UNITED NATIONS DEVELOPMENT PROGRAMME

SUMMARY OF NATIONAL COOLING ACTION PLANS (NCAPs)

ACKNOWLEDGMENTS
The views expressed in this publication do not necessarily represent those of the United Nations Development Programme, its Executive Board, the United Nations Member States, the Montreal Protocol, Multilateral Fund or the Clean Cooling Collaborative.

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CITATION
United Nations Development Programme. 2023. Summary of National Cooling Action Plans (NCAPs) Supported by UNDP. All rights reserved. UNDP, New York.

PUBLISHED
United Nations Development Programme
304 East 45th Street, 9th Floor
New York, NY 10017
www.undp.org

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INTRODUCTION

Roughly
2 BILLION
AC units are now in operation around the world, making space cooling one of the leading drivers of rising electricity demand in buildings.

Energy consumption for space cooling as more than
TRIPLED
since 1990.

By 2050, it is estimated that
14 BILLION
cooling devices will be needed to meet demand, four times as many pieces of cooling equipment than are in use today.

Economic development, rapid urbanization, rising global temperatures and more frequent heat waves are driving an increase in demand for cooling. Increased cooling causes more climate change, which then creates the need for even more cooling[1]. Urgent actions are needed to break this negative feedback loop.

In hot climate countries, cooling is a significant contributor to greenhouse gas emissions[2]. Air conditioners and electric fans currently consume 20% of the electricity used in buildings around the world and their use is expanding more rapidly than any other building appliance[3]. According to projections by the International Energy Agency, global energy demand for cooling is expected to triple by 2050[4]. If cooling efficiency is not improved significantly, an increase in greenhouse gas (GHG) emissions from energy consumption and refrigerants will ensue.

While cooling is essential to human health, food security and economic productivity, inefficient cooling services worldwide can threaten the 2030 sustainable development agenda, since all the sustainable development goals (SDGs) are impacted by energy and climate change. As an integrated and comprehensive approach, National Cooling Action Plans (NCAPs), a global policy best practice, have gained prominence among countries beginning to develop long-term policy strategies achieving sustainable energy and climate change goals at both national and international levels[5]. Starting in 2018 several countries opted to develop an NCAP with technical support from specialized agencies and address the cross-cutting nature of cooling, to bring stakeholders from government, industry and academia to the table, discuss needs and possible solutions, and translate this into a document that would provide a roadmap for action[6].

Though NCAPs were seen as an effective tool to strategize sustainable cooling actions, a wide contrast in scope and methodology was observed among the NCAPs. To address this gap and accelerate global efforts on strategic planning to deliver on cooling, in 2020 the Cool Coalition brought together several of NCAP pioneers (UNDP, ESCAP, GIZ, WBG, SEforAll, KCEP, EF Chine etc.) and members and developed a guiding framework and holistic but modular methodology as reference with customized approach to implement it. The NCAP Methodology takes the approach of––think holistically and plan strategically, where reducing the cooling demand at the neighborhood level and buildings level with better planning and passive solutions, along with meeting the demand efficiently and promoting behavioral measures to ensure optimal operations.

Recognizing the importance of sustainable cooling, UNDP, with the Clean Cooling Collaborative (CCC) (formerly known as the Kigali Cooling Efficiency Programme (K-CEP)), supported twelve countries in developing their National Cooling Action Plans (NCAPs): Bangladesh, Chile, Costa Rica, Cuba, Ghana, Lebanon, Mexico, Nigeria, Panama, Philippines, Sri Lanka, and Trinidad and Tobago.

This publication presents the key findings from the eleven countries that have developed and published their NCAPs with UNDP's support[7].

[1] www.cleancoolingcollaborative.org/the-challenge

[2] IEA report, The Future of Cooling, 2018

[3] www.cleancoolingcollaborative.org/the-challenge

[4] IEA report, The Future of Cooling, 2018

[5] www.seforall.org/data-stories/role-of-national-cooling-action-plans.
www.unescap.org/sites/default/d8files/event documents/NCAP%20workshop%20June%2030%20summary_13072021.pdf

[6] https://wedocs.unep.org/bitstream/handle/20.500.11822/33094/CoolRep.pdf?sequence=1&isAllowed=y

[7] All countries have completed and published their NCAPs, except for the Philippines.

The NCAPs are important instruments to promote sustainable and smart cooling practices in countries. They cover regulatory, policy, technical and operational areas through which countries can contribute towards the targets of the Paris Agreement and the Kigali Amendment under the Montreal Protocol. The NCAPs identify potential energy demand reduction and energy efficiency interventions, suggest pathways for synergies between efficiency improvements and the transition from high global warming potential (GWP) refrigerants and propose a framework for the implementation of these actions in an integrated national cooling plan. In addition, there is huge potential to build sustainable cooling infrastructure coupled with renewable energy, particularly in the cold chain sector. In Small Island Developing States (SIDS), district cooling could potentially address a significant portion of cooling demand in buildings if upfront investments can be secured.

The development of NCAPs is a multi-stakeholder consultative process. The process identifies stakeholders in the public and private sectors, civil society, and were able to bring them together to discuss policies, strategies, standards, and action plans. Ultimately this multistakeholder process of NCAP development is intended to harmonize them with the existing framework of the Montreal Protocol, and with countries' wider energy transition and climate mitigation and adaptation plans as set out in their regular reviews of Nationally Determined Contributions (NDCs).

The benefits of this multistakeholder process have already been realized in some countries whose NCAPs have been supported by UNDP. For example, the World Bank's Cooling Facility, through which funds from the Green Climate Fund (GCF) will be channeled, is one of the world's first multi-country financing initiatives to focus on cooling and in Bangladesh, Panama and Sri Lanka (among other countries), the facility will support energy efficient buildings, providing thermal comfort with both passive measures and low carbon cooling solutions[8].

The NCAPs have been developed and endorsed by national governments and represent their views on long-term and sustained action in the cooling sector. They indicate a government's willingness to pursue efficient, climate-friendly cooling through the policies and programs that are included within the plans. They are also intended to be complementary with other national plans and strategies and can inform the latter. For example, an NCAP process will be considered as successful if its components can be integrated into the review of the country's national NDC targets, as was the case, for example, in Lebanon soon after the completion of their NCAP. Cambodia is one of the pioneering countries to integrate NCAP recommendations to their updated NDCs and climate strategy, specifically promoting passive cooling solutions in buildings sector and energy efficiency in cooling sector[9].

Each country's NCAP is unique in terms of its scope and targets. Some countries' NCAPs describe ambitious and high-level goals, while others are grounded in specific policies and programs that are already being implemented[10]. All the NCAPs include a focus on the key cooling sectors, including the building and residential sector, supermarkets and cold chain, to a varying degree. But each country's NCAP is nationally driven, reflecting its own unique situation and priorities.

The Cool Coalition NCAP Methodology is an important global tool to guide countries developing NCAPs with customized approach based on country context.

The NCAPs also all include detailed roadmaps , which provide more detailed recommendations, required actions, timetable, the responsible agency within government, other stakeholders to be involved, indicative costs, and the key existing policies to link to. These action plans will be instrumental in shaping countries' future climate and energy policies.

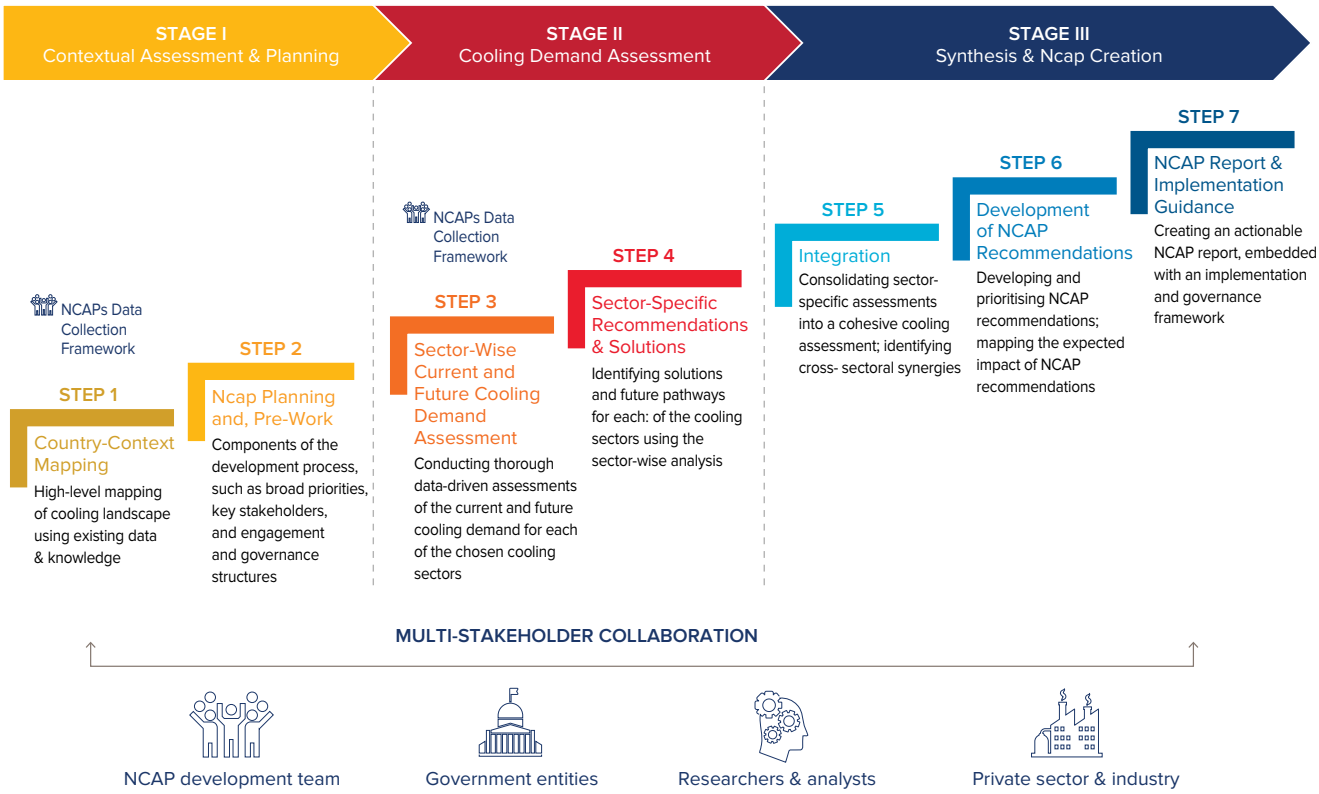
[8] https://coolcoalition.org/world-bank-mobilizes-usd157-million-for-clean-cooling-from-green-climate-fund/#:~:text=In%20North%20Macedonia%2C%20Panama%2C%20Bangladesh%20and%20Sri%20Lanka%2C,an%20additional%20USD%24722.8%20million%20in%20World%20Bank%20co-financing

[9] https://coolcoalition.org/pilot-projects/passive-cooling-in-cambodia

[10] www.cleancoolingcollaborative.org/wp-content/uploads/2021/08/K-CEP-Phase-I-Impact-Report.pdf

The NCAP Methodology developed by the UNEP Cool Coalition takes the approach of—think holistically and plan strategically, this means *first* reduce cooling demand at the neighborhood and buildings level through better urban planning and passive solutions, *second* meet the demand with energy-efficient equipment and *third* promote optimal operation, maintenance, and behavioral measures to ensure cooling is delivered only to where and when it is needed. The Methodology is comprehesive and modular, it covers the multiple sectors cooling and considers access to cooling for all, while allowing for customization in function or country's unique context. Data analysis to determine cooling demand and associated emissions projections are an integral and vital aspect of the NCAP Methdology, as these provide evidence for countries to define their baseline, priorities and well-infomred policies and intervention actions.

This integrated approach enables to keep in perspective the inter-linkages and synergies of cooling, and any steps towards climate-friendly cooling, even if applied in phases, will follow common guiding principles and goals. The below figure elucidates the various stages recommended in the methodology to develop NCAPs.



Policy Measures

The NCAPs propose a number of policy measures to reduce electricity consumption and greenhouse gases in the countries, for example, Minimum Energy Performance System (MEPS) and labels, changes to energy buildings codes, fiscal and financial incentives for energy-efficient and climate-friendly equipment, promotion of green building certification, operation and management practices, awareness raising and training activities.

MEPS are one of the most impactful ways for countries to reduce electricity consumption and greenhouse gas emissions. The NCAPs of the eleven countries supported by UNDP show that several countries are planning and implementing stringent MEPS and labels for room air conditioners and refrigerators. However, the status of MEPs implementation varies greatly among the eleven countries. Some countries were in advanced stages of MEPs implementation (Cuba), other countries were in the process of updating their MEPs (Costa Rica, Ghana, Panama), while some countries had MEPs in place, but enforcement was a challenge (Nigeria), and finally, a few countries were found to have no MEPs in place (Lebanon, Trinidad & Tobago). Without MEPS and labelling, end-users are lacking clear guidance on energy-efficient appliances. Importers, sellers and manufacturers have little incentive to place more energy-efficient appliances on the market, since uninformed end-users tend to purchase the appliances with the lowest up-front costs. These measures will greatly assist in reducing the energy consumption of these appliances and the need to build new electricity infrastructure to meet rising demand. Making cooling more efficient will also yield multiple benefits, making it more affordable, more secure, and more sustainable, and saving as much as trillions in investment, fuel and operating costs[11].

The NCAPs reveal that Bangladesh has instituted a Standards and Labelling Programme to set minimum energy performance standards for room air conditioners, along with other consumer appliances. In Cuba, minimum energy efficiency indices are used for the import and evaluation of refrigeration and air conditioning equipment, and it is expected that their MEPS will be reviewed every two years. In Panama, minimum import standards have been established and Panama's NCAP has indicated the update of regulations and standards on the energy efficiency of RAC equipment as a high priority. In Mexico, RAC equipment includes a comparative label that shows minimum energy efficiency required, the energy efficiency ratio of the equipment and the percentage of energy savings against the minimum value of the compliance standard.

In Sri Lanka, energy and environmental performance labels have been developed allowing consumers to identify the most efficient products and attaching the energy-efficiency label for all equipment. These labels will become mandatory soon prior to placement in the market. While Nigeria has existing MEPS for domestic refrigerators and air conditioners, it was found that enforcement of MEPS is lacking and that most of the products do not have the energy efficiency labels. On the other hand, Trinidad and Tobago currently has no MEPS and labelling established specifically for RAC appliances. A new initiative being developed in the country would utilize MEPS and labels supported by testing facilities to enable the market to migrate towards energy efficient equipment in the RAC sector. Finally, despite its large market penetration for refrigerators and air conditioners, Lebanon also does not yet have a MEPS and labelling system in place and the appliances in use have a low energy performance in comparison with other countries. UNDP's projects identified these gaps and proposed a set of actions through the NCAPs for countries to set ambitious MEPS and enforcement mechanisms.

Market projections

Market projections are an integral and vital aspect of the NCAP methodology. These projections are used to estimate the current and future cooling demand and its impacts, as well as different pathways that countries could take for lowering the climate impact of cooling in their respective cooling sectors.

UNDP took a bottom-up approach on the market projection of the cooling demand. However, due to the varied spans of cooling sub-sectors, almost all NCAPs reported a common challenge of data availability, quality and reliability. Therefore, market projections of NCAPs reflect a modular methodology to cover specific sub-sectors rather than holistic projections of cooling sectors in the countries. This modular approach enables countries to simplify data collection and helps to prioritize the sub-sectors with the highest emission reduction potential. Accordingly, the common focus of market

[11] https://economictimes.indiatimes.com/industry/energy/power/global-energy-demand-for-air-conditioners-to-triple-by-2050-iea/articleshow/64175009.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

projections for the eleven NCAPs shows **that countries consider residential and commercial RAC sub-sectors as priority (and/or low-hanging fruit) sub-sectors for the actionable NCAP recommendations.** Market projections for other key sub-sectors (i.e., industrial, mobile, transport sectors) are not covered in most of the NCAPs, but limitedly in some countries, for example Ghana with mobile AC, Panama with industrial refrigeration, and Sri Lanka with transport refrigeration.

Market projections provide an analysis of business as usual (BAU) cooling energy demand, energy and cost savings, and emission reduction potential because of reduced electricity consumption by 2050 based on the NCAP's proposed pathways. Table 1 shows the figures for savings and emission reductions representing the focused sectoral scopes of the market projections presented for each NCAP. While the cooling sector's whole potential is beyond the proposed NCAP actions, these figures are being utilized by countries to raise ambition of their NDCs with data-driven estimates and actionable recommendations of NCAPs.[12]

ASSESSING INVESTMENT POTENTIAL AND UNLOCKING FINANCIAL RESOURCES

Many of the NCAPs also highlight the need for additional financial investments for cooling. For example, Lebanon's NCAP estimates that the costs for the operation of an incentive and disposal system for refrigerators and room air conditioners over nine years to be USD 187.5 million. In Nigeria, the NCAP estimates that the cost of implementation will be around USD 134 million; this amount includes a total of 900,000 units to be replaced in a pilot program.

In general, the challenges and market barriers facing the cooling sector can be categorized as economic, regulatory, technical and related to market scalability. While there are relatively few risk mitigation mechanisms that are traditionally applied for cooling projects, global entities are joining forces to create innovative financial instruments to incentivize and catalyze energy efficiency investments. Some of these innovative financing models provide safety nets to cover uncertainties in lending risks from the bank's perspective

Table 1. Estimated energy, cost savings and CO_2 reduction with the proposed NCAP actions

Region	Energy Savings TWh)	Cost Savings (US$ billion)	To-be-Avoided MT CO_2-eq emissions
Bangladesh	9.45	1.23	6.75
Chile	4.90	0.64	3.50
Cuba	3.15	0.41	2.25
Costa Rica	6.80	0.88	2.60
Ghana	4.20	0.55	4.30
Lebanon	3.10	0.40	3.20
Mexico	42.66	5.55	29.17
Nigeria	70.50	9.17	72.50
Panama	0.80	0.10	0.57
Sri Lanka	19.43	2.53	13.88
Trinidad and Tobago	1.60	0.21	1.20

[11] The estimates are based on the NCAP projections of energy savings and CO_2 emissions reduction potentials in line with NCAP recommendations. Where year-2050 projections do not exist in the NCAP, the earlier year (usually 2030) projections were extended with similar growth rate to the year-2050. World average electricity price was taken as 0.130 US$ per kWH (Sep-2021), which is the global average price for households/businesses, according to GlobalPetrolPrices.com. The calculation only includes indirect emissions due to electricity usage and doesn't include emission reductions due to replacement of refrigerants.

and mitigate high upfront capital expenditure (CAPEX) risks from an investor's view. These financing models mainly target small and medium-sized enterprises (SMEs) since they play a strategic role in economic growth and development globally.

The financing schemes might vary from one country to another based on its financial landscape and priority areas, but the outcomes can be optimized if the financial instrument is well designed and/or customized to fit the various parameters existing in different countries, economies, and sectors. This may help to create the conditions needed to ensure a sustained supply of private finance for energy efficiency investments, motivate partnerships in profit and risk sharing business models, and adopt a portfolio approach for sustainable cooling across countries. Some of the innovative financial models that can be deployed include energy savings insurance (ESI) models, revolving loans to the public sector, cooling as a service, leasing models, on wage models and on bill models, and energy service companies (ESCO) models. The NCAPs have also identified additional financial mechanisms, such as import levies, carbon credit-based incentives, and other climate financing instruments, to address the first cost barriers.

While the NCAP's integrated approach highlights upfront cost barriers, provides analysis of cumulative financial needs and recommendations for instruments, the scope of NCAP recommendations in most cases come short of sufficient and in-depth conversations with potential donors and local banks in addressing the finance barriers. This creates a potential imbalance for NCAP implementation on financing, compared to the level of elaboration ensured by policy and technology recommendations. Overall, a few NCAPs reported about the pre-investment challenges, including difficulties in engaging public and private finance entities as well as the complexity of designing financial instruments. These challenges imply the need for tailored capacity building to overcome information asymmetry between policy, industry, and finance stakeholders.

It should be noted that financing instruments/modalities for sustainable cooling are not at a high maturity level, for example, compared to renewable energy or energy efficiency financing for industry sectors. Therefore, the design of such instruments is relatively complex and takes time. This translates to the need for dedicated resources for technical assistance in designing financial instruments and business models. In this regard, current and future NCAPs may consider specific financing action plans not only at the onset of financing national projections but also to overcome pre-investment challenges.

Conclusion

These eleven NCAPs build upon the extensive experience of UNDP in the cooling sector and are a critical part of advancing our new sustainable cooling offer. UNDP is already supporting more than 50 countries on refrigerant transition and cooling efficiency through programmes supported by the Multilateral Fund, Global Environment Facility, bilateral programmes, as well as platforms such as the Cool-Up Programme, Cool-Coalition, SE4ALL, CCAC, and Clean Cooling Collaborative. We hope this summary can inspire more countries to develop their national cooling plans and motivate the creation of strong partnerships for the implementation of their national cooling plans. The UNDP Chemicals and Waste Hub is devoted to supporting developing countries in the implementation of the Montreal Protocol for ozone layer protection and combatting climate change. We aim to help build capacity for the sustainable and safe use of chemicals and to improve resource efficiency. Building on our broad networks and integrated expertise, UNDP will strengthen its partnerships with financial institutions and investors to develop innovative business models that could leverage the comparative advantages of all partners for a sustainable future for all and one which leaves no one behind.

> For more information please go to UNDP's Sustainable Cooling Offer

BANGLADESH

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Country Profile

Bangladesh is a densely populated, low-lying, mainly riverine country located in South Asia. According to the World Bank, Bangladesh had an estimated population of 164,689,383 in 2020, with an annual growth rate of 1%.

The country has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, high temperature and humidity. Due to its tropical location, dense urban morphology and higher-than-average population density, buildings in Dhaka and other major cities are likely to be adversely affected by the projected changes in climate, particularly by increases in temperature. The average monthly maximum temperature in Dhaka has increased by about 1.6 °C in the last 20 years, as shown in Figure 1.

Market Status of the Cooling Sector

- **Space cooling in buildings**

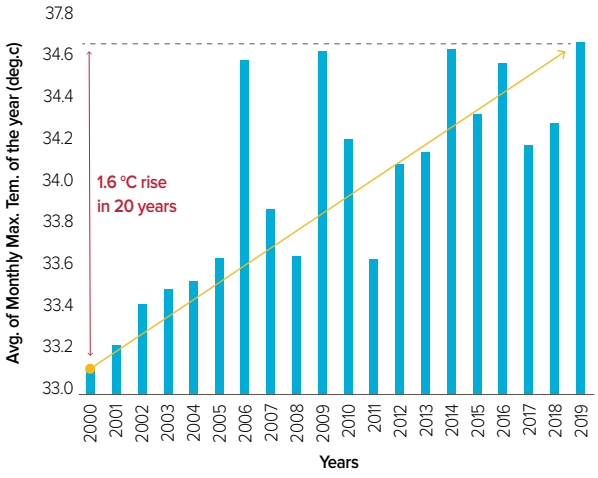
  The built environment in Bangladesh will grow with rapid urbanization, leading to an increase in the need for air conditioning and refrigeration (Figure 2). It is believed that around 6-7 percent of Bangladeshi households now have access to room air conditioners (ACs). Around 50 to 60 percent of these are one AC families; the rest possess more than one AC. Demand for room ACs is growing with the rise in economic growth, which offers a tremendous opportunity for the sector to expand. AC sales are estimated to grow at an annual average rate of 10 to 12 percent in the next 10-15 years and is likely to reach 18 million tonnes of refrigeration (TR). There has been a sharp rise in the adoption of inverter room air conditioners in recent years, alongside a significant decline in uptake of fixed speed room air conditioners.

- **Refrigeration**

  The stock of refrigerators in 2019 was estimated at 28.5 million units, due to the availability of refrigerators at an affordable and competitive price from local manufacturers, who can now cater for 90 percent of the local demand. Domestic refrigerator sales are expected to have 15 percent average growth, reaching saturation point in 2025 with around 60 million units and then will start to decline in further years. Walton Hi-Tech Industries Ltd (the leading manufacturer in the country) and other companies have already started exploring the overseas market.

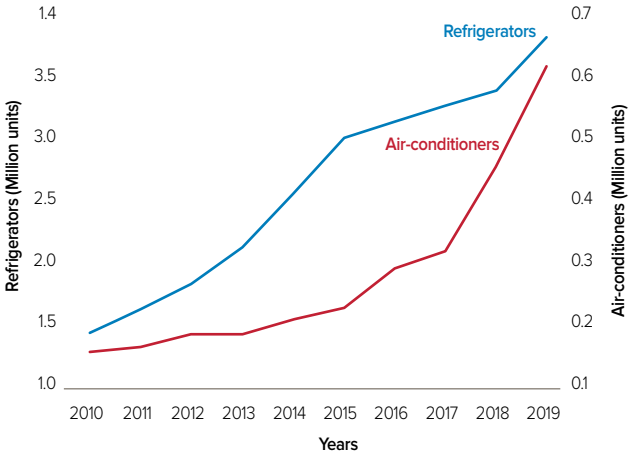
  On commercial refrigeration, around 80 percent of the current market demand is met from local assemblers, which are largely SMEs. Many enterprises in the informal sector are also engaged in this trade. The market size of commercial refrigeration – combining deep freezers, coolers, remote condensing units and

Figure 1. Temperature rise in Dhaka City from 2000 to 2019



Source: Bangladesh Meteorological Department (BMD).

Figure 2. Refrigerators and Air-conditioners Sales in Bangladesh from 2010 to 2019



Source: Bangladesh Refrigerator Manufacturers and Exporters Association (BRAMA).

water coolers – is estimated to be around 1 million TR and can reach around 3million TR with an average annual growth of 10 percent by 2030.

- **Cold Chain**

  Cold chain infrastructure in Bangladesh predominantly comprises a large quantity of refrigerated warehousing space, refrigerated transport and storage capacities for market linkage However, the bulk of the infrastructure for the handling of fresh produce (fruit and vegetables) has not been built yet.

  The use of reefer transport as one of the components of cold chain is on the rise. Almost all transport refrigeration systems continue to utilize HFCs, with a prevalence of HFC-134a and R-404A. HCFCs are mainly used in ship refrigeration systems, including ship breaking/building, and fishing vessels. The fish freezing sector has also emerged. Bangladesh Fish Freezers Association indicates that there are around 300 fish freezers in operation, with medium-sized capacity of refrigerant range from 0.75 to 1.0 TR, where Ammonia (R-717) is used as the refrigerant and R-22 is used for pre-cooling.

  Bangladesh has limited post-harvest storage infrastructure, with current cold storage capacity of 5.5 million tonnes in 427 cold storages all over the country. The cooling capacity of cold storage varies between 500 and 30,000 tonnes. These units are basically single crop (potato) storage. Cold storage cooling requirements are largely met by vapor absorption units using ammonia and compressors using R22.

  While primary producers and retailers suffer loss and damage of up to 60 percent of their seasonal fruits, vegetables, fish, milk and meat items, there remains a lack of necessary small scale cold storage facilities. The irregular supply of grid electricity is a major obstacle and solar-powered mini cold storage (of an average 8-10 tonnes capacity) could become a viable alternative. Furthermore, there is significant potential to improve energy efficiency through the renovation of storage facilities. The Government of Bangladesh encourages the spread of mini cold storage with solar and other alternative power sources through SREDA (Power Division).

- **Mobile air conditioning**

  Demand for mobile air conditioning (MAC) is growing rapidly and now forms a significant proportion of the total cooling needs in Bangladesh. It should be noted that future cooling requirements in this sector will differ, depending on whether public transport is emphasized over private transport.

  Data shows that refrigerant demand for MAC and refrigeration grew exponentially over the last decade, but the rate of growth has eased recently. Most demand is for servicing. Older vehicles with CFC-based ACs are now being serviced with HCFC-22, as CFCs were phased out some time ago. MACs fitted in new imported vehicles are mostly R-134a based. As a result, demand for R-134a in the servicing of MACs has also begun to increase in recent years.

- **Refrigeration and air conditioning servicing sector**

  The refrigeration and AC servicing sub-sectors are responsible for around 55-60 percent of HCFC-22 consumption in Bangladesh. Room air conditioners and commercial refrigerators generate the largest demand for servicing. An important concern in the servicing sector is refrigerant emissions caused by leaks, and the consequent ozone and/or climate impacts. Leaked chillers must be refilled by trained service technicians for optimal performance of the system. Around 50,000 technicians work in the servicing sector, but most have no technical academic qualifications. The livelihoods and social security of the technicians are also key concerns as they often don't have stable incomes and are excluded from social security schemes.

Energy Consumption and GHG emission

In the RAC sector, electric fans for cooling consume about 60 percent of total residential energy. Current technology, using efficient motors, offers the potential for energy savings of 25 percent. The refrigerator/freezer sector has the potential to save 55 percent of energy, by achieving variable speed compressors, and high-performance heat insulation. Air conditioning systems have the potential to save 50 percent, by using a high coefficient of performance (COP) with large heat exchanging coils and variable speed compressors.

The energy consumption rate and energy efficiency and conservation (EE&C) potential of home appliances (Energy Efficiency and Conservation Master Plan up to 2030, 2016, SREDA) are shown in Figure 3.

Air conditioning consumes around 50 percent of the energy used in commercial buildings, with lighting using between 10 and 30 percent. It is estimated that the simple replacement of air conditioners and lighting systems with highly energy efficient ones can save about 50 percent of total electricity consumption in the commercial sector. However, it is not easy to introduce EE&C measures for all buildings, and therefore a realistic figure is an estimated 10 percent.

It should be noted that the RAC sector has not been accounted for in the Intended Nationally Determined Contributions (INDC) of Bangladesh. The RAC sector is responsible for an increasingly significant share of emissions, which, at the same time can be mitigated effectively at a low cost.

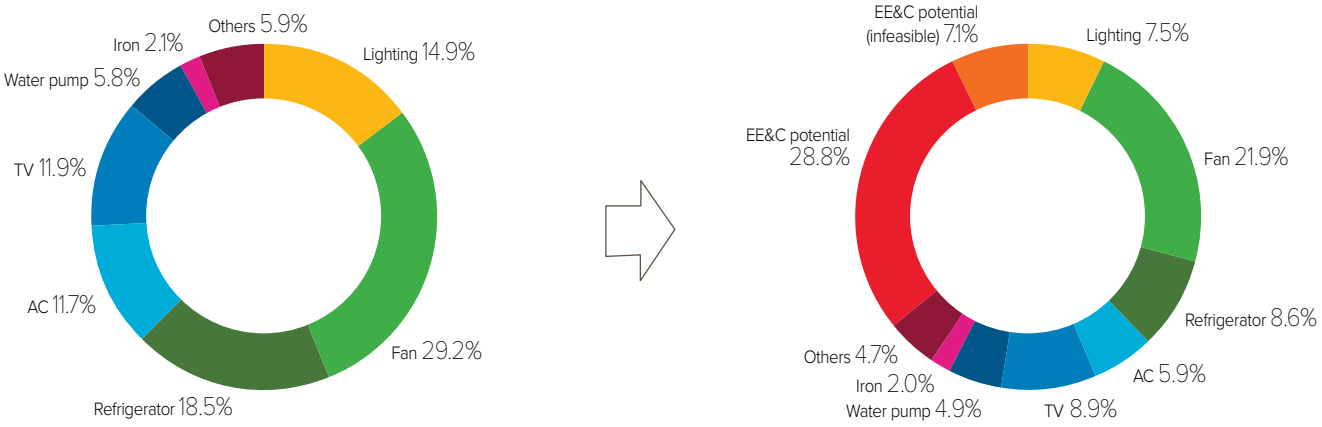
Mitigation Action Plan

Before Bangladesh signed the Kigali Amendment to the Montreal Protocol, the country was taking steps towards a reduction in cooling demand through the: 1) preparation and implementation of the Bangladesh National Building Code (BNBC) and the Energy Efficiency Conservation Master Plan (EECMP) ; and 2) implementation of several projects on the phase out of CFCs and HCFCs and the transition to low ozone depleting potential (ODP) refrigerants.

The BNBC includes energy-efficient elements that assists in reducing heat transfer, thus enhancing thermal and visual comfort. In addition, regulatory and policy actions in the adoption of energy-efficient building practices – lead to regulatory compliance by mainstreaming passive building design principles that are focused on occupants' comfort – and can significantly reduce the cooling requirement. The BNBC also encourages minimum energy performance in commercial buildings and instituted a Standards and Labelling Programme to set minimum energy performance standards (MEPS) for room air conditioners, along with other consumer appliances.

The Energy Efficiency and Conservation (EE&C) Master Plan has developed specific EE&C programmes to achieve energy savings in the building sector by the Sustainable and Renewable Energy Development Authority (SREDA). Under this EE&C Master Plan, three EE&C programmes are underway: energy management; energy efficient labelling and energy efficient buildings.

Figure 3. Current and Potential Energy Consumption of Home Appliance in Bangladesh



A: Present Electricity Consumption

B: EE Case Electricity Consumption

Source: SREDA.

These are targeted at large energy consuming entities and equipment in the industrial, residential and commercial sectors. According to the Master Plan, it is estimated that these activities will result in 4.4 Mtoe per year of energy savings between 2015 and 2030.

Key Stakeholders

An Implementation Framework has been proposed for the implementation of the Cooling Plan, with the Steering Committee (SC) to be chaired by the Secretary of the Ministry of Environment, Forest and Climate Change (MoEFCC), and will act as the highest decision-making body to provide policy guidance for implementation of the Cooling Plan recommendations, in coordination with respective ministries/agencies. Other key stakeholders include:

- Government ministries/agencies: National Ozone Unit (MoEFCC); Ministry of Power and Mineral Resources; Ministry of Industry; Ministry of Finance; Ministry of Planning; Sustainable and Renewable Energy Development Authority (SREDA); Customs – National Board of Revenue (NBR); Bangladesh Standards & Testing Institution (BSTI).
- Universities, Associations: Bangladesh University of Engineering and Technology (BUET); Bangladesh Refrigeration Air Conditioning Merchant Association (BRAMA); ASHRAE; RAC Manufacturers Association; RAC Importers Association; Cold Storage Association.

Acknowledgements

This National Cooling Plan has been prepared by the Ozone Cell, Department of Environment Ministry of Environment, Forest and Climate Change of Bangladesh, with assistance from United Nations Development Programme. The NCAP is funded by the United Nations Development Programme (UNDP) through the Kigali Cooling Efficiency Programme (K-CEP).

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CHILE

Country Profile

The Republic of Chile is in South America between the Andes Mountains and the Pacific Ocean, with a surface area of 756,950 km^2. It has a population of 17.6 million inhabitants (2017). The climate of Chile varies significantly due to Oceanic effects, the mountains and the latitude with a very wide range of climates, from desert, Mediterranean, humid temperate, cold steppe and polar. In 2017 there were 6.49 million households, by 2030 the number may rise to 7.38 million households. With the same growth rate (1%), it is estimated that there will be 9.01 million households by 2050, and 88 percent of the population will be living in urban areas. Chile is a party to the United Nations Framework Convention on Climate Change and the Montreal Protocol. It ratified the Kigali Amendment in 2019.

Market status of the cooling sector in Chile

Refrigeration and air conditioning (RAC) are the major sectors responsible for HFC consumption nationwide, covering 70% of the substances in 2018. In fact, the most bulk-imported substances in this respect (i.e., HFC-134a, R-507A, R-410A and R-404A in order of importance) are mainly associated with the different sub-applications of the RAC sector. The main substances explaining the HFC consumption growth are R-507A and HFC-134a. In the case of HFC-134a, the sustained increase is due to the wide use in all sub-applications of the RAC sector.

On the other hand, R-507A has been strongly promoted in the market since 2005, mainly to replace substances such as HCFC-22 and R-404A in commercial and industrial refrigeration, in the first case due to the implementation of the HPMP and in the second case because it has been considered more efficient. When leakages occur, all the charges of R-404A have to be replaced due to the splitting of its components; rather than simply refilling the system.

Regarding the use of HFCs by sub-application, the forecast of HFC consumption as of 2050 in a BAU scenario (business-as-usual), shows that the Fixed Air-Conditioning (AC) and Industrial Refrigeration will lead the use of HFCs; see Figure 1 below.

Figure 1. **HFC consumption projection (ton) by 2050 by sub-application**

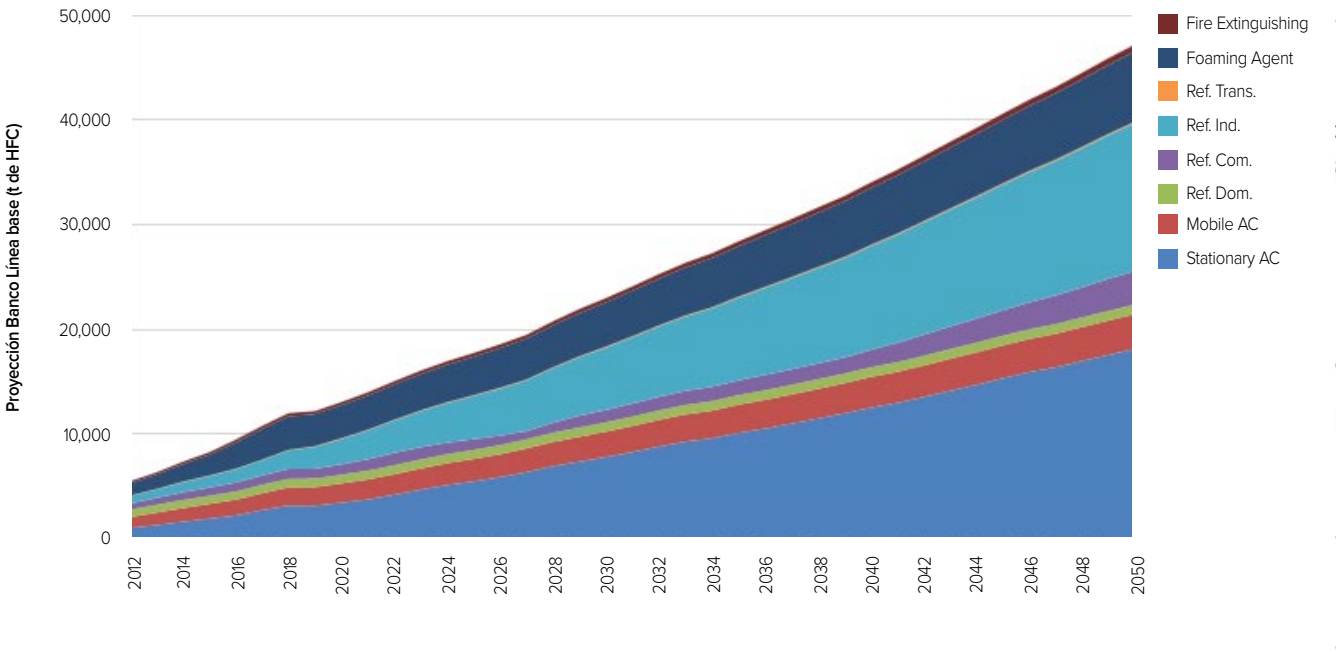
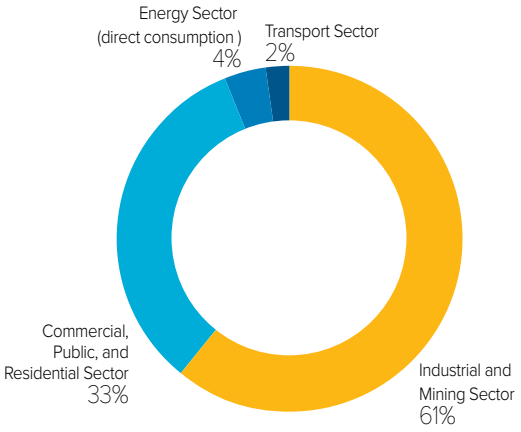


Figure 2. **Electricity consumption by sector in 2018**



Source: www.energiaabierta.cl 8.

Energy consumption and GHG emission

The national energy balance available and its related databases[2] show the main sectors consuming electricity as of 2018. Out of 76,143 GWh total consumption, 61% corresponds to the industrial and mining sectors, 33% to the commercial, public, and residential sectors (CPR), 4% to the consumption of the energy sector and 2% to transportation as shown in Figure 2.

According to the research "Uses of household energy, Chile 2018" published in 2019[3], the devices showing the highest consumption levels are refrigerators (19.4%), lighting (16.9%), television (16.3%) and stand-by consumption (9.2%). Air conditioning consumes 0.9%.

Although the electrical consumption of house ACs is not relevant at present, this situation shall change in the coming years considering the growing projections in the use of these appliances due to the increase in temperatures. Thus, the incidence of RAC equipment in residential electricity consumption could be increasingly significant.

Mitigation Plan

EE CERTIFICATION AND LABELING FOR ELECTRICAL EQUIPMENT

The following table summarizes the electrical appliances belonging to the RAC sector requiring an EE certification and those that shall also inform their EE through labelling. This information was obtained from the Superintendence of Electricity and Fuels (SEC) databases.

Table 1. **Appliances related to the RAC sector requiring EE certificate and labeling**

Appliance	Use	Labelling	Technical Comments
Freezer	House	Yes	In terms of performance, the following products are exempted from this requirement: Refrigerators, freezers and refrigerators-freezers used as means for cooling with other devices than moto-compressors. Those manufactured exclusively for industrial purposes. Special designs for commercial use. Those using batteries as a power source. Those supplied with three-phase alternating voltage. Any type of absorption refrigerators (Monovalent, Bivalent or Trivalent). Refrigerators using semiconductor cells as cooling system (Peltier Effect). Wine cellars, because although it is true that they may have a Cooling circuit with a compressor, they do not operate within the temperatures of the testing standard.
Refrigerator	House	Yes	
Refrigerator-Freezer	House	Yes	
Air Conditioners	House	Yes	Applies to single-phase equipment, direct expansion of refrigerant gas, divided type or unit type, without air distribution through ducts, up to 12 kW (42000 Btu/h) and condensed by air. Electric heat pumps for water heating of swimming pools or any other use besides air conditioning and dehumidifiers are not considered. Portable or mobile air conditioning equipment is also waived.
Commercial cold-storage appliances	Used in food exhibits and sales	No	Applies to refrigerated displays, single-phase and/or three-phase, having built-in compressor, in direct contact with customers, and under or equal to 3 meters length.

Table 2. **Technical information of products from the RAC sector having MEPS**

Product	Labelling	Technical Comments
Refrigerators, refrigerators-freezers and freezers.	As of 2017, only refrigerators, refrigerators-freezers and freezers A, A+ and A++ can be traded. A (42≤ EPI < 55) A+ (30 ≤ EPI < 42) A++ (EPI< 30)	Exempt Resolution 74/2015 of the Ministry of Energy.
Air conditioners that are single-phase, direct expansion of refrigerant gas, split type or unit type, without air distribution through ducts, up to a thermal power of 12 kW (42000 Btu/h) and that are condensed by air.	As of November 2019 (21 months after the resolution was issued), air conditioning equipment holding a classification below A. (42≤ EPI < 55).	Exempt Resolution 4/2018 of the Ministry of Energy.

MINIMUM EE STANDARDS (MEPS)

Chile holds minimum standards in the categories of four products: non-directional lamps for general lighting (2013, in process of being updated); refrigerators, refrigerator-freezers and freezers for household use (2015, in process of being updated); three-phase induction electric motors (2017); and air conditioning (2018). The selection of these products is based on their energy consumption, technology available, national and international experience, and the cost of the measures, among other factors. In the table below, the information of the MEPS for RAC equipment is provided.

PROGRAMS AND INITIATIVES OF THE AGENCY FOR SUSTAINABLE ENERGY (ASE)

The ASE implements different EE measures and programs defined by the Ministry of Energy that represent an opportunity to improve the energy performance of RAC sector companies in their different sub-applications. These programs include:

1. Energy Efficiency in Public Buildings and Infrastructure Program (EEPBIP).
2. Clean Driving Program: focused on certifying and acknowledging efforts made by transportation companies in sustainability and EE.
3. Micro and SME Energy Management: focused on training and providing information on various technical tools to improve energy performance in small and medium-sized companies, also informing on funding alternatives for their implementation4.
4. Energize in your SME Program: program holding seven different initiatives related to energy management in companies.
5. Energy Excellence Seal: recognition granted by the Ministry of Energy to the leading companies in energy management.

SUSTAINABLE CONSTRUCTION CERTIFICATIONS AND EE LABELS FOR HOUSES AND BUILDINGS

Various initiatives in the construction sector seek to reduce the need for cooling and heating devices in houses and buildings, and in improving their EE. The initiatives currently being implemented are:

- Sustainable Building Certification (SBC)
- Sustainable Housing Certification (CVS) (currently holds voluntary requirements related to low or zero GWP refrigerants).
- Green Building Council (GBC) Certification
- Housing Energy Rating (HEC) and public buildings.

CLEAN PRODUCTION AGREEMENTS (CPA)

CPAs are coordinated by the Agency for Sustainability and Climate Change (ASCC) to promote cleaner production through goals and specific actions to be implemented by a specific production sector.

One of the requirements incorporated in some CPAs is energy management of the member companies -as in the CPA-IV of the processed food industry- which includes goals related to the measurement of energy consumption of cooling systems and the relationship with the use of refrigerants.

LONG-TERM CLIMATE STRATEGY (LTCS)

The LTCS is an intersectoral work coordinated by the Climate Change Office of the Ministry of the Environment that seeks to determine the different sector al mitigation objectives and measures required (Sectoral Mitigation Plans) to reach carbon neutrality goals by 2050 and the mid-term goals established in the NDCs. This strategy is the main instrument included in the draft Climate Change Framework Law (MMA, 2020a).

In this context, all sectors shall consider the impact of refrigerants used in different industries and the benefits in terms of climate change mitigation that may result from a good management of these substances. This becomes more relevant when considering the impact of complying with the Kigali Amendment in the mitigation objectives of the Paris Agreement.

CAPACITY BUILDING AND CLIMATE EMPOWERMENT STRATEGY

This strategy is one of the various means for the implementation of the Nationally Determined Contribution (NDC), which is focused on strengthening sectoral, national and subnational capacities of individuals and organizations (public and private), academia and civil society, to reach the mitigation and adaptation goals of the country (MMA, 2020b).

This strategy is essential to fulfill the need of capacity building in the RAC sector established in the framework of a National Cooling Plan that aims to advance in efficient technology with low or zero GWP refrigerants.

CLIMATE CHANGE TECHNOLOGY TRANSFER AND DEVELOPMENT STRATEGY (CCTTDS)

This strategy represents other means of implementation of the NDC aiming at promoting and strengthening technology transfer and development by supporting and promoting the cultural, social, environmental and economic transformations required to achieve a sustainable, resilient and carbon neutral development by 2050 (MMA, 2020b). The Ministry of Sciences and the Agency for Sustainability and Climate Change (ASCC) of the Ministry of Economy, together with the Ministry of Environment, leads the CCTTDS.

HUELLACHILE PROGRAM

This program is carried out by the Ministry of Environment Climate Change Office and seeks to promote the quantification, reporting and management of carbon in public and private institutions. It has a tool to calculate GHG emissions inserted in the PRTR One-Stop Window System. Members must report “fugitive emissions”, which include emissions related to refrigerants’ leakage. However, it has been noted that members do not manage and record the information properly.

The most relevant and immediate action is the development of refrigerants reporting methods. These reports could include information such as: type of gas used, annual purchases, and uses within the company (quantity used, quantity recovered, quantity regenerated), among others. This is essential within the scope of a future HFC reduction plan (*Kigali HFC Implementation Plan, KIP*).

Challenges for the RAC sector in terms of refrigerants and EE

Twenty-seven interviews held with different public and private actors involved in the entire supply chain of the RAC sector identified several challenges related to the objectives of the National Cooling Plan Proposal, particularly regarding the transition to efficient cooling technology with low or zero GWP.

- **Challenge 1: Develop and disseminate information on new energy efficient technologies with low or no GWP refrigerants**

The Ozone Unit of the MMA has implemented various pilot projects for technology renewal with low or zero GWP refrigerants. Hence, this type of initiative shall be replicated incorporating EE criteria, strengthening the development of information on the different technologies applicable in the sector and communicating their benefits.

- **Challenge 2: Promote the improvement in energy and environmental performance of installed technology**
  Another problem shared by users is the number of installed systems and equipment with several years of useful life under appropriate maintenance. In this case, it is necessary to develop the necessary tools and information to help users to improve the energy and environmental performance of their facilities, based on reconversions or complementary measures.

- **Challenge 3: Generate funding for a technological change**
  The main barrier affecting the transition to efficient technology with alternative refrigerants is the significant investment required for this replacement. In this regard, it is necessary to generate relevant financing opportunities to change technology. In this context, the Ozone Unit has implemented various projects to reduce ozone depleting substances' consumption, co-financed by the Multilateral Fund (MLF) of the Montreal Protocol and other partners, as appropriate.

- **Challenge 4: Improve professionals' skills and practices in the RAC sector**
  A crosscutting barrier identified by all the users interviewed was the limited capacity in the sector to guarantee the necessary technical support to introduce new technology. In this regard, the technical knowledge of persons working in that sector, as well as the practices carried out in the installation and maintenance processes of cooling equipment/systems showed significant deficiencies. In fact, a significant percentage of high energy and refrigerants consumption is due to the bad practices of technical staff. In this context, it is essential to strengthen and expand the scope of training programs about good cooling practices developed by the Ozone Unit since 2003 to raise awareness and train professionals in EE and alternative refrigerants.

- **Challenge 5: Disseminate information about the Kigali Amendment to the Montreal Protocol, timelines, and implications**
  The main reason for the inaction and poor proactivity of the RAC sector in the introduction of efficient technology with low or no GWP is the lack of knowledge and/or understanding about the Kigali Amendment, its deadlines and implications. Thus, it is necessary to increase the dissemination of this information among all users of the sector, strengthening promotional activities currently implemented by the Ozone Unit.

Key Stakeholders

Stakeholder consultations and coordination are important for the successful implementation of the NCAP. The following stakeholders were consulted in the development of this NCAP.

Acknowledgements

The proposal of NCAP for Chile was funded by the Kigali Cooling Efficiency Programme (K-CEP) through the United Nations Development Programme (UNDP) and developed by Ms. Paz Maluenda in close coordination with the National Ozone Unit of the Ministry of Environment of Chile and the regional team of the UNDP Chemicals and Waste Hub and the UNDP Chile country office.

Stakeholder	Roles and responsibility
Ministry of Environment (MMA)	Responsible for the design and implementation of environmental policies, plans and programmes, as well as the protection and conservation of biological diversity and renewable natural resources and water, promoting sustainable development, the integrity of environmental policy and its normative regulation.
Ministry of Energy (ME)	Government institution responsible for elaborating and coordinating the different plans, policies and regulations for the development of the country›s energy sector.
Ministry of Education	Governing body of the State responsible for promoting the development of education at all levels.
Superintendency of Electricity and Fuels	Oversees the proper operation of electricity, gas and fuel services, in terms of their safety, quality and price.
Energy Sustainability Agency	Promote, strengthen and consolidate the efficient use of energy at national level, contributing to the competitive and sustainable development of the country.
Agency for Sustainability and Climate Change (ASCC)	Aims to promote cleaner production through goals and specific actions to be implemented by a specific productive sector through Clean Production Agreements.
HuellaChile	Encourages the calculation, reporting and management of Greenhouse Gases (GHG) in public and private sector organizations in the country.
Chilean Chamber of Refrigeration and Heating	Trade organization that brings together companies in the refrigeration, air conditioning, heating and ventilation sector; developing, disseminating, promoting and protecting good technical practices in the sectors it represents.
Importers, technical services (public and private)	Dealers of refrigerants and cooling equipment, installers, servicing workers, and personnel responsible for managing refrigerants.

COSTA RICA

Photo by Shutterstock/Solarisys.

Country Profile

The Republic of Costa Rica is located in the Central American Isthmus. It is bordered to the north Nicaragua to the north and Panama to the south, the Caribbean Sea to the east and the Pacific Ocean to the west, with a surface area of 51,100 km^2. It has a population of 5,213,362 (INEC, 2022). The tropical climate reflects two well-defined periods, one rainy season and one dry season. The average annual temperature varies from 21°C in the plains to 27°C. In 2014 there were 1.4 million households, by 2030 the number may rise to 1.7 million households. With the same growth rate, it is estimated that there will be 2.3 million households by 2050. Costa Rica is a party to the United Nations Framework Convention on Climate Change and the Montreal Protocol. It ratified the Kigali Amendment in 2018.

Market Status of the Cooling Sector

The amount of imported HFCs grew steadily during the period analysed, with considerable increases in the import of R-134a, mainly due to the increase in the vehicle fleet (MAC) and the domestic refrigeration sector. In addition, there is an increase in R-410A, due to the migration of many systems in the RAC sector from HCFC refrigerants such as R-22.

In 2016, around 90% of domestic and commercial air conditioning equipment was made up of ductless split type equipment, typically using refrigerants such as R-410A. New equipment is manufactured with R-290 (but with no market penetration in Costa Rica) and as for industrial air conditioning equipment such as chillers, they are commonly found with R-134a and R-410A, both of which have also been used lately as a substitute for R-22. In the case of mobile air conditioning, it is normal to find equipment using R-134a.

During 2019, only R-600a (isobutane) was imported in the range of natural refrigerants, although some companies in the RAC sector claim that certain customers are opting for R-744 (carbon dioxide) systems, no movement in imports was observed.

The distribution of imported RAC equipment in 2019 for the different sub-sectors corresponds to: refrigerators and cold rooms with 69%, air conditioners around 17%, freezers 13% and others 1%, over the total imported equipment.

In 2018, a total of 149,768 domestic and commercial refrigerators were imported to Costa Rica, where 68% use R-134a refrigerant, 25% R-600a, 5% R-404A, while for 2019 a total of 154,705 units were imported, of which 57% use R-134a refrigerant and 42% use R-600a, evidencing the increase in the use of R-600a.

In 2018, 16,428 freezer units were imported, of which 45% use R-134a, 32% use R-600a, 12% use R-290 refrigerant, 5% use R-410A and 4% with R-404A. In 2019, a total of 40,959 freezers were imported, of which 74% use R-600a, 24% use R-134a and 1% use refrigerants R-290 and R-410A.

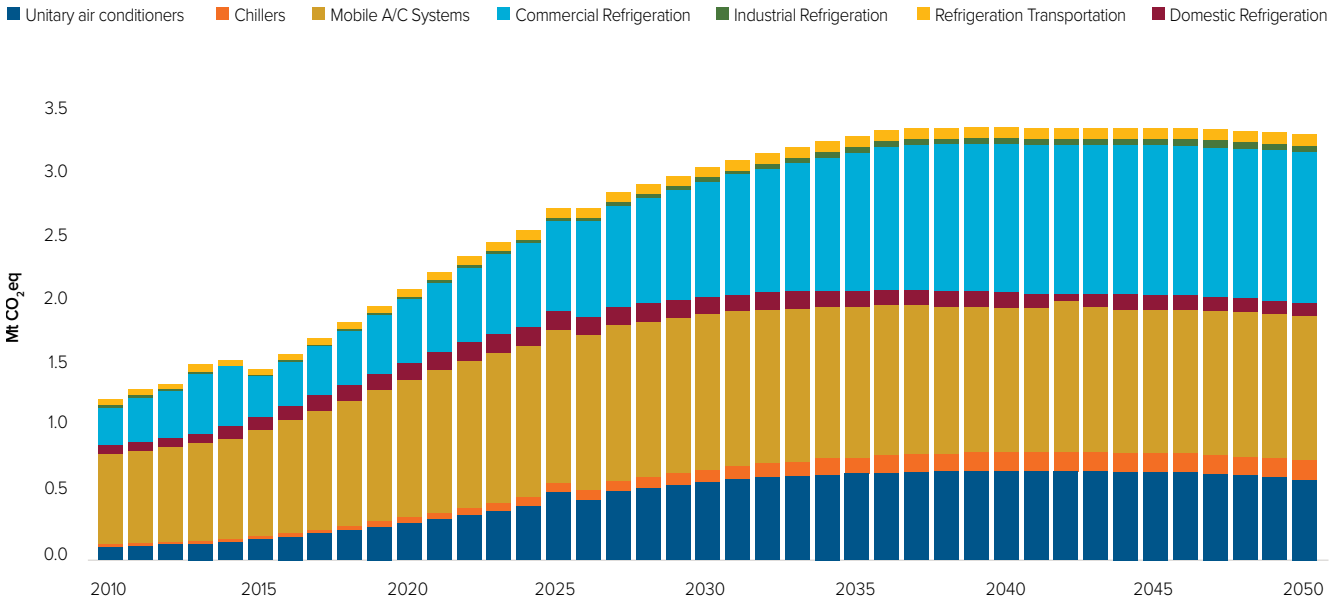
In the case of air conditioners, an important sub-sector in terms of the amount of equipment entering the country, a total of 34,430 units were imported in 2018, with 93% of the equipment using R-410A, 4% using R-134a and 3% using R-22. In 2019, 37,055 new units entered the country, with 88% using R-410A, 2% using R-22 and 1% using R-600a.

The case of chiller imports is a clear example of the limitation in the classification of tariff headings at the customs level, as this equipment is included in various headings, making it difficult to distinguish even the types of equipment in air conditioning chillers or process equipment.

The freezer sub-sector showed a positive behaviour during the last year with the import of most commercial (smaller applications) and domestic equipment using R-600a in 73% of the imported equipment, followed by R-134a and other refrigerants in much smaller quantities.

For the remaining sub-sectors, such as refrigerated transport, industrial refrigeration and much of commercial refrigeration, it is difficult to obtain accurate information on imports and stock of equipment.

Figure 1. **BAU Scenario: GHG Emissions in the RAC Sector to 2050**



Source:Greenhouse Gas Inventory of Refrigeration and Air Conditioning for Costa Rica (2012-2016).

Energy consumption and GHG emission

Electricity distribution in Costa Rica is made up of 8 distribution companies: ICE has 49.48%, CNFL has 21.58%, municipal companies (ESPH, JASEC) and rural electrification cooperatives have 21.80% and only 0.31% do not have access to energy through a distribution line, but most of them have access to a distributed generation system, mostly photovoltaic.

The INTE/ISO 14064-1:2019 Specification with guidance, at the level of organizations, for the quantification and reporting of greenhouse gas emissions and removals, presents the reality and importance of calculating and identifying the carbon footprint of organizations. These emissions can be categorized into: Direct and Indirect emissions.

Costa Rica is not a manufacturer of RAC equipment and HFC refrigerants, so the total direct emissions are linked to the service sector. For the calculation of CO_2-eq, the generation emission factor of the corresponding country is applied. For 2018, the emission factor for electricity production was 0.0395 kg CO_2/kWh produced, according to data from the IMN.

According to the Inventory of Greenhouse Gases in Refrigeration and Air Conditioning (2012-2016), it was identified that for the year 2015 the total emissions of the RAC sector reached 1.47 Mt CO_2eq, of which 0.50 Mt CO_2eq represented direct emissions and 0.97 Mt CO_2eq. represented indirect emissions. The refrigerated transport and mobile air conditioning sub-sectors are responsible for most of the indirect emissions due to the fossil fuel used to electrically power these systems in vehicles.

Figure 1 presents an analysis of total emissions in Mt CO_2eq for the years 2010 and 2050, in a BAU scenario, where these projected emissions could exceed 3.0 Mt CO_2eq from 2035 onwards, hence the importance of establishing mechanisms to reduce refrigerant consumption and raise energy efficiency standards in the country, as mitigation actions for these scenarios.

Mitigation Plan

ENERGY GENERATION

In Costa Rica, thanks to the joint efforts of the government, distribution companies, cooperatives and private enterprise, electricity coverage of 99.6% of the

Table 1. **Distribution of the electricity matrix for the years 2017 to 2019 according to source**

	2017		2018		2019	
MWh	MWh	%	MWh	%	MWh	%
Renewable	11,172,683	99.67%	11,196,902	98.60%	11,217,218	99.15%
No renewable	37,415	0.33%	158,551	1.40%	95,636	0.85%
Gross Production	**11,210,098**		**11,355,453**		**11,312,854**	

Source: Fuente: CENCE, ICE.

territory has been achieved. The balance by generation source in 2019 with 99.15% of generation from renewable sources and only 0.85% from non-renewable generation.

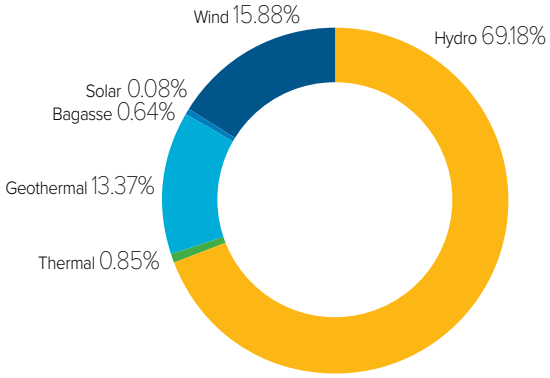
The total gross generation for 2019 was 11,312GWh. For 2017 the total gross generation was 11,210GWh with 99.67% renewable generation (the year with the highest renewable generation in history) and 2018 with an output of 11,355 GWh with 98.60% renewable generation (see Table 1).

Figure 2 shows the distribution of the electricity matrix as a percentage of gross production by source, where hydroelectric generation is the most relevant and the basis of the matrix with 69.18%, followed by wind and geothermal, which together represent 29.25%.

ENERGY EFFICIENCY

- **MEPS and labelling system.** Below table presents existing MEPS and labelling regulations in Costa Rica.
- **Update of MEPS.** Work is being carried out with different stakeholders in the country to establish an environmental label for domestic refrigerators, including aspects such as: high energy efficiency, no impact on the ozone layer, very low impact on climate change, use of recycled materials, more environmentally friendly packaging, among others. This standard has completed the public consultation process under the name: "INTE B16 Type I Environmental Labelling. Environmental criteria for household refrigerators".

Figure 2. **Energy production by source for 2019**



	GWh 2019
Renewable	**1,512.58**
Solar	**9.59**
Bagasse	**72.05**
Wind	**1,796.34**
Hydro	**7,826.66**
Thermal	**95.64**
Gross Production	**11,312.85**
Exchange	**2.26**
Demand	**11,334.11**
% Growth	**1.97%**
With respect to 2018	

Source: Energy production by source for 2019. Source: CENCE, ICE.

Number	Title	Regulation
INTE E11-1:2015	Energy efficiency. Domestic refrigerators and freezers. Part 1. Requirements. This standard has a volumetric range for domestic refrigerators up to 1,104 litres and domestic freezers up to 850 litres and operating by means of a hermetic motor compressor	For domestic refrigerators and freezers, the maximum energy consumption limits
INTE E10-1:2015	Energy efficiency. Self-contained commercial refrigeration equipment. Requirements	For commercial refrigerators, the standard that regulates the maximum energy limit. It applies to new, used and rebuilt models with a volumetric range of 50 litres of usable refrigerated space or more, so it sets the lower volume limit, but does not specify a maximum limit of application.
INTE E14-1-2018	Energy efficiency. Air conditioners. Part 1: Energy efficiency requirements and limits for air conditioners with rated capacities up to 19,050 W (65,000 Btu/h)	For air conditioning which indicates the minimum efficiency ratio, with a scope of equipment up to 19,050 W or 65,000 BTU/h.
Technical Regulation RTCR: 482:2015	Electrical Products Refrigerators and Freezers Household Appliances Operated by Hermetic Motor-Compressor. Energy Efficiency Specifications	
Guideline 011-MINAE		It is addressed to the heads of all public administration institutions, including those bodies, entities, companies, and institutions of the centralized, decentralized institutional and territorial public sector, whereby it establishes the prohibition to acquire low efficiency equipment, luminaires and appliances that cause high electricity consumption to be used in buildings and pedestrian transit facilities occupied by the public sector.
Ministerial Resolution N° 0274-2019-MINAE	Regulation for the right and use of a Costa Rican environmental label (EACR) or an energy efficiency label (EECR) on a product or service	Costa Rica has had voluntary regulations on energy efficiency issues (domestic refrigeration), and the first specific technical regulation for equipment in the RAC sector with RTCR 482:2015
29751-MINAE-H-MEIC	Technical Regulation on Energy Efficiency and Labelling for the Regulation of Refrigerators, Refrigerator-Freezers and Freezers	It excludes mobile refrigeration equipment, refrigerators, and refrigerator-freezers larger than 1100 l and portable equipment. The policy and legal framework is in place to assess the energy efficiency of most equipment in the RAC sector, although important equipment such as industrial refrigeration and air-conditioning (in the case of air-conditioning, equipment larger than 60 000 BTU) and mobile refrigeration are still pending.

- **NCAP implementation.** Develop a national proposal for a plan to guide the RAC sector during its technological transition towards the use of high-performance refrigeration and air conditioning equipment, which makes use of refrigerants with less impact on the environment and climate. This transition aims to reduce the burden of GHG emissions to the atmosphere, mitigating climate change, within the frameworks of the Montreal Protocol and the Paris Agreement, in line with the objectives of sustainable development.

ACTION PLANS

- Development of migration strategy towards alternative technologies with low-GWP refrigerants in the RAC sector.
- Formulation of financing mechanisms and development of specific marketing strategies for market transition in the RAC sector towards more Energy Efficient systems.
- Formulation of specialized working groups for the implementation of the efficient and sustainable cooling and air conditioning sector plan.
- Technical training capacity building in the refrigeration and air conditioning sector.
- Development of an information standardization mechanism for imported equipment in the RAC sector.
- Development of mechanisms to promote the procurement of efficient and sustainable RAC technologies in the public sector.
- Development and implementation of a platform for the management and disposal of end-of-life RAC and refrigerant equipment.
- Development of a market monitoring, verification and compliance system.

Key Stakeholders

Stakeholder consultations and coordination are important for the successful implementation of the NCAP.

Acronym	Definition
CEDET	Electricity Dstributors
CFIA	Costa Rican Association of Engineers and Architects of Costa Rica
CONASSIF	Supervision of the Financial System
CONESUP	National Council for Private University Higher Education
DE	Directorate of Energy, MINAE
DIGECA	Directorate of Environmental Quality Management
ECA	Costa Rican Accreditation Body
GEF	Global Environment Facility
GIZ	German Corporation for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
ICE	Costa Rican Electricity Institute
IMN	National Meteorological Institute
INA	National Institute for Apprenticeships
INTECO	Technical Standards Institute of Costa Rica
LEE	ICE Energy Efficiency Laboratory
MH	Ministry of Health
MEP	Ministry of Public Education
OTO	Ozone Technical Office
PROCOMER	Promotora de Comercio Exterior de Costa Rica
SEPSE	Energy Subsector Planning Secretariat
SICOP	Integrated Public Procurement System
U4E	United for Efficiency
UNDP	United Nations Development Programme
Others	General Directorate of Customs, importers, municipalities, dealers, and traders of RAC equipment, Organized groups of technicians and large installation and maintenance companies RAC, Refrigeration and air-conditioning equipment trading houses, Importers, traders, and technicians, Cement production plants, Organized technical groups, Development Banking System, Sedes Don Bosco, Samuel Foundation, DCC, MEIC, ICRC, DCC, GCF, CONARE, CONESUP, MNC, UNED, CONARE, UCCAE, SNC, DGA and SINAMECC

Acknowledgements

The NCAP was developed by Energy Efficiency Interventions Project (K-CEP Global) in coordination with the regional team of the UNDP Chemicals and Waste Hub, Ozone Technical Office and UNDP Costa Rica country office.

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CUBA

Country Profile

The Republic of Cuba is an archipelago located in the Caribbean Sea basin, with a surface area of 109,886 km^2. It has a population of 11,209,628 (ONEI, 2018). The tropical climate reflects two well-defined periods, one rainy season and one dry season. The average annual temperature varies from 24°C in the plains to 26°C and more on the eastern coast, with a diurnal variation of 11°C. In 2012, there were 3.82 million households; by 2030 the number may rise to 4.2 million households. With the same growth rate, it is estimated that there will be 4.5 million households by 2050, and 82 percent of the population living in urban areas. In 2020 the urbanization rate was 78 per cent. Cuba is a party to the United Nations Framework Convention on Climate Change and the Montreal Protocol. It ratified the Kigali Amendment in 2019.

Market Status of the Cooling Sector

- **Domestic refrigeration.** Currently in the country there are about 3.5 million domestic refrigerators, most of them based on HFC-134a.
- **Commercial Refrigeration.** Display cabinets, freezers and vending machines are mainly found in tourist areas, food markets, restaurants, and cafeterias. Cold rooms are used in the service sector (education, health) and in the food industry. 74% of the commercial units used HFCs (mainly R134a and R404A) in 2019.
- **Industrial refrigeration** includes the food industry and some government ministries that own cold-storage plants. In 2019, the presence of HFCs in this sector was 79.8%. The refrigerants R134a and R404A represented 91.6% of all HFCs.
- **Refrigerated transport** is used to preserve frozen food and ice cream for their distribution. In this subsector, R134a and R-404A are mainly used, representing approximately 78% of the overall use (2019).
- **Domestic Air Conditioning.** 136,187 AC units are installed in state institutions (2019), plus about 600,000 AC units are installed in Cuban homes, representing 15 percent of the existing housing stock.
- **Commercial and industrial AC.** These systems are mainly used in tourism.
- **Mobile AC.** There are about 16,461 automobiles with AC (2019).

There has been growth in the domestic refrigeration, industrial refrigeration, mobile refrigeration and AC sub-sectors, while the growth in AC systems can be considered negligible. However, in domestic and commercial AC equipment, a growth between 5 to 10 % per year is predicted, due to the continuous development of tourism. The government of Cuba reported 739,572 CO_2-eq of HFC consumption (imports) in 2020 and 6.23 tons of HCFC-22 (equal to 11,276.3 CO_2 eq) in 2019.

Energy consumption and GHG emission

Cuba reached 100% electrification of the country by 2018. Electricity generation is based mainly on thermal power stations (CTE) and generator power units, which represent 80% of the overall generation. The current installed electric power is approximately 6,661 MW. Peak demand so far has been 3,318 MW, below installed capacity. Electricity generation in 2019 was 18,341 GWh. This represents the emission of 14.67 million tons of CO_2. At present, the emission factor of the electricity network in Cuba is 0.8 CO_2 kg/kW-h. In 2018, only 4.5% of power was generated from renewable energy sources in Cuba. Electric power is subsidized by the state. Prices for residential areas have a growing tax scale with the aim of encouraging savings.

According to the latest GHG inventory, in 2016, gross emissions rose to approximately 50,214 kt of CO_2 equivalent. The electricity consumption of air conditioning and refrigeration equipment is not officially determined. In the development of the national cooling plan, an estimate was made. It is considered that the RAC sector has an electrical energy consumption that represents approximately 20% of the total (See table 2). The residential sector constitutes 71 percent of RAC sector emission.

Table 1. **Electricity consumption distribution (2019)**

	Total Nacional	
Sector	Consumption (GWh)	%
Residential	9,257	50.47
No Residential	6,388	34.82
Sub Total	**15,645**	**85.29**
Total Losses	2,696	14.71
Total	**18,341**	***100***

Mitigation Plan

ENERGY GENERATION

It is estimated that Cuba will generate 30,000 GW-h electricity by 2030, with an installed capacity close to 9,000 MW. The installation of 4 new CTE of 200 MW each is planned. The government outlined their policy in three areas: 1) transform the structure of energy sources used in the generation and consumption of electricity, increasing the share of renewable energy sources; 2) increase efficiency in the generation and consumption of electricity, achieving a reduction in the costs of the kWh delivered by the SEN (Servicio Eléctrico Nacional – National Electric System); and 3) increase the environmental sustainability of the economy and reduce pollution.

Based on Decree-Law No. 345/2019, it is expected that 24% of generation will be through renewable energy by 2030. It is planned to install 2,144 MW connected to the national grid, which includes the construction of 19 bioelectricity facilities, 13 wind systems, 700 MW Photovoltaic and 74 small hydroelectric plants. It is estimated that the implementation of these programs will allow the generation of more than 7000 GWh per year, avoiding more than 6 million tons of CO_2 emissions.

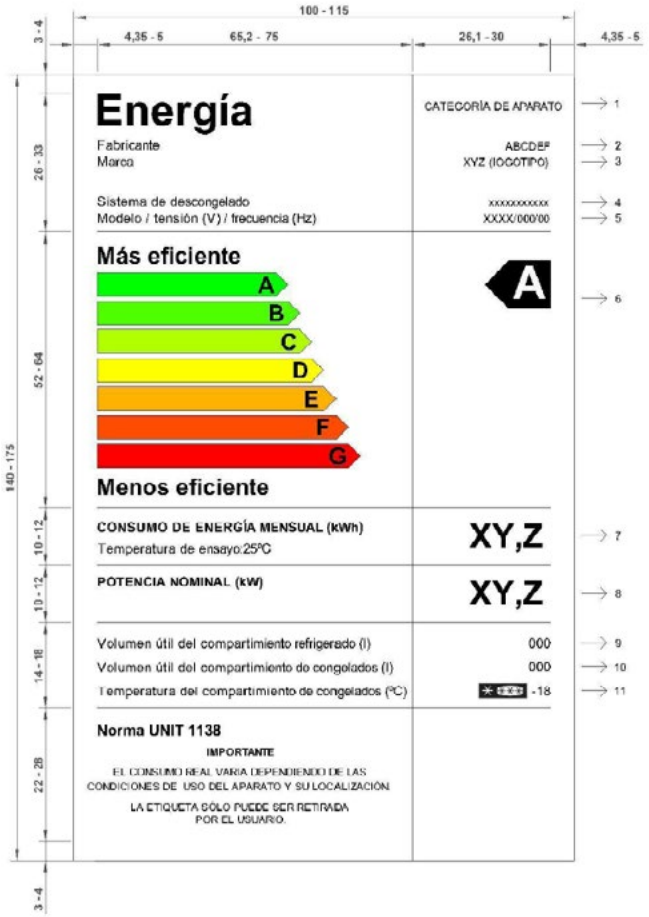
ENERGY EFFICIENCY

- **MEPS and labelling system.** In Cuba, minimum energy efficiency indices are used for the import and evaluation of refrigeration and AC equipment. These were stated in the Technical Regulation on Energy Efficiency for Electrical End-Use Equipment (Resolution 136/2009 of the Ministry of Basic Industries). The penetration in the market of any equipment requires the technical acceptance by ONURE (National Office for the Rational Use of Energy by its acronym in Spanish). The first step is the application to the National Testing Laboratories (LABET) to verify compliance with the MEPS. The regulations stipulate that energy-efficient equipment must attach the energy-efficiency label (Figure 4) to be sold in the country.

Table 2. **Estimated electricity consumption and emissions of RAC equipment**

Sector	Consumption (GWh/year)	Emission de CO_2 (Mt)	Percentage (%)
Domestic Refrigeration	1,285	1.028	7.00
Domestic AC	1,450	1.160	7.90
MINTUR	352	0.282	1.92
MINAG	80	0.064	0.44
MINCIN	86	0.069	0.47
Other ministries and entities	480	0.384	2.62
TOTAL	**3,733**	**2.987**	**20.35%**

Figure 4. Energy labelling



- **Update of MEPS.** It is expected that MEPS will be reviewed every two years. New energy efficiency values were approved by the end of 2021. For domestic refrigerators, the lowest efficiency class admitted will be B, which is one level higher than the current minimum standard. Table 3 shows the proposed new EE standard for AC units. Others, like freezers, are updated also.

- **Replace Programme.** During 2007 and 2009, almost 2.6 million refrigerators were replaced in the Energy Revolution Programme. It is estimated that 292 ktCO_2 eq were avoided annually. Also, some 78,000 AC units were replaced. The new product has an average annual consumption of 2,098 kWh, while the old one was 4,032 kWh. The GHG mitigation is 42.3 kt CO_2eq per year.

- **Standards and resolutions.** Cuba has developed a various of standards and polices related to the cooling sector, including building design, specifications and design requirement of HVAC systems and technical and economic analyses in the installation of air-conditioning systems in tourism.

- **NCAP implementation.** The NCAP is an exceptional opportunity to integrate all the ongoing and planned actions to be implemented in the future, with a focus on integrated programmes for energy efficiency improvement and phasing down of HFCs.

Table 3. Propose new energy efficiency standard for AC units

Proposed values for window unit			Proposed values for split AC units		
Cooling Capacity	**EER (BTU/Wh)**	**EER (W/W)**	**Cooling Capacity**	**EER (BTU/Wh)**	**EER (W/W)**
3500 W (12000 BTU/h)	≥ 9.4	≥ 2.75	3500 W (12000 BTU/h)	≥ 10.0	≥ 2.92
5250 W (18000 BTU/h)	≥ 9.0	≥ 2.63	5250 W (18000 BTU/h)	≥ 9.75	≥ 2.85
7000 W (24000 BTU/h)	≥ 8.5	≥ 2.48	7000 W (24000 BTU/h)	≥ 9.60	≥ 2.80
			14 067W (48000 BTU/h)	≥ 10.0	≥ 2.92
			10500 W (36000 BTU/h)	≥ 9.23	≥ 2.70
			17854W 60000 (BTU/h)	≥ 10.40	≥ 3.05

INITIATIVES PROPOSED FOR THE IMPLEMENTATION OF THE NCAP

- Creation of key stakeholders' group
- Policy measures
- Development of integrated program, including evaluation of finance mechanism for market transformation
- Evaluation of RAC EE technologies
- Enhancing MEPS and labeling system
- Improvement of energy efficiency of existing systems
- Training and capacity building
- Market monitoring, verification, and enforcement
- Outreach and communications
- Regional collaboration
- International cooperation

Key Stakeholders

Stakeholder consultations and coordination are important for the successful implementation of the NCAP.

Stakeholder	Roles and responsibility
Ministry of Science, Technology and the Environment (CITMA)	Its mission is to direct, execute and control the State and Government policy in the areas of science, technology, environment; the use of nuclear energy, standardization, metrology and quality control, promoting the coherent integration of these to contribute to the sustainable development of the country.
Technical Office of Ozone (OTOZ), belonging to Cubaenergía, CITMA	Responsible for implementing the Montreal Protocol obligations
General Customs of the Republic	It is the control body that guarantees the security and protection of socialist society and national economy, as well as tax collection and foreign trade statistics. Ensure that no unauthorized RAC equipment or refrigerants penetrate the country.
National Office for the Rational Use of Energy (ONURE), MINEM	Responsible for regulating, control and inspecting processes for the operation and efficient use of energy carriers in the country. Training in the management of the rational use of energy.
National Office of Statistics and Information (ONEI)	It is the national entity commissioned to direct the National Statistical System and is responsible for the methodological direction of the Government Information System, which includes its organization, coordination, integration and control. It has a database containing relevant information about RAC systems.
Ministry of Industry (MINDUS)	Body to which the manufacturers of RAC belong.
Institute of Refrigeration and Air Conditioning (IRC), MINDUS	It carries out research and innovations in the field of refrigeration, air conditioning and ventilation. Leads the Technical Committee for Standardization, LABET tests and certifies RAC equipment of national and international production.
Ministry of Higher Education (MES)	Universities with Mechanical Engineering Faculties act as education and training centers. They also carry out research and development projects on energy efficiency in general and on RAC systems in particular.
Ministry of Education (MINED)	Theoretical and practical training of refrigeration technicians takes place at polytechnics. It is also responsible for the training of these students and refrigeration mechanics in Good Refrigeration Practice.
Food Industry Ministry (MINAL)	One of its functions is to regulate and control the policy of quality management, maintenance, investment and industrial development in food processing entities.
Ministry of Domestic Trade (MINCIN)	Personal services (hairdressing, barbering, laundry, watchmaking and others) and commercial and domestic technical services (repair shops for household appliances, and others) belong to this category.
Ministry of Agriculture (MINAG)	It has a significant number of industrial cold stores. It is the first link in the production and commercialization of food.
Ministry of Tourism (MINTUR)	All hotels and extra hotel sector of the country.
Importers, technical services (public and private)	They are the dealers of refrigerants and cooling equipment, installers, servicing workers, and personnel responsible for managing refrigerants.

Acknowledgements

The NCAP was developed by MSc. Rafael Quintero Ricardo in coordination with the regional team of the UNDP Chemicals and Waste Hub, Ozone Cuban Unit and UNDP Cuba country office.

GHANA

Country Profile

Ghana is a West African country near the equator. Ghana covers a total land area of 239,000 km^2 with an estimated population of 31 million, distributed as 57.3% urban and 42.7% rural. It has a relatively high annual population growth rate of 2.4% in line with the 2.5% average for Sub-Saharan Africa.

Ghana is signatory to the UNFCCC; a National Climate Change Committee has been formed and a National Climate Action Plan has been developed. Ghana has also put in place an implementation plan for its NDC, including RAC sector mitigation actions. Ghana ratified the Kigali Amendment on 2 August 2019 and reported consumption of 471,391 CO_2eq of HFCs and 16 ODP tonnes of HCFCs in 2020.

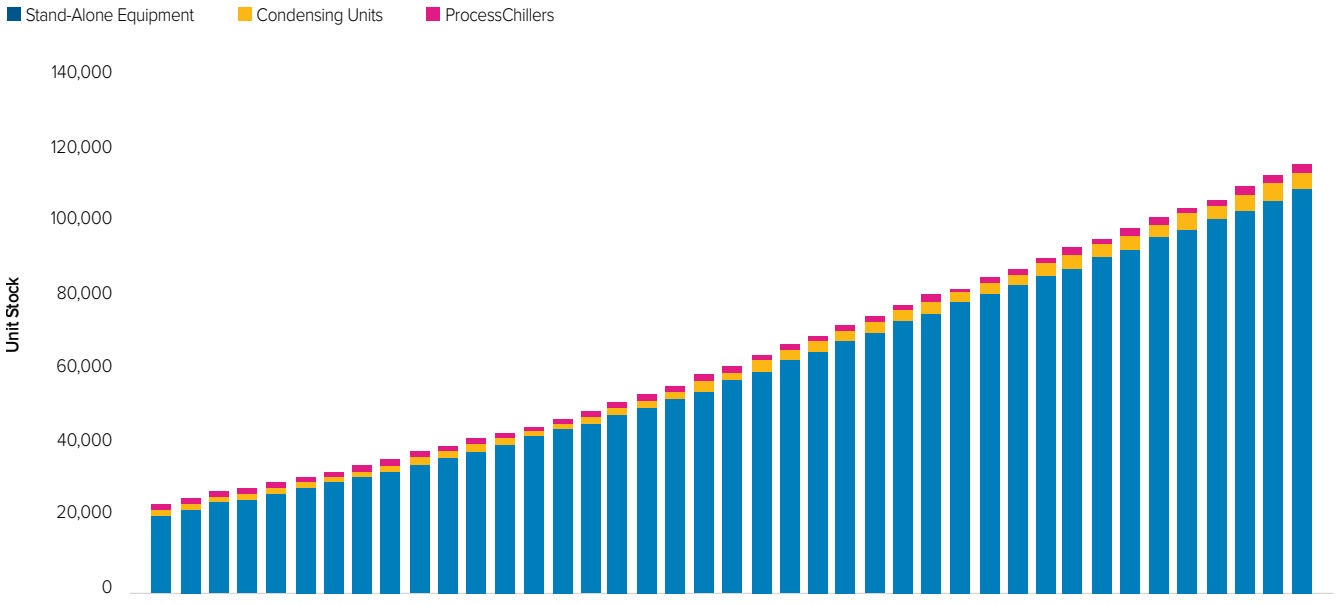
Market Status of the Cooling Sector

In Ghana, the cooling market is largely based on synthetic refrigerants, the exception being ammonia plants used for large cooling loads in industry and a limited number of large cold storages, and hydrocarbons (R600a) which is dominating application in domestic fridges and freezers today.

- **Domestic refrigeration:** It is the fastest growing sub-sector, driven by expanding nationwide electricity coverage and increasing urbanization. The stock of refrigerators is estimated to be over 6 million units in 2015, predicted to grow to 23 million in 2050. The refrigerant distribution stands at 63% for R-134a and 37% for R-600a refrigerators (GCI/GIZ/EPA, 2018)[2].
- **Commercial and industrial refrigeration:** Commercial refrigeration has also witnessed considerable growth, driven mainly by shops and supermarkets fitted with standalone units (i.e., drink dispensers, display cabinets) in the growing urban landscape. The refrigerants are typically R-134a and R-600a in the standalone units, and R-404A in the condensing units.

The big users of industrial refrigeration in Ghana are mainly the breweries as well as processing companies of multinationals such as Nestle, Unilever and cocoa companies. Refrigeration systems vary, from large central ammonia plants in the breweries, to low-capacity chiller units operating with HFCs for small cooling load applications. Local subsidiaries of multinational companies have their cooling systems usually decided by their mother companies.

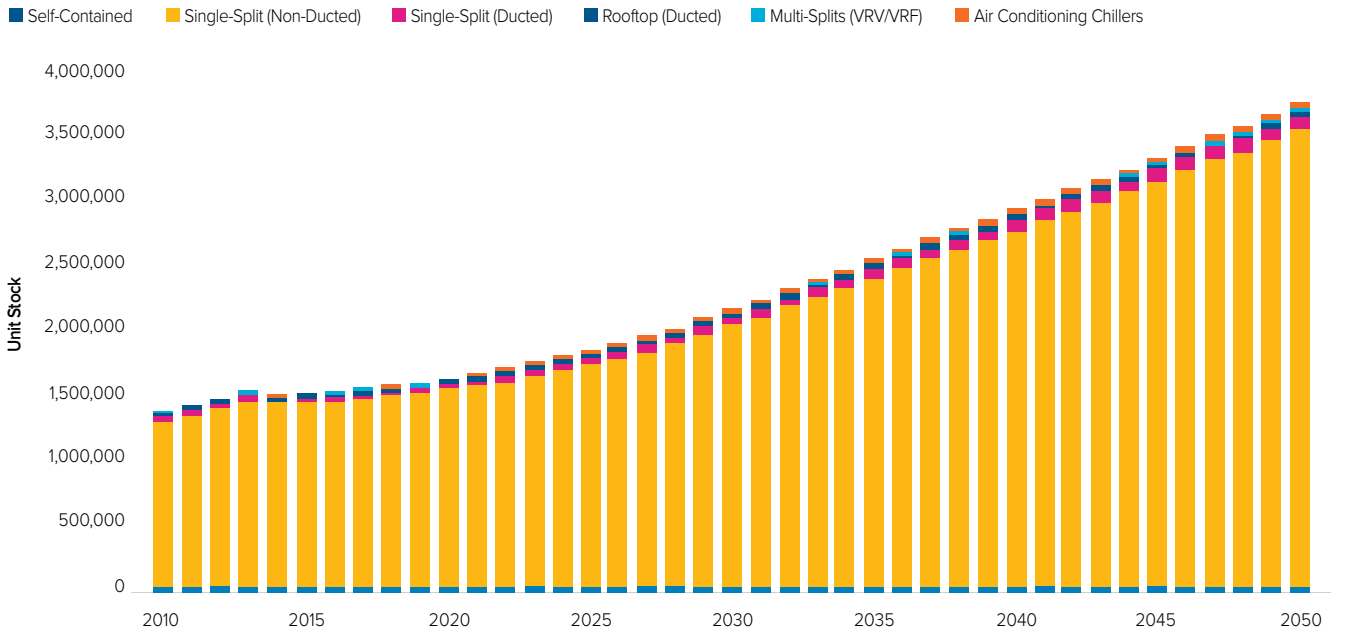
Figure 1. **Projected growth of Commercial and Industrial Refrigeration stock**



- **Transport refrigeration:** This sub-sector is an important link in the cold chain for preserving food, medicine, and other perishable commodities. In Ghana, it has remained greatly underutilized, except for the ice cream industry and a few others. R-134a and R-404A are the predominant refrigerants in the transport sub-sector, exposed to the bad road conditions which can cause higher leakage rates and frequent breakdowns. Similar to the MAC sub-sector, it is difficult to regulate the emissions from this sub-sector based only on national regulations, because the technology used is organized by the global automotive industry.
- **Stationary air conditioning:** The sub-sector is dominated by unitary AC of which the single split has the largest share. The stock of AC non-ducted units in Ghana was estimated to be 1.3 million in 2010. The annual growth rate for AC units is estimated at 4.4% between 2016-2030.

  R-410A and R-22 refrigerants dominate the units on the market, while R-22 units are more dominant (68%) because they are cheaper compared to R-410, both in the cost of the units and the price of the refrigerant. Under the HPMP, over 10,000 existing R-22 single split units have been converted to R-290. The Ghana Energy Commission, with support from UNEP U4E, has introduced new R32 energy efficient units to the market through the EcoFridges programme3. New R-290 fixed speed units were also introduced through a collaboration between Ghana EPA and GIZ, and this is expected to grow in the future.
- **Mobile air conditioning (MAC):** The sub-sector is a rapidly growing sub-sector as the vehicle ratio per 1000 people increased from 50 to 70 during 2010-2015, reaching 2 million cars in 2015. Although R-134a has been the dominant refrigerant, a few new saloon cars have been imported with R-1234yf MACs recently, which are several times more expensive than R-134a. MAC systems operate on poor road conditions and leakage rates are usually very high.
- **Marine sub-sector:** The cooling system in the local marine sub-sector is limited to fishing activity, comprised of ice making plants and refrigeration systems on board the fishing vessels. Commercial ice production is capital intensive and unprofitable on a small scale. As a result, only a few ice making plants serving the fishing communities exist today. Three refrigerants are used in the existing ice plants, R22, R404A and R717, with R22 plants dominating.

Figure 2. **Projected growth of Stationary Air Conditioning stock**



Industrial fishing vessels have onboard refrigeration systems for catch preservation, usually by freezing or keeping in chilled brine. Three refrigerants used in these systems are R22, R502 and R717 (ammonia) with R717 dominating. Refrigeration on most of the fishing vessels is inefficient, saddled with breakdown repairs and suffering high refrigerant leakage.

Energy consumption and GHG emission

Ghana's RAC sector has grown steadily due to nationwide electricity coverage, rapid urbanization, population growth, and expanding middle class. This has also increased the sector's contribution to national GHG emissions, from both direct and indirect sources, as follows:

- In the BAU scenario, energy demand for the RAC sector is estimated to triple by 2050 and corresponding GHG emissions to increase from 5 Mt CO_2eq in 2015 to 13 Mt CO_2eq in 2050, with a breakdown of 70% indirect and 30% direct emissions (Figure 3).
- Unitary ACs, MACs and Domestic Refrigeration are the major contributors to current/future total RAC emissions with the largest share (58%) being the split AC units.
- In the mitigation scenario, the sector's total emissions could be reduced from 12.8 Mt CO_2eq to 8.5 Mt CO_2eq by 2050, as it is illustrated in Figure 4.

Mitigation Plan

ENFORCEMENT OF A MEPS AND LABELLING SYSTEM

In Ghana, the Energy Efficiency Standard and Labels for Room Air Conditioners, introduced in 2005, was the first attempt in the RAC sector, but they have not been revised since. The study carried out on 106 split units in the country showed that the majority had their Energy Efficiency Ratio (EER) very close to the minimum EER of 2.8, even though higher EER units are available on the market. The following key activities are recommended to support the proposed priority matrix for MEPS/Labels shown in Table 1:

- Development of MEPS for VRV's and Split Ducted Units.
- Review of MEPS every five years for Split non ducted, VRV's and Split ducted units.
- Review of Ghana Building Code to include Certification of building with sustainable cooling.
- Establishment of an AC Testing Facility for VRV's and Split Ducted Units

Figure 3. **BAU projection of Direct and Indirect emissions**

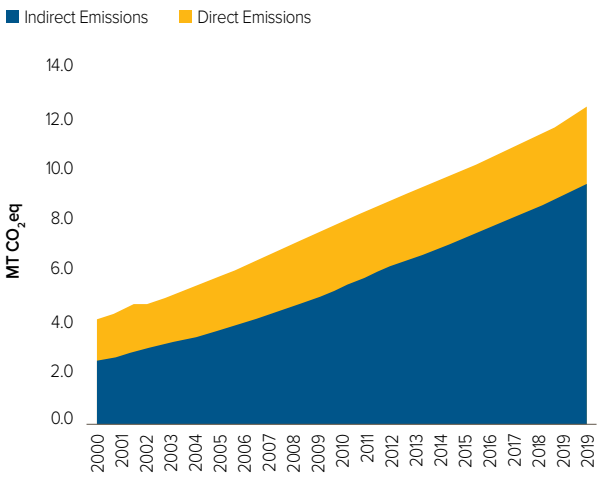


Figure 4. **BAU and Mitigation scenario for the RAC sector**

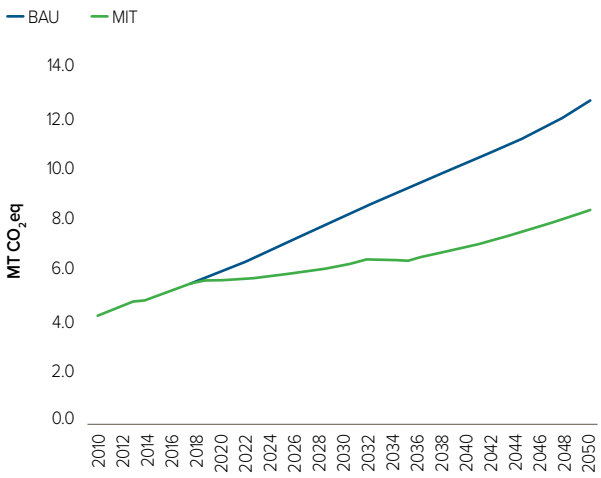


Table 1. **Proposed priority matrix for MEPS and Labelling Systems**

Planning Stage Implementation Stage

Priority Matrix for Meps & Labels

	Year				
Sub-sector: Unitary air conditioning (Stationary AC)	2022	2023	2024	2025	2026
i. Single split (ducted)					
ii. Multi-split (VRV/VRF)					

TRAINING AND CAPACITY BUILDING

New energy efficient technologies with low-GWP alternatives require capacity building and training actions on installation, operation, maintenance, and safety issues. The NCAP recommends the prioritization of the following training activities:

- Training for RAC technicians on energy efficiency integration into RAC servicing.
- Update of RAC training school curriculums and design of Certification Programs.
- Energy modelling/simulation training for Architects, Mechanical and Electrical Engineers to include the efficient, low-GWP alternatives in their design.

FUNDING AND FINANCIAL MECHANISMS FOR MARKET TRANSFORMATION

This includes funding and financing schemes to bridge the high upfront costs of alternative systems with lower operating costs due to energy savings. In this regard, the Ghana Energy Commission, with support from UNEP U4E and BASE, is currently implementing the ECOFRIDGE Project which aims to develop a market-based approach to enable the affordable replacement of old, inefficient split AC's and domestic refrigerators in households with more efficient and lower-GWP alternatives.

OPPORTUNITIES FOR REGIONAL COLLABORATION

Harmonizing MEPS, labelling and standards among countries with similar usage and energy cost conditions across the same product categories can help with verification, testing and compliance. Thus, coordinated efforts are recommended to boost regional collaboration on MEPS/labelling through the following initiatives under implementation in the region and Ghana: i) West Africa Energy Cooling Initiative; ii) West Clean Energy Eco-fridge Project; and iii) ECOWAS Center for Renewable and Energy Efficiency (ECREE) project.

WASTE MANAGEMENT

There are companies in Ghana that deal with waste from the RAC sector, recycle the plastic and metal components of old AC units to produce plastic pavement blocks, iron rods etc. Banned refrigerants are the major waste component that is currently very difficult to manage since there is no refrigerant destruction/disposal plant in Ghana. Currently, banned refrigerants once recovered are canned and stored. When financing is made available (through project grant, or carbon finance), they are transported abroad for proper incineration. Thus, Ghana EPA/NOU is currently pushing for a destruction/disposal plant to be established in the country. Such a plant project will need to be complemented with capacity building on the collection and transportation of inefficient RAC appliances and waste refrigerant to the waste plant.

Key Stakeholders

Ghana already has a network of key stakeholders under the National Committee on Ozone Depleting Substances (NACODS), serving as an advisory body for the NOU/ EPA on all ODS-related matters. The following members of NACODS are identified as key stakeholders:

- Ministry of Environment, Science & Technology and Innovations, Ministry of Energy, Ministry of Trade and Industry, Ministry of Food and Agriculture, Ministry of Works and Housing, Ministry of Finance
- Energy Commission, Ghana EPA, Ghana Meteorological Agency, Ghana Revenue Authority – Customs Division, Council for Scientific & Industrial Research (CSIR), Chemicals Control & Management Centre, Factories Inspectorate Department, Ghana Standard Authority (GSA)
- RAC Associations (National Air-conditioning & Ref. Workshop Owners Association (NARWOA) and RAAG), Ghana Association of Industries, Ghana Institution of Engineering (GHIE), Ghana Institution of Architects (GIA), Friends of the Earth – Ghana (NGO), Universities.
- Distributers, suppliers, servicing companies, technicians, end-users.

Acknowledgements

The NCAP was developed by Ing. Dr. Kwame Owusu-Achaw and Ing. Herbert Bimpong, on behalf of Ghana EPA/NOU. The work was carried out under the direct supervision of the National Ozone Officer (NOO) in Ghana, supported by the United Nations Development Programme (UNDP) in Ghana and its regional team of the Chemicals and Waste Hub, and in coordination with key national stakeholders including the Energy Commission. The NCAP was funded by the Kigali Cooling Efficiency Programme (K-CEP), now called Clean Cooling Collaborative, through UNDP.

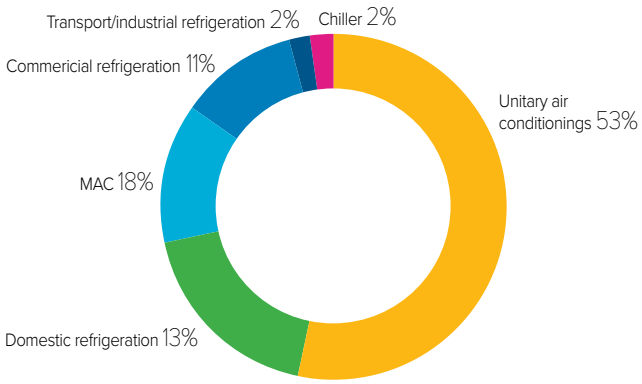
Photo by Shutterstock/Felix Lipov.

LEBANON

Country Profile

Lebanon is a relatively small country in the Middle East with an area of 10,452 km² and a population close to 5.5 million, making it the tenth most densely populated country in the world. Lebanon's urbanization rate currently stands at 88.6% and forecasted to reach 93.4% by 20501. Additionally, Lebanon hosts more than 1 million refugees from different origins in recent years. An estimate from the Climate Impact Lab (2019) indicates that in Lebanon, the number of days with over 35°C temperatures will increase dramatically from 6 days in 2020 to 36 in 2050. Lebanon has signed the Paris Agreement on 22 April 2016 and ratified the Kigali Amendment on 5 February 2020.

Figure 1. Split of GHG emissions by subsectors

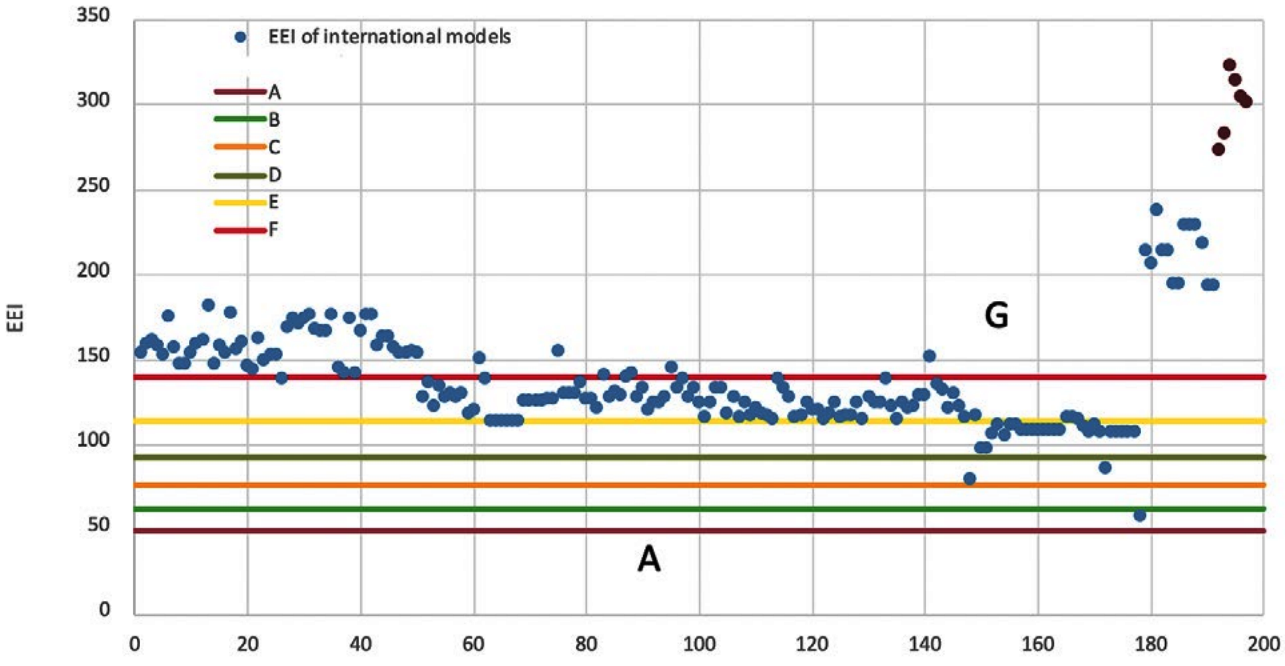


Market Status of the Cooling Sector

Lebanon has a high market penetration of Refrigerators and Air Conditioners (RAC). The market of domestic refrigerators is saturated, and the stock will remain at around 2.2 million units in the long run. In the year 2010, the sale of AC units (all types) was about 277,000 units, with a share of unitary AC over 78%. However, there is a significant drop in the market size of unitary ACs after 2010, which was caused by an unstable economic situation. While Lebanon is phasing-out ozone-depleting refrigerants, the RAC market is dominated with units based on high GWP refrigerants like other countries. Lebanon reported the HFCs consumption of 1,743,012 CO_2eq and 569 metric tons of HCFCs (equal to 972,967 CO_2eq) in 2020.

Lebanon does not have a Minimum Energy Performance System (MEPS) and labelling system in place. Appliances in use have a low energy performance in comparison

Figure 2. Appliance mapping within proposed labelling classes



with other countries. Without MEPS and labelling, end-users are lacking clear guidance on energy-efficient appliances. Importers, sellers and manufacturers have little incentive to place more energy-efficient appliances on the market, as uninformed end-users tend to purchase the appliances with the lowest up-front costs.

Energy consumption and GHG emission

In 2019, the Electricité du Liban (EDL) installed capacity was 2,449 MW, making 66% of the country's demand that is reported to be 3,669 MW (MoE&W, 2019). More than 95% of electricity is generated from heavy fuel oil and diesel. The grid emission factor (GEF) in the analysis of NCAP is assumed constant at 0.6732 tCO_2/MWh.

7.7 $MtCO_2eq$ | Energy related emissions 5.1 Mt CO_2eq (68%)

Currently, the RAC sector accounts for about 7.7 $MTCO_2eq$ in annual GHG emission (32% of direct refrigerant emission and 68% of indirect energy related emission) and 6,000 GWh (2018) in electricity consumptions which is about 26% of Lebanon's total electricity demand. In the RAC sector, room AC, refrigerator, and commercial and industrial refrigeration represent 53%, 24% and 20% of electricity consumption respectively. Under the BAU scenario, the GHG emission will increase to 10 MTCO2-eq and about 8,000 GWh in electricity consumption by 2030.

Mitigation Scenario

In the Mitigation Scenario, RAC electricity demand peaks around 2030 at just over 6,500 GWh, a 19% reduction on the BAU RAC peak demand of 8,000 GWh.

Table 1. **Modelling parameters for the BAU scenario**

Equipment type	Lifetime [years]	Main refrigerants	Initial charge (IC) [kg]	EER (2018)	Service emission factor [% of IC]	Disposal emission factor [% of IC]
Split residential AC	1,285	R22, R410A	0.9	3.2	10	95
Split commercial AC	1,450	R22, R410A	1.8	3.1	10	80
Rooftop ducted	352	R22, R407C, R410A, R134A	10	2.9	8	75
Multi-splits	80	R22, R407C, R410A	15	3.6	10	80
AC: chillers	86	R22, R134A, R410A	35	3.2	22	95
Car air conditioning	480	R134A	0.6	2.7	20	100
Large vehicle AC	1,450	R134A	8	2.7	30	100
Domestic refrigeration	352	R134A, R600A	0.175	1.3	2	80
Stand-alone equipment	80	R134A, R404A, R290A, R744	0.4	2.8	3	80
Condensing units	86	R22, R134A, R404A, R744, R717	5	3.1	30	100
Centralized systems	480	R717	500	2.0	40	100

Table 2. **Modelling parameters for the BAU scenario**

Subsector	Refrigerants			Energy efficiency ratios		
Category	Current	2030	2050	Current	2030 (MIT)	2050 (MIT)
UAC	R22, R410A	R290	R290	3.2	4.3	6.1
Chiller	R22, R134a, R410A	R290, R744, HFO	R290, R744, HFO	3.5	4.3	5.2
MAC	R134a	HFO1234yf, R290, R744	HFO1234yf, R290, R744	2.6	3.2	4
Domestic refrigerators	R134a, R600a	R600a	R600a	1.3	2.1	3.1
Commercial refrigerators	R134a, R404A, R290, R744	R290, R600a, R744	R290, R600a, R744	2.1	2.4	3.3

With the transition to energy-efficient and low GWP RAC appliances, GHG emissions can be further lowered, by 2050, to 4.5 MTCO$_2$eq and electricity demand to below 5,000 GWh, which is 44% lower than BAU, 10% below 2010 demand and 25% below the 2018 levels.

Refrigerant related emissions - 2.5 Mt CO$_2$eq (32%)

Roadmap of NCAP

The NCAP aims at an effective action plan that tackles GHG and ODS emissions with coherent policies. The NCAP of Lebanon includes five main components: 1) a market study, 2) a proposal for a MEPS and Labels regulation, 3) options for financing mechanisms, 4) integration of the NCAP into NDC, and 5) a roadmap for the transition to carbon neutrality in the cooling sector by 2050.

Figure 3. **GHG emissions by subsectors by 2050 BAU and MIT scenarios**

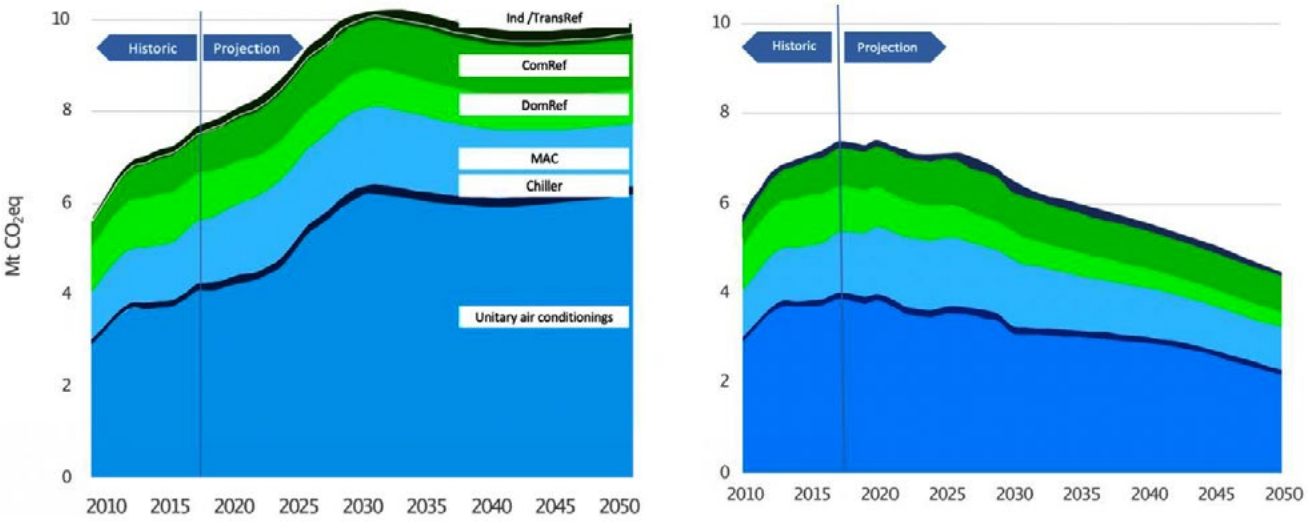


Table 3. Recommended roadmap milestones for the NCAP implementation

Feature	Status (2020)	2025	2030	2050
Cross-sectoral financing	No or limited dedicated incentive programs for cooling appliance	• Import levies based on energy consumption of appliances and their labels • Import levies based on GWP content of refrigerants • Carbon credit programme to finance take-back system	Continued	Continued
Energy	No mandatory MEPS and labels for appliances	• Mandatory MEPS and labels for ACs and refrigerators according to the recommendations of the NCAP • Compliance and spot testing of MEPS and labels • Ban on import of second-hand appliances	• Mandatory MEPS and labels for commercial refrigeration and AC systems (alignment with U4E model standards) • Updated MEPS and labels for domestic refrigerators and ACs	Increasingly ambitious MEPS and labels
Buildings	No-mandatory building standards	Target building standards (< 150 KWH/m^2); Improved tightness and insulation standards; Cool rooftops for >50% of new buildings	Target building standards (< 100 KWH/m^2); Cool rooftops and/ or solar for all new buildings and 50% of old buildings;	Target building standards (< 50 KWH/m^2); Cool rooftops/ rooftop solar for all buildings;
Industry/ Manufacturing	F-gases: No/limited restriction on F-gases;	• F-gases: Levies on F-gases based on NCAP; • Ban for F-gas use on appliances with ready alternatives: refrigerators; < GWP 10 ACs; < 1000 commercial AC and refrigerator • Manufacturing: Incentives climate friendly and energy efficient design • Mandatory certification and registration for all cooling technicians	• F-gases: Increased levies • Ban for F-gas use on appliances with ready alternatives: refrigerators; < GWP 10 ACs; < 1000 commercial AC and refrigerator • Mandatory certification and registration for all cooling technicians	• F-gases: Phase out of HFC; HFC limits < GWP 10 • Mandatory certification and registration for all cooling technicians
Transport	No/limited cooling standards	>25% of new vehicles with AC or refrigeration systems with refrigerants < GWP10	>55% of new vehicles with AC or refrigeration systems with refrigerants < GWP10	>75% of new vehicles with AC or refrigeration systems with refrigerants < GWP10
Waste	No or limited recycling of cooling appliances & recovery of refrigerants	Establishment of a central recycling facility, establishment of a take back programme	Achieving > 80% recycling quota for all mass cooling appliances; environmental sound destruction of refrigerants and foam blowing agents	Achieving > 90% recycling quota for all mass cooling appliances and destruction of refrigerants and foam blowing agents
Agriculture and food	No cold chain standards	25% of all cold stores with renewable power and integrated cooling appliances	50% of all cold stores with renewable power and integrated cooling appliances	>75% of all cold stores with renewable power and integrated cooling appliances

Acknowledgements

The NCAP was developed by HEAT GmbH. The work was carried out under the direct supervision of the National Ozone Office (NOU) in Lebanon and in coordination with the United Nations Development Programme (UNDP) in Lebanon and the regional team of the Chemicals and Waste Hub. The NCAP is funded by the Kigali Cooling Efficiency Programme (K-CEP – now Clean Cooling Collaborative) through UNDP.

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MEXICO

Country Profile

Mexico is a country in the southern portion of North America and covers 1,972,550 km^2, making it the world's thirteenth -largest country by area. Mexico is the tenth-most-populous country in the world, with approximately 126 million inhabitants. The country has the fifteenth largest nominal GDP (US$1.15 trillion).

Mexico was the first developing country to present its NDC to comply with the Paris Agreement. The country committed unconditional measures to reduce GHG emissions by 22% and black carbon emissions by 51% until 2030. Mexico ratified the Kigali Amendment on 25 September 2018. The country reported HFC consumption of 48,211,034 CO_2eq and 120 ODP tonnes of HCFCs in 2020.

Market Status of the Cooling Sector

Mexico has an important RAC appliance industry as the main exporter in Latin America and the fifth largest in the world. It is also a leader in the export of two-door refrigerators with freezers and is the second biggest exporter of refrigerators/freezers with a market value at 11% of world sales, only behind China.

In the domestic RAC sector, there are around 35.2 million homes in Mexico and more than 5.9 million AC units are estimated to be in use in homes, of which 2 million are window-type. 38.3 million people in the country do not have AC equipment in their homes. The penetration of domestic refrigerators grew from 82.1% in 2010 to 87.5% in 2020, reaching 30.8 million in use in homes. However, there are 4.4 million homes without refrigeration equipment. In 2013, 3.6 million domestic RAC appliances were sold in Mexico, while 2019 sales increased by 25% to 4.5 million domestic RAC equipment.

In the commercial sector, there are 4.6 million commercial refrigeration equipment (mostly self-contained, such as bottle racks, freezers, condensers for cold rooms and centralized systems in supermarkets). There are also 4.2 million AC units for commercial/service sector use in hotels, restaurants, schools, hospitals, stores, supermarkets, pharmacies, etc. In terms of sales, in 2013, commercial RAC equipment sales were 0.5 million, while in 2019 it was 0.9 million with an 80% increase.

- **Domestic refrigeration:** The country is at 87.5% saturation for domestic refrigerators. The stock of domestic refrigerators is estimated to grow to 43.2 million units in 2050. In the Mexican market, medium and small capacity refrigerators are dominant with approx. 77% share, such as the two-door units with low electrical consumption (Figure 1). Figure 2 shows that 78% of the domestic refrigerators in the national inventory are less than 10 years old, thus, in general with a good energy performance in compliance with the Mexican energy standard. Approx. 19% of the equipment has an operational life of more than 10 years.
- **Commercial refrigeration:** There were 4.6 million commercial refrigeration equipment in Mexico, in 2018. This subsector has significant growth projection up to 7.3 million units by 2030 (Figure 3). This subsector includes self-contained equipment (HFC-134a or R-404A), remote condensers and evaporators with condenser to cool rooms (HCFC-22, HFC-134a, R-404A) and large capacity centralized systems with a series of evaporators remotely connected to compressors/condensers that use large amounts of refrigerant, mainly HCFC-22 or R-404A. Low-GWP hydrocarbon refrigerants are already an

Table 1. **Quantity of RAC equipment in domestic sector**

Equipment	Total units installed
Refrigerators	30.8 million
Air conditioners	5.9 million

Table 2. **Quantity of RAC equipment in commercial sector**

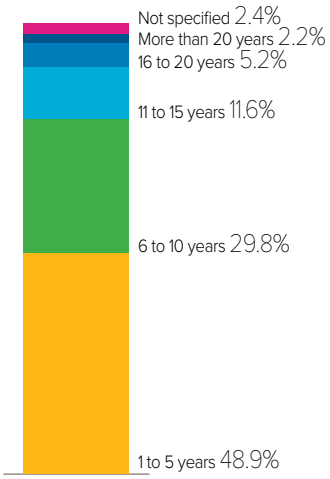
Equipment	Total units installed
Refrigerators	4.6 million
Air conditioners	4.2 million

Figure 1. Domestic refrigeration unit by capacity and climate distribution

Refrigerator capacity	Compact	Small	Medium	Large	Extra large	Total teams = [year 2018]	
Liters	<170	170 to 283	311 to 425	453 to 566	567		
ft³	<6 ft³	6 to 10 ft³	11 to 15 ft³	16-20 ft³	> 20 ft³		
Extreme warm region	215,330	1,856,294	3,192,825	1,930,545	230,180	7,425,175	26%
Temperate region	469,886	5,795,267	6,735,040	2,506,061	156,629	15,662,883	54%
Tropical region	290,695	2,441,835	2,209,279	813,945	58,139	5,813,892	20%

Compact	Little	Medium	Big	Extra big	Total
975,911	10,093,395	12,137,144	5,250,552	444,948	28,901,950
3.40%	34.90%	42.00%	18.20%	1.50%	100%

Figure 2. Age of domestic refrigerators



option in self-contained refrigerators, and there are also applications of trans-critical CO_2 systems in supermarkets in the country.

- **Domestic air conditioning:** In 2018, the sale of AC equipment of the different types exceeded 800,000 units per year; by 2030 it is estimated that it would reach the annual sale of 2.5 million units, with an estimated total stock of 11 million (Figure 4). In the Mexican market, sales of window-type AC units have fallen from 74% to 8%, which has been displaced by split units with on/off and inverter versions. Split units are now the dominant technology on the market. As for the inverter type, they reach more than 50% of the market and compete with the on/off type equipment, even though their initial cost was higher. These units are in the transition from HCFC-22 to R-410A and recently with HFC-32 (with GWP 83% lower than HCFC-22).

Figure 3. Commercial refrigeration stock projection

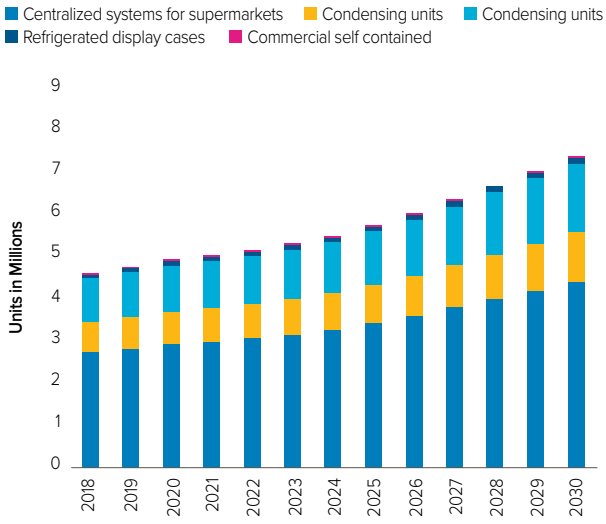


Figure 4. Domestic AC stock projection

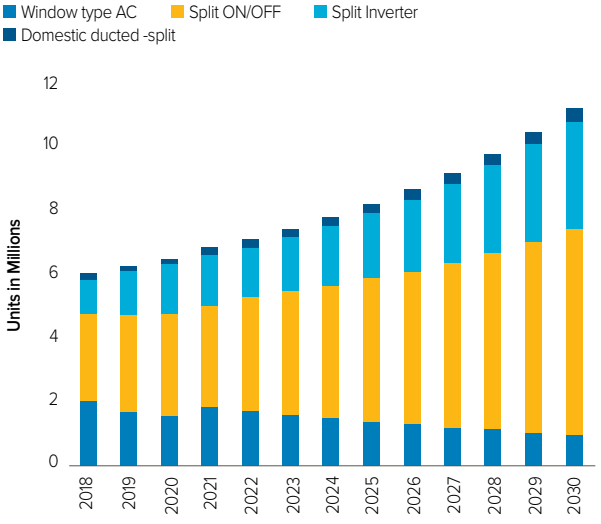
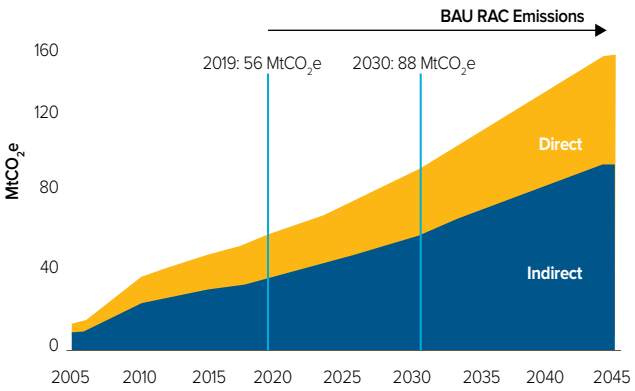


Figure 5. **Electricity consumption in the RAC sector (2019)**

Domestic sector	Energy consumption [TWh]
Refrigeration	13.06
AC	16.57
Domestic RAC	29.63
Refrigeration	11.92
AC	26.99
Commercial RAC	38.91

Figure 6. **BAU emissions from the RAC sector**



- **Commercial air conditioning:** This includes equipment classified with ducts, package, multi-split, large capacity chillers and process chillers. The growth of package type equipment in retail stores, shopping centers, cinemas, etc. has been significant with a growth rate of 8.5%, displacing about 15,000 obsolete units each year. Chillers, for AC systems with chilled water plants, show an annual growth rate of 5.7% and this segment is forecasted to triple by 2030.

Energy consumption and GHG emission

- According to the Sixth National Communication on Climate Change in 2015, Mexico was responsible for almost 1.3% of global GHG emissions and the thirteenth highest on the planet, with total emissions of 699.56 $MTCO_2e$. HFC emissions, as direct emissions in 2015, represented 1.8% of emissions for the country with almost 12.62 $MTCO_2e$.
- In 2019, RAC sector electricity consumption was estimated to be 30 TWh in domestic RAC and 39 TWh in commercial RAC (Figure 5), which accounts for 7.7% of energy consumption in the country goes to refrigeration and 13.4% to air conditioning. As of 2019, the residential and commercial RAC sector has a contribution of 56 $MtCO_2e$ in total (21 $MtCO_2e$ of direct and 35 $MtCO_2e$ of indirect emissions). By 2045, in the BAU scenario, these emissions may increase 2.7 times, reaching up to 152 $MtCO_2e$ (Figure 6). This size of emissions reveals the importance of serving the RAC sector in Mexico.

Mitigation Plan

In 2016, the National Energy Efficiency roadmap (CONUEE) was published, which establishes energy efficiency goals at 2.2% reduction in the 2020-2035 period and 2.5% in the 2035-2050 period (Table 3). Although there are no commitments in the Mexico's NDCs to mitigate indirect emissions from RAC appliances; penetration of higher efficient RAC appliances has an additional mitigation potential with indirect emissions of 3.6 $MtCO_2e$ under NDC. Comparatively, the reduction of electricity consumption in the residential and commercial RAC sector in accordance with the goals established by CONUEE by 2030 (-2.2% reduction) would allow mitigating up to 7.1 $MtCO_2e$ by 2030.

Table 3. **National goals for Energy Efficiency**

2020-2035	2035-2050
Average annual rate of 2.2% reduction in the intensity of final energy consumption	Average annual rate of 2.5% reduction in the intensity of final energy consumption

Table 4. Summary of indirect mitigation for RAC subsectors

Mitigation option analyzed	Mitigation potential by 2030 6th CNCC ($MtCO_2e$)	Estimated potential EE Goals ($MtCO_2e$)
Refrigerators	1.1	0.8
Air conditioners	1.3	3.6
Refrigerators	0.6	1.5
Air conditioners	0.6	1.3
Total	3.6	7.1

National Regulations and Capacities

- **Labelling:** In Mexico, RAC equipment includes a comparative label (given in Figure 9) that shows minimum energy efficiency required, the energy efficiency ratio of the equipment and the percentage of energy savings against the minimum value of the compliance standard.
- **Standards:** The voluntary standards qualify for the premium performance in efficiency, which is known as the FIDE Seal in Mexico and establishes requirements that exceed the minimum required in the National Official Standards (NOM), which are the mandatory standards. Mexico currently has seven NOMs of RAC equipment and six high performance standards and FIDE (Figure 10).

Figure 9. Energy efficiency labelling in Mexico

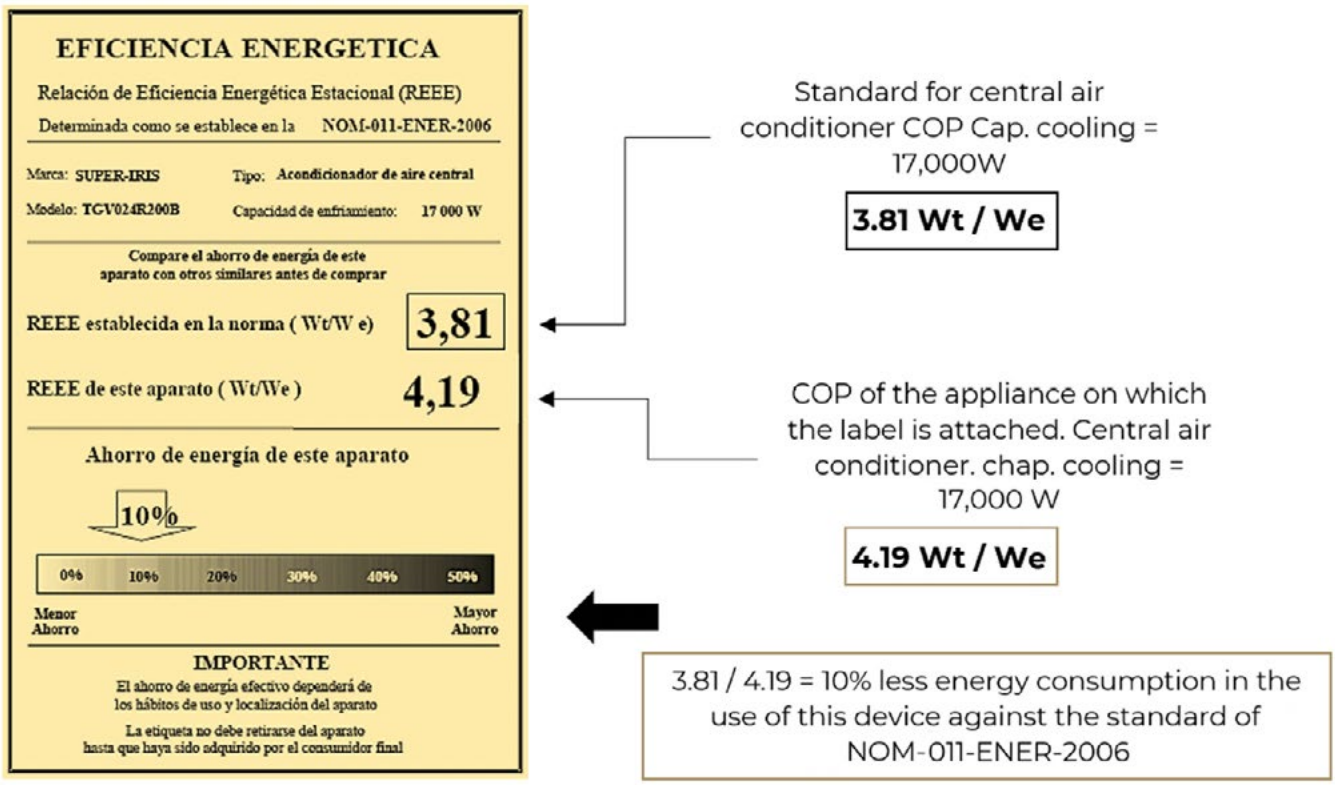


Figure 10. Summary of indirect mitigation for RAC subsectors

Team	Mandatory	Voluntary standard [Specification]
Household Refrigerators and Freezers	NOM-015-ENER-2018	FIDE 4111
Commercial Refrigerators and Freezers	NOM-022-ENER-2014	FIDE 4117
Condensing and evaporating units for remote refrigeration	NOM-012-ENER-2019	
Split/multi split AC	NOM-023-ENER-2018	FIDE 4121
Central type AC	NOM-011-ENER-2006	FIDE 4116
Room type AC	NOM-021-ENERSCFI- 2017	FIDE 4113
Split-inverter AC	NOM-026-ENER-2015	FIDE 4174

In general terms, the Mexican standardization system has made it possible to have a relatively updated inventory of equipment with good energy performance. Likewise, it is the main legal tool used to adopt energy efficiency in the RAC sector. The latest updates, such as NOM-022, include safety guidelines for the use of flammable refrigerants (up to 150 g) in self-contained equipment for commercial use. In the future, it will be very important to regulate medium and large capacity equipment that has the highest penetration in the market, use hydrocarbons and other alternatives to HFCs requiring special attention on safety issues. It is also necessary to carry out feasibility studies that allow the regulation of commercial air conditioning equipment greater than 5 tons of refrigeration (TR), which currently does not have a mandatory or voluntary standard.

- **Testing Laboratories:** The Energy Efficiency Regulations area of CONUEE supports and supervises the operation of the evaluation infrastructure in accordance with the Official Mexican Energy Efficiency Standards (NOM-ENER) through verification units, laboratories and certification bodies. Mexico currently has 86 testing laboratories, 215 verification units, and 13 certification bodies for all sectors, including RAC.
- **Regulations for charging natural refrigerant**s: Flammable refrigerants such as hydrocarbons (HC) will require additional regulatory efforts, including review the current load limits for flammable refrigerants based on several relevant international standards (IEC 60335-2-89, IEC 60335-2-40). Thus, Mexican versions of the standards (NMX-J-521/2-24-ANCE-2014 and NMX-J-521/2-40-ANCE-2014) will be required to be updated in line with international standards. With such updates, the penetration of HC based equipment can be accelerated in the medium term.
- **Training and certifications:** The Montreal Protocol Unit has trained 4,044 technicians in the proper handling of refrigerant substances and provided the required tools and equipment. This channel could also be used to incorporate energy efficiency considerations for the RAC technicians training curriculums. In Mexico, there are currently three standards of official competence in place for the training and certification of RAC servicing technicians:
  - Standard EC0850 – Installation and maintenance of RAC systems
  - Standard EC0443 – Installation and maintenance of commercial RAC systems
  - Standard EC0506 – Provision of installation and maintenance services for refrigeration systems up to 25 tons of refrigeration

In the current standards, official certifications on the handling of natural refrigerants, carbon dioxide (CO_2) or hydrocarbons are not yet considered. As a priority action, it is necessary to incorporate the concepts of energy efficiency at the same level as the safe handling of substances, and proper operation of the equipment.

NCAP Roadmap and project proposals

The following lines of actions in the NCAP are proposed based on the thematic recommendations and priority areas of relevant national policies:

- Policies, regulations
  - Development of the national inventory of RAC equipment in the commercial sector.
  - Study of the incorporation of low GWP refrigerants into the Federal Public Administration (APF) energy efficiency program in buildings.
  - Study to update the yellow label of RAC equipment NOMs (mandatory labels).
- National capacity building and financing: Regulations
  - Preparation of an energy efficiency manual for RAC equipment and the use of low GWP refrigerants for the use of SMEs.
  - Preparation of evaluation guide for energy efficiency projects in the RAC sector.
- Efficient technologies
  - Feasibility study of district cooling in hotels.
  - Feasibility study of the use of CO_2 as a refrigerant in refrigeration systems in supermarkets.
  - Study of requirements for the redesign of compressors in the manufacture of commercial refrigeration equipment in Mexico.
- Investment-replacement projects: These aim to replace inefficient RAC equipment older than 16 years old with efficient, low GWP equipment in the commercial and domestic sectors. The estimated cost of these projects ($91,343,334) includes costs of project preparation, efficient equipment, collection of inefficient equipment, and destruction of F-gases.
  - Replacement of refrigeration equipment in SME hotels
  - Replacement of refrigeration equipment (cold rooms, self-contained refrigerators and freezers) in public markets
  - Replacement of domestic refrigerators
  - Replacement of window-type air conditioning units with equipment inverter with low GWP coolant

Key Stakeholders

Government entities: Ministry of Energy (SENER); National Commission for the Efficient Use of Energy, CONUEE); Ministry of the Environment and Natural Resources (SEMARNAT); General Directorate of Climate Change Policies (DGPCC); National Institute of Ecology and Climate Change (INECC); General Directorate for Air Quality Management and the Pollutant Release and Transfer Register (DGGCARETC); Montreal Protocol Unit (UPM); Trust for the Saving of Electric Energy (FIDE); General Administration of Customs (SHCP).

International cooperation agencies: UNDP, UNIDO, GIZ, AFD, AIE, EBM, etc.

Sectoral entities and others: RAC equipment manufacturing companies; Chambers of RAC manufacturers and distributors; Chambers and Associations for the promotion of energy efficiency; Convenience Stores and Commercial Sector Associations; Developers and Construction companies; Service and Maintenance companies; End users; Academy and research and development centers.

Acknowledgements

The NCAP or National Cooling Strategy of Mexico was developed on behalf of the Ministry of Environment and Natural Resources, in consultation with different governmental agencies, international agencies, NGOs, universities and specialists. The NCAP is funded by the Kigali Cooling Efficiency Programme (K-CEP) through the United Nations Development Programme (UNDP).

NIGERIA

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Country Profile

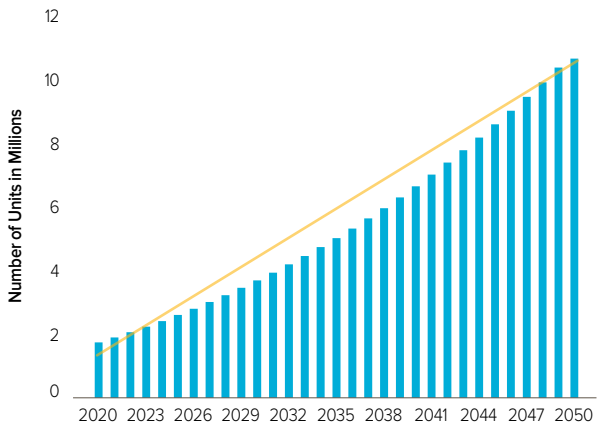
The Federal Republic of Nigeria is a country in West Africa. It is the most populous country in Africa, with a population of over 211 million, with 52% in rural areas and 48% in urban areas. Nigeria is expected to experience mean monthly temperatures over 30°C from 2020-2039 under a scenario of unabated global warming (SEforALL, 2020). At COP26 in Glasgow, Nigeria announced its commitment to cut its carbon emissions and reach net-zero by 2060. Nigeria ratified the Kigali Amendment on 20 December 2018 and reported consumption of 2,620,048 CO_2eq of HFCs and 167 ODP tonnes of HCFCs in 2020.

Market Status of the Cooling Sector

Residential Air Conditioners (ACs) and Domestic Refrigerators are identified as two major subsectors to reduce the country's emissions and improve energy efficiency.

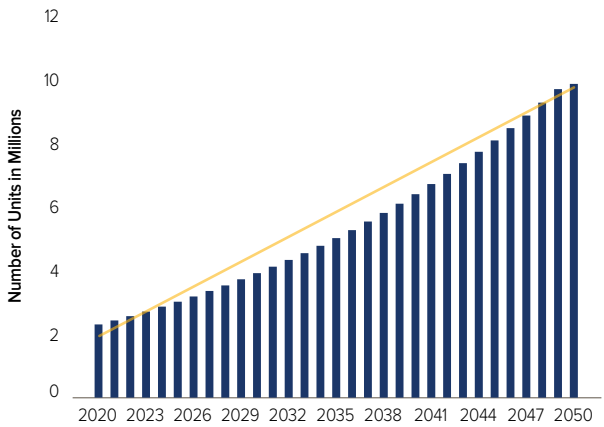
- **Air Conditioners:** There are varying estimates for the AC market in Nigeria. The estimate used is an initial stock of just over 1 million in 2010, which increased to nearly 8 million units by 2020 and is projected to reach 71.4 million units by 2050 (Figure 1). The overall increase in the size of the stock appears extreme, however, Nigeria is a country with increasing population and increasing access to electricity, resulting in large market development in the next 30 years.
- **Domestic refrigerators:** The ownership of refrigerators is much higher than ACs. The total stock is expected to increase from 9.5 million in 2010 to an estimated 88 million units in 2050. This indicates that refrigerators are considered a basic requirement by consumers, who often obtain one as soon as they have access to electricity. This results in sales increasing from 2.3 million in 2020 to 9.9 million in 2050, with a 4-fold increase as shown in Figure 2.
- **Life Cycle Cost:** The life cycle cost (LCC) of an appliance is defined as the sum of the purchase price added to the operational cost (electricity, servicing, and disposal cost) over the lifespan of the appliance. It is an important measure of affordability for appliances that often have a higher purchase cost but lower operational costs due to energy efficiency. A demonstrative analysis of estimated LCCs for average size refrigerators or ACs at each efficiency level of the current Nigerian MEPS regulation shows (in Figure 3 and Figure 4) that:
  - For refrigerators, within an 8-year useful lifetime, a 5-star refrigerator has the lowest LCC, even when considering a 60% purchase price premium over a 1-star refrigerator. This LCC difference (5-star vs. 1-star refrigerator) is around 312 USD in the 8-year span.
  - For ACs, within a 12-year useful lifetime, a 5-star AC has the lowest LCC, even when considering

Figure 1. AC yearly sales 2020-2050



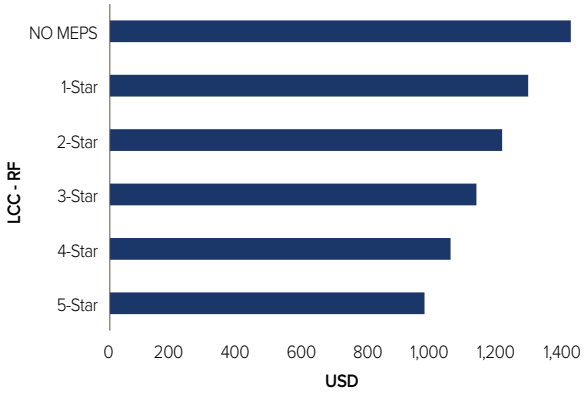
Source: HEAT analysis.

Figure 2. Refrigerators yearly sales 2020-2050



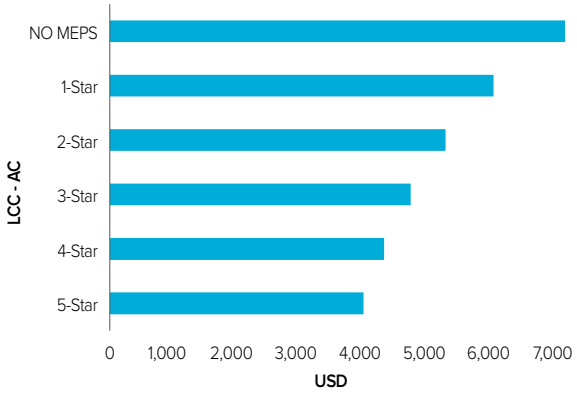
Source: HEAT analysis.

Figure 3. Estimated LCC for average size refrigerators in Nigeria



Source: HEAT analysis.

Figure 4. Estimated LCC for average size ACs in Nigeria



Source: HEAT analysis.

a 50% purchase price premium over a 1-star refrigerator. This LCC difference (5-star VS. 1-star refrigerator) is around 1,998 USD in a 12-year span.

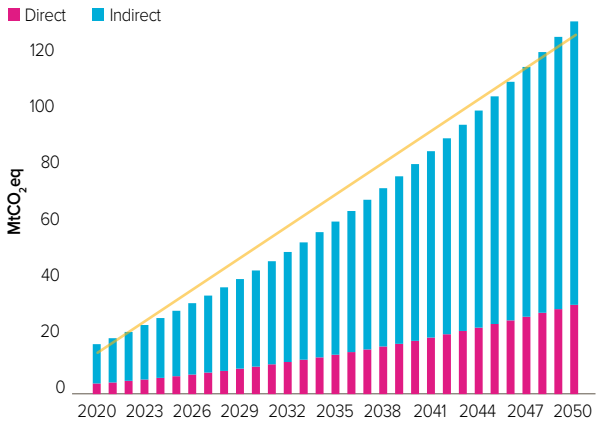
Energy consumption and GHG emission

- **Air conditioners:** Electricity demand for ACs was estimated to be around 24 TWh in 2020 and increasing 7-fold up to 176 TWh by 2050. With a grid emission factor of 0.573 tCO_2/MWh (IGES, 2021), total emissions may increase from 18 $MtCO_2eq$ in 2020 to 133 $MtCO_2eq$ in 2050 (Figure 5). The majority (79%) of emissions is estimated to come from the use of electricity (indirect emissions).

- **Domestic refrigerators:** Electricity demand from refrigerators was estimated at 14.5 TWh in 2020 from the 9.5 million units in Nigerian households and, in the BAU scenario, it will increase 4-fold by 2050. The rate of increase of refrigerators stock is less than that of ACs as they start from a larger ownership base. In parallel, GHG emissions are projected to increase almost 4-fold during the same period, exclusively due to energy demand increases as, for direct emissions, the Isobutane-R600a is covering a larger market share, and the industry is largely moving in that direction.

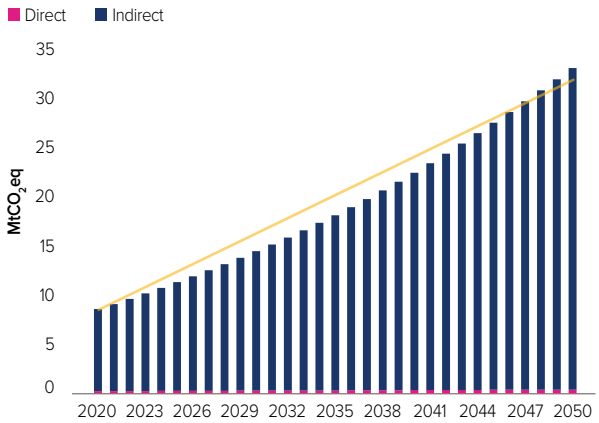
The projections in Figure 5 and Figure 6 of large increases pose challenges to the odds of Nigeria in achieving its climate targets and this highlights the

Figure 5. GHG Emissions from AC units



Source: HEAT analysis.

Figure 6. GHG Emissions from domestic refrigeration units



Source: HEAT analysis.

Table 1. **ACs and Domestic Refrigeration sectors potential GWh savings in 2030 and 2050**

RAC scenario	Year 2030	Year 2050
BAU (GWh)	84,492	233,089
Recommended MEPS (GWh)	71,050	162,568
Savings (GWh)	13,442	70,521

need to enforce the existing regulations (e.g., MEPS) and to update them regularly to more stringent levels. Simultaneously, reducing the grid emission factor through implementation of renewable energy sources will also be essential to achieve Nigeria's NDC targets.

Mitigation Plan

Under the BAU scenario, the total GHG emission of these sub-sectors is 166 $MtCO_2eq$ in 2050. In the mitigation scenario with implementation of recommended MEPS, the electricity demand can be lowered to 163,000 GWh (30% reduction) and GHG emissions to 93 $MtCO_2eq$ (44% reduction).

PROPOSALS FOR MEPS, LABELS, AND MONITORING, VERIFICATION AND ENFORCEMENT (MVE)

Nigeria has existing MEPS for domestic refrigerators and ACs, but it was found during the market survey that enforcement of MEPS is lacking and most of the products do not have the energy efficiency labels. The following recommendations provide a list of activities for the timely market migration towards energy efficient appliances and the reduction of national emissions in Nigeria:

- Enforcement of a mandatory MEPS level:
  - For domestic refrigerators: Enforce the current MEPS (EEI≤80) with no difference between climate class and prepare the market for further MEPS updates.
  - For domestic room ACs: enforce the current MEPS (EER≥2.80).
- Adoption of a mandatory labelling scheme:
  - For domestic refrigerators: closed-scale 1-star to 5-star labelling scheme, with top efficiency level 5-star being mostly empty initially.
  - For the room ACs: closed-scale 1-star to 5-star labelling system, with top efficiency level 5-star being mostly empty initially.
- Adoption of a timetable for updating MEPS and labels:
  - Update MEPS for domestic refrigerators in 2025 and 2028, with energy reduction of 46% and 55% when compared to current MEPS for Subtropical refrigerators.
  - Update to the Seasonal Energy Efficiency metric with new MEPS in 2025 (SEER≥4.8 for capacities below 4.5 kW) and 2028 (SEER≥5.5 for capacities below 4.5 kW).
- Develop appliances' test procedure and adopt updated international metrics.
- Establish a national certification scheme for service technicians, including information on MEPS, labels, proper maintenance of appliances with low GWP, flammable refrigerants.
- Establish an effective product registration and market surveillance mechanism:
  - Adopt a national product database for RAC appliances, whereby manufacturers and importers register their appliances and report their annual sales.
  - Develop the capacity of customs controls on the import of appliances below the future MEPS level and to ban and control the import of second-hand appliances.
  - Empower the "Federal Competition and Consumer Protection Commission" to perform market monitoring and ensure labels are correctly presented.

- Develop national awareness campaigns and Green Procurement schemes.
- Develop a central internet portal or mobile apps to inform the public on comparative information for upfront prices and the Life Cycle Costs of appliances.

ADDITIONAL ENABLING POLICIES AND REGULATIONS

Complementary to MEPS, labelling and MRV mechanisms, it is recommended to enforce additional enabling policies and regulations to accelerate the market transformation, such as:

- Import ban of second-hand cooling equipment.
- Implementation of swap-out program to encourage consumers to replace their old and energy inefficient domestic refrigerators by offering direct cash rebates on the new 4- & 5-star units.
- Strategies for the safe and environmentally sound handling of the collected refrigerators:
  - Recycling Step 1: includes the recovery of refrigerant and oil from the refrigeration circuit, separating oil from refrigerant, and removing of the compressor and grid.
  - Recycling Step 2: includes the treatment of the insulation foam with possibly the recovery of foam blowing agents and further dismantling and separation of valuable materials.

Funding and Financing Mechanism for Market Transformation

To promote the transition to climate-friendly and energy-efficient cooling, integrated financial and funding mechanisms are recommended, including the following elements:

- Strengthening and enforcing the existing MEPs and label program, through an incentive program for efficient appliances with ultra-low GWP refrigerants.
- Raising national funds in support an accelerated phase-down of HFCs in support the Kigali Amendment and its advancement.
- A refrigerators' swap out pilot program for the accelerated replacement of old, inefficient refrigerators with highly energy-efficient appliances.
- Additional financing and funding for the national administrative program for MVE activities and for the integration of the NCAP into the NDC.

Cost assumptions and required funds: The required funds are estimated through a bottom-up cost analysis. For the refrigerator swap-out program, the level of incentive has been proposed at 113 USD in the case of a 4-star appliance and 173 USD for a 5-star appliance. The total estimated costs for the program implementation for a total of 900,000 units to be replaced in the pilot program are shown in Table 2. The largest cost is associated with the swap-out incentive accounting for 85% of the total cost.

Table 2. **Total cost of program implementation**

Total cost of activities		Cost for 9 years (USD)
Activity 1	Refrigerator Swap-out pilot program/ongoing recycling	115,028,267
Activity 2	Secondhand refrigerator import ban established	1,545,000
Activity 3	MEPS and labels review and update	15,190,000
Activity 4	Fluorinated gas phase-down	1,000,000
Activity 5	Financing mechanism set up	800,000
	Total	133,563,267

Table 3. Tax revenue from refrigerators

Energy classes	Mean unit price [USD]	Import-tax (theoretical)	Import-tax (practical)	Tax revenue per device	Price per unit (USD)	Revenue from refrigerator taxes
1-Star	300	66.67%	75.00%	225	525	Assumption: 100% class A devices imported
2-Star	350	42.86%	50.00%	175	525	
3-Star	400	25.00%	30.00%	120	520	
4-Star	450	11.11%	15.00%	68	518	
5-Star	500	0.00%	5.00%	25	525	**15,750,000**

Source: HEAT analysis.

Table 4. Tax revenue from AC appliances

Energy classes	Mean unit price [USD]	Import-tax (theoretical)	Import-tax (practical)	Tax revenue per device	Price per unit (USD)	Revenue from refrigerator taxes
1-Star	300	50.00%	75.00%	240	640	Assumption: 100% class A devices imported
2-Star	350	33.33%	50.00%	225	675	
3-Star	400	20.00%	30.00%	150	650	
4-Star	450	9.09%	15.00%	83	633	
5-Star	500	0.00%	5.00%	30	630	**11,700,000**

Source: HEAT analysis.

Funding program to cover the cost: Includes import tax/levy from equipment and tax on HFC imports.

Import tax or levy: The proposed taxation level is suggested to be set at 5% of the cost of devices with a 5-star rating increasing to 75% in the case of 1-star devices, and total revenue is estimated in total of 27,5 million USD (based on annual imports of ca. 1 million appliances).

HFC Tax: The proposed tax on bulk imported HFCs on a mass (kg) basis and proportional to its GWP matching the goals of the Kigali Amendment. The proposed HFC tax is recommended to range between 30 and 70 USD per t CO_2eq, as a tax per kg of HFC/HCFC refrigerant. The total collected tax for room ACs and refrigerators, where HFC-134a and HFC-410A are mainly used, would range between 52 and 121 million USD per year (Table 6).

Table 5. Tax options for HFC and HCFC tax per kg

Refrigerant	GWP	HFC tax: 30 USD/t CO_2eq: Tax [USD/kg]	HFC tax: 70 USD/t CO_2eq: Tax [USD/kg]
HCFC-22	1,810	54.30	126.70
HFC-134a	1,300	39.00	91.00
HFC-410A	2,088	62.64	146.16

Table 6. Expected HFC yearly tax revenues

Refrigerant	Average 2008-2014 [t]	Tax @ 30 USD/t CO_2eq	Tax @ 30 USD/t CO_2eq
HFC-134a	415	16,164,720	37,717,680
HFC-134a	570	35,741,489	83,396,808
Total		51,906,489	121,114,488

Table 7. **Total revenue estimated over 9 years (until 2030)**

		Revenue for 9 years ($)
Revenue 1.1	Import taxes for inefficient refrigerators	141,750,000
Revenue 1.2	Import taxes for inefficient room ACs	105,300,000
Revenue 2	A tax on HFC imports is legally established and operating	467,155,882
	Total Revenue	714,205,882

Total revenue from the dual tax: With 9-years projection (until 2030), the total revenue is estimated over 700 million USD in a conservative scenario (Table 7), well above the required fund for the NCAP implementation (ca. 133 million USD). Over time, the amount would be expected to increase on the appliance tax component and decrease on the HFC tax component.

Key stakeholders and their current and potential role

Stakeholder	Roles and responsibility
Federal Ministry of Environment	Ministry of Environment hosting the National Ozone Unit is responsible for the phase out of high GWP refrigerants, and the implementation of the Montreal Protocol and its Kigali Amendment, etc.
The Nigerian Customs Service (NCS)	Enforce regulations pertaining to refrigerants and appliances entering Nigeria. NCS will be responsible for collecting the taxes levied.
Federal Ministry of Power	Developing policies and enforcement strategies including penalties for non-compliance.
Energy Commission of Nigeria (ECN)	Support the development of MEPS and policies. Key stakeholders in the management of funds that are raised through the appliance and refrigerant tax.
Standards Organization of Nigeria (SON)	Proposed issuing authority for MEPS and label certificates to manufacturers and importers. Testing center for RAC appliances. Establish and manage a central online database for market surveillance.
Federal Competition and Consumer Protection Commission (CCPC)	CCPC would be a possible recipient of funds to carry out awareness and education campaigns with consumers related to the use of energy efficient RAC appliances.
Electricity utilities	(Abuja Distribution Company etc.) Support in the implementation of the programme
Manufacturers, Assemblers and Distributors	Bringing the appliances on the market and will be responsible for the registration of the energy efficiency classification of the appliances.
Financial Institutions	(Ecobank, FBN Holdings etc.) Receive, distribute and manage funds for the rebate scheme
Recycling and disposal facilities	Recycling old appliances and recovery and destruction of HCFC and HFCs. The recycling and disposal facilities receive equipment from retailers, assemblers, or services companies.

Acknowledgements

The NCAP was developed by HEAT GmbH. The work was carried out under the direct supervision of the National Ozone Officer (NOO) in Nigeria and in coordination with the United Nations Development Programme (UNDP) in Nigeria and the regional team of the Chemicals and Waste Hub. The NCAP is funded by the Kigali Cooling Efficiency Programme (K-CEP – now Clean Cooling Collaborative) through UNDP.

PANAMA

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Country Profile

Panama is a transcontinental country in Central and South America, with a tropical climate and temperatures of little seasonal variation. Panama controls the Panama Canal which connects the Atlantic Ocean with the Pacific Ocean. Panama's total area is 74,177 km^2 with a population of 4,176,869 in 2018, in which the urban population exceeds 75%, making Panama the most urbanized in Central America.

Panama is one of three countries in the world to be carbon negative, meaning that it absorbs more CO_2 than it releases into the atmosphere. Panama ratified the Paris agreement and presented its NDC to the UNFCCC in April 2016. Panama ratified the Kigali Amendment on 28 September 2018 and reported HFCs consumption of 1,946,551 CO_2-eq and 10.8 ODP tonnes of HCFCs in 2020.

Market Status of the Cooling Sector

Panama had a very high average GDP growth rate between 2007 and 2018 at 10.9% annually, this resulted in an increase of the installed capacity of RAC equipment. Figure 1 shows how the import of RAC equipment has increased significantly, especially between 2015 and 2018.

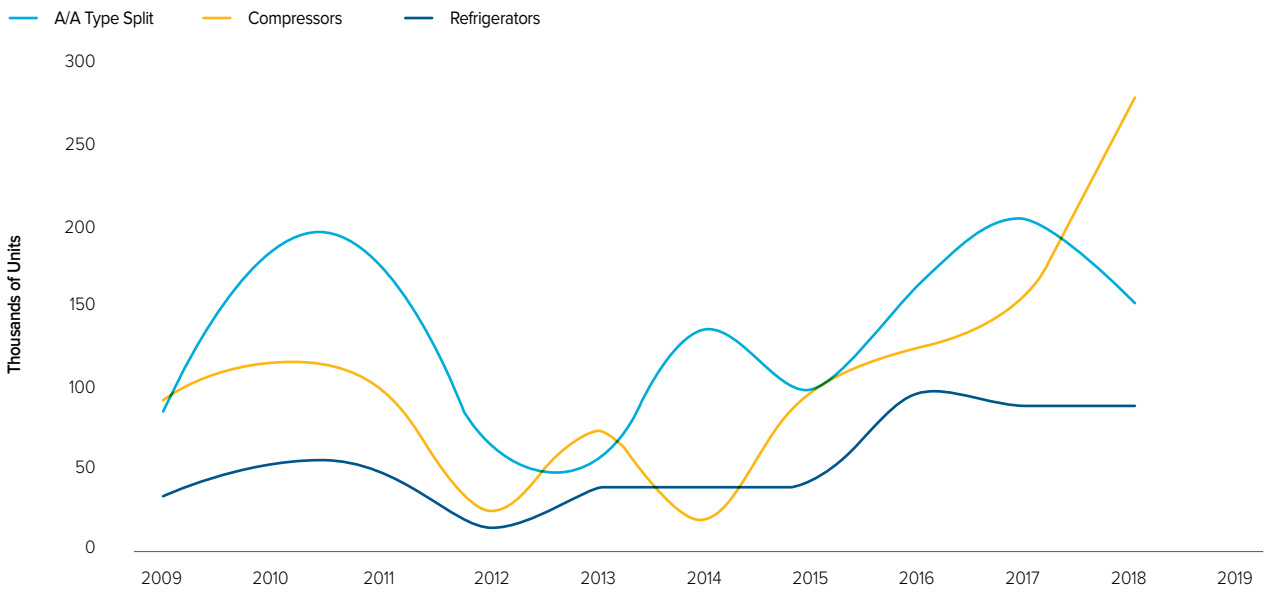
In line with Panama's Montreal Protocol obligations, the progressive reduction of HCFC imports have been achieved after import quotas came into force as of 2013 (Figure 2). The gradual reduction of HCFC imports (18.1% in 2015-2019) has led to the replacement of these refrigerants with low ODP substances, mainly due to the increased imports of HFCs (28.5%) as shown in Figure 3.

- **MEPS, labelling:** Panama has developed five standards and technical regulations for air conditioning equipment and refrigerators in 2017-2018 for split, room, window and central ACs, and domestic refrigerators.
- **Sustainable building regulations:** Panama developed a Sustainable Building Regulation, which requires the registration of new building projects. Buildings must reduce energy consumption by 15% through passive measures and comply with minimum COPs for its AC systems. Panama has also developed a voluntary certification (Eco-Protocol) for existing buildings.

Energy consumption and GHG emission

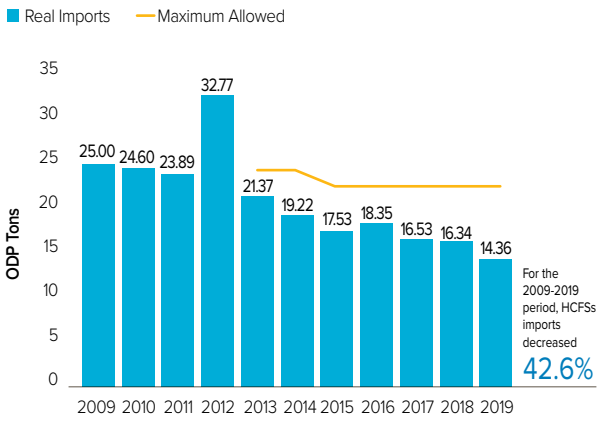
In Panama, 70% of electricity generation comes from renewable sources, mainly hydroelectric. The RAC sector consumed a total of 3,450 GWh of electrical energy in 2018, which represents 53% of the total consumption

Figure 1. **Import of selected RAC equipment (2009-2018)**



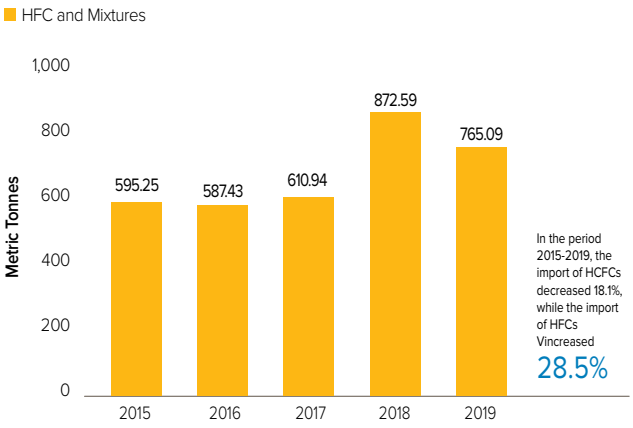
Source: ANA and UNO Databases 2009 - 2018.

Figure 2. HCFC imports (2009-2019)



Source: NOU/MINSA Import Database, 2009-2019.

Figure 3. HFC imports (2015-2019)



Source: Data from NOU/MINSA Import Records.

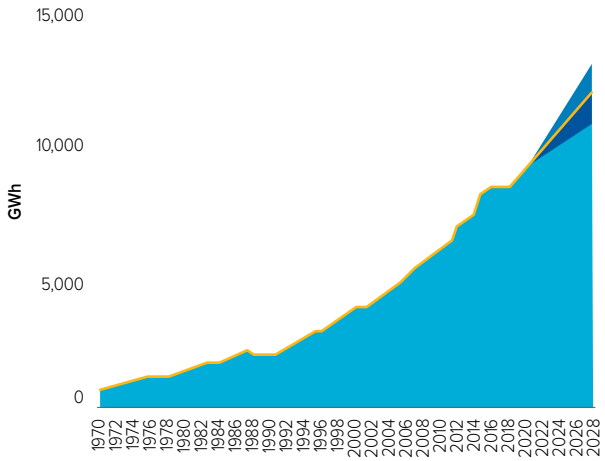
of the province of Panama. Figure 4 indicates that the highest consumption of electrical energy in the province of Panama is concentrated in the four RAC sub-sectors are as follows: Residential (44.0%), commercial and services (42.0%), government (39.9%) and industrial (32.0%).

Overall, the country's electricity consumption is largely related to RAC services, estimated at 42% of the total electricity consumption. For a horizon of 10 years the total consumption for the RAC sector in 2028 would be projected as 4,956 GWh, which is an additional 1,507 GWh (ca. 40%) consumption compared to 2018 level (Figure 5).

Table 1. Regulations and guidelines of RAC sector energy efficiency approved in Panama

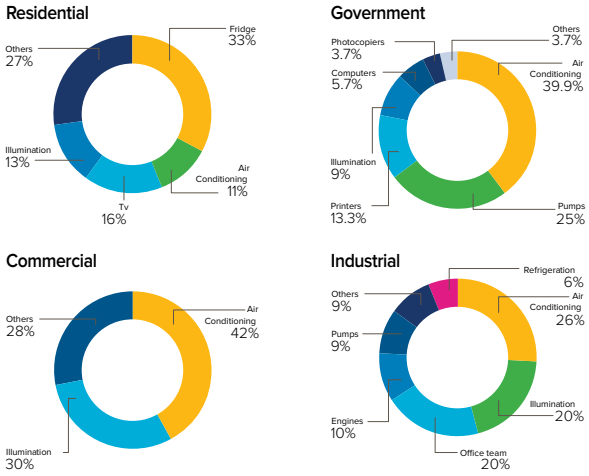
Equipment	Document		Resolution
A/A Split Inverter	Regulation	DGNTI - COPANIT 104:2017	N° 114 de 2017
	Standard	DGNTI - COPANIT 509:2017	N° 69 de 2017
A/A Split ON/OFF	Regulation	DGNTI - COPANIT 103:2017	N° 115 de 2017
	Standard	DGNTI - COPANIT 508:2017	N° 65 de 2017
A/C room/window	Regulation	DGNTI - COPANIT 102:2017	N° 116 de 2017
	Standard	DGNTI - COPANIT 507:2017	N° 67 de 2017
A/A central	Regulation	DGNTI - COPANIT 101:2017	N° 117 de 2017
	Standard	DGNTI - COPANIT 506:2017	N° 119 de 2017
Refrigerator	Regulation	DGNTI - COPANIT 105:2017	N° 31 de 2018
	Standard	DGNTI - COPANIT 511:2017	N° 28 de 2018

Figure 4. Electricity consumption (2018)



Source:SNE Energy Statistical Compendium 1970-2018.

Figure 5. RAC sector electricity consumption projection



Source: Statistical Compendium, National Secretariat of Energy.

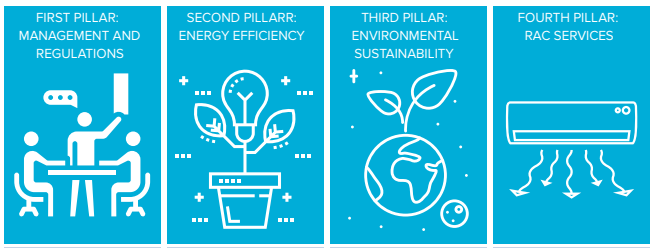
Mitigation Plan

Panama's National Cooling Plan complements the National Policy for the Rational and Efficient Use of Energy (UREE) and the National Energy Plan 2015-2050, through issues such as energy efficiency standards, labelling, sustainable building, waste management of appliances as well as the introduction of new technologies and good service practices in the RAC sector. Similarly, the NCAP includes many of the HCFC Phaseout Management Plan's (HPMP) topics, such as training, certification of competencies, capacity building of technicians and training institutes, recovery, recycling and regeneration of refrigerant gases, among others.

The National Waste Management Plan 2017-2027 and the Electronic Appliance Waste project of the Ministry of Health are also linked to the NCAP in terms of managing waste from RAC equipment. The Government Strategic Plan 2019-2024 emphasizes the importance of refrigerated transport services, and the Cold Chain, not only for the agricultural sector but also for the healthcare sector.

Panama's National Cooling Plan has four pillars or priority themes as sketched in Figure 6. Each pillar contains several thematic areas (18 in total) which are made up of specific activities, and the level of priority. Each thematic area also links with multiple SDGs (Figure 7).

Figure 6. Structure of the Cooling Plan



Thematic areas:	Thematic areas:	Thematic areas:	Thematic areas:
1.1: Governance 1.2: Regulations and standards 1.3: Alternative technologies 1.4: Monitoring, verification and compliance	2.1: Efficient equipment 2.2: Building design 2.3: Preferences and Consuming patterns 2.4. District Cooling	3.1: National GHG Inventory 3.2: Environmental labeling 3.3: Refrigerant recovery and recycling 3.4: Equipment disposal and recycling 3.5: Communication	4.1: Inclusion 4.2: Training 4.3: Certification 4.4: Cold chain 4.5: Mobile air conditioning (MAC)

Figure 7. SDGs mapping of NCAP thematic areas

PILAR	THEMATIC AREAS	2	3	4	5	6	7	8	9	10	11	12	13	17
MANAGEMENT AND REGULATIONS	1.1 GOVERNANCE													✓
	1.2 REGULATIONS AND STANDARDS					✓	✓	✓			✓	✓	✓	
	1.3 TECHNOLOGIES AND ALTERNATIVES					✓		✓				✓	✓	
	1.4 MONITORING, VERIFICATION AND COMPLIANCE					✓	✓	✓			✓	✓	✓	
ENERGY EFFICIENCY	2.1 EFFICIENT EQUIPMENT					✓		✓				✓	✓	
	2.2 BUILDING DESIGN					✓		✓			✓	✓	✓	
	2.3 PREFERENCES Y CONSUMING PATTERNS					✓						✓	✓	
	2.4 DISTRICT COOLING					✓		✓			✓	✓	✓	
ENVIRONMENTAL SUSTAINABILITY	3.1 NATIONAL GREENHOUSE GAS INVENTORIES											✓	✓	
	3.2 ENVIRONMENTAL LABELING											✓	✓	
	3.3 REFRIGERANT RECOVERY AND RECYCLING											✓	✓	✓
	3.4 EQUIPMENT DISPOSAL AND RECYCLING					✓						✓	✓	✓
	3.5 DIVULGATION						✓	✓	✓		✓	✓	✓	
RAC SERVICES SECTOR	4.1 INCLUSION			✓	✓			✓		✓				
	4.2 TRAINING			✓			✓	✓				✓	✓	✓
	4.3 CERTIFICATION			✓			✓	✓				✓	✓	
	4.4 COLD CHAIN	✓	✓	✓			✓	✓					✓	✓
	4.5 MOBILE AIR CONDITIONING (MAC)	✓										✓	✓	

FIRST PILLAR: MANAGEMENT AND REGULATIONS

- **Governance [Priority: High]:** Formalizing the framework for the implementation of the NCAP through establishing an inter-institutional commission to implement the NCAP strategy.
- **Regulations and Standards [Priority: High]:** Develop/update of regulations and standards on i) Energy efficiency of RAC equipment; ii) safety standards for natural refrigerants; iii) design of RAC systems and insulation for buildings; iii) design for district cooling systems; iv) Installation, maintenance and disposal of RAC equipment; vi) Certification of technicians.
- **Alternative Technologies [Priority: High]:** Accelerate the transition of the RAC sector through i) development of incentives for clean and efficient technologies; ii) elimination of indirect incentives for the for the use of inefficient equipment with high ODP and/or GWP.
- **Monitoring, Verification and Compliance [Priority: High]:** Establish a reporting and registration mechanism/database to control imported RAC equipment (including energy efficiency and refrigerant charges) and facilitate the process of permits and verifications.

SECOND PILLAR: ENERGY EFFICIENCY

- **Efficient Equipment [Priority: Medium]:** Promote the replacement of inefficient equipment and increase the demand for efficient equipment through i) inclusion of specifications for high-efficiency, low-GWP equipment into the public procurement policies; ii) replacement programs for inefficient equipment installed in public institutions and residential sector; iii) establishment of an accredited energy efficiency testing laboratory.
- **Building Design [Priority: Medium]:** Support green building design through i) strengthening the capacities of the municipalities and entities responsible for verifying compliance with Sustainable Building Regulations; ii) inclusion in the university curricula, the design of passive cooling measures; iii) fiscal incentives for green buildings.
- **Consumption Preferences and Patterns [Priority**: High]: Influence the patterns of use of AC systems and the demand for efficient RAC equipment through i) identification purchasing patterns in the various consumer sectors; ii) life cycle cost analysis of RAC equipment (purchase, operation and maintenance); iii) sectoral awareness raising activities.
- **District Cooling [Priority: Low]:** Create favorable conditions for district cooling projects through i) mapping the greatest potential for district cooling ii) pilot demonstration projects; iii) incentives and awareness raising on the benefits of district cooling.

THIRD PILLAR: ENVIRONMENTAL SUSTAINABILITY

- **National Inventories of Greenhouse Gases [Priority: Medium]:** Understand the impact of the RAC sector on the environment through i) surveys on the RAC equipment in the market; ii) scenarios of direct and indirect emissions from the use of RAC equipment.
- **Environmental Labeling [Priority: Low]:** Influence purchasing patterns of end users through environmental labeling for energy efficient and low GWP technologies.
- **Recovery and Recycling of Refrigerant Gases [Priority: Medium]:** Facilitate the conditions for the storage, recovery, and recycling of refrigerant gases through i) development of refrigerant collection, recycling and recovery centers; ii) support mechanisms for the final disposal, elimination or export of refrigerants to be destroyed.
- **Disposal and Recycling of Equipment [Priority: Medium]:** Identify and strengthen recycling, disposal of equipment in an environmentally responsible manner through i) linking the incentives to purchase efficient equipment with the responsible disposal of old and inefficient equipment; ii) strengthen capacities of RAC equipment recycling centers nationwide.

- **Communication [Priority: High]:** Make available to everyone both the impacts of the use of substances with high GWP and ODP, and the potential benefits of alternative substances and energy efficient technologies that exist in the market.

FOURTH PILLAR: REFRIGERATION AND AIR CONDITIONING SERVICES

- **Inclusion [Priority: High]:** Identify strategies for more inclusive environment through i) identification of barriers and solutions to ensure women's participation and gender equality in the RAC sector; ii) evaluation of the coverage of basic RAC services and identify opportunities in rural communities/businesses; iv) analysis of the social impact and economic potentials of expanding access to RAC services.
- **Training [Priority: High]:** To have a workforce qualified and updated in good RAC practices through i) a registry of professionals dedicated to RAC services; ii) standardized minimum contents for courses on good refrigeration practices; iii) strengthening institutions to train RAC professionals as well as government policymakers and enforcement officers.
- **Certification [Priority: Medium]:** Promote the implementation of a certification system/scheme for RAC service professionals through i) a database of certified RAC professionals accessible to the public; ii) inclusion in public procurement policies for relevant service requests that only RAC personnel with competency certification will be considered.
- **Cold Chain [Priority: Low]:** Encourage the development of cold chain infrastructure with the energy efficient, low-GWP cooling systems through i) identification of the environmental impact and savings potential in the cold chain, by using clean and efficient technology; ii) financial incentives for greening efficient cold chain.
- **Mobile Air Conditioning [Priority: Medium]:** Identify improvement opportunities in the MAC sector for low-GWP refrigerants through i) a registry of transport with specific RAC equipment; ii) preparation of a baseline of refrigerant consumption in the MAC sector; iii) assessment of alternatives to high GWP substances in the MAC sector; iv) pilot demonstration projects.

Acknowledgements

The development of the NCAP was coordinated by Maxim Rebolledo, on behalf of Ministry of Health and Ozone Unit, in close collaboration with specialist experts, National Secretariat of Energy, Ministry of Environment, UNDP Panama and the regional team of the UNDP Chemicals and Waste Hub. The NCAP is funded by the Kigali Cooling Efficiency Programme (K-CEP) through the United Nations Development Programme (UNDP).

SRI LANKA

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Country Profile

Sri Lanka is an island located on the far southern edge of the Indian subcontinent in south-central Asia, with a land area of about 65,000 sq. km (6.5 million hectares). Since its geographical position is closer to the Equator, the country receives ample sunlight throughout the year resulting in hot and humid climate conditions.

The average yearly temperature of the country ranges from 28°C to 32°C. Higher temperatures are experienced generally in the Northern, North-Central and Eastern regions of the Island, ranging from 33.3°C to 34.7°C. The average pattern of climate in a particular local area could be determined by the variations in precipitation via South-West monsoon, North-East monsoon and two inter-monsoons in between. Sri Lanka's mean annual rainfall was reported to be 1850 mm and can range from 900 mm to 5000 mm.

A total population of 21,670,000 was reported during 2018, where Urban, Rural and Estate populations were represented by 18.2%, 77.4% and 4.4% respectively (Department of census and statistics 2018). The urban population growth, as per the World Bank (2020) has grown around 1.2% annually.

Market Status of the Cooling Sector

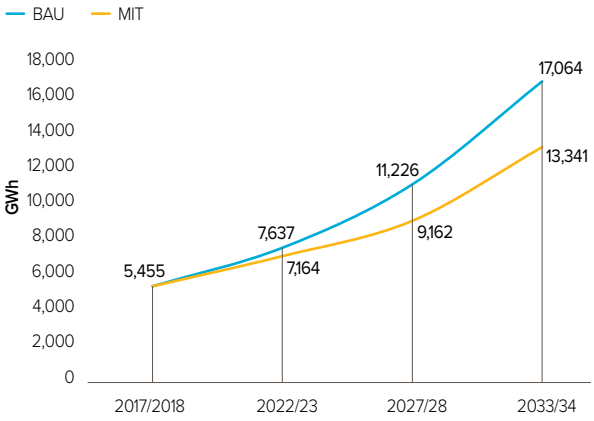
The change in lifestyle and growth of both industrial and service sectors require more cooling of the living, working and manufacturing spaces. Refrigeration and Air Conditioning demand in Sri Lanka is driven by population growth and socio-economic and environmental factors. Since Sri Lanka is a country with hot and humid climatic conditions, the popularity for use of air conditioning equipment is on the rise. The trend for higher air conditioning demand is triggered by population growth and rise in income level.

The vast majority of Ozone Depleting Substances (ODS) consumption in the country is contributed by refrigeration and air-conditioning, while foam and aerosol sectors represent considerably less. The types of air-conditioners demanded include room (residential) air-conditioning, commercial air-conditioning, central air-conditioning, variable refrigerant flow (VRF) systems and mobile air-conditioning. With the phase out of Chlorofluorocarbons (CFCs) in the early 2000s, Hydrochlorofluorocarbons (HCFCs) and Hydrofluorocarbons (HFCs) have been increasingly consumed in domestic and commercial cooling, which significantly contribute to global warming by acting as Greenhouse Gases (GHGs). The most widely used HFCs in Sri Lanka include HFC-134a, R-404A, R-407C, R-410A, R-407C, HFC-152a.

The growth of cooling demand has been projected up to 2038 and pro-active measures are recommended to achieve cooling related energy reduction targets.

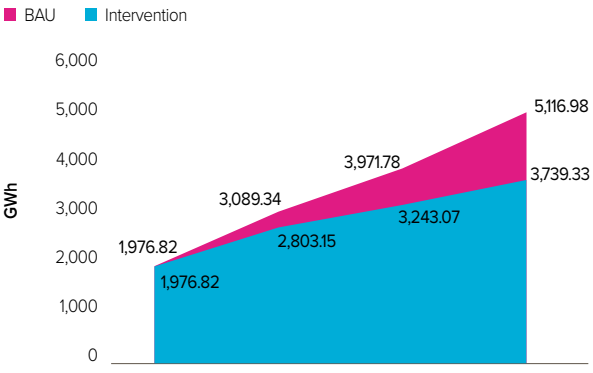
- **Space Cooling:** Space cooling is a major sector in the total cooling requirement of Sri Lanka. Unitary type air conditioners constituted the dominant share of the Sri Lankan space cooling sector. Of all the residential buildings, around 5% - 7% use air conditioners, thus the very low penetration in this market implies that great demand may occur in the future. The residential sector is likely to be the leading driver for growth of air conditioners in Sri Lanka due to economic growth, global warming and heat island effect etc.
- **Cold Chain & Refrigeration:** Cold chain refrigeration in Sri Lanka is a highly fragmented industry. The country has a fairly large number of cold storages or refrigerated warehouses for dairy, fisheries, poultry, and meat, but the other elements that make up an uninterrupted cold chain, such as pack houses and ripening chambers, are largely missing. However, the increase in demand for fresh products, meat and perishable packaged foods is leading to a significant growth in this sector, which is increasingly relying on sustainable cold chain networks.
- **Transport Sector:** The vehicle population in Sri Lanka over the last few years has considerably increased mainly due to the influence of economic growth, increase of individual income, population growth and rapid growth of highway road systems. Scenarios indicate that the projected motor car, bus, dual purpose vehicles population of Sri Lanka will reach up to nearly 2.2, 0.3 and 1.2 million respectively by 2037-38. The reference scenario indicates that the

Figure 1. Projected annual energy consumption BAU and Intervention scenarios in space cooling in buildings



Source: NOU/MINSA Import Database, 2009-2019.

Figure 2. Projected annual energy consumption BAU and intervention scenarios in cold chain and refrigeration sectors



	2018/19	2022/23	2028/29	2032/33
BAU	1,976.82	3,089.34	3,971.78	5,116.98
Intervention	1,976.82	2,803.15	3,243.07	3,739.33

Source: Data from NOU/MINSA Import Records.

total refrigerant demand in the transport sector is expected to increase, and the intervention scenario suggests that, through pro-active measures, the total demand can be reduced.

Energy consumption and GHG emission

The optimization of the cooling demand in the space cooling sector of new buildings is a preferred best practice to reduce energy demand because a large portion of cooling demand is yet to come. Green or eco design of buildings (including expanded use of passive cooling), improvement of cooling equipment efficiency, and improvement of operations and maintenance practices can save 3,723 GWh of energy consumption (Figure 1) and achieve a GHG emission reduction of 1.94 million MT CO_2eq in 2033/34.

In the cold chain and refrigeration sector, active intervention can reduce cooling energy demand by 5-12% in the years 2032-2033 for dairy, fisheries, and poultry over the current baseline. However, in the retail sector, the energy saving potential would be around 10–15% during the same period. The total annual energy consumption scenarios in cold chain and refrigeration sector are shown in Figure 2.

Recommendations and Mitigation Strategies

SHORT TERM

- Promote passive cooling during nighttime, where the outdoor conditions are comfortable, by using proper materials, good orientation, natural ventilation, etc. instead of room air conditioners.
- Reduce cooling load of the building by selecting the proper orientation, using passive designs and envelope improvements.
- Formulate National Policies for food security by promoting cold chain technology. Enhance awareness of farmers to manage produce both pre-harvest and post-harvest, to minimize spoilage.
- Introduce appropriate policy measures to improve energy efficiency of equipment.
- Enact regulations, labelling and awareness for fulfilling Minimum Energy Performance (MEPs).
- Create new regulations/codes of building design need to be introduced for local authorities.

- Establish Awareness programs for the general public on new regulations/codes of building design.
- Develop procedures to permit import of star rated air conditioners only.
- Establish testing facilities and certification mechanisms for air conditioners.
- Promote Building Management System (BMS), Internet of Things (IOT), sensors and dampers for efficient air conditioning systems.
- Encourage star labelled fans and room air conditioners in new and existing buildings.
- Enhance standardized training programs and certification systems.
- Follow the green procurement guidelines for procuring HVAC equipment and systems.
- Review existing energy policies related to the transport sector and adopt strategies concerning climate energy co-benefits. This requires multi-disciplinary policy approaches linking all relevant sectors including transport, energy, food, health, agriculture etc.
- Prioritize country specific energy sources, energy efficient transportation methods, and existing cooling demands for the transport sector etc. Challenges in the areas of energy efficiency, costs and safety, policy and regulatory frameworks and service sector training needs and country specific climatic factors as well as special challenges to be faced need to be identified and addressed.

MEDIUM TO LONG TERM

- Initiate the national policy for advising buildings owners to maintain the internal temperature between 24-26°C with recommended humidity and airflow to conserve energy and achieve healthy living for occupants.
- Research and develop a mechanism for designing comfortable and habitable spaces in housing units and commercial buildings need to be established.
- Research and develop activities including using indigenous methods for air conditioning throughout the country at appropriate institutes to achieve national objectives.
- Promote technologies such as ice bank systems, and district cooling systems where applicable.
- Promote retrofitting and retro commissioning of AC systems in existing buildings, which are 10 years or older to reduce cooling requirement and energy consumption based on the assessment.
- Encourage developing cold chain infrastructure with use of low-GWP refrigerant based energy efficient cooling systems.
- Offer more incentives from the government for cold chain investments that help to improve farm incomes. It will also be a major move in supporting the achievement of the Sustainable Development Goals (SDG 1 – No poverty and SDG 2 – Zero hunger).
- Provide specialized training facilities for cold chain professionals and technicians to promote proper utilization and operation of technology, as well as energy efficiency.
- Deploy active interventions by both the government and private sector for developing cold chain infrastructure to achieve better cooling energy performance.
- Design a programme for retrofitting existing cold storages to reduce refrigerant demand and energy consumption.

INDIGENOUS KNOWLEDGE AND RESEARCH: COOLING AND REFRIGERATION

Ancient farmers in Sri Lanka have been using traditional practices of food production and preservation methods, which have been tested over the long period. Sri Lanka has had long architectural traditions in harmony with nature, dating back from the period of ancient kings, which have been steadily influenced by different cultural aspects. During the past few years, professionals

in Sri Lanka involved in building construction have considerably focused on sustainable issues pertaining to energy efficiency, climate benefits, and sustainable use of resources and minimizing waste generation, holistically based on green building principles. Most of the conventional buildings consume significant amounts of energy. This has been recognized by modern architecture, and therefore, sustainable energy measures are considered in designing new buildings and renovation of old buildings. Natural lighting and ventilation are the most important aspects of traditional or vernacular architecture that need to be learned from history in designing energy efficient buildings.

RECOMMENDATIONS

- Identify methods and practices adopted by ancient Sri Lankans for food conservation and assess their potential use for sustainable food storage in future.
- Identify policy gaps related to identification and promotion of indigenous knowledge and developing strategies to incorporate traditional practices into energy related processes to reduce GHG emissions.
- Promote further research to explore the range of socio-economic and environmental benefits of indigenous knowledge and their current applications which are still isolated or confined to particular areas of the country.
- Given the geographical location of Sri Lanka, the effect of sunlight, wind and other climatic factors need to be considered to have climate-sensitive design of buildings in Sri Lankan context.

Acknowledgements

The NCAP was developed with assistance from United Nations Development Programme (UNDP) and received financial support from the Clean Cooling Collaborative (former K-CEP). The work was coordinated by Prof. W. L. Sumathipala (PhD) and carried out under the supervision of National Ozone Unit, Ministry of Environment, Government of Sri Lanka.

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TRINIDAD AND TOBAGO

Country Profile

Trinidad and Tobago is a twin-island nation in the southernmost part of the Caribbean, with a population of 1.4 million. It consists of the main island, Trinidad and Tobago and numerous smaller islands with an overall area of 5,128 km^2. The island has a growing economy mostly influenced by the petrochemical industry. Unlike other Caribbean countries, the tourism sector plays a minor role.

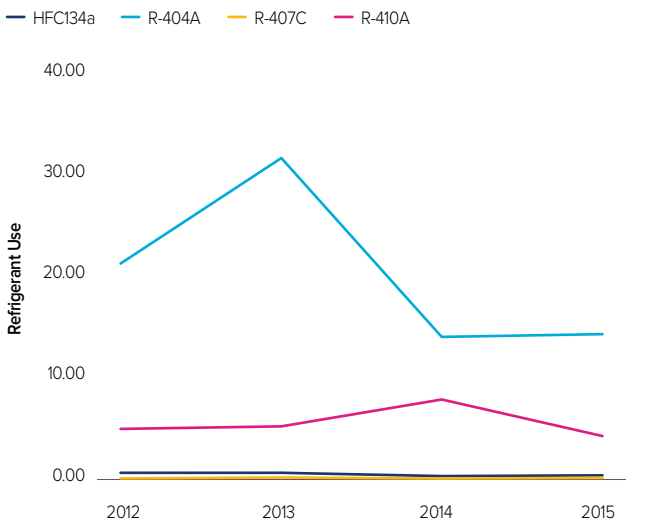
Trinidad and Tobago presented its NDC to the UNFCCC in 2015, including a target of 15% emission reduction (equivalent to 103 $MtCO_2e$) in its industrial, power generation, and transportation sectors by 2030. Trinidad and Tobago ratified the Kigali Amendment on 17 November 2017 and reported HFCs consumption of 4,425,345 CO_2eq and 14.5 ODP tonnes of HCFCs in 2020.

Market Status of the Cooling Sector

The RAC Sector in Trinidad and Tobago has two primary applications: i) space cooling in residential, commercial and mobile sectors; and ii) refrigeration in the residential, commercial and industrial applications. The primary HFC refrigerants imported are HFC-134a and HFC-410a, which are used predominantly for the servicing of RAC equipment. Other alternatives used, though on a small scale, are ammonia, hydrocarbons, and carbon dioxide.

- **Space Cooling – Residential, Commercial, and Mobile Air-conditioning:** The stationary air-conditioning categories consist primarily of three distinct types of equipment:
  - Air-conditioning units predominantly split units and with window units to the lesser extent. The average capacity of the air conditioning units is 18,000 BTU per hour and the units utilize several refrigerants including HFC-410A.
  - The chilled water systems in commercial applications are larger AC systems mainly installed in commercial and institutional buildings such as offices, malls, hotels, data centers, laboratories, and hospitals. The average capacity of these centralized chillers are 300 tonnes of refrigerant, mostly with HFC-134a or less with HFC-410A.
  - The mobile air-conditioning sector encompasses all Acs for vehicles. The mobile sector mainly utilizes HFC-134a. The country had 397,000 vehicles registered in 2015, and this number is expected to triple by 2030.
- **Residential Refrigeration:** This sub-sector utilizes refrigerants R134a and R600a, but predominantly R134a, which accounts for pprox.. 86% usage within the residential sector.
- **Commercial refrigeration**: This sub-sector includes hotels, supermarket and refrigerated transportation, where there are installed bottle chillers, cold rooms, display cool cabinets and ice making machines. Based on the ODS Alternatives Survey (2017), R-134a, R-404A, R-407C and R410A are the four primary refrigerants. The transport subsector primarily utilizes HFC-134a and R-404A, and HFC-134a accounts for 50% of the total usage.
- **Industrial refrigeration:** In Trinidad and Tobago, industrial refrigeration mainly utilizes R-404A and R-410A, with R-404A representing approximately 75% of the total usage. The overall usage has almost halved between 2013 and 2014, which was due to the decrease in oil prices. The reduction in oil prices led to a drop-in industrial activity, as well as a decline in the deployment of new projects in the industrial sector.

Figure 1. Industrial Refrigeration usage by year



BARRIERS TO ENERGY EFFICIENCY IN THE RAC SECTOR

Previous projects1 in Trinidad and Tobago identified key barriers for the introduction of energy efficiency in the RAC sector, which were confirmed during the NCAP development, as illustrated below.

Energy consumption and GHG emission

It is estimated that residential and commercial cooling sector accounts for 1479 GWh, pprox.. 17% of total energy usage in Trinidad and Tobago. Commercial would account for 70% of this value while residential accounts for 30% (Table 2). The overall market for space cooling and refrigeration is projected to increase over the next five years. Table 3 shows RAC related import data, including % 5-year growth value in Trinidad and Tobago in 2016 with a cumulative value of US$ 5.75B (OEC, 2017).

For Trinidad and Tobago, the estimated electricity grid GHG emission factor is 0.687 $kgCO_2$/kWh (IEA, 2015). In BAU scenario, Trinidad and Tobago's RAC sector contributes 1.3 $MtCO_2eq$ of total GHG emissions; direct emissions of 0.2 Mt and indirect emissions of 1.1 Mt.

Table 1. **Barriers to EE in the RAC sector**

Actors	Barriers	Description
Institutions	Information	Lack of reliable and clear indication of RAC energy performance, lack of direct information about the sector which affects effective decision-making on the part of regulators, service technicians, and consumers.
	Tariff distortion	Subsidized electricity tariffs distort the market, causing energy efficiency to be undervalued.
	Regulatory frameworks and policy development synergies	Currently the Trinidad and Tobago Electrical Commission Act does not allow for wheeling or the feeding of electricity from independent operators into the grid without consent from the state owned utility. Therefore there must be legislative reform to facilitate the use of renewable energy so that it can be financially attractive to potential users.
Consumers	Information	• Lack of understanding of energy-efficiency benefits. • Lack of information about the value of equipment energy performanc.e • Lack of information on the applicability of the use of renewable energy in providing services such as air conditioning /cooling. • Uncertainties about energy savings as energy savings are not directly measurable but can only be inferred.
	Affordability	High up-front costs for retrofits and new installations.
	Principal-agent problem	Occurs when the people who are purchasing RAC equipment are not the ones paying for the electricity to operate them. This is frequent in rental homes.
Manufacturers/ Retailers	Availability of products	• Lack of energy-efficient products available on the market. • Lack of available capital for investment in product upgrades.
	Financial barriers	Energy-efficiency projects considered high risk by financial institutions.
	Technical barriers	A large gap in professional capacity to produce efficient equipment exists in developing countries.

Table 2. End-use of Electricity for RAC (GWh, 2015)

Sector/RAC System	Refrigeration	Air Conditioning	Total
Commercial (Rates A1 and B1)			
Light	248	166	414
Centralized	373	248	621
Residential (Rates A and B)			
Light	177.6	266.4	444
Total			**1,479**

Source: Review of the Status of the Trinidad & Tobago Electricity Commission 2010-2015, and assumptions.

Table 3. OEC RAC related import Data (2016)

Item	Value/% of total imports	Projected 5-year growth in imports (%)	Related Application
Air-conditioners	US$27M (0.47%)	6.6%	Space Cooling
Cars	US$263M (4.6%)	2.6%	
Perishable Foods	US$422.95M (7.5%)	0.3%	Refrigeration
Refrigerators	US$26.6M (0.46%)	2.0%	
Packaged Medicaments	US$112M (2.0%)	0.7%	
Blood	US$12.3M (0.21%)	-0.7%	

Source: Review of the Status of the Trinidad & Tobago Electricity Commission 2010-2015, and assumptions.

Mitigation Plan

The National Cooling Plan aims to tackle sustainable cooling through the four project initiatives, which include i) the development of policy instruments; ii) support for refrigerant replacement; iii) capacity building, and partnership efforts; and iv) monitoring, verification, and enforcement activities.

DEVELOPMENT OF POLICY INSTRUMENTS

- **The implementation of minimum energy performance standards (MEPS) and labelling programs:** Trinidad and Tobago currently has no MEPS and labelling established, specifically for RAC appliances. This initiative would utilize MEPS and labels supported by testing facilities to enable the market to migrate towards energy efficient equipment in the RAC sector.
- **Implementation of Minimum Energy Efficiency Standards (Building Codes):** Alongside MEPS, minimum energy efficiency standards (MEES) for buildings would establish a minimum energy rating and a certification scheme for buildings, and then would be supported by introduction of compulsory EE building codes. MEES would promote efforts on EE and green building design, reducing the demand for cooling in residential and commercial buildings.
- **The implementation of public procurement measures and incentives:** This initiative is aimed at public procurement policy to support market migration through the development of financial and other public incentives toward the adoption of EE, low-GWP appliances.

SUPPORT FOR REFRIGERANT REPLACEMENT

- **The development of an alternative refrigerant implementation strategy:** This would include the promotion of natural refrigerants along with complementary/mandatory safety standards which are to be aligned to phase-out activities under the Montreal Protocol.
- **The introduction of not-in-kind technologies and services:** A barrier to the adoption of energy efficient RAC technology in Trinidad and Tobago is the high up-front cost to switch to more efficient technologies. The country shall promote the introduction of not-in-kind technologies such as district cooling and/or different business mechanisms such as Cooling as A Service.

- **Mechanism for recovery, recycling and safe disposal of refrigerants:** Commercially driven efforts for recovery, recycling, and disposal (RRRD) shall be supported, including instruments to effectively track refrigerant usage, training for technicians and companies in RRRD and mechanisms for environmentally friendly disposal of end-of-life refrigerants.

CAPACITY BUILDING AND PARTNERSHIP DEVELOPMENT

- **Training and capacity building:** From the policy maker perspective, capacity building shall be geared towards the design and implementation of EE legislation, MEPs, labelling, data collection, verification, and enforcement activities. For the service sector, training actions on EE and low-GWP technologies can address knowledge gaps related to installation, operation, and maintenance of flammable refrigerant-based equipment. Currently various RAC training programmes are offered with different curriculum/qualification structures. Thus, an equivalence assessment shall also be considered with the aim of standardization of the qualifications offered, and integration into the existing Professional Certification Scheme for RAC professionals, which was launched first time in April 2017.
- **Outreach and communication activities to sensitize, educate, and inform:** The communication strategy would address the information needs of both the supply and demand side of the sector and sensitize the public on the financial and environmental benefits of utilizing EE, low-GWP technologies, standards, codes, and fiscal incentives.
- **The Harnessing of opportunities for regional collaboration:** Trinidad and Tobago would seek to harmonize MEPS, labelling and measurement standards among countries within the Caribbean region with similar usage and energy cost conditions across the same product categories. Regional collaboration shall extend to regional market surveillance authorities creating recognition of test results and labelling. Trinidad and Tobago shall take the initiative at the CARICOM level to establish a standard and harmonized approach.

Figure 2. **Cooling Strategy initiatives relationship diagram**

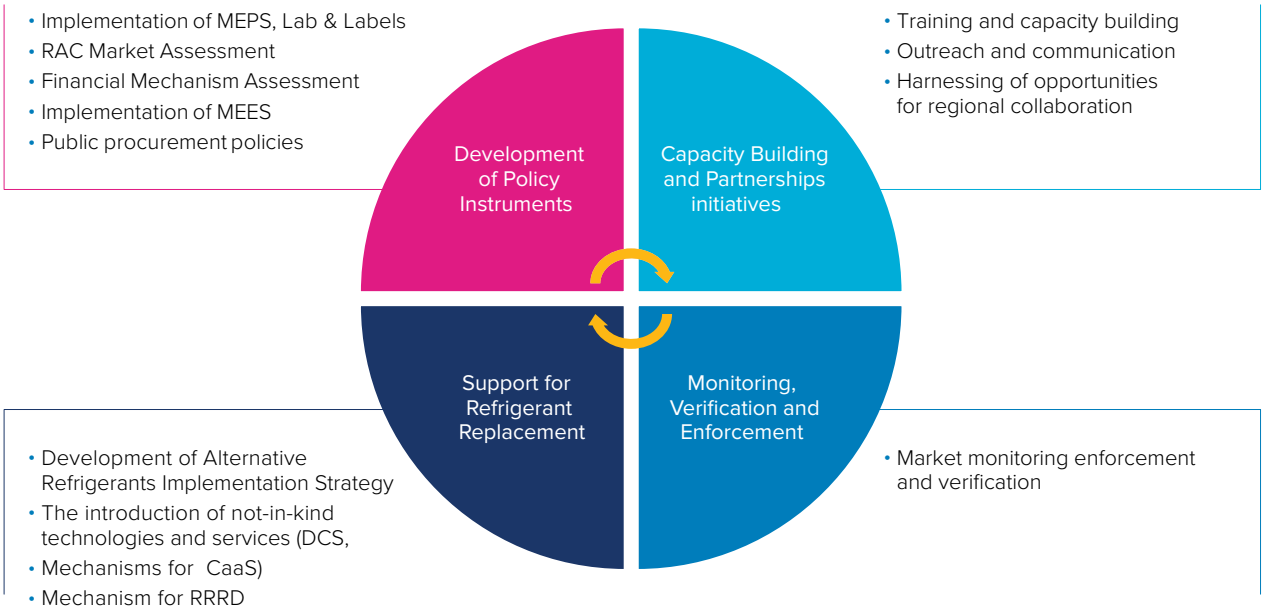
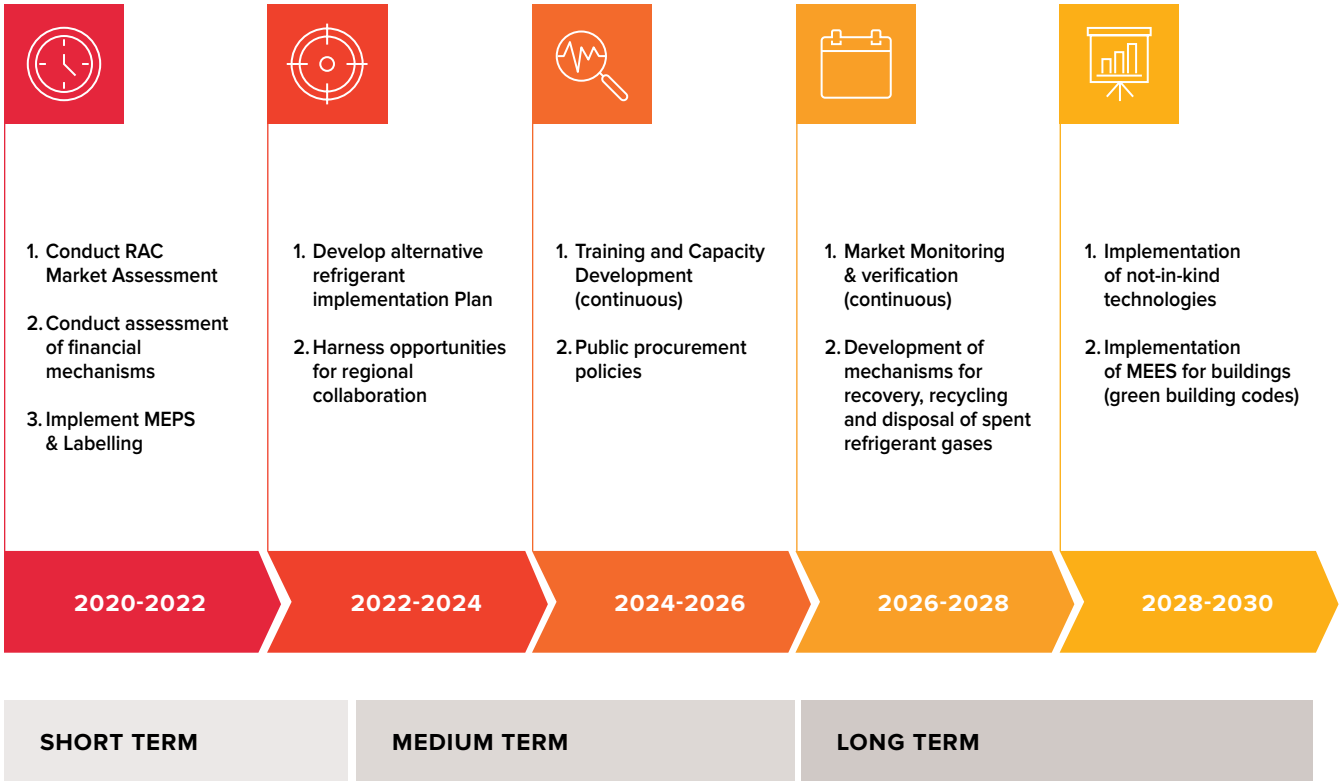


Figure 3. **NCAP timeline**



MARKET MONITORING, VERIFICATION AND ENFORCEMENT

- The development of data collection and analysis mechanisms for market monitoring, verification, and enforcement are essential. These mechanisms shall include the information needed to evaluate performance over time, energy savings, compliance with the standards and labelling (S&L) regulations and levels of equipment sales. Data collected can also be used to incorporate EE into HCFC phase-out and HFC phase-down plan.

NCAP IMPLEMENTATION FRAMEWORK

The implementation of the projects under the NCAP shall be managed by a Cabinet appointed Committee over 10- year implementation period, through following timeline diagram (Figure 3) as illustrated above.

Key Stakeholders

Table 4. List of key stakeholders

Stakeholder	Roles and responsibility
Environmental Policy and Planning Division (EPPD) of the Ministry of Planning and Development (MPD)	The EPPD of the MPD, as the focal point of the UNFCCC and the Montreal Protocol, is the lead public partner responsible for the development of the NCAP.
Ministry of Energy and Energy Industries (MEEI)	The MEEI oversees enforcing the country´s energy policy and planning.
Ministry of Trade and Industry (MTI)	The MTI is a critical stakeholder for the Montreal Protocol through the licensing system of refrigerants and refrigeration equipment. It grants import and export permits and will also be integral for the MEPs.
Ministry of Finance	The MOF oversees fiscal appropriations of Government funds for various projects. The MOF is responsible for any tax incentive to be implemented, including tax exemptions and other fiscal measures.
Ministry of Public Utilities	The MPU is a critical stakeholder as it involves in electricity generation and distribution in the country.
Ministry of Labor and Small Enterprise Development	Key stakeholder for collaboration with the National Entrepreneurial Development Company Ltd. (NEDCO) and the Occupational Safety and Health Agency (OSHA) which are agencies under this Ministry.
Town and Country Planning Division (TCPD)	The TCPD is a critical stakeholder in areas that concern building codes and the approval of building structures and hence would be instrumental in the inclusion of energy efficiency in these areas.
Trinidad and Tobago Bureau of Standards (TTBS)	The TTBS is a crucial partner to monitor the import of ODS-dependent equipment, MEPS and national labeling standards for refrigerants.
Tobago House of Assembly (THA)	The THA is seen as a key partner to ensure that all initiatives are implemented on the island of Tobago.
Environmental Management Authority (EMA)	EMA is a statutory body established by the Government, to provide guidance on national environmental standards and surveillance for compliance with national environmental regulations.
Solid Waste Management Authority (SWMCOL)	State-owned enterprise responsible for the design and implementation of solid and hazardous waste management systems and structures, and landfill management of three landfills in the country.
Trinidad and Tobago Electricity Commission (T&TEC)	The T&TEC is the single power utility servicing the entire country and the largest utility in the whole of the English-speaking Caribbean.
Regulated Industries Commission (RIC)	RIC monitors public sector services (water, wastewater, and electricity) and represents the interests of consumers. RIC will participate by setting up appropriate tariffs for upcoming technologies and services.
Air Conditioning and Refrigeration Association (ARIA)	Membership Association primarily made up of companies, professionals, and students from the RAC sector of Trinidad and Tobago and it operates long-established training center ARIA Technical Institute (ATL).
Refrigerant Recovery Recycle Association (RRRA)	Non-profit organization formed to assist in the development of mechanisms aimed at recovery, recycling, and final disposal of refrigerants in a sustainable manner.
School of Refrigeration and Air-conditioning (SORAC)	Private institution focusing the training of RAC Technicians at the craft level. The institute provides theoretical & practical training and is responsible for training over one thousand artisans in this field.

Acknowledgements

The NCAP of Trinidad and Tobago was developed on behalf of the Government of Republic of Trinidad and Tobago. The work was carried out under the direct supervision of the EEPD of the Ministry of Planning and Development (MPD), in coordination with UNDP in Trinidad and Tobago and its regional team of the Chemicals and Waste Hub. The NCAP is funded by the Kigali Cooling Efficiency Programme (K-CEP) through the United Nations Development Programme (UNDP).

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