email and cold calls as part of the market assessment, with the vast majority indicating that they did not have the

information requested. It's a common practice for suppliers to order the equipment required for each specific project, and they maintain only small quantities of ACs and refrigerators. Many hotels import from overseas retailers or directly from suppliers.

Technology providers face significant challenges in selling energy efficient equipment since the price is initially higher and it is hard to gain trust with respect to promised future benefits (e.g. savings).

Barriers that hinder investments by clients in more energy-efficient equipment include:

- higher up-front costs relative to inefficient products;
- limited understanding of the benefits and perception that the risk of a new technology is too high;
- investment in greater efficiency competes with other opportunities that are perceived to have a better risk-return profile (e.g. more advertising);
- limited credit capacity or access to finance;
- lack of trust in the performance of new and unknown technologies; and
- lack of trust in after-sales services and provider's responsibility.

Most of the retail stores and suppliers hold small amounts of stock and mainly order on request. Hotels/ commercial buildings have complained that they cannot always get the refrigerator or AC of their choice and in some instances shipping can take up to eight (8) weeks from a major export market.

4.11. Overview of the Cold-Chain

The NCS addresses cooling in terms of cold chains (i.e. refrigeration) and thermal comfort (i.e. air conditioning). Dependable cold chains are essential to ensure that goods (e.g. a farmer's produce, a fisherman's catch, and a pharmaceutical company's medicines) can reach consumers without premature loss. Maintaining refrigeration at the appropriate temperatures for commodities, benefits producers, who reap more stable revenues and can access additional markets. In addition, consumers also benefit from more affordable and nutritious foods and medicines. Additionally, a robust cold chain is vital to enabling the consumption of healthy and safe food, particularly in terms of nutritional quality and keeping microbial counts at the lowest possible levels in accordance with local and/or international health standards.

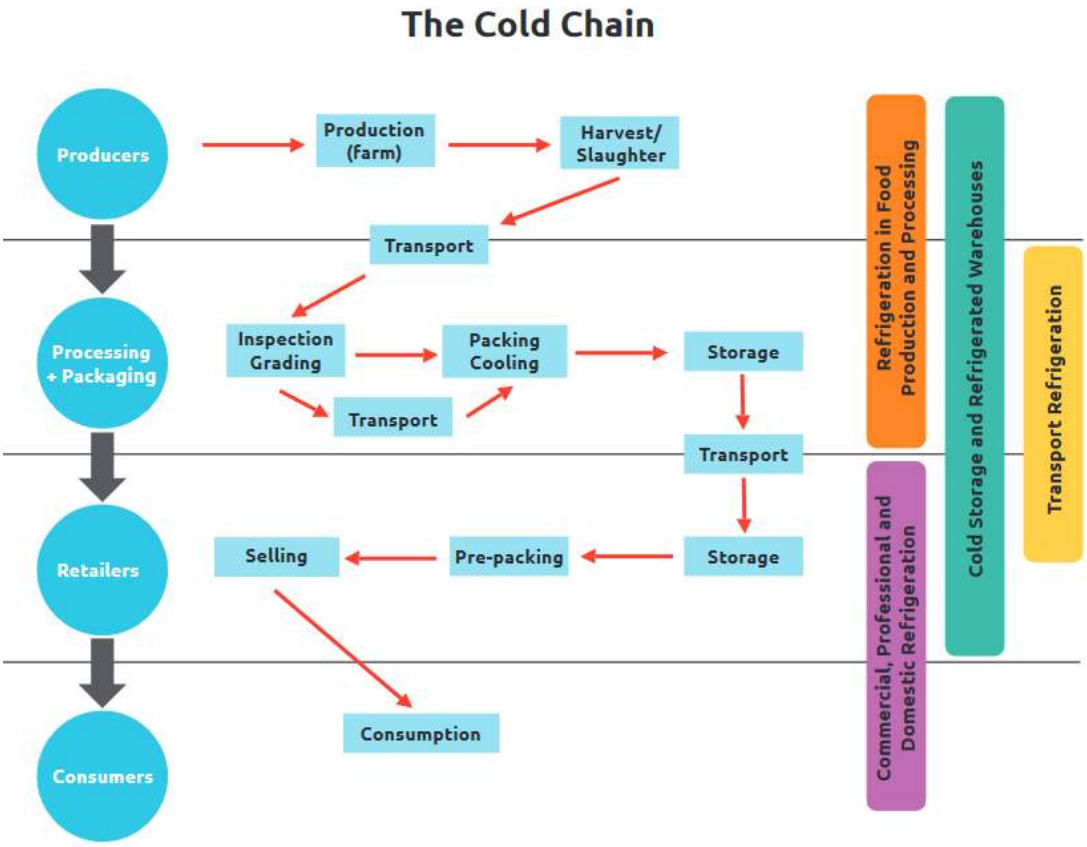

Figure 18. The Cold chain diagram by Judith Evans and IIR [54]

The cold-chain contributes to the economy and workforce by creating businesses and providing jobs e.g. refrigeration and air conditioning technicians, importers and retailers of refrigerant, truck drivers, warehouse staff, logistics coordinators, inventory clerks, packaging staff, forklift operators, just to name a few.[55] Improving the energy efficiency of equipment in warehouses and storage sites could typically yield energy savings of 30-40%.[56]

[54] UNEP OzonAction (2018). Cold Chain Technology Brief Transport Refrigeration https://wedocs.unep.org/bitstream/handle/20.500.11822/32571/8142Transpor_Ref_EN.pdf?sequence=1&isAllowed=y

[55] World Refrigeration Day 2020. Speech by Trevor Prescod, Minister of Environment and National Beautification. https://www.nationnews.com/nationnews/news/246336/cold-chain-sector-critical-role

[56] UNEP OzonAction (2017). Cold Chain Technology Brief Cold Storage and Refrigerated Warehouses. http://wedocs.unep.org/bitstream/handle/20.500.11822/26804/7939-CCRefWhouses.pdf?sequence=1&isAllowed=y

Fishing vessels and fisheries cold storages are an important component of the cold chain in Barbados. For vessel even if their primary use is to catch fish, they also have to provide adequate temperature conditions for the fish until its unloaded. There are over 1000 fishing vessels registered in Barbados and approximately 30 fish landing sites, categorized according to type of physical infrastructure and facilities as primary (markets), secondary (sheds) and tertiary (beaches). The majority of catches are landed at the primary sites and are often sold by the boat captain or owner directly to fish vendors (predominantly women), processors and consumers. The primary fish landing sites are at Bridgetown, Oistins, Consett Bay, Payne's Bay, Weston and Speightstown[57]. Fisheries complexes and markets are equipped with chill rooms (in some instances up to 5 tonne capacity)/ice storage rooms and flake ice machines respectively for the storage of fish, thus contributing to a reduction in wastage and spoilage.

Barbados has a modern efficient cold storage facility located at the Bridgetown port thereby facilitating receipt of goods directly to and from the cruise and cargo ships. 1 million cubic feet of chilled and frozen storage are available to farmers, florists, manufacturers, pharmacists or anyone requiring chilled or frozen storage space. There is a 50-50 ratio of chilled and frozen storage.

The facility is located within the port and has its own customs officers and health inspectors on-site. Produce and pharmaceuticals are brought directly from the ships into the facility and transported onwards to the distributors and retailers.

While the facility itself is HACCP certified, and the cold chain is intact until products leave the facility. Many products are transported using refrigerated trucks but there is evidence that some products are transported using open back trucks thereby breaking the cold chain. This seems to apply mainly to food produce that is imported for sale in the vendors' markets.

Other HACCP certified facilities, i.e. hotels, food processing businesses etc. are obliged to ensure that the chain is not broken and therefore must use refrigerated transportation.

4.12. Financial Sector

Financial institutions are also confronted with barriers when it comes to lending money for energy efficiency projects. First, there is a limited visibility of green investment opportunities. Financial institutions are typically not familiar with the return and risk profile linked to such investments and have no systematic evaluation and monitoring process in place to identify and track green

[57] FAO (2016). Fisheries and Aquaculture Profile Barbados. https://www.fao.org/fishery/en/facp/14/en

investments. In addition, it is complicated to finance small and medium-sized enterprises due to high collateral requirements.

The Commercial Banking sector in Barbados does not appear to fund Energy Efficiency Implementation as a stand-alone service. The Central Bank of Barbados has a Credit Guarantee scheme which has rarely been used as the commercial banks do not believe in lending to high-risk sectors. Hotels, for example are considered high risk and therefore few have been able to borrow to implement many of the recommendations made by the CHENACT Project. Small and medium size enterprises in the commercial and retail sectors are also considered high risk.

The Energy Smart Fund project (funded by the IDB), managed by the Energy Division in the MESBE and operated by the Enterprise Growth Fund Ltd (EGFL) was specifically set up for businesses to implement energy efficiency and renewable energy solutions. However, the uptake by hotels was lower than anticipated in the 1st phase of the Programme. This can be attributed to the fact that some hoteliers were already heavily indebted, some to loans with the EGFL through the Small Hotels Investment Fund also operated by EGFL. Notwithstanding, the second iteration of the Programme will have a renewed focus on small and medium enterprises as well as the hotel sector to which the hotel sector may access under Component 1 of the Programme.

Even if some large commercial banks have Energy Efficiency funds and Energy Efficiency trained staff, the preferred investment products are mostly related to lending for cars and mortgages. The credit unions provide loans to members to the tune of 3 ½ times their deposit but not specifically for energy efficiency and renewable energy.

4.13. Education and Capacity Building in the RAC Sector

The Samuel Jackman Prescod Institute of Technology (SJPI) offers a Diploma in Refrigeration and Air Conditioning with a curriculum updated in 2017. The programme consists of two parts with the aim to provide an understanding of the overall technology, the industry and develops technical competencies to install, operate and repair. The programme also helps to develop communication abilities and responsible attitudes to work.[58]

[58] Samuel Jackman Prescod's Programme Catalogue 2016-2017 http://sjpi.edu.bb/wp-content/uploads/2017/11/SJPI-PROGRAMME-CATALOGUE-2016-2017-061117.pdf

Recommended adjustments to the curriculum are submitted by instructors for review and approval by the Academic Board. It is not stipulated when a new formal revision will be made to the curriculum. Since the last formal update, recommendations for further updates to the curriculum have been made based on consultancies such as that undertaken through the Capacity Building Component of the implementation of Barbados' HPMP. Instructors have also been exposed to various capacity-building initiatives for exposure to emerging trends and information related to the RAC sector. In light of the ongoing Covid-19 situation the SJPI has transitioned to a blended teaching/learning approach which incorporates existing online theory and practical teaching resources.

The Barbados Vocational Training Board offers an Apprenticeship programme in RAC. This programme is designed to enable apprentices to acquire the competencies and skills required by a journeyman in the trade of Air-Conditioning and Refrigeration. Modules cover a wide array of topics and skills including the various types of refrigeration systems and how to install them. The Board works to ensure that its students are competent in the necessary skills in order to complete installations knowledgeably and safely.[59]

The Technical Vocational Education and Training Council has developed the Air Conditioning and Refrigeration Level II Caribbean Vocational Qualification (CVQ). While the curriculum consists of a comprehensive list of practical mandatory and elective modules that address Good RAC practices there are no specific modules on ozone and climate friendly and energy efficient refrigerants and refrigerant technologies. At the time of writing, the work required to establish assessment centres and to certify CVQ Level 4 Assessors as well as Internal and External verifiers remained to be completed.

The Refrigeration and Air Conditioning Association of Barbados has facilitated a number of professional training programmes of relevance to the sector over the years and several of its members have also participated in local training courses organised by the NOU, MENB on Good Practices in Refrigeration and air conditioning as well as on new and alternative refrigerants and refrigerant technologies. Staff members of the SJPI and members of the association have also participated in regional and international training sessions and seminars with the funding support provided by the ODS and HFC Management Programme, MENB.

[59] Barbados Technical and Vocational Board – AC and Refrigeration
https://bvtb.gov.bb/apprenticeship_programme/air_conditioning_and_refrigeration/

The German Development Agency (GIZ), the Government of Grenada and C-COOL initiative hosted a consortium for training institute experts from Barbados and other Caribbean countries to enhance regional collaboration. Such cooperation helps to facilitate an exchange of ideas and minimize duplication of effort across national institutions and the region as a whole.

Under the HPMP education and awareness component, activities have been expanded beyond coverage of ozone layer destruction and its effects to include a focus on areas such as: technical information, technology transfer, industry transformation and synergistic benefits of adaptation of alternative technologies.

5. Implementation Strategies

There are numerous approaches and opportunities to address cooling demand through energy conservation, energy efficiency, and alternative refrigerants and refrigerant technologies with lower global warming potentials (GWPs). Better building energy codes, minimum energy performance standards, energy labels, use of ozone and climate friendly refrigerants, design practices, operations and maintenance, and awareness constitute the primary areas on which the Government of Barbados should focus in order to comprehensively transform the cooling market in Barbados. This section includes a core set of recommendations that are presented as a basis for additional actions to implement the National Cooling Strategy for the RAC sector towards meeting the transition to the use of ozone and climate friendly and energy efficient refrigerants and refrigerant technologies and relevant national environmental and sustainability goals and objectives. This list is not exhaustive, but rather defines the principal areas of focus that merit further pursuit and elaboration.

5.1. Refrigeration and Air Conditioning Sector Market Assessment

A RAC Market Assessment is a critical tool that provides the data/information necessary to responsibly drive market adoption of ozone and climate friendly and energy efficient cooling products. These assessments pinpoint which refrigerants and RAC technologies exist on the ground at the time and assist policy makers and other stakeholders to identify which technologies may be best suited to the Barbados context. The information gleaned from the Market Assessment would also serve to develop and/or refine national policies, regulations and institutional frameworks to effect the transition to ozone and climate friendly and energy efficient RAC technologies and improved management and modernisation of the RAC sector.

Importantly, Barbados does not manufacture refrigerants or RAC equipment, therefore, to successfully chart the way forward for the increased uptake of the preferred technologies in the local

RAC market, it is essential that international market availability and international market trends also be assessed as these will impact the rate of uptake. Taking this into account, the country may also have to consider taking the approach to utilise a combination of lower GWP alternative refrigerants and refrigerant technologies with the ozone and climate friendly and energy efficient alternatives and assess the benefits and barriers to such an approach before making a decision. Considering this and the HFC phase-down schedule, taking an integrated approach to the selection of RAC equipment for the various applications will foster opportunities to fill equipment availability gaps and improve energy efficiency.

Strategic Measure 1. In view of the limitations encountered with data collection in the preparation of this document, it is recommended that an updated market assessment be conducted to identify the quantity and types of refrigerants and RAC equipment in use in all sectors of the economy and maintain an inventory. The assessment should also include a detailed review of the estimated costs of alternatives and the estimated cost implications associated with conversions and switching preferred alternatives for the various RAC applications. Data that was not obtained from the agriculture, fisheries, telecommunications and manufacturing sectors etc. should be included in the subsequent assessment.

Strategic Measure 2. Stipulate as appropriate and promote the selection of ozone and climate friendly and energy efficient refrigerants and RAC equipment for available applications for new installations or at the time of replacement. Where ozone and climate friendly and energy efficient cooling products are unavailable on the local or international market, lower GWP alternatives should be utilised.

Strategic Measure 3. Facilitate the increased market penetration and uptake of ozone and climate friendly and energy efficient RAC technologies through the introduction of incentives as feasible and appropriate.

5.2. Building Energy Codes and High-Performance Building Design to Reduce Cooling Demand

There are numerous opportunities to reduce cooling needs in Barbados. Some architects and builders are using green building practices that save their clients over the long-term operational costs of ownership or leasing since they consume less energy. Adopting and enforcing robust building energy codes for residences and commercial/public buildings will facilitate widespread use of these practices, which should apply to both new construction and major retrofits. The Global Alliance for Buildings and Construction identifies codes as one of the primary opportunities for climate change mitigation and improved energy efficiency in buildings.

The importance of building codes is grounded in the fact that the inherent energy demands of a building are established during the construction phase. Further, the implementation of an energy-efficient building envelope typically represents a marginal increase in the overall construction cost during the construction phase, when compared to standard construction materials and practices. In contrast, changes to the building envelope post-construction are typically unattractive from an owner's cost-benefit point of view, due to the high refurbishment costs. As a result, such upgrades tend to be delayed until major building renovations are accomplished as part of wider objectives for the building (e.g. modernizing the style or the purpose of the space).

Strategic Measure 1. Update the existing Barbados National Building Code to incorporate energy efficiency and ozone and climate friendly refrigerants and clean energy considerations into building design (i.e. commercial, home etc.). a review of the building codes to include the best materials to be used for building and construction projects and insulation standards, under policy measures 57a and 58a. [60] The updates on the Building Code can build on the CARICOM Regional Energy Efficiency Building Code (CREEBC), which includes MEPS for equipment in commercial buildings, building insulation properties and efficient control technologies. The test procedures and MEPS level should be analysed with a view to homogenizing with international standards. Refer to the Energy Efficiency Guidelines for Office Buildings in Tropical Climates for additional information.

Strategic Measure 2. Implement a mandatory Barbados National Building Code that includes Minimum Energy Efficiency Standards (MEES), green considerations in municipal buildings and in all new construction to begin to bring about the shift towards clean and green and energy efficient building practices

Strategic Measure 3. Adopt practical MEPS, MEES and Energy Labels for RAC equipment that can help to propel the government's efforts to reach 100% renewable and carbon neutrality by 2030. **Please refer to Annex A** for examples of the proposed MEPS.

Strategic Measure 4. Adopt a sustainable Public Procurement Programme for a priority cooling product to showcase the energy savings in buildings and accelerate the uptake of efficient and climate-friendly technology and enhance competitiveness.

[60] Implementation Plan for the BNEP https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030 P29

Strategic Measure 5. Adopt the introduction of EE building standards (codes) for all Government housing and building projects in the first instance.

Strategic Measure 6. Enhance through policies the minimum energy performance and high energy performance in buildings and their components and systems to aim for a net-zero consumption.

Strategic Measure 7 Promote and require, if feasible, public display of building performance through a labelling system. This will improve decision-making, including labels, certificates and public disclosure of energy consumption for selected buildings.

Strategic Measure 8. Promote greater collaboration between architects, RAC technicians and engineers during the design, planning process and/or construction phase to ensure that HVAC/RAC systems selection (i.e. size, refrigerant energy efficiency etc.), placement and installation are adequately considered and adopted.

5.3.Implementation of Public Procurement Measures

The Government of Barbados is committed to meeting its obligations under the Montreal Protocol and is championing sustainability, environmental and climate change issues. Therefore, in order to be successful, it is recognised that the government must not only utilise a multidisciplinary and holistic approach, but it must lead by example. Further, as the third largest consumer of electricity in the country and a significant end-user of RAC products, making the switch to ozone and climate friendly and energy efficient cooling products where feasible will contribute significantly to reducing energy demands, demonstrating in a practical way the Government's commitment to stated national objectives for a more energy efficient, clean and green economy, result in significant savings in terms of energy costs.

Within the public sector, new RAC equipment is purchased or donated for new construction projects as well as for renovation projects. Additionally, the Government also occasionally receives donations of AC equipment from the governments of other countries, which are either used to replace older inefficient equipment or equipment that has reached end of life at government facilities or that can be installed in existing buildings which did not have AC previously.

When selecting RAC equipment for purchase or giving consideration to the acceptance of gifts of RAC equipment, procurement officers and relevant officers responsible for making purchasing decisions as well as government officials making the decisions on the acceptance of donations from other countries must be mindful of the impact of purchasing and or accepting equipment that may reverse the energy efficiency and environmental gains achieved in other areas. While it is understood that thermal

comfort, availability, noise level, price and other non-environmental and non-energy factors will instinctively constitute the most significant influence on selection decisions, there must be a pervasive shift in thinking to consider environmental and energy efficiency and energy conservation first, etc. if any meaningful change is to occur.

Additionally, there is also the need to ensure that inefficient equipment that is replaced as part of government projects is not sold or given to individuals or businesses to be installed at other premises as this not only reverses any cost savings, energy efficiency and environmental gains attained thereunder but also sends mixed messages to the public and could potentially derail and/or undermine efforts to get stakeholders and the wider public on board with transforming the way energy and RAC is viewed and utilised.

Strategic Measure 1. Promote energy efficiency by mandating it in tendering and public sector procurement processes for RAC equipment (selection, installation and maintenance) for state owned buildings in either new building construction and the retrofitting, replacement of existing buildings to reduce emissions of GHGs, energy consumption and cooling demand.

Strategic Measure 2. Adopt a sustainable Public Procurement Policy/Programme for priority cooling products to support accelerated uptake of efficient and climate-friendly technology. Cost savings can be redirected to other areas of the public service that require funding, and this approach delivers clear messaging to stakeholders and the wider public that may engender greater buy-in and support.

Strategic Measure 3. Implement policies and procedures/protocol that include MEPS, mandatory and/or voluntary labelling prior notification of product import/export, verification of product conformity mechanisms be applied to all import of appliances and effectively implemented. These measures will help to guard against the importation of cooling products that are inefficient and not environmentally friendly. These policies would apply to new, old, repaired, second hand, refurbished cooling appliances and any such manufactured or reconditioned second hand appliances.

Strategic Measure 4. Ensure that sustainable education and awareness programmes are in place to promote the widespread adoption of environmental and energy efficiency goals for RAC equipment. Adequate education and awareness can also help to alleviate frustrations with procurement processes and may promote more of a willingness to comply if the purpose, process and goals are clearly articulated.

5.4. Cold-Chain Enhancements

Lacking or deficient cold chain infrastructure is not uncommon in many countries. As a result, tonnes of produce go to waste as they are not stored and transported in favourable thermal conditions. Besides the economic impact it also contributes to climate change related emissions as almost 15% of food related $CO_{2equivalent}$ emissions comes from losses in food supply chains and indirectly due to the electricity wasted.[61] The World Health Organization estimates that up to 50% of vaccines are wasted globally every year in large part because of the missing link of temperature control due to logistics or lack of infrastructure.[62]

Reduced food loss and waste brought about by consumer behaviour change, improved cold chains logistics and practices, and agricultural practices also presents an impactful opportunity for the reduction of food waste, monetary and greenhouse gas emissions savings.[63]

Ensuring a comprehensive cold chain using energy-efficient and climate-friendly cooling solutions is key to reducing the loss of value, improve market competitiveness and ensure essential goods to reach the population.

Strengthening the Barbadian cold-chain brings an opportunity to progress in the achievement of the sustainable development goals. It will increase incomes for farmers and fishers (SDG1) improving their access to markets and reducing post-harvest losses. Amidst the COVID-19 pandemic and other threats that require inoculation countries are preparing to ensure universal, effective and safe access to vaccines and medicines that are necessary to ensure healthy lives and promote well-being (SDG3).

Hazard Analysis and Critical Control Point (HACCP) is an internationally recognized system for reducing the risk of safety hazards in food within the cold chain. A HACCP System requires that potential hazards are identified and controlled at specific points in the process. This includes biological, chemical or physical hazards. Any company involved in the manufacturing, processing or handling of food products can use HACCP to minimize or eliminate food safety hazards in their product. One of the major requirements of a HACCP system is proper cold storage. All hotels in Barbados, which operate with the European Federation of Tour Operators are required to install HACCP systems in the hotels and are required to purchase from HACCP certified businesses and most food processing companies and

[61] UNEP, 2020. Why optimized cold-chains could save a billion COVID vaccines.
[62] WHO, 2018. Monitoring vaccine wastage at country level
[63] UNEP and IEA, Cooling Synthesis Report, 2020.

the hospitals are HACCP certified. The existence of this system in critical areas helps to minimise spoilage and food waste in the country.

It is recommended that policy and regulatory assessment, awareness and capacity building, and technology upgrades be considered to ensure an enhanced food chain.

Strategic Measure 1. Conduct an assessment of cold chains nationally with the aim of determining the amount of food, commodities, blood, flowers etc. lost due to spoilage and waste and the associated costs to businesses and the country overall

Strategic Measure 2: Adopt regulatory, legal and voluntary measures to support the use of low-carbon and energy-efficient technology in the cold chain and ensuring the compliance with national standards for minimum energy efficiency and ozone and climate friendly refrigerants.

Strategic Measure 3. Foster awareness, knowledge and capacity in the use of energy-efficient, ozone and climate-friendly and safe refrigeration alternatives in the food cold chain. This includes monitoring and analysing the efficiency and carbon impact of each link in the cold chain and identifying high-potential areas for improvement.

Strategic Measure 4. Implement policy/regulatory measures to ensure adequate logistics and traceability are a pathway to control the quality of a cold chain from the input to the output.

Strategic Measure 5: Adopt incentives to improve the capacity of temperature-controlled warehouses for fisheries and farmers considering energy efficient and ozone and climate friendly equipment.

5.5.Education, Training and Capacity Building

As technology changes, MAC and RAC technicians need to update their skills and learn how to safely and properly install and maintain the new RAC technologies. Technicians are sometimes trained with a focus on servicing and repairing malfunctioning equipment. Optimizing energy efficiency may not be fully considered in training and daily practice.

Strategic Measure 1: Conduct updates as appropriate of the Technical training curricula of the SJPI, BVTB, TVET Council and the NOU, MENB as appropriate to include good RAC practices including recovery, reclamation, recycling, safe handling, disposal and operational considerations for the chemicals stipulated in the Kigali Amendment to the Montreal Protocol that are used as refrigerants as well as natural refrigerants, that are not already covered in the curriculum and that are primarily imported into Barbados.

Strategic Measure 2. Develop a training programme for government officials on administering MEPS, MEES and MVE to address the considerations of cooling products as appropriate.

Strategic Measure 3. Develop and deliver a training programme for retailers and end-users (e.g. public facilities, hotels) on product eligibility, installation, safety, registration, procurement modalities, accounting, financial assessments and vendor risk assessment.

Strategic Measure 4. Enhance the energy audit protocol to include the collection of data specific to each electrical item on property. This is particularly important for the A/C and refrigeration equipment.

Strategic Measure 5. Provide Support to the TVET Council as appropriate for the implementation and promotion of the Air Conditioning and Refrigeration CVQ Level II and CVQ Level IV Assessor programmes as well as the establishment of relevant Assessment Centres.

Strategic Measure 6: Continue routine training of MAC and RAC technicians on Good RAC practices and new and alternative refrigerants and refrigerant technologies as well as introduce EE training with the traditional mix of both theoretical and practical components. Additionally, consider using a mix of physical equipment such as AC test banks with energy monitoring equipment to demonstrate teachings in a practical way, with supplements through online coursework and hands-on field experiences as appropriate and where possible.

5.6. Development and Implementation of Demonstration Projects for the RAC sector

Demonstration projects are practical ways of promoting innovations and capturing and disseminating best practice through the development and analysis of live projects. Such projects assist with building a local evidence base to test and support industry improvements. Over the years, Barbados has successfully implemented a number projects that involve capacity building, public awareness, development of policy, regulatory and legislative frameworks in relation to the RAC sector. Against this backdrop, as the country moves forward with the preparation for Stage II of the HPMP, the future development of HFC phase down management plans, implementation of National Energy Policy and related projects, at the time of writing the country is in a good position to develop and execute demonstration projects for the RAC sector that would assist in further promoting the deployment of ozone and climate friendly and energy efficient refrigerants and refrigerant technologies.

Further, such projects are important to showing the technical feasibility and viability of utilising the preferred modern refrigerant technologies in the RAC sector (domestic, commercial, industrial, mobile) to build practical experience and confidence among technicians and end-users and as a result

may positively contribute to increasing the rate of uptake of these technologies across the various industries and sectors and by extension the country.

Strategic Measure 1. Identify and develop Demonstration pilot project opportunities in collaboration with regional and/or international partners to execute in government buildings e.g. fisheries complexes, storage facilities, government offices, care facilities, medical facilities, blood banks etc., qualifying businesses in the commercial sector, hotel industry etc. as appropriate

Strategic Measure 2. Execute education and awareness initiatives to sensitise stakeholders and the wider public about the outcomes of the projects, promote energy and cost savings etc.

Strategic Measure 3. Replicate the successful outcomes of the pilot projects across the relevant sectors where possible and appropriate.

5.7. Awareness Raising and Communications

The Government of Barbados has successfully implemented a number of public education and awareness campaigns over the years. Though the information is sound, useful and reliable, the lack of human and financial resources has impacted the government's ability to communicate these messages on a consistent basis, over the long term and to a wider audience as required.

While the local industry players are largely aware of energy efficient cooling solutions, it is unknown generally what the level of understanding is among end user/consumers and the wider public concerning information related to lifetime cost of ownership savings of more energy efficient products, and what percentage of the public that is aware is applying this in their decision making when purchasing RAC equipment. There is some anecdotal information, which suggests that generally consumers prioritise choosing RAC equipment based on up-front cost, availability and style with energy efficiency possibly being a later consideration. Therefore, there will be a greater need for education and awareness raising initiatives to help consumers to better understand how to interpret energy cost savings, product energy labels and how to tap into incentives or other promotional offerings etc. Once consumers are made aware of the benefits and their role in helping to solve a problem, they typically make the preferred choice in relation to purchases. Information for developing consumer awareness campaigns can be leveraged by engaging with stakeholders from civil society. Consumer awareness on energy conservation, environmental sustainability and proper utilisation of cooling services is key for effectively securing energy savings and achieving environmental gains.

Moreover, from an administrative standpoint, industry will also need to be sufficiently sensitised to be able to understand MVE requirements for labelling etc. and how to comply and participate in incentive programmes or promotions that may be available.

Importantly, consumers that are more aware, oftentimes help to advance change by not only consciously selecting preferred products and/or by demanding better products, but they can also demand that more environmentally responsible practices be employed in their immediate sphere e.g. in their homes and businesses. Therefore, mass awareness campaigns over a long period of time can change consumer/end user behaviour, and lead to realisation that regular and proper maintenance is important.

Strategic Measure 1. The MENB and Ministry of Energy and Business Development as well as relevant stakeholders (e.g. Barbados Light & Power Co. Ltd., Barbados Chamber of Commerce and Industry (BCCI), Barbados Hotel and Tourism Association, (BHTA) The Barbados Manufacturers Association (BMA), The Small Business Association (SBA), The Barbados Renewable Energy Association (BREA) and consumer groups etc.) should work together as appropriate to develop joint/collaborative education and awareness initiatives as it relates to RAC equipment in order to capitalise on synergies, reduce duplication of effort, support continuity of messages and share associated costs.

Strategic Measure 2. Develop a dedicated communications and outreach strategy geared toward informing the industry about compliance with policy updates such as minimum energy performance standards, appropriate product labelling etc. and preparing stakeholders for the changes, enhancing consumer awareness about the requirements and their benefits etc.

Strategic Measure 3. Implement a mass educational campaign to promote the selection of efficient cooling equipment to raise awareness. This can be achieved through appropriate product labelling, and the government and industry's collaboration on awareness campaigns.

Strategic Measure 4. Engage with the tourism sector to foster the development of educational programmes for their guests to emphasise the importance of energy efficiency and environmental conservation and make the information available on the hotels' websites.

Strategic Measure 5. Promote awareness to sensitize both the construction community as well as end-users about the multiple benefits of efficient buildings and the importance of the regular servicing of equipment and the employment of good RAC practices by technicians working on their equipment e.g. reduced operational costs, health and comfort, environmental and societal benefits.

Strategic Measure 6. Encourage the business sector to install Asset Management programmes, if not already in place, as an added measure to ensure that data verification on RAC equipment is readily available to facilitate decision-making. Businesses can be sensitised to the fact that Asset Management programmes contribute to better management, maximisation of equipment lifespan, expenditure control and cost savings.[64]

5.8. Alternative Cooling Technologies and Solutions

Alternative cooling technologies should be explored, particularly those that may have synergies with the planned expansion of renewable energy in the country. Tariffs that favour shifting electricity loads from on-peak to off-peak hours (i.e. Time of Use tariff) are currently being tested by the BL&P. This type of pricing scheme is expected to be a key component for the highly ambitious renewable energy targets of the government, as they facilitate matching production to demand. Some of the alternative technologies may include energy storage for users with large and regular cooling requirements, such as the food processing industry (particularly dairy), data centres, etc.

The current Time of Use pilot tariff from BL&P currently charges BBD 0.219 per kWh during on-peak and BB$ 0.062 per kWh during off-peak tariffs. This price difference offers a good incentive for such users. It allows the economical production and storage of cooling energy (either in the form of chilled water tanks or ice banks) during off-peak hours for its use during on-peak hours.

Other alternative cooling technologies may include absorption chillers. These chillers use waste heat from either industrial processes (such as sugarcane bagasse cogeneration) or excess heat from Domestic Hot Water (DHW) solar collectors. These technologies allow for an alternative utilization of energy resources to reduce cooling demands in the electricity grid; however, they do not benefit from the Time of Use tariff as they use other energy sources. Incentive schemes to support cooling technologies from alternative energy sources will therefore address the attractiveness gap of such investments.

Solar thermal energy for air conditioning is another potential area of growth if the appropriate incentives are implemented. Uptake and implementation of international environmental tourism and sustainability standards could lead to a greater focus on renewable energy and energy efficiency standards across the sector. Many hotels in the region are “Green” and have been since the 1990s.

[64] https://smallbusiness.chron.com/purpose-asset-management-program-46436.html

Over 70% of the hotels in Barbados received full or partial energy audits between 2010 and 2018. Significant improvements were seen in areas such as lighting, air-conditioning, pool pumps and some installed PV systems. It is imperative to include a focus on refrigeration, air conditioning, and the refrigerants used in the equipment given its outsized impact.

Nature-based and passive technology solutions can be implemented at domestic to industrial or city scales. These range from traditional or indigenous low-tech to modern high-tech solutions. Some of the most effective low-tech solutions include nature-based solutions such as flowing water and ponds, shade trees, plants, soil sinks to passive technologies such as insulated windows, green roofs and reflective roofs and walls etc. These measures can help to increase the reliability of cooling and increase safety for vulnerable populations in extreme weather events. [65]

Strategic Measure 1. Implement a targeted energy storage promotion plan for large cooling users to ensure and optimise usage of the Time of Use pilot tariff from BL&P.

Strategic Measure 2. Develop an incentive scheme that promotes cooling technologies from alternative energy sources.

Strategic Measure 3. Foster the consideration or inclusion of Nature-based and passive technologies in building and residences renovations and new constructions. Engage with technology suppliers to organise showcase events focused on alternative and environmental solutions they can offer to the market.

Strategic Measure 4. Conduct a feasibility study regarding the use of alternative or not-in-kind technologies like District Cooling as an alternative to high GWP, low energy efficient technologies taking into consideration the outcomes of other national and regional discussions and studies on this issue.

Strategic Measure 5. Promote the consideration of alternative delivery mechanisms in the feasibility studies for large construction projects or retrofits. District cooling opens the possibility to use more efficient technologies (e.g. centrifugal chillers) and system configurations (e.g. using seawater either as a heat sink for conventional chillers or direct cooling source). In both cases, the additional infrastructure costs and complexity of the system are typically only viable for large cooling installations that serve multiple clients such as hotel complexes, housing developments etc.

[65] SEforALL, 2020. Chilling Prospects. https://www.seforall.org/system/files/2020-07/CP-2020-SEforALL.pdf

5.9. Enhanced Refrigerator and AC Requirements to Unlock Additional Energy Savings and GHG Reductions

Well-defined and enforced standards and labels are fundamental for transforming the Barbados market for cooling products and a move to implement standards and labels for the RAC sector links directly to policy measure # 53a from the Implementation Plan for the BNEP "Create EE standards for appliances and equipment used for residential, commercial and industrial purposes".[66] The Caribbean region has started the process of adopting mandatory minimum energy performance standards (MEPS) and energy labels based on the CARICOM Energy Efficiency regional standards, CRS57:2018 - Requirements for Energy Labelling for Refrigerant Appliances and CRS59:2019 –Requirements for Energy Labelling Air Conditioners.

Annex A. contains more stringent efficiency requirements, refrigerant gas GWP limits, and test metrics aligned with the U4E *Model Regulation Guidelines*[67] that can drive greater energy and environmental impacts for target market segments. For example, these recommendations could be used in a future sustainable public procurement program that aims to pull high performance products into the market, similar to the way in which the United States of America and Canada use the Energy Star rating as a basis for procuring certain covered product. Additionally, they can also be utilised as criteria for superior products to qualify for optional incentive programmes; and/or as a voluntary approach for an interested market segment that wishes to go beyond baseline MEPS requirements, (e.g. Sustainable Public Procurement Programme or hotels that wish to demonstrate their leadership on sustainable cooling).

Strategic Measure 1. Set MEPS and labelling requirements that will positively impact the cost to own and operate cooling appliances and equipment, including Room Air Conditioners, Domestic Refrigerators and Commercial Refrigeration equipment.

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[66] The implementation Plan for the BNEP P29 https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030

[67] Available for Air Conditioners at: https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners and available for Refrigerating Appliances at: https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-refrigerating-appliances/

Strategic Measure 2. Adopt an ozone friendly, low-GWP refrigerant criterion by combining refrigerant transition with energy-efficiency improvement, which will approximately double the emissions impact of either policy implemented in isolation and help lower costs.[68]

Strategic Measure 3. Strengthen existing MEPS and labelling requirements based on updated market, technology and economic assessments conducted on the cost and availability of new technologies when needed, or once every five years after a new regulation enters into force.

5.10. Market Monitoring, Verification and Enforcement (MVE)

Monitoring, Verification and Enforcement (MVE) ensures the integrity of market-transformation. Programme administrators must oversee products sold in the market, help verify compliance with MEPS and labels (e.g. through product testing), enforce these requirements, and report the results so that consumers and businesses trust and benefit from cooling products that meet their energy claims.

Data collection and the existence of a functioning legal and administrative framework are critical to a successful MVE system. Accordingly, when establishing an MVE scheme, it is important to have a strong foundation within the national framework encompassing legal authority, enforcement powers and penalties. In addition, the legal frameworks must clearly delineate responsibilities between the different government agencies that implement MVE nationally. On the matter of data collection, some data is collected by the Customs and Excise Department through its ASYCUDA World platform and the Department of Commerce and Consumer Affairs and the NOU, MENB through the licensing and Quota system and national surveys. However, gaps remain in the data which need to be filled going forward in order to improve the MVE system.

A Product registration system (PRS) or databases is a key resource for those undertaking monitoring, verification and enforcement (MV&E) activities in relation to product efficiency standards and labelling programs.

[68] Low GWP refrigerant using ACs are already available on the global market. For example, ~68 million units use R-32 (GWP 677) as of December 2018, and Godrej has sold 600,000 with R-290 (GWP 3) in India and Southeast Asia as of September 2018. Safety issues related to flammable refrigerant could be mitigated by updated safety standards and improving training for installation, maintenance, and awareness. https://www.marketsandmarkets.com/PressReleases/low-gwp-refrigerant.asp

PRSs are a comprehensive and integrated data repository of value to government, industry and the public alike. The systems allow the identification of the types of products being imported and/or being offered for sale, certification of whether equipment meets the established regulations and are approved for import/sale. The system serves as an updated repository of information related to the national RAC equipment plant and facilitates the identification of technology trends, and the monitoring of efficiency and refrigerant transition progress. Importantly, the system makes key information needed to meet national and international energy and greenhouse gas reporting requirements readily available. Additionally, consumers would benefit from real time registration data at their fingertips in order to compare market offerings and make informed choices about the energy efficiency of products they wish to purchase.

Strategic Measure 1: Review the feasibility of implementing a Product Registration System to serve as the central repository for product information, facilitates informed choices by consumers, ensures compliance at the time of registration, supports identification of non-compliant equipment at national borders and facilitates evaluation of the S&L programme.

Strategic Measure 2. Adopt a Product Registration System if proven to be feasible technically and financially within the national context. The most common source of funding is the government's general operating budget, complemented by registration fees, certification fees, labelling fees, verification testing fees and enforcement fines applied to the importers/manufacturers of regulated products.

Strategic Measure 3. Establish product testing and enforcement procedures for newly regulated cooling equipment. The procedures should consider details on sample size and acquisition protocols, lab accreditation requirements (ISO/IEC 17025 certified), and a challenge process that manufacturers can utilize if the initial testing of their product is found to be non-compliant.

5.11. Funding and Financial Mechanisms

A transition to more energy efficient and ozone and climate friendly cooling solutions requires a significant amount of capital. In this regard, it is recognised that both public (domestic and non-domestic) and private[69] funding sources will have to be utilised in order to finance ozone and climate friendly and energy efficient refrigerant and RAC equipment transition. Domestic resources from the

[69] United Nations Environment Programme, 2017 - Accelerating the global adoption of climate-friendly and energy-efficient refrigerators https://united4efficiency.org/wp-content/uploads/2017/11/U4E-RefrigerationGuide-201801-Final-R1-1.pdf

consolidated fund as appropriate will be needed to support the advancement of the work necessary to achieve the overall objective.

Non-domestic public funding sources include multilateral financial institutions such as the World Bank, the Inter-American Development Bank (IDB), the Development Bank of Latin America (CAF); bilateral development cooperation agencies, and the Multilateral Fund that supports implementation of the Montreal Protocol as appropriate. In addition, climate finance facilities such as the Green Climate Fund (GCF) and the Global Environment Facility (GEF) can also be a funding source for qualifying projects that have an energy efficiency element.

Technical support may also be sought from the Climate Technology Centre and Network (CTCN) to implement funding and financial mechanisms as part of the Nationally Appropriate Mitigation Actions (NAMA). While there are many sources of financing available, "delivery mechanisms" are required to enable the funding to be used properly.[70] Some of these mechanisms include:

- Trade-in or Replacement Programmes,
- On-bill financing schemes,
- Shared and guaranteed savings energy performance contract models,
- Leasing schemes,
- Cooling as a service (CaaS),
- Bulk procurement programmes, and
- Government bonds & tax incentives.

Each of these models has different advantages and uses a different path to overcome specific barriers and require the full support of the various public and private sector stakeholders connected to the refrigeration and air conditioning sector. The models would be combined with financial and non-financial risk mitigation mechanisms and tailored to local conditions. Successful implementation depends on a thorough understanding of the market, a strong engagement of the key stakeholders, the successful creation of an environment of trust and a well-designed model offering a sustainable solution by creating value for all players involved.

[70] United Nations Environment Programmeme and Basel Agency for Sustainable Energy, 2019 - Manual of Financing Mechanisms and Business Models for Energy Efficiency http://energy-base.org/wp-content/uploads/2013/11/Manual-of-Financing-Mechanisms-and-Business-Models-for-Energy-Efficiency2.pdf

Further, under the current system of duties and taxes, there is no differentiation between refrigerants and energy efficient and ozone and climate friendly equipment in terms of the amount charged. One way of reducing the attractiveness of the cheap inefficient equipment to the market is to increase the duties and taxes on such equipment while reducing the duties and taxes on the energy-efficient and climate-friendly equipment. This is also a policy measure under the Implementation plan: Policy Measure #56 "Produce a system of duties, taxes and economic incentives to promote greater use of high-efficiency energy technologies in conjunction with the Ministry of Energy and Business Development and the Ministry of Finance, Economic Affairs and Investment.[71]

Strategic Measure 1. Develop a financial delivery mechanism combining public and private funding as appropriate to accelerate financing of clean and efficient cooling. The development of such a mechanism may be performed according to published guidance and tool kit e.g. U4E guidance documents, C-COOL toolkit to facilitate use of the "Cooling as a Service" (CaaS) financial mechanism.

Strategic Measure 2. Examine the current tax structure relating to the importation of refrigerants and RAC equipment into Barbados, and develop and implement financial instruments and economic incentives for the import of high EE, ozone friendly and zero to low GWP RAC equipment with ozone and climate friendly refrigerants and disincentives for RAC equipment with low energy efficiency which utilise refrigerants that are ozone depleting and/or have high GWPs.

Strategic Measure 3. Access funding opportunities locally, regionally and internationally to support the RAC market transformation.

5.12. NDC Enhancement

The NDC update submitted in 2021 sets an objective of becoming the first 100% green and fossil-fuel free island-state in the world by 2030. The enhanced ambition mitigation objectives are 35% and 70% reduction relative to business-as-usual emissions in 2030 without international support (unconditional) and conditional upon international support, respectively. The conditional mitigation contribution includes a 20% increase in energy efficiency across all sectors as compared to BAU.

Barbados, as well as the other signatory countries to the Paris agreement in 2015 has raised the ambitions of the NDC and has the opportunity to include energy efficient and climate friendly cooling

[71] Implementation Plan -Barbados National Energy Policy P 29 https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030

actions in the NDC implementation plan to benefit from the GHG and energy savings these bring and contribute in the achievement of the climate goals. In subsequent NDC enhancement processes the establishment of quantitative energy efficiency targets per sector and the inclusion of refrigerant gases in the calculation methodologies is key.

Strategic Measure 1. Include priority mitigation and adaptation actions related to cooling, such as the transition towards the use of ozone and climate friendly and energy efficient refrigerants and refrigerant technologies, updating of building codes, the introduction of MEPS and labels, and/or other relevant recommendations contained in the NCS implementation plan and further NDC enhancements.

5.13. Linking the NCS and Refrigerant Management (HCFC Phase-out and HFC Phase-Down)

The activities carried out as part of the HCFC Phase-out Management Plan (HPMP) and the impending development of the Kigali Amendment Implementation Plan linked with the NCS represent an opportunity to jointly address the phase-out of ODS, the phase down of HFCs and the transition to the use of zero and or low GWP refrigerants while reducing the associated electricity consumption and climate impact of cooling products.

Strategic Measure 1. Build upon HPMP and NCS activities in the development and implementation of the HFC phase down programme as appropriate. Reference the measures outlined in the NCS to ensure that synergies are capitalised upon and duplication of effort is avoided**.**

Strategic Measure 2. Update the Good Practice guide on RAC to include new refrigerants and refrigerant technologies as needed.

5.14. Recovery, Recycling, Reclamation and Waste Management (Transport, Storage and Disposal of Refrigerants and RAC Equipment)

Transitioning the local RAC market to ozone and climate friendly and energy efficient refrigerants and refrigerant technologies does not solve the challenge of existing products that ultimately must be recovered, recycled, collected, transported, stored and disposed of in an environmentally-friendly manner. Recovered refrigerant gases should be safely recycled, recovered or destroyed at sufficiently high temperatures and by means of appropriate incineration or other approved technology. Other components classified as hazardous waste (e.g. switches containing mercury, capacitors containing PCBs, circuit boards) must also be recovered for a safe disposal process. The scrap metal extracted from the cylinders and equipment may be recycled as a revenue generating source. Plastics are a challenge, although some parts can be recycled.

According to the Implementation Plan- BNEP Policy measures 59 a, 59b and 59c, "Standards and Protocols for the safe and effective disposal of equipment and devices in the energy sector" under various agencies and ministries[72] A processing and recycling scheme to handle refrigerant cylinders, refrigerators and air conditioning equipment at the end of useful life will be an aligned activity that can contribute to reducing waste from the cooling sector. For the successful operation of such scheme, it is crucial to implement policies, regulations and activities that support the effectiveness of the waste management programme.

Strategic Measure 1. Develop mechanisms to support commercially driven initiatives for recovery, recycling, reclamation and disposal in accordance with national, regional and international policies and laws as appropriate. Examples of supporting mechanisms include, co-financing recovery and recycling facilities, outreach activities, improving entrepreneurial capacities (business modelling and planning).

Strategic Measure 2. Develop a national protocol inclusive of supporting national mechanisms for the effective collection, tracking and storage of spent refrigerant and equipment that has reached the end of its lifespan as appropriate. The Hazardous Waste Management plan developed by the NOU, MENB and the Ministry of Energy and Business Development as part of the Energy Smart Fund II project can be utilised as a basis for this work.

Strategic Measure 3. Designate a location to facilitate the national storage of spent refrigerants and other hazardous chemicals as appropriate.

Strategic Measure 4. Develop a programme with local waste brokers to ensure that refrigerant is properly recovered from RAC equipment and stored before it is dismantled.

Strategic Measure 5. Identify suitable national, regional and international mechanisms or opportunities for the safe and environmentally friendly disposal of refrigerants and related equipment.

[72] The Implementation Plan BNEP P 29 https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030

Strategic Measure 6. Establish “new for old" or "return" subsidy schemes to be used to ensure the safe and permanent removal of old appliances from the market. These schemes must meet the challenge of a safe management of the flow of waste.

Strategic Measure 7. Enact legislation to discourage discharge of refrigerant gases into the atmosphere. Refrigerant recovery is a technically simple process but requires careful handling of waste gases to ensure that they are recycled, recovered, stored and destroyed safely.[73]

5.15. Reinforce Regional Collaboration

Regional cooperation helps to streamline/standardise the requirements for various operations across regional industries and sectors in pursuit of achieving common goals and objectives e.g. Caribbean Single Market and Economy (CSME), the movement of skilled labour across the various regional territories etc. As a member of CARICOM , Barbados should, as appropriate, seek to participate in regional initiatives associated with enhancing the RAC sector that are in keeping with national goals and objectives and, which foster greater regional collaboration.

Regional efforts to harmonize standards and MEPS among countries play a useful role in verification process and enforcement of compliance measures. Harmonized measurement standards also support the work of market surveillance authorities because fewer tests are required and used across the various markets, thus avoiding duplication of efforts and the wasting of time and money. Through, harmonization the burden of developing new standards increases the comparability of products among countries and improves market transparency.

Strategic Measure 1. Participate in the development of a unified curriculum for HVAC-R training at tertiary institutions in the region as appropriate.

Strategic Measure 2. Support, as appropriate the cooperation and collaboration between Caribbean RAC/HVAC associations, the Air Conditioning and Refrigeration European Association (AREA) or other similar international organisations

Strategic Measure 3. Support, as appropriate, a regional certification and licensing scheme for technicians.

[73] Additional insights may be found in OzonAction’s Demonstration of a Regional Strategy for ODS Waste Management and Disposal in the ECA Region and Customs Quick Tool for Screening ODS

Strategic Measure 4. Participate in initiatives to develop mechanisms for collaboration with neighbouring territories on data sharing, mutual recognition of product testing results, market monitoring, and training etc. as appropriate.

Strategic Measure 5. Participate in initiatives to develop strategies for regional collaboration and recognition of MEPs and labelling systems.

In small economies, regional collaboration is essential to achieve a programme that is cost-effective. In particular, the appliance testing, and product registration systems should be developed jointly by the various Caribbean states, in order to avoid unnecessary duplication of efforts. A CROSQ-led programme is exploring opportunities to leverage testing facilities in Jamaica. CROSQ is also preparing guidance on good regulatory practice. This work links directly with the CARICOM regional standards for refrigerating appliances, lighting and air conditioners, namely CRS57, CRS58 and CRS59 respectively.

6. NCS Implementation

The operationalisation and effective implementation of the Barbados National Cooling Strategy for the RAC sector will require the engagement, buy-in and mobilisation of implementation partner ministries, key stakeholders and the wider public in addition to the successful execution of a number of critical activities.

6.1. Key Implementation Ministry Partners and Stakeholder Groups

There are a number of key implementing Ministry partners and main stakeholders whose roles are important to supporting and ensuring the successful implementation of the NCS. Importantly, effective implementation will be dependent upon the identification of one or more Ministries to lead the process as appropriate. Additionally, there are also a wide variety of stakeholders that will naturally be directly or indirectly involved due to their anticipated contributions to the process or due to the impact that the outcomes of the NCS will have on the lives and operations of individuals and organisations respectively. Therefore, the success of the strategy will hinge upon ensuring that all stakeholders are adequately informed and consulted, and that communication between all parties involved remains consistent. Active engagement and participation by stakeholders serves to engender a greater sense of ownership in the process and a willingness to participate and see the process through to completion. Additionally, it also serves to avoid duplication of effort within government and the ability to capitalise on synergies and sharing of resources and workload for the benefit of the Ministries involved in the activity.

Important mechanisms to encourage participation include the establishment of formal working groups/committees and the convening of sensitisation and update meetings coordinated through the lead implementing Ministry (ies).

Table 4: Initial List of Implementing Partner Ministries and Main Stakeholders Identified

Stakeholder	Description
Government	
Ministry of Environment and National Beautification	Promotes and facilitates the sustainable use of our resources by encouraging the involvement of all citizens and integration of environmental considerations into all aspects of national development.
• National (ODS) and (HFC) Management Programme/NOU	Responsible for the development coordination and implementation of policies, plans, programmes and activities to ensure phase-out and Phase down of ODS and HFCs respectively in accordance with the country's obligations under the Montreal Protocol, and to guide the transition towards the use of ozone and climate friendly and energy efficient refrigerants and refrigerant technologies at the national level.
• Climate Change Section	Coordinates the work necessary to systematically reduce Barbados' greenhouse gas emissions and enhance national resilience to climate change.
• Environmental Protection Department	The EPD is the pollution prevention, monitoring, control and enforcement Division of Barbados. The mission of the EPD is to promote sustainable practices through control, regulation and enforcement.
• Policy Research, Planning and Information Unit (PRPIU)	Facilitates information dissemination, and research functions to support environmental policy design, implementation, evaluation and reporting processes.

• Project Management and Coordination Unit (PMCU)	Provides both the physical infrastructure and non-physical framework required to ensure the proper management of the solid waste generated on the island.
• Sanitation Service Authority	Responsible for the collection and disposal of garbage, the control of and maintenance of cemeteries. It also provides for the closure of Cell 3 of the Mangrove Landfill.
Ministry of Energy and Business Development Energy Division	Provides advice on energy policy as well as to collaborate with agencies within the small business sector on the delivery of quality service to the sector and to coordinate standardised related activities to support the policies of government.
• Department of Commerce and Consumer Affairs	Administration of the Miscellaneous Control Act, Cap. 329; administration of the Control of Standards Act, Cap. 326A; administration of the Act, Cap. 331; administration of the Metrology Act; develop and implement consumer protection programs.
• Barbados National Standards Institution	Preparation and promotion of the use of standards; maintaining laboratories for testing; promotion of quality assurance; acting as Custodian of National Standards and certification of goods and services.
Ministry of Finance, Economic Affairs and Investment	Provides expert policy and technical advice to the Minister of Finance on all matters pertaining to financial management and fiscal policy, including public expenditure, taxation and other revenues and debt management.

• Customs and Excise Department	Provides for the collection of duties and taxes on imported goods and locally manufactured goods; collection of Value Added Tax on local goods and services; controlling the movement of passenger vessels and aircraft in and out of Barbados.
• Town and Country Development Planning Office (TCDPO)	Provides for the orderly and progressive development of land in both the urban and rural areas of Barbados, through the use of modern planning techniques in order to attain sustainable and harmonious development.
• Roofs to Reefs Programme (R2RP)	Ensures that Barbados' economic plans are developed in a holistic manner in accordance with, and complimentary to the country's Sustainable Development Agenda in order to build a climate resilient economy.
Ministry of Education, Technological and Vocational Training	Responsible for the general management of all educational services, contributions to international organizations and administration of the Project Implementation Unit.
• Samuel Jackman Prescod Institute of Technology (SJPI)	Delivers the Diploma in RAC Programme and has the potential to become certified as a TVET approved Assessment Centre for the CVQ Level II
• Barbados Vocational Training Board	Provides for an adequate supply of trained manpower in all branches of economic activity; the supervision of apprentices, training programmes, and the testing and certification of trainees and apprentices.
• Technical and Vocational Educational and Training (TVET) Council	Provides for the Technical and Vocational Education and Training (TVET) Council in accordance with the TVET Act, 1993-11; Management of the Employment and Training Fund (ETF), which aims to promote and support training
Ministry of Agriculture and Food Security	Guides agricultural, fisheries and rural development and to ensure an adequate supply of wholesome food for all at an affordable price.

• Fisheries Division	Manages and coordinates staff, provides services and incentives to the fishing industry inclusive of those required by the Fisheries Management Plan and Laws.
Ministry of International Business and Industry	Promotes the interests of Barbados in its international relations so as to contribute to sustainable national development by helping to make Barbados a leading international business and leisure centre.
Ministry of Housing, Lands and Maintenance	Provides quality and affordable housing, land and office accommodation solutions for its customers as well as to provide the proper maintenance of government buildings.
Ministry of Foreign Affairs and Foreign Trade	Promotes the interests of Barbados in its international relations so as to contribute to sustainable national development by helping to make Barbados a leading international business and leisure centre.
Ministry of Tourism and International Transport	Provides leadership in the sustainable development of Barbados's tourism industry through the formulation of policy, the provision of attractive and wide-ranging concessions to facilitate sustainable product development, the provision of timely and quality research, the development and maintenance of industry-accepted world class standards and the facilitation of appropriate product development that ensures maximum economic benefit to Barbadians.
Ministry of Legal Affairs	Provides for the administration and execution of policies and programmes for the provision of legal and judicial services.
Ministry of Transport, Works and Water Resources	Seeks to achieve efficiency and effectiveness whilst safeguarding the public interest in the goals to provide efficient road networks, the proper maintenance of vehicles, certain electrical services and public

	transportation as well as matters relating to water resources.
• Barbados Building Standards Authority	Responsible for the enforcement of the provisions of the Barbados National Building Code and the Building Act so as to facilitate the cost-effective construction of buildings.
• Government Electrical Engineering Department	Provides for the maintenance of streetlights, inspection of electrical wiring in all buildings and overseeing that proper electrical standards are maintained, as well as maintenance of electrical and air-conditioning systems.
Private Sector/Industry Associations	
Refrigeration and Air Conditioning Association of Barbados - RAC Technicians - MAC Technicians - Refrigerant and RAC Equipment retailers and Importers - Facility owners and procurement Managers	An association established under the Companies Act of Barbados to provide a forum for its members to discuss and resolve issues of common concern. It also conducts training for its members, updates members on new and emerging technologies, liaises between government and the RAC industry and coordinates with the NOU in its phase-out projects.
Barbados Chamber of Commerce and Industry (BCCI)	Purpose is to help local businesses prosper and grow by facilitating a more enabling business environment in Barbados and the CARICOM Single Market. Their goal is to be the 'top-of-mind' source for local business (trade and industry) information and to enhance the social development of Barbadian communities. To this end, BCCI vigorously participates in policy development and implementation that enhances economic development in Barbados.

Architects, Engineers, Project Managers (Construction projects)	Responsible for the design and construction of buildings.
Barbados Light and Power Co. Ltd.	Safely provides energy and energy services that are cost effective and reliable for customers.
Non -Governmental Organisation (NGO)	
Barbados Renewable Energy Association	Focused on Renewable Energy and Energy Efficiency at the residential, commercial, industrial and national Levels.
National Committee	
National Ozone Steering Committee	A diverse group of stakeholders that provides technical advisory services to the NOU and supports in the planning, formulating and implementing programmes and projects to assist Barbados to meet its obligations under the Montreal Protocol.

6.2. Implementation Timeline

The implementation of the measures defined in the National Cooling Strategy should be jointly led by the Ministry of Environment and National Beautification and the Ministry of Energy and Business Development with the assistance of a Cabinet appointed Working group comprised of a number of main governmental, non-governmental and private sector stakeholders over a fifteen (15) year implementation period.

NCS Implementation Strategies	Years														
	2022 - 2024			2025 - 2027			2028 - 2030			2031 - 2033			2034 - 2036		
RAC Market Assessment															
NDC Enhancement															
Funding and Financial Mechanism															
Alternative Cooling Technologies and Solutions															
Education, Training and Capacity Building															
Implementation of Public procurement Measures															
Enhanced refrigerator and AC Requirements to Unlock Additional Energy Savings and GHG Reductions															
Development and Implementation of Demonstration Projects for the RAC sector															
Cold Chain Enhancements															
Barbados National Building Code 2013, Building Energy Codes and High Performance Building Design to Reduce Cooling Demand															
Refrigerant Management (HCFC Phase-out and HFC Phase down)															

Awareness Raising and Communication																
Recovery, Recycling, Reclamation and Waste Management (Transport, Storage and Disposal of Refrigerants and RAC Equipment)																
Regional Collaboration																
Market Monitoring, Verification and Enforcement (MVE)																

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8. Annex A: Suggested MEPS and Labelling Requirements for Air Conditioners and Refrigerating Appliances

Air Conditioners

Table A1. Model Regulation Guidelines' Suggested MEPS and Labelling Requirements for Ductless Split and Self-Contained Air Conditioners in Barbados (for 2023 or after)

Grade	Rated Cooling Capacity ≤ 4.5 kW	4.5 kW < Rated Cooling Capacity ≤ 9.5 kW	9.5 kW < Rated Cooling Capacity ≤ 16.0 kW
High Efficiency	7.40 ≤ CSPF	7.00 ≤ CSPF	6.60 ≤ CSPF
Intermediate	6.60 ≤ CSPF < 7.40	6.00 ≤ CSPF < 7.00	5.50 ≤ CSPF < 6.60
Low Efficiency	5.70 ≤ CSPF < 6.60	4.90 ≤ CSPF < 6.00	4.30 ≤ CSPF < 5.50
Minimum Requirements for CSPF	5.70	4.90	4.30
Reference Standard	ISO 16358-1:2013		
Climate Group (Temperature Bin Hours)	0A (Model Regulation)		

CSPF: cooling seasonal performance factor

See Table A2 for outdoor temperature bin hours of 0A climate group.

See the U4E Model Regulation Guidelines for Air Conditioners and the Supporting Information Document for details.

Table A2. 0A Temperature bin hours for calculating CSPF

Outdoor temperature	0A
℃	Bin hours
21	5
22	23
23	76
24	205
25	383
26	537
27	646
28	671
29	630
30	596
31	501
32	361
33	206
34	86
35	32
36	11
37	3
38	1
Total	4973

Table A3. MODEL Regulation guideline's Suggested Requirements for Refrigerant Characteristics (numbers shown are upper limits)

	GWP	ODP
Self-Contained System	150	0
Ductless Split System	750	0

All units shall comply with standard ISO 5149: 2014 or IEC 60335-2-40:2018, a subsequent revision, or a nationally-modified edition of ISO 5149 or IEC 60335-2-40. See the U4E Model Regulation Guidelines and Supporting Information Document for details.

Refrigerating Appliances

Table A4. Suggested Maximum Annual Energy Consumption (AEC_{Max})

Reference Ambient Temperature	Product Category	AEC_{Max} (kWh/year)
24°C	Refrigerators	0.163×AV+102
	Refrigerator-Freezers	0.222×AV+161
	Freezers	0.206×AV+190
Reference Standard	IEC 62552: 2015	

where AV is Adjusted Volume, as calculated per the Equation below

$$\boldsymbol{Adjusted\ Volume}\ (\boldsymbol{AV}) = \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} (\boldsymbol{V_i} \times \boldsymbol{K}_i \times \boldsymbol{F_i})$$ where:

- V_i: Volume of *i*th compartment
- K_i is volume adjustment factor and Fi is frost adjustment factor.

See the U4E Model Regulation Guidelines for Refrigerating Appliances and the Supporting Information Document for details.

Table A5. Suggested Requirements for Refrigerant Characteristics (numbers shown are upper limits)

	GWP	ODP
All types	20	0

Products using hydrocarbon (HC) refrigerants shall comply with IEC 60335-2-24:2010/AMD:2017, or a subsequent revision, or a nationally-modified edition of IEC 60335-2-24. See the U4E Model Regulation Guidelines for Refrigerating Appliances and the Supporting Information Document for details.