GIZ Cool Contributions fighting Climate Change II

Philippines – Refrigeration and Air Conditioning Inventory 2025

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The RAC GHG inventory provided inputs for the 2025 update of the Nationally Determined Contributions of the Philippines under the Industrial Process and Product Use Sector (IPPU) for indirect emissions and to the energy sector for energy efficiency.

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Abbreviations

ASEAN	Association of Southeast Asian Nations
BAU	Business-as-Usual Scenario
CCC	Climate Change Commission
CCD	Cooling Degree Days
CFC	Chlorofluorocarbon
COP	Coefficient of Performance
CSPF	Cooling Seasonal Performance Factor
DOE	Department of Energy
DENR	Department of Environment and Natural Resources
DOF	The Department of Finance
DOTr	Department of Transportation
DTI	Department of Trade and Industry
EEF	Energy Efficiency Factor
EER	Energy Efficiency Rating
EMB	Environmental Management Bureau
GDP	Gross Domestic Product
GEF	Grid Emission Factor
GFI	Government Financial Institution
GHG	Greenhouse Gases
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HH	Household
HPMP	Hydrofluorocarbons Phase Out Management Plan (HPMP)
IGES	Institute for Global Environmental Studies

IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
MAC	Mobile Air conditioning
MEPS	Minimum Energy Performance Standards
MIT	Mitigation Scenario
MLF	Multilateral Fund
MRV	Measuring, Reporting, and Verification
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contributions
ODS	Ozone-Depleting Substances
PELP	Philippine Energy Labelling Program
PESLP	Philippine Energy Standards and Labelling Program
POD	Philippine Ozone Desk
RAC	Refrigeration and Air Conditioning
TESDA	Technical Education and Skills Development Authority
UAC	Unitary Air Conditioning
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

This document provides an overview of the relevance and processes related to the development of Refrigeration and Air Conditioning (RAC) inventories as well as the context of the C4 project, focusing on the significance of the RAC sector in relation to national strategies under the Paris Agreement and the Montreal Protocol. It also examines the specific climatic and market conditions in the Philippines, along with general insights into its RAC sector. This foundational information will support a more in-depth analysis of the sector's emissions and potential mitigation strategies.

1.1. Project context

The Cool Contributions to Climate Change C4 is a project of the GIZ to support developing countries in developing and strengthening measures to reduce GHG emissions from the RAC sector. Over this time, the project has collaborated closely with key local authorities, including the Climate Change Commission (CCC), the Department of Energy (DOE), and more. In the second iteration of this project (C4 II), the effort continues to support effective coordination among these entities with initiatives that continue to support climate-friendly refrigeration. As part of this, an inventory of GHG emissions of the RAC sector has been carried out and is the main subject of this report.

This inventory aims to provide a comprehensive assessment of greenhouse gas (GHG) emissions in the Philippine RAC sector. The report covers:

- Business-as-usual (BAU) GHG emissions from refrigerant and energy use in the RAC sector.
- A mitigation scenario demonstrating the potential market adoption of energy-efficient appliances using low Global Warming Potential (GWP) refrigerants.

This report examines the range of RAC appliances currently available in the Philippine market, their energy consumption, and the refrigerants they use to estimate the corresponding GHG emissions. Existing RAC technologies are compared with international best practices to evaluate their emissions reduction potential. Furthermore, future trends in each RAC subsector are analysed under both BAU and mitigation (MIT) scenarios.

1.2. Importance and benefits of RAC sector inventories

Inventories aim to provide estimates of the installed equipment stock across various RAC subsectors and combine them with the average technical parameters of each subsector to estimate emissions over time. This provides a reliable database that can serve as a foundation for planning and monitoring GHG emission reduction efforts and support the development of interventions.

This equipment-based RAC GHG inventory includes:

- Sales figures and stock levels for each subsector.
- Technical specifications of the RAC systems that drive GHG emissions, including average energy efficiency, refrigerant distribution, and leakage rates.
- GHG emissions per RAC unit.

- Total GHG emissions for the entire RAC sector, differentiating between direct and indirect emissions.
- Future projections of RAC stock and GHG emissions.
- Mitigation scenarios based on the implementation of various technical solutions.

Inventories and the data they provide can be used for the planning and development of interventions in the RAC sector. Generally, these will focus on emissions reductions, but they can also be used for other important purposes:

- Identifying subsectors with the highest GHG emissions and the most significant emission reduction potential through available technologies.
- Supporting national GHG inventories for reporting under the UNFCCC, including projections of future emissions and their implications for RAC sectoral mitigation plans and Nationally Determined Contribution (NDC) targets.
- Facilitating mitigation strategies, such as the development of Minimum Energy Performance Standards (MEPS), energy labelling programs, and restrictions on high-GWP refrigerants.
- Assessing the impact of legislation on different RAC subsectors.
- Establishing a framework for a Measuring, Reporting, and Verification (MRV) system or a comprehensive product database.

A wide range of stakeholders can utilise the data of an RAC inventory to support climate-friendly development activities and for strategic planning and policy development:

- **Climate Change Commission (CCC):** Can incorporate RAC sectoral mitigation targets into national climate strategies and contribute to climate reporting, including National Communications and Biennial Update Reports.
- **Department of Environment and Natural Resources (DENR):** Can use inventory data for GHG emission control, mitigation planning, and UNFCCC reporting on HFCs, including F-gas tracking in National Communications and Biennial Update Reports.
- **Department of Energy (DOE):** Can establish and maintain a national product database to monitor, review, and update MEPS and energy labelling for RAC equipment.
- **RAC Industry:** Gains insights into the national carbon footprint of the RAC sector, aiding in the development of low-carbon product strategies and market adaptation.
- **Department of Trade and Industry (DTI):** Can reference the inventory when formulating RAC-related product testing standards for safety and performance.
- **The Department of Finance (DOF), Government Financial Institutions (GFIs), and Private Banks:** Can develop financing mechanisms and incentives to support the transition to low-carbon RAC technologies.

- **Department of Science and Technology:** for research and development of low-GWP future-friendly RAC technologies.
- **Technical Education and Skills Development Authority (TESDA) and Vocational Training Institutions:** Can integrate low-carbon technology practices into training programs and curricula to build workforce capacity for sustainable RAC practices.

1.3. Geography and basic information of the Philippines

The Republic of the Philippines is set in an archipelago in Southeast Asia, made up of approximately 7,641 islands. It is situated within the Pacific Ring of Fire, covering a total area of about 300,000 square km[1]. The population of the country was approximately 119 million people in 2023[2].

The country's terrain is predominantly mountainous, with large tropical rainforests and a tropical climate. The climate features distinct rainy and dry seasons, with a monsoon season that brings heavy rainfall between May and October. In Manila, the mean annual temperature is around 27°C, with an average annual precipitation of approximately 2,348 mm[1].

Given the persistent high temperatures throughout the year, there is a substantial and increasing demand for cooling technologies in the Philippines. This demand intensifies during the hot and humid months from May to November. Projections indicate that, under climate scenarios RCP2.5 and RCP8.5, the number of Cooling Degree Days (CDDs) in the Asian region could increase by 30% to nearly 100% by 2100, respectively[3]. This trend suggests that, alongside the air conditioning sector, the need for food refrigeration and other cooling applications is expected to rise.

1.4. Energy production, consumption, and factors influencing the growth of the RAC sector

The demand for energy in the Philippines is rising steadily, driven by multiple factors, but primarily by population growth and economic development. The population of the country has increased by around 15% between 2015 and 2025 to 119 million, which, combined with a decreasing pattern in household size[4], has resulted in a total increase of 27% in the total number of households demanding electricity to nearly 30 million by 2025. More households mean a higher demand for electricity-intensive appliances such as air conditioners (ACs) and refrigerators, significantly contributing to the country's energy load, especially in urban areas.

Economic growth also drives the growth of cooling demand (and therefore energy demand) as it supports the improvement of household incomes, increasing the affordability of modern

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[1] Climate Change Commission (2022). First Biennial Transparency Report of the Philippines to the UNFCCC. United Nations Framework Convention on Climate Change.

[2] World Bank Data: Population, total – Philippines. Available online: Link.

[3] Hasegawa, T., Park, C., Fujimori, S., Takahashi, K., Hijioka, Y. and Masui, T. (2016). Quantifying the economic impact of changes in energy demand for space heating and cooling systems under varying climatic scenarios, Palgrave Communications 2(1), pp. 1-8.

[4] Philippine Statistics Authority (2022). Household Population, Number of Households, and Average Household Size of the Philippines (2020 Census of Population and Housing). Available online: Link.

appliances that contribute to greater electricity use. The Philippine economy expanded by 5.2% in 2024, reflecting increased industrial and commercial activity. This trend is particularly evident in urban areas, where rapid urbanisation and infrastructure development lead to high-density housing, commercial centres, and industrial zones, all requiring extensive energy use for lighting, cooling, and operations.

Climate conditions will also play a role in driving energy demand. With an annual mean temperature of around 27°C in Manila and a long, hot and humid season from May to November, the demand for cooling technologies is more a necessity than a luxury. Climate projections indicate that Cooling Degree Days (CDDs) in Asia could increase between 30% and 100% by 2100, further exacerbating the demand for air conditioning and refrigeration. This increasing reliance on cooling appliances places additional pressure on the country's electricity grid.

The total demand for energy in the Philippines has increased steadily in recent decades and is dominated by fossil fuels in the form of coal and oil products. This means that increases in energy demand from the RAC sector result in large increases in GHG emissions.

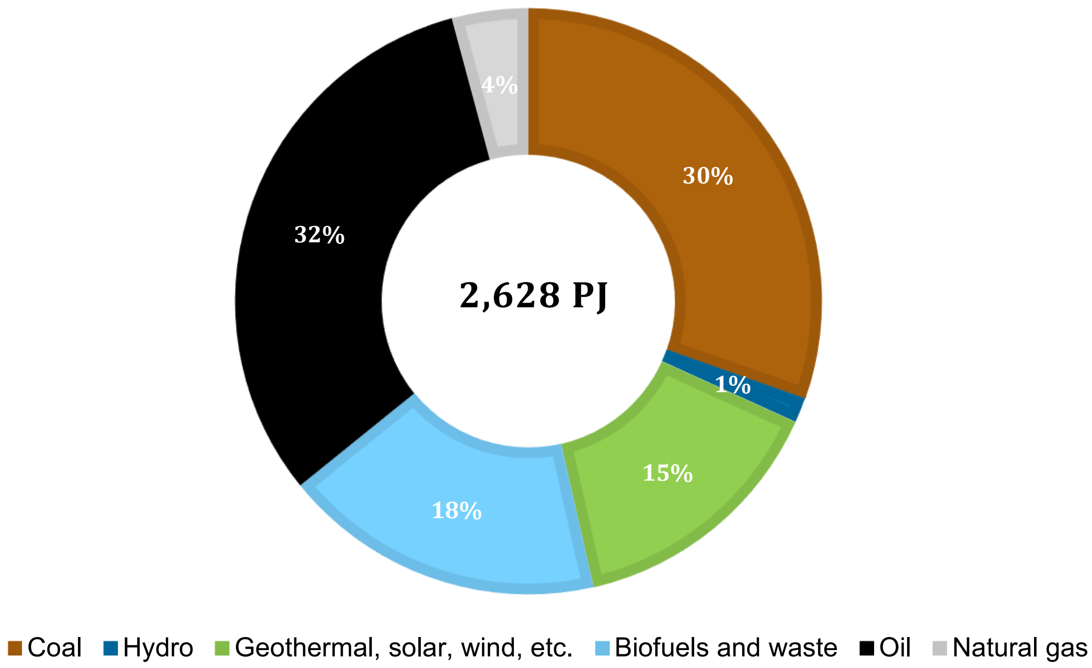

Figure 1: Total Primary Energy Supply of the Philippines in 2022 (Source: International Energy Agency).

In terms of electricity, the proportion that is generated from coal has increased steadily in the last two decades to around 60% in 2022. This results in a large grid emissions factor of 636 grams of CO_2 produced for each kWh consumed[5]. This makes energy efficiency in the RAC sector even more important to prevent massive increases in emissions as the population keeps growing and the affordability of cooling progresses.

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[5] Institute for Global Environmental Strategies (2022). List of Grid Emission Factors, version 11.0. Available online: Link.

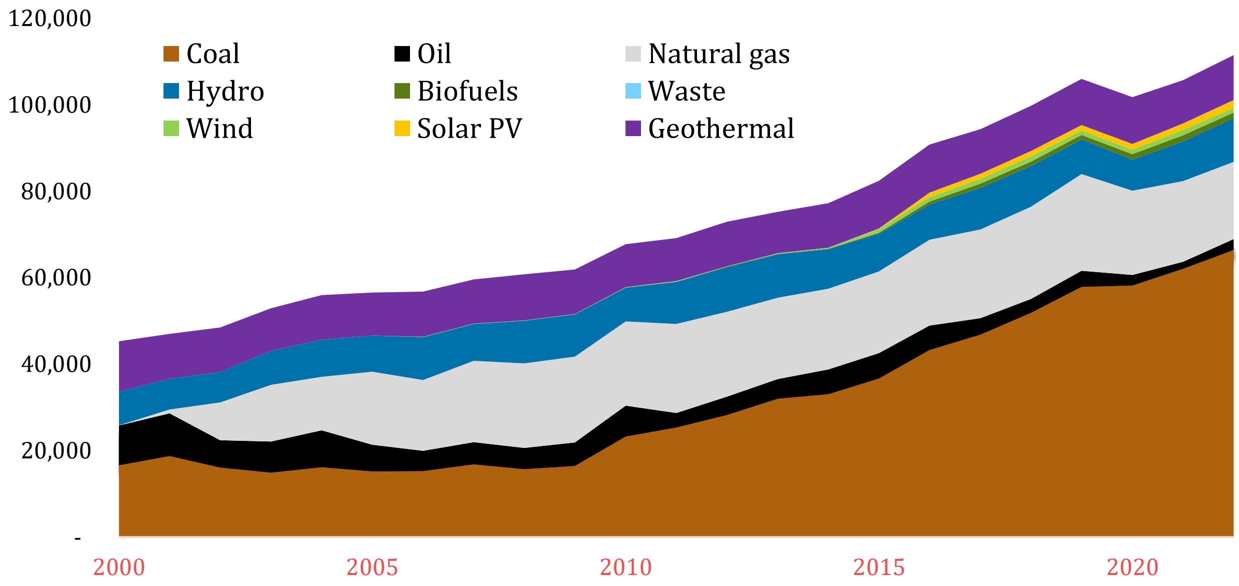

Figure 2: Electricity generation by fuel type. (Source: International Energy Agency).

1.5. Regulatory framework

The Philippines has established a comprehensive regulatory framework to promote environmentally friendly technologies in the Refrigeration and Air Conditioning (RAC) sector, aligning with both national policies and international commitments.

The C4 project has supported the Philippines since 2016, assisting the ozone, climate, and energy regulatory agencies to develop interventions, capacity, and strategies to enable the country to transition towards climate-friendly cooling.

1.5.1. National Policies and Regulations

The RAC sector GHG inventory was communicated to the CCC, which established Executive Order 174, the Philippine Greenhouse Gas Inventory Management System (PGHGIMRS). Request for concurrence was forwarded to the DENR as the lead agency for the GHG inventory in the Industrial Process and Product Use (IPPU) sector. Initially, the C4 project has worked with the Philippine Ozone Desk (POD), the national ozone unit, and the Climate Change Division of the Environmental Management Bureau (EMB) for the 2017 to 2019 inventory.

In 2019, the Energy Efficiency and Conservation Act (Republic Act 11285) was enacted. RA 11285 sets the policy framework for the implementation of Minimum Energy Performance Standards (MEPS) for appliances to enhance energy efficiency in households, particularly in the Refrigeration and Air Conditioning (RAC) sector (i.e., cooling and refrigeration). In its latest iteration, the MEPS adopted new metrics of energy efficiency performance, the Cooling Seasonal Performance Factor (CSPF) for AC and the Energy Efficiency Factor (EEF) for domestic refrigerators to better capture the annual performance of these appliances. In this update, the minimum requirements of energy efficiency for unitary air conditioners were also raised.

MEPS are regulatory measures that set minimum allowable levels of energy efficiency that appliances must meet to be allowed in a market, ensuring that inefficient units don't enter the market, resulting in reduced energy demand. The MEPS programme is supported by the Philippine Energy Standards and Labelling Program (PESLP) which mandates manufacturers, importers, distributors, and retailers to affix a label with basic information to appliances with basic information on the energy performance and related information to ensure that the market can make informed purchasing decisions. The information present on the label includes:

- **Star Rating**: Indicates the energy efficiency performance, with more stars representing higher efficiency.
- **Energy Efficiency Rating**: Based on the CSPF value of the unit.
- **Refrigerant Type and Global Warming Potential** (GWP): Information on the refrigerant used and its environmental impact.
- **QR Code**: Provides access to detailed product information, including greenhouse gas emissions and estimated monthly energy consumption.

In terms of CSPF, it is a metric that better reflects the annual performance of an AC as it considers the energy performance throughout the year and real usage patterns, rather than the more limited and prescriptive Energy Efficiency Rating (EER) units. In the latest update of the MEPS, the Philippine government raised the MEPS requirement for AC from a CSPF of 3.08 to 3.19 for fixed-speed units and 3.7 for variable-speed units.

Cooling Seasonal Performance (CSPF)		
For All Cooling Capacities		
EEPR	Fixed Speed	Variable-Speed
One-Star	3.19 – 3.44	3.70 – 4.72
Two-Star	3.45 – 3.70	4.73 – 5.22
Three-Star	3.71 – 3.96	5.23 – 5.89
Four-Star	3.97 – 4.19	5.90 – 6.40
Five-Star	≥ 4.20	≥ 6.41

Figure 3: Updated MEPS and labelling requirements for ACs in CSPF values starting in 2025 (Source: Philippine Energy Labelling Program, 2024).

1.5.2. International Commitments and Regional Initiatives

At an international level, the Philippines supports the attainment of international climate and environmental objectives through its active participation in global and regional forums, primarily the Paris Agreement and the Montreal Protocol.

The Philippines ratified its commitment to the Montreal Protocol in 1991, committing to the global effort to eliminate ozone-depleting substances (ODS). The country successfully phased out major ODS such as CFCs, halons, carbon tetrachloride, and methyl chloroform ahead of schedule. Under its HCFC Phase-out Management Plan (HPMP), the Philippines has implemented a freeze on HCFC consumption since 2013, with the goal to achieve a full phase-out by 2040 (UNIDO, 2023)[6].

As part of the evolution of the Montreal Protocol in line with broader climate goals, the Philippines ratified the Kigali Amendment in 2022, which entered into force in 2023, obligating the country to gradually reduce its consumption of hydrofluorocarbons (HFCs) by 80% by 2045. These actions are supported by national policies such as licensing and quota systems and are overseen by the Department of Environment and Natural Resources (DENR) to ensure compliance with both ozone and climate protection commitments (UNIDO, 2023).

Under the Paris Agreement, the country commits to a projected 75% reduction in greenhouse gas emissions by 2030, with 2.71% unconditional and 72.29% conditional upon international support. These reductions cover energy, transport, industry, waste, agriculture, and the refrigeration and air-conditioning (RAC) sector. The country recognises the dual climate impact of this sector through energy consumption and the use of high-global warming potential (GWP) refrigerants.

The Philippines' National Communication and BTR outline specific strategies targeting emissions in the RAC sector, aligned with the Kigali Amendment to the Montreal Protocol and the country's Hydrofluorocarbon (HFC) phase-down strategy. Measures include improving the energy efficiency of appliances, phasing down HFCs, and promoting natural refrigerants such as R-290 (propane) and R-744 (CO_2) in commercial and industrial systems. These initiatives form part of a broader national effort to integrate mitigation actions across key sectors, ensuring that climate action is both inclusive and technically grounded (Climate Change Commission, 2022)[7].

At a regional level, the Philippines cooperates in the Association of Southeast Asian Nations (ASEAN) initiatives to harmonise energy performance standards for air conditioners. The ASEAN Regional Policy Roadmap recommends aligning testing and energy performance evaluation standards with ISO 5151 and ISO 16358, facilitating regional consistency and promoting the adoption of energy-efficient RAC technologies.

Similarly, the Roadmap advocates for the gradual strengthening of more stringent MEPS to a CSPF of 6.09 by 2025, a target that the Philippines has committed to. However, in the latest update of the MEPS, the levels fell well short of this target. The Department of Energy (DOE) continues to evaluate the feasibility of adopting more rigorous standards, considering factors such as market readiness, technological availability, and economic implications for consumers and manufacturers.

2. Scope of the inventory

This inventory aims to provide an assessment of GHG emissions from the RAC sector in the Philippines and an estimate of the future trends using a stock model that accounts for major RAC subsectors and their appliances. This approach relies on historical sales data to estimate current and future equipment stock, while growth trends and market dynamics inform projections for future stock levels. Emissions calculations are performed per subsector and appliance type,

[6] United Nations Industrial Development Organisation (UNIDO) (2023). Philippines – HCFC Phase-out Management Plan (HPMP) Stage III, first tranche – project document.
[7] Climate Change Commission (2022). First Biennial Transparency Report of the Philippines to the UNFCCC.

incorporating data and assumptions of key technical and usage parameters that determine both direct and indirect emissions from appliance use.

2.1. Key elements that make up the Inventory

The Inventory is an important tool to guide the government's decision-making in this sector, providing information for interventions and providing feedback on the progress of the market as it responds to the changing conditions of the market and emerging policies. The key elements in this inventory include:

1. Stock and Sales Data Analysis
    a. The inventory uses existing data on the sales and stock for each RAC subsector to provide a time series of sales and stock.
    b. Future stock estimates are determined based on observed growth trends and technological adoption rates.
2. GHG Mitigation Potential Assessment
    a. The mitigation potential of the RAC sector in the Philippines is estimated following the Intergovernmental Panel on Climate Change (IPCC) guidelines.
    b. This assessment helps to identify opportunities for reducing emissions through efficiency improvements and refrigerant transitions.
3. Energy and Refrigerant Use Analysis
    a. The inventory estimates historical, current, and future energy consumption and refrigerant usage for each appliance type.
    b. This analysis is crucial for understanding both direct emissions (from refrigerant leakage) and indirect emissions (from electricity consumption).
4. Comparison with Best Practices
    a. Existing RAC technologies deployed in the Philippines are benchmarked against international best practices to identify potential GHG emission reduction opportunities on a per-unit basis.
    b. This comparison helps policymakers and industry stakeholders prioritise energy efficiency improvements and low-GWP refrigerant adoption.
5. Scenario Analysis
    a. The inventory evaluates future trends in RAC subsectors under Business-as-Usual (BAU) and Mitigation (MIT) scenarios.
    b. These scenarios provide insights into how policy interventions, technological advancements, and market transformations can impact sector-wide emissions.

The inventory follows the categorisation framework outlined in the RAC NAMA Handbook, Module 1: Inventory (GIZ, 2014)[8]. The RAC subsectors and appliances are classified according to their function and market segment, and this inventory focuses on estimating the actual emissions at the unit or appliance level. This bottom-up approach allows for greater accuracy in quantifying sector-specific emissions and facilitates more targeted mitigation strategies.

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[8] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2014). NAMAs in the refrigeration, air conditioning and foam sectors. A technical handbook. Module 1: Inventory. Available online: *Link*.

The RAC subsectors included in this inventory follow the same definitions as in the 2019 inventory (GIZ, 2019)[9], including the following:

1. **Unitary Air Conditioners (UAC):** This includes a variety of types of UAC, including Window-type ACs, split residential ACs, and split commercial ACs up to a size of 14 kW.
2. **Air Conditioning Chillers**: This includes chillers that serve larger multi-split AC systems for commercial buildings. Their size can vary significantly depending on the size of the application, but the assumed size for this inventory is 250 kW.
3. **Mobile Air Conditioners**: This includes the ACs in passenger vehicles in the circulating stock in the Philippines. This also includes Large Mobile Air Conditioners, which is largely made up of buses.
4. **Domestic Refrigeration**: This includes domestic refrigerators.
5. **Commercial Refrigeration**: This is largely composed of the refrigeration needed in commercial applications such as food retail.

2.2. Methodology

The methodology used in this report is based on internationally recognised approaches, including those outlined by GIZ (2014), Penman et al. [10](2006), the IPCC Tier 1 and Tier 2 methodology (2006) [11], and 2019 iterations of the RAC inventory. This approach ensures robust coverage of the RAC sector GHG emissions, including both direct and indirect emissions. In this report, the terms "system," "appliance," "equipment," and "unit" are used interchangeably to refer to RAC devices.

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

Unlike alternative refrigerant inventories such as Ozone-Depleting Substances (ODS) alternative surveys, which typically use the Tier 1 methodology, this inventory is based on a combination of Tier 2 and Tier 1 methodologies that support a reasonably detailed and disaggregated emissions analysis, however, it still relies on top-down figures to make projections for subsectors where more detailed data was not available. In an ideal case scenario, a Tier 2 methodology is ideal as it provides better disaggregation and details to support interventions, but the methodology that has been achieved for this report is strong as:

[9] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2019). Refrigeration and Air Conditioning Greenhouse Gas Inventory for the Philippines. Available online: Link.

[10] IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[11] Penman, J., Gytarsky, M., Hiraishi, T., Irving, W. and Krug, T. (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories - Chapter 7 Emissions of Fluorinated substitutes for ozone depleting substances. Available online: Link.

- It accounts for both refrigerant-related emissions and their mitigation options, as well as GHG emissions from energy use and their mitigation strategies.
- It facilitates the preparation of GHG mitigation actions, such as Nationally Appropriate Mitigation Actions (NAMAs), in relevant RAC subsectors.
- It supports the further development and review of Nationally Determined Contributions (NDCs).
- Since Tier 2 inventories are unit-based, they enable the establishment of a Measuring, Reporting, and Verification (MRV) system at the appliance level to track mitigation efforts accurately.

Table 1: IPCC Tiers 1 and 2 comparison (IPCC, 2006).

Methodology	Approach	Data granularity	Emission sources covered
Tier 1	Sector-based aggregation	Estimates emissions at an aggregate sector level.	Focused primarily on refrigerant demand and usage.
Tier 2	Unit-based aggregation	Assesses emissions at the individual appliance level.	Accounts for both direct and indirect emissions.

The Tier 2 methodology offers a more detailed and accurate emissions assessment compared to Tier 1, making it more suitable for policy planning, emissions reduction strategies, and compliance with international climate commitments.

The Tier 2 approach accounts for both direct and indirect emissions associated with RAC appliances at various stages of their lifecycle:

1. Direct Emissions (Refrigerant-Related):
    a. Manufacturing Stage: Emissions from refrigerant leakage during the assembly and initial charging of new RAC units.
    b. Operational Stage: Refrigerant losses due to leakage, servicing, and accidental releases during regular appliance use.
    c. End-of-Life Stage: Residual refrigerants that escape when appliances are decommissioned or improperly disposed of.
2. Indirect Emissions (Energy-Related):
    a. Electricity Consumption for Cooling: The emissions generated by the production of electricity that is used to power RAC appliances.
    b. Grid Emission Factor (GEF): The emissions intensity of the Philippines' power grid, which determines the indirect GHG emissions from RAC energy use.

Unlike Tier 1, which only estimates refrigerant demand and consumption at a sectoral level, Tier 2 provides a comprehensive view by incorporating energy efficiency considerations and real-world emissions data at the unit level.

Accounting for Refrigerant Consumption

The inventory tracks refrigerant use at all key stages of the product life cycle, including:

- Refrigerants are charged into newly manufactured appliances.
- Refrigerants in active use within operational appliances (average annual stock).
- Residual refrigerants remaining in appliances at the end of their service life.

2.3. Data collection and quality

The data collection requirements to generate a RAC sector inventory usually include a combination of primary data collection efforts supported by secondary and tertiary data sources to provide sufficient details for the needed analysis and granularity. The use of multiple data sources ensures a comprehensive and reliable assessment of GHG emissions from the sector while optimising resource requirements to produce it.

This chapter highlights the importance and relevance of different types of data, the sources used for this iteration of the Inventory, and the general level of quality of the data for each subsector.

2.3.1. Primary data: Importance and constraints

Primary data refers to the collection of firsthand information directly from the market's main stakeholders, including manufacturers, importers, retailers, end-users, and servicing professionals. This method typically provides the most accurate and up-to-date information on equipment stock, sales trends, energy efficiency levels, and refrigerant usage. However, this method presents significant challenges:

- Resource Limitations: Conducting large-scale surveys, stakeholder interviews, and on-the-ground assessments requires significant time, funding, and technical expertise.
- Challenges in Accessing Stakeholders: Given the fragmented nature of the RAC sector and the involvement of multiple stakeholders, direct data collection would have required extensive coordination and logistics.

Projects funded by the Multilateral Fund (MLF) with the Montreal Protocol usually have allocated resources for conducting surveys and stakeholder consultations. It is recommended that close coordination with these projects are undertaken during the inventory process to have a cohesive approach in primary data collection.

Alignment with the Montreal Protocol Country Program Report is also recommended for inventory compilers. The national ozone unit regularly conducts validation with bulk chemical importers and completed MLF projects which collect adequate information that is useful for the inventory.

2.3.2. Secondary data

Secondary data refers to previously collected information from official institutions, market reports, and research studies. These sources can provide essential insights into the historic and current stock of RAC appliances, refrigerant consumption patterns, and energy efficiency levels. As this data has already been collected for other purposes, its availability greatly reduces the need for primary data collection for the production of the Inventory.

As secondary data sources have usually been collected for alternative purposes, they usually still require significant analysis and manipulation to make it suitable for the Inventory.

The main secondary sources used in this inventory include:

- Government Reports and Policies:
    - Appliance sales and registration data from the Philippine Energy Labelling Program (PELP), which is implemented by the Department of Energy. This data source primarily covers UAC and domestic refrigerators.
    - Philippine Ozone Desk Report and HCFC Phase-Out Management Plans (HPMP) FCC project for cold chain produced by various MLF implementing agencies for the Environmental Management Bureau (EMB).
    - Road sector data sets from the Department of Transportation (DOTr) provided stock data for mobile air conditioning.
    - National-level data on demographics and macroeconomics are primarily sourced from the World Bank.
- Market Research and Industry Reports:
    - Euromonitor International market research report: Supermarkets in the Philippines, produced in 2023.
    - ASEAN Regional Policy Roadmap for Air Conditioners (United for Efficiency, 2022).
    - International Energy Agency (IEA) reports on energy efficiency and GHG emissions in Southeast Asia.
    - 2019 RAC Inventory and the relevant background data that was produced for the GIZ.

2.3.3. Tertiary data sources

Tertiary data consists of aggregated data and scientific publications that provide global benchmarks and international comparisons. These sources help contextualise the Philippine RAC sector within broader regional and global trends. Key tertiary sources used include:

- IPCC Guidelines (2006, 2019)[12] for GHG Emissions Estimation in the RAC Sector.
- GIZ (2014) – RAC NAMA Handbook for Developing Country Inventories.
- Penman et al. (2006) – Guidelines on Emissions Calculations and Tier 2 Methodologies.
- Reports from the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), and the World Bank on Refrigerant Transition Strategies.

[12] IPCC (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

2.3.4. Data quality

The data quality from the PELP, the Department of Transportation, and the economic and demographics macro statistics are very robust, leading to strong market estimates for the domestic AC, refrigeration, and mobile air conditioning sectors. On the other hand, the estimates for AC chillers and commercial air conditioning are more dependent on assumptions from the supermarket industry market research report and the somewhat outdated estimates from the 2019 Inventory.

In terms of the technical specifications and usage patterns for the RAC appliances have been derived from well-established, internationally agreed defaults as presented in the IPCC Guidelines.

In terms of the results, the totals presented are believed to be strong approximations based on the available data. However, it is acknowledged that for some RAC sub-sectors, such as AC chillers, the trends are more indicative, as are the potential savings.

2.4. Modelling parameters

In developing the Refrigeration and Air Conditioning (RAC) sector inventory, a combination of primary, secondary, and tertiary data sources was utilised to establish accurate modelling parameters. While primary data collection, such as direct surveys and interviews, provides tailored and specific insights, it was not extensively conducted in this study due to constraints in time and resources, as well as the availability of substantial secondary and tertiary data.

A critical parameter in calculating indirect emissions from electricity consumption is the Grid Emission Factor (GEF), which measures the CO_2 emission intensity per unit of electricity generated. For this inventory, a GEF of 0.636 kg CO_2/kWh[13] was applied, based on data from 2022. Due to the absence of reliable projections for future GEF values, this factor was consistently used across both the BAU and Mitigation scenarios.

To provide robust future estimates of future emissions, it is important to identify credible and plausible growth trajectories of RAC appliances. In the absence of specific forecasts from the government or the industry, historical data and projections of population and economic growth are combined with observed market patterns in other developing countries to generate robust growth assumptions.

For residential appliances, the growth assumptions looked at population total population growth and changes in ownership rates. For commercial appliances, changes in GDP were used to generate growth assumptions. In both cases, the growth rate assumptions applied are judged to be conservative.

The key technical and performance parameters for the different subsectors are depicted in Table 2 and include the equipment's lifetime in years, the key refrigerants for each subsector, the initial

[13] Average operating emission factors provided by the Institute of Global Environmental Studies to estimate baseline emissions for CDM project. Institute for Global Environmental Strategies (2022). List of Grid Emission Factors, version 11.0. Available online: Link.

charge, the energy efficiency performance factor, and direct emissions of the units from servicing and disposal.

Table 2: Modelling parameters of the BAU scenario.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Energy Efficiency 2025 (CSPF or EER)	Service emissions factor (% of IC)	Disposal emissions factor (% of IC)
UAC	10	R410A, R32, R290	0.875	3.2	10%	95%
AC Chillers	15	R134a, R290, R1234yf, R123	40	2.75	22%	95%
Mobile AC	15	R134a, R290, R1234yf	1	2.95	20%	100%
Large vehicle AC	15	R134a, R290, R1234yf	8	2.98	30%	80%
Domestic Refrigeration	20	R134a, R600a	0.175	1.5	2%	80%
Stand-alone equipment	15	R134a, R600a	0.4	1.5	3%	80%
Condensing units	20	R134a, R290, R407C, GWP150, R744, R1234yf	4	2.15	30%	85%
Centralised systems for supermarkets	20	R134a, R290, R717, R1234yf	230	1.73	38%	90%

While this methodology follows a similar process to that of the 2019 Inventory, the data sources, modelling tools, and assumptions have been adapted and updated to represent changes in the market, changes in technology, improved understanding, etc. As such, some significant differences exist in the results for some of the subsectors between the two inventories.

3. Results

After the analysis described in section 2, the results of the estimations and projections are presented below, starting with the total stock of operating units in the country by subsector. This will be followed by an illustration of the energy and emissions demanded by the RAC sector.

3.1. Subsector stock data analysis

The subsector analysis in this chapter follows the sub-sector classification provided in section 0, to provide a separate view of each subsector and enable the development of interventions and monitoring of each subsector separately.

3.1.1. UAC sales and stock data

Unitary Air Conditioners cover all the AC units registered and sold in the country with a cooling capacity under 14 kW. This category of RAC equipment includes a variety of AC types, including window type, single splits, multi splits, etc. The primary source of information for the subsector comes from the PELP, which provides information on all the registered models and total sales. It is of note that, due to confidentiality reasons, full access to this dataset is not possible; rather, sales by size and efficiency brackets have been provided. Also, the PELP has only been collecting data from 2021 and as early as 2025, data is available for 2021 and 2022 only.

UAC usage has been increasing, with estimated sales reaching over 1.5 million units in 2024, up from the estimated 680,000 units in 2010 reported in the 2019 Inventory. This growth is larger than projected in that inventory, resulting in a larger stock of operating units, and their energy demand and generation of emissions. The estimated operating stock based on the updated sales figures is 9.6 million units in 2020, and they are conservatively projected to increase to over 15.6 million by 2050. This is a 63% increase over the 2020 levels (Figure 4).

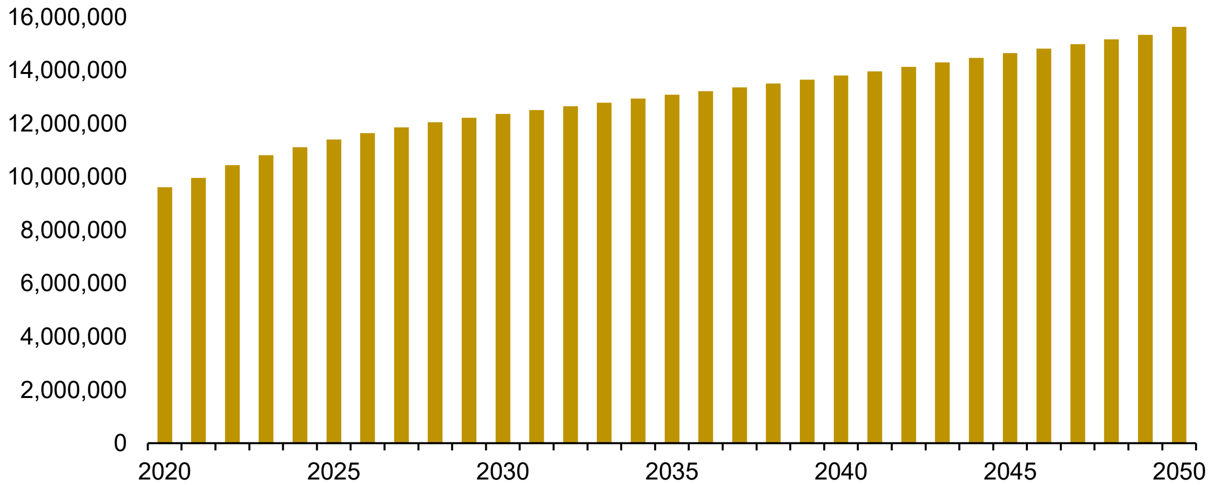

Figure 4: UAC stock in the Philippines from 2020 to 2050 (Source: HEAT Analysis).

On a positive note, the implementation of the MEPS programme for AC is having a positive impact in the market, with an increasing number of units sold in the market having 5 stars, the maximum possible in the scheme. In 2022, 62% of all the UACs sold in the Philippines were 5 stars, representing an EER greater than 4. This would indicate that there is significant room to increase the MEPS, especially targeting the models that are currently sitting in the 1-star category, which is almost a quarter of the market.

Star Rating	EER	2021	2022
1	3.08 - 3.31	23%	24%
2	3.32 - 3.55	13%	9%
3	3.56 - 3.79	6%	4%
4	3.80 - 4.00	1%	1%
5	≥ 4.01	56%	62%
		100%	**100%**

Figure 5: Proportion of UAC sales within each category of energy efficiency in the Philippines MEPS and labels program (Source: PELP).

At the same time, the country seems to still have a strong reliance on window-type AC units that tend to be smaller and of lesser efficiency. Of all the models registered in the PELP, 34% are window-type. This reliance is thought to be because window-type units can be cheaper to purchase and install than split units. However, in the long term, the energy efficiency losses are almost certain to result in overall cost increases over the life of the unit.

3.1.2. AC chillers sales and stock data

For this sub-sector, there was no new data collected in this inventory. As such, the sales data from the previous Inventory was used, and projection assumptions were updated, primarily in reference to GDP growth, and linking the growth of this market to GDP.

Based on the above, the estimated stock of operating AC chillers in 2025 is around 8,800. While the number may seem small, these are large units operating in large commercial buildings with cooling capacities that can range from 50 kW up to 500 kW. At the same time, the GDP growth expectation is optimistic, resulting in the number of large commercial buildings requiring these systems to more than double by 2050 to 18,200 (Figure 6). These projections compare well with the previous Inventory, indicating strong consistency of results.

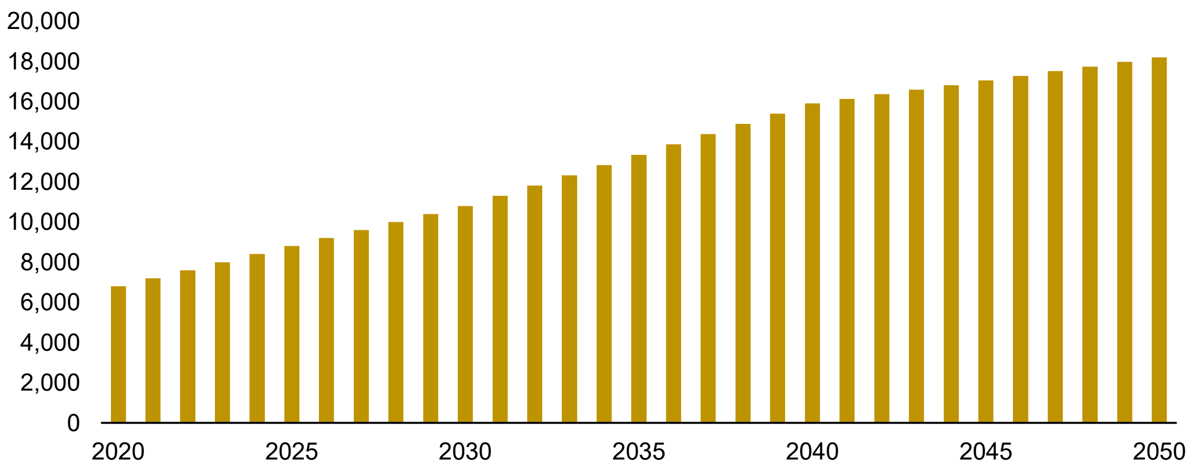

Figure 6: Projected stock of AC chillers in the Philippines from 2020 to 2050. (Source: HEAT Analysis).

3.1.3. Mobile air conditioning

A more robust data source in the form of the Department of Transportation Motor Vehicle Registration Database was used in this Inventory, providing a robust stock of vehicles for several years. The data for vehicles, however, is limited to 2020.

The total stock of vehicles (and it is assumed that in a country like the Philippines, they are all equipped with AC) is estimated at 5.3 million in 2025 and growing. By 2050, the total stock is estimated to reach 12 million, more than twice the 2025 number. This Sub-sector also includes the AC for large cabin vehicles (primarily buses), which have been estimated separately. The total number of LVAC is estimated at 38,000 in 2025 and growing to over 80,000 in 2050.

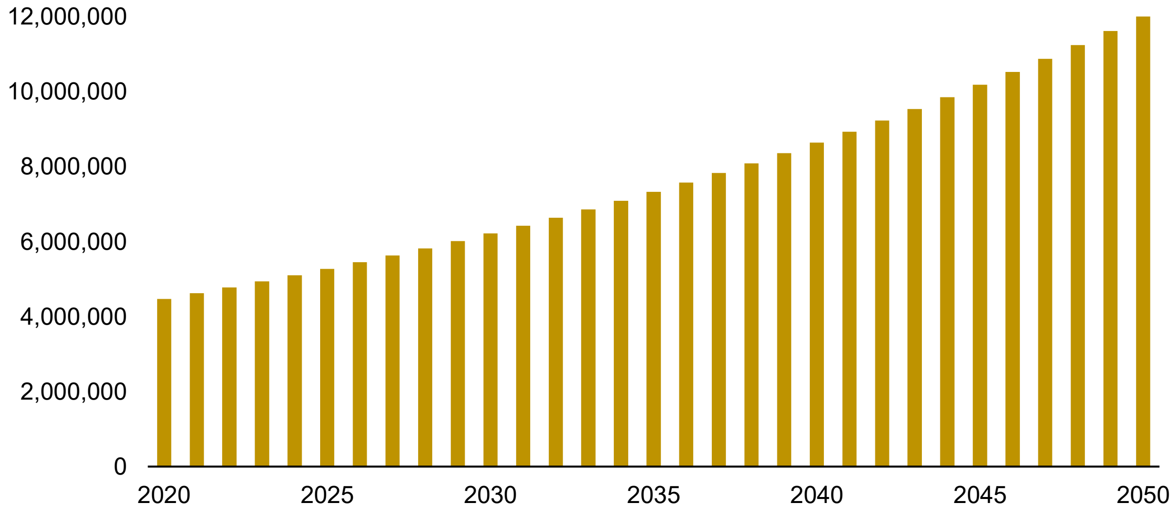

Figure 7: Projected stock of MAC systems in the Philippines from 2020 to 2050. (Source: HEAT Analysis).

It is important to note that MACs are a difficult subsector to influence in terms of energy efficiency, as they are part of a larger piece of technology (vehicles), which is in itself subject to a myriad of existing policies and regulations. As such, energy consumption from MAC is included in vehicular energy performance (which can range from 3% to 20% of the total depending on climate, traffic, etc, IEA, 2019) and regulated through vehicle policies. Furthermore, MAC energy is sourced from the vehicle's fuel rather than electricity from the grid, making it difficult to compare and include with the other subgroups.

3.1.4. Domestic refrigeration

As domestic refrigeration is also subject to MEPS and product registration obligations, the PELP has also been able to provide information on total sales. For the projects, similar assumptions have been used to those of the UACs. The domestic refrigerator stock is estimated to be 16 million units in 2025 and will grow to almost 21 million by 2050. The growth is lower than ACs, as domestic refrigerators are seen to be more of a necessity, and the current ownership rates are likely to be much closer to their market saturation levels, at which point, the growth is limited by population growth and not economic factors.

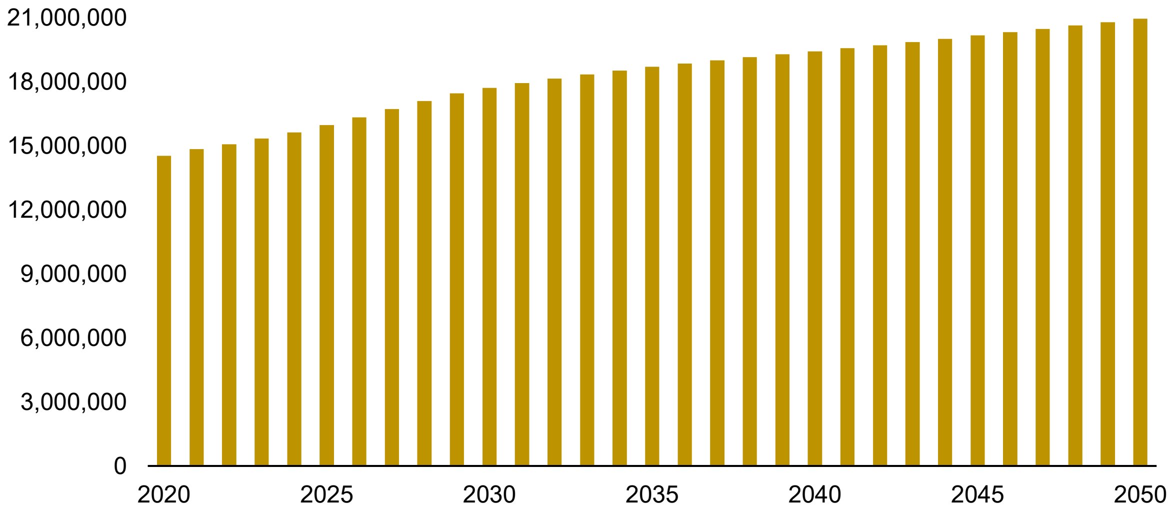

Figure 8: Projected stock of Domestic Refrigerators in the Philippines from 2020 to 2050. (Source: HEAT Analysis).

An important note is that there seems to be a tendency for the main refrigerant used in refrigerators to be R600a (isobutane), which is a climate-friendly option. While this follows general international trends of refrigerant use in domestic refrigerators, it is good that only 6% of the market was still using R134a.

3.1.5. Commercial refrigeration

The commercial refrigeration subsector is made up of three types of applications that have been estimated separately:

- Standalone units, which are found in most food retailers regardless of size.
- Condensing units, which are for mid-size applications such as a small supermarket system of a refrigerated room, etc. These tend to be in the 5 to 10 kW range.
- Centralised systems for supermarkets. These are large commercial applications that serve several refrigeration applications in supermarkets or similar stores.

For this subsector, new data were obtained for supermarkets through a market research report that indicated the total number of supermarkets in the country. It is assumed that each supermarket in the report will have one such system. For the other two applications, the sales numbers that were reported in the 2019 Inventory have been used, and updated growth assumptions based largely on GDP growth have been used.

The total stock of commercial refrigeration applications grows from around **1.5 million units in 2025 to 2.6 million in 2050.** An overall growth of over 60%. However, the largest growth was observed in the supermarket segment as the food retail industry consolidates under the larger companies in the sector aided by general trends of urbanisation. The growth in supermarkets in the period is around 160%.

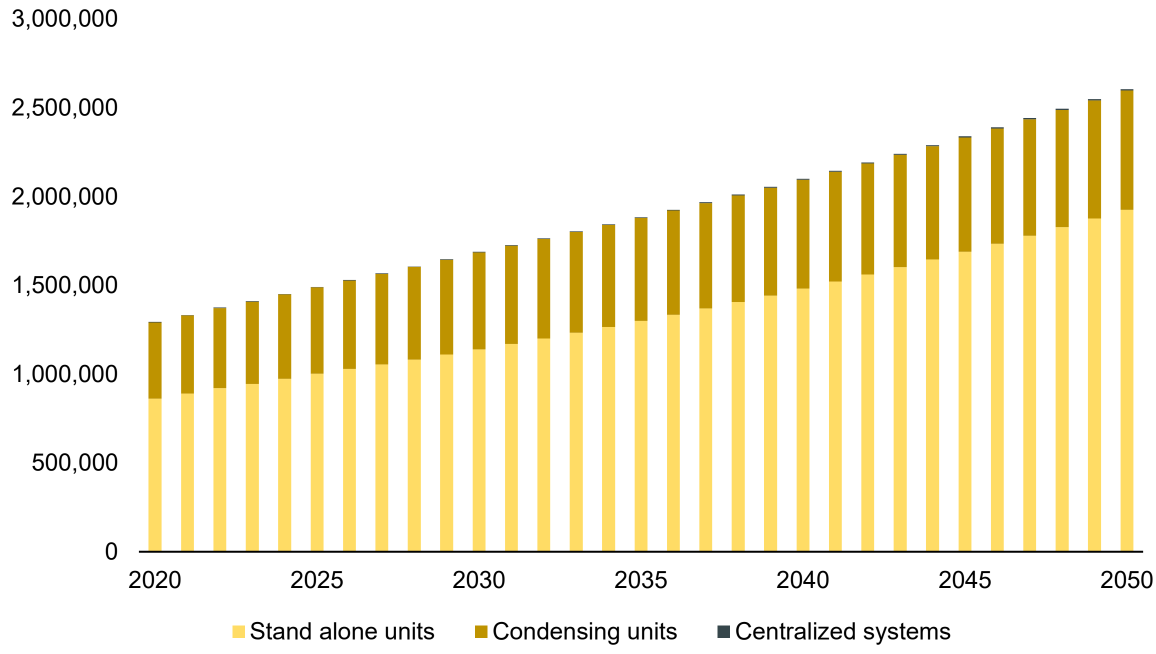

Figure 9: Projected stock of Commercial Refrigerators in the Philippines from 2020 to 2050. (Source: HEAT Analysis).

3.2. BAU emissions and projections in the RAC sector

From the estimated stocks of RAC sector appliances and systems presented in the previous section, the previous section, and the methodologies of direct and indirect emissions in Chapter 2, the total emissions for the RAC sector are 35.5 MtCO2eq, an 81% increase in emissions from 2010 (excluding MAC indirect emissions). This is almost 23% of all emissions in the country[14].

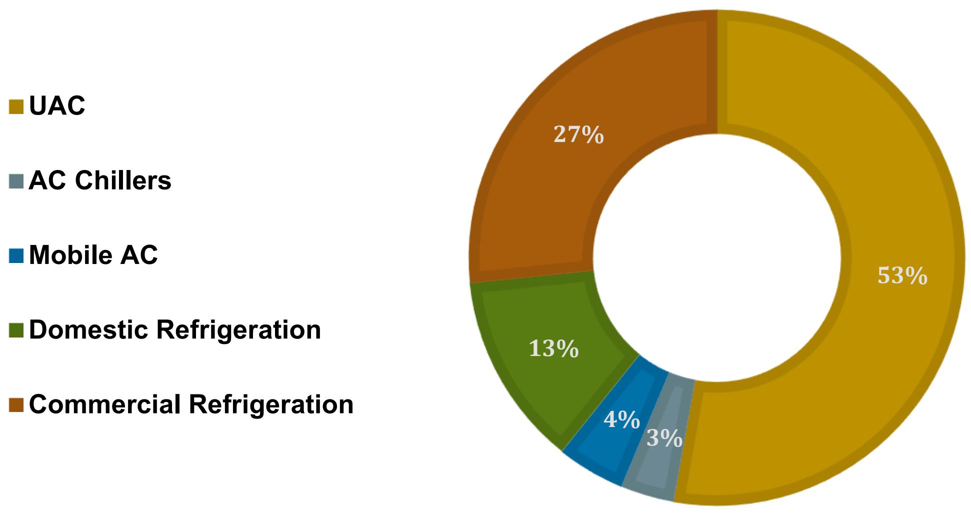

Figure 10: Estimated RAC emissions in 2025 by subsector (Source: HEAT Analysis).

[14] Worldometer: Philippines CO2 Emissions. Available online: Link.

Of the estimated emissions, the largest subsector by far is UAC, accounting for over half (53%) of all emissions. This is due to the large (and increasing) stock of UAC units and their significant consumption per unit. Commercial refrigeration is the next largest source of emissions (27%) as the food retail industry grows significantly along with population and the economy. Significantly, as the food retail industry modernises, it will increase its demand for refrigeration. The remaining 20% of emissions are spread among the other three subsectors: 12% from domestic refrigeration, 4% from MAC, and 4% from AC chillers.

If the indirect emissions from the MAC sector were included in this account, the proportion would change significantly, as there is a large stock of units. However, as discussed before, MAC emissions may be better classified under the transport sector as the emissions come from the vehicle, from a different fuel, and effective change on these emissions is more a matter of vehicular regulation than the RAC sector.

RAC emissions in the Philippines are projected to increase to 45.7 $MtCO_2eq$, a 29% increase from the 2025 total. Throughout the period, commercial refrigeration increases in the total share as UAC decreases. This is largely due to the greater potential for energy efficiency improvements in the UAC sector than in the commercial sector. By 2050, UAC account for 41% of total emissions, while commercial refrigeration is projected to increase to 35% (Figure 11).

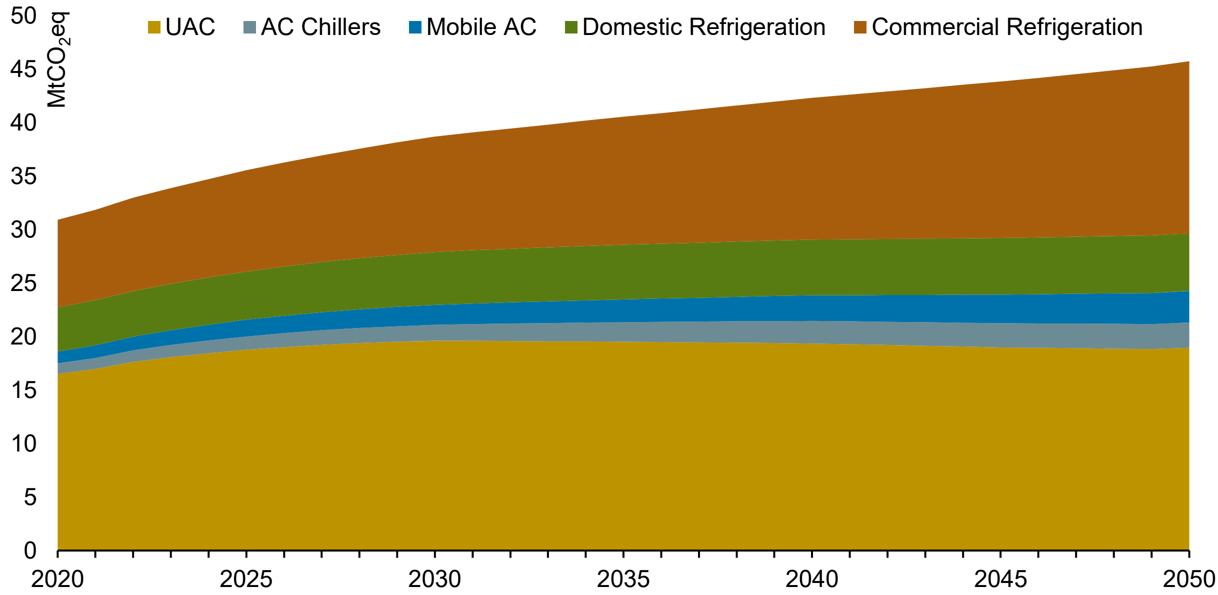

Figure 11: Estimated RAC sector emissions from 2020 to 2050 (Source: HEAT Analysis)

This is a conservative estimate considering the growth in the stocks of RAC systems, but it assumes gains in energy efficiency across all sectors, limiting some of the potential emissions growth in the economy. There is still significant potential for further emissions reductions through energy efficiency as well as the greening of the electricity grid.

3.3. Alternative technologies

Considering the impact of the RAC systems on the climate, it becomes imperative to transition the sector into a more sustainable path. This transition focuses primarily on the implementation of interventions to reduce the direct and indirect emissions estimated in this report.

In terms of direct emissions, a key strategy is to transition away from high-GWP HFC refrigerants in favour of low-GWP alternatives, especially natural refrigerants such as hydrocarbons (HCs), ammonia (NH_3), and carbon dioxide (CO_2). Some key applications include R-290 (propane) and R-600a (isobutane), which are already being adopted in household and commercial refrigeration due to their low cost, low environmental impact, and high energy efficiency.

To reduce indirect emissions, the key approach that is directly applied to the RAC sector is the improvement of the energy efficiency of appliances, which has the potential to significantly reduce electricity consumption. Technologies such as variable-speed compressors (inverter technology), advanced heat exchangers, and smart cooling controls help optimise energy use.

There are other options to reduce the impact of the RAC sector, but they are not directly applied to this sector. These include the reduction of cooling demand in buildings through improved building construction and optimisation of refrigeration systems in industry and commercial applications through improved system design.

Finally, the greening of the electricity system will result in a significant reduction of emissions from electricity use. However, in recent years, the installation of coal-based power plants has dominated the sector in the country.

This report presents an alternative emissions development path (Mitigation Scenario) to explore the emissions reduction opportunities available in the Philippines. The focus is only on options that can be directly applied to the RAC sector, so this expresses itself in applying stronger MEPS and promoting low GWP refrigerants.

3.3.1. Mitigation scenario emissions for the Philippine RAC sector

For the Mitigation Scenario (MIT), a faster strengthening of MEPS in the UAC and refrigeration sub-sectors is assumed, while design requirements for AC chiller installation and commercial refrigeration are implemented. Considering the relatively slow progress in recent years, the assumed improvement in the MEPS is conservative, but it could be much more aggressive. Similarly, the MIT Scenario assumes a modest-paced transition to low-GWP refrigerants, which could be more aggressive under a supportive policy environment.

3.3.2. Energy saving potential

Based on the above description, the estimated savings in the MIT scenario by 2050 are 7% compared to the total from BAU, around 4.2 TWh per year. The largest energy savings come from the UAC sector with 1.9 TWh, followed by Commercial Refrigeration at 1.4 TWh. The cumulative total estimated in this scenario is almost 45 TWh over the period (Figure 12).

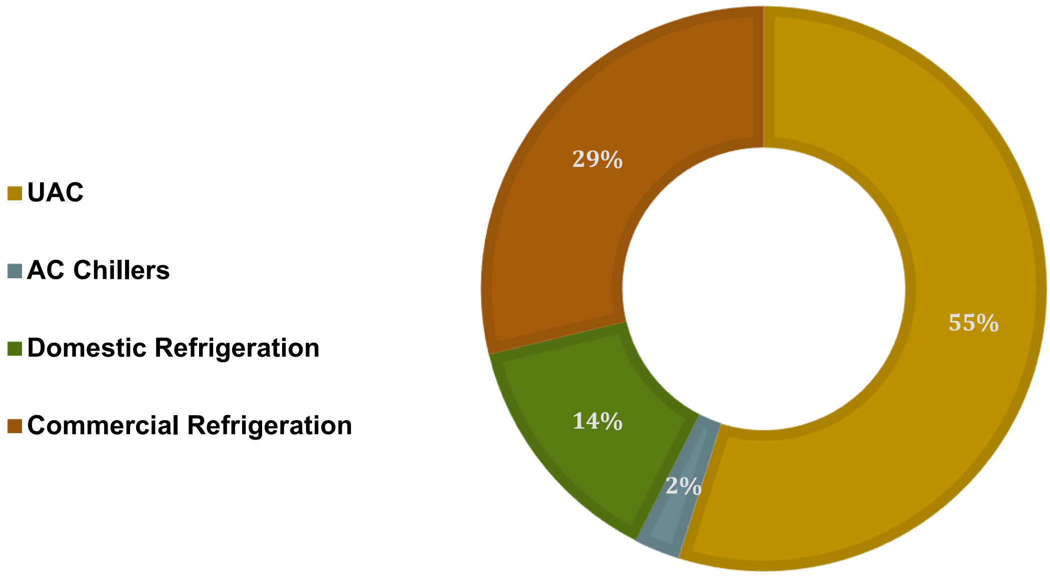

Figure 12: Cumulative energy savings in the MIT scenario by 2050 (Source: HEAT Analysis).

As indicated above, 7% is a conservative yet significant amount of savings from the RAC sector. However, in terms of the technology options available in some of the RAC subsectors, this amount could increase significantly.

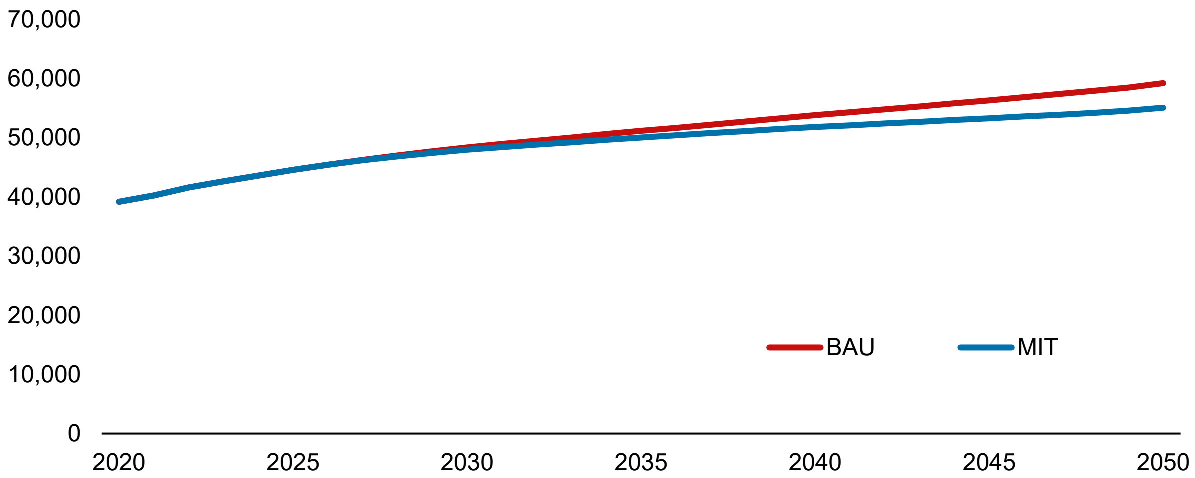

Figure 13: BAU and MIT energy demand time series comparison 2020, to 2050 (Source: HEAT Analysis).

3.3.3. Use of low-GWP refrigerants

As a signatory of the Montreal Protocol and the Kigali Amendment, the Philippines aims to meet its commitment to the scheduled global phase-down of the use of HFCs. These high-GWP greenhouse gases have been commonly used in RAC systems. The Philippines, classified under Article 5 Group 1 countries, is obligated to adhere to a specific HFC consumption reduction schedule as per the red line below.

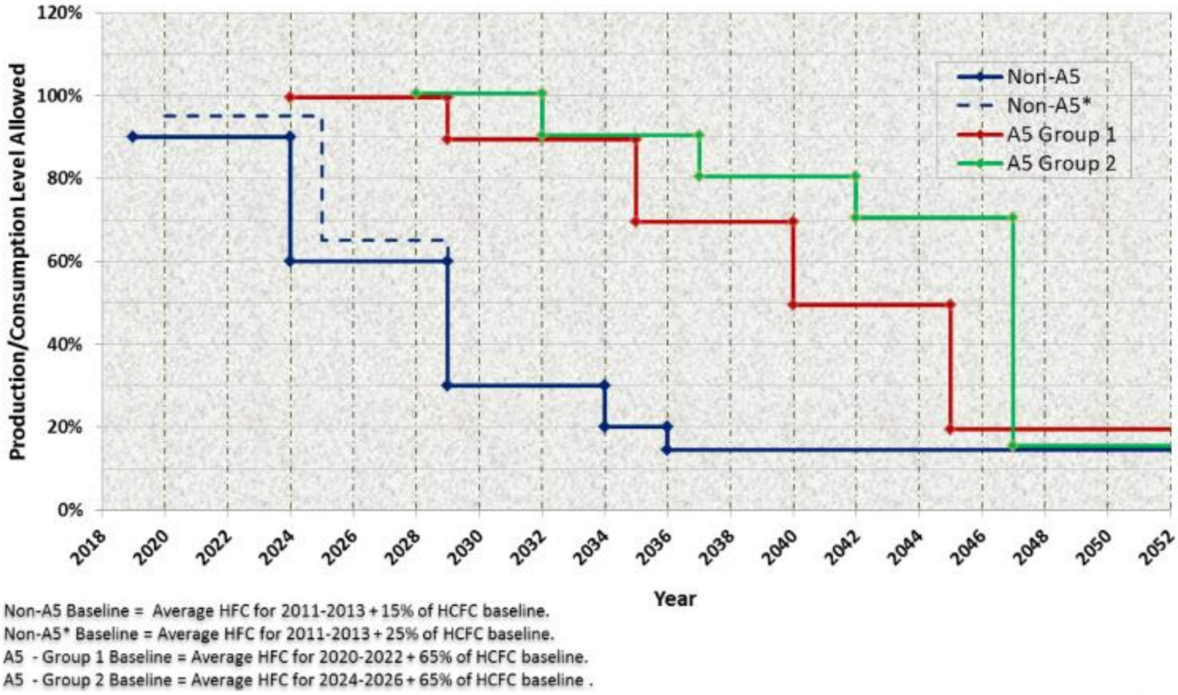

Figure 14: Kigali Amendment HFC reduction schedule. The red line applies to the Philippines (Source: UNEP).

Under the Business-as-Usual (BAU) scenario, without additional interventions, the Philippines' GWP-weighted HFC consumption is projected to increase during the modelling period due to the growing demand for RAC appliances. In the latter decade of the period, HFCs will begin to decline as low-GWP refrigerants become more commonplace. However, the decline is slow without the support of specific policies that support the introduction of natural refrigerants.

In the MIT scenario, HFCs consumption decreases at a significantly faster pace as the Philippines is projected to implement strategies to support the attainment of the Kigali targets. In the MIT scenario, the Philippines achieves over 12% of GHG emissions by 2050 compared to the BAU scenario or 5.7 $MtCO_2eq$ (Figure 15). Over 53% of these reductions are from direct emissions (refrigerant use). This is a 38% reduction in direct emissions over the period. This reduction is still short of achieving the Kigali Amendment targets, but it gets the country much closer. Cumulatively, the emissions reductions reach over 53 $MtCO_2eq$ from 2020 to 2050.

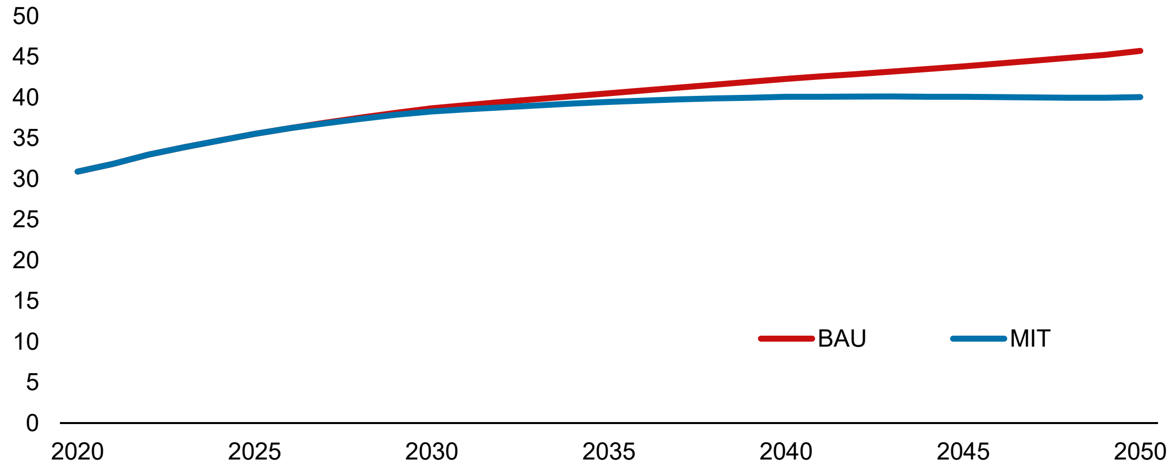

Figure 15: Total emissions from the RAC sector for BAU and MIT scenarios. (Source: HEAT Analysis).

The majority of emissions savings come from the UAC sector as greater adoption of R290 is assumed towards the end of the period. This is also the case for MAC and Commercial Refrigeration, where technologies are available to replace existing AC systems in the market and strong policies could achieve a faster adoption, as technologies are available for most sectors to reduce refrigerant emissions.

3.3.4. Unitary air conditioning emissions

UAC is the largest contributor to energy demand and GHG emissions in the Philippines RAC sector, with 52% and 53% of energy demand and GHG emissions, respectively, and it is the fastest growing sector as residential and commercial applications continue to expand.

For the MIT scenario, the UAC sub-sector results in savings of 8% in energy demand **and 12% of direct emissions from 18.8 MtCO_2eq in 2025 to 16.5 MtCO_2eq in 2050 (Figure 16).** This sub-sector is the largest energy consumer and GHG emitter as the number of UAC units increases significantly from an estimated 11.4 million units in 2025 to 15.6 million in 2050.

This level of emissions is an increase from the estimated levels in the 2019 Inventory. This is largely due to a larger-than-projected increase in the sales of AC units in recent years. At the same time, there have been updates in the estimation of annual demand per unit, resulting in a slightly higher annual average consumption per unit.

It is important to note that the UAC sub-sector is the only one to achieve an overall demand reduction in energy demand from the 2025 totals due to the already existing MEPS and their assumed progression in this scenario.

However, this sector presents one of the largest sectoral potentials for significant emissions reductions as the market has readily available high-efficiency AC units to support the strengthening of the MEPS. For example, based on data from the PELP, we can see that over 60% of units in the market have a CSPF over 4. Furthermore, in 2024, the PELP showed 55 AC models of various cooling capacities with a CSPF of 6 or more. At the same time, there is an increasing focus on R290 technologies, which have been demonstrated to be viable and are commercially available, although the supply is limited at the time. Strong support from government policy is essential to develop this market.

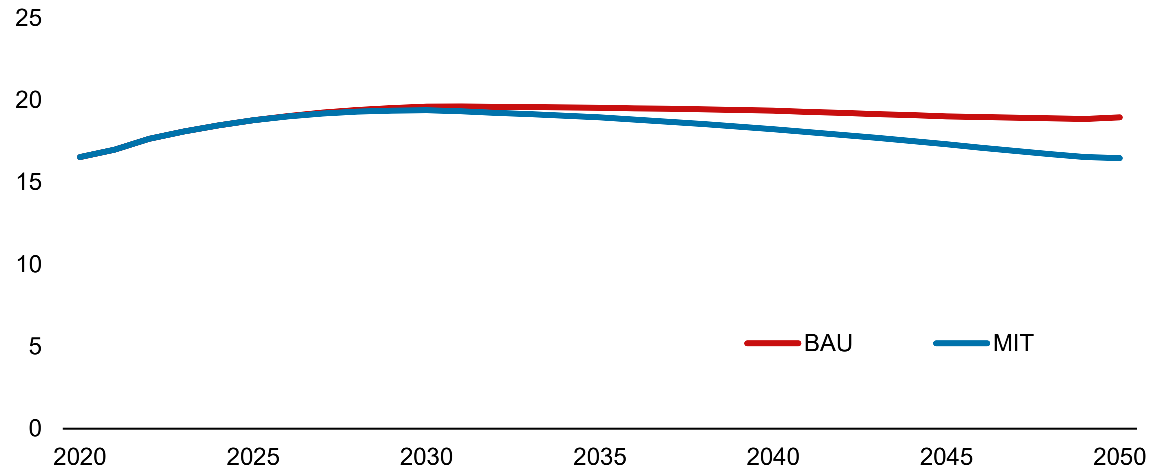

Figure 16: UAC projected emissions in the BAU and the MIT scenarios (Source: HEAT Analysis).

3.3.5. AC chiller emissions analysis

AC Chiller emissions are projected to increase from 1.25 $MtCO_2eq$ in 2025 to 2.36 $MtCO_2eq$ in 2050, a 90% increase resulting from the steady increase in the development of commercial facilities (office buildings, shopping centres, etc) that require large central AC installations. This is assumed from the steady economic growth sustained in recent years, and the assumption that this will be sustained in the medium term.

In the MIT scenario, a limited 6% emissions reduction is currently projected as energy efficiency gains in this sub-sector are judged to be more limited compared to that of UAC as incentives (who accrues the benefits of energy efficiency) for the installation of top-performing equipment are missing for developers and there are no mandatory policies requiring high-performance chillers. Furthermore, the installation and maintenance of high-performance AC chillers require a level of technical expertise that is in limited supply in the country.

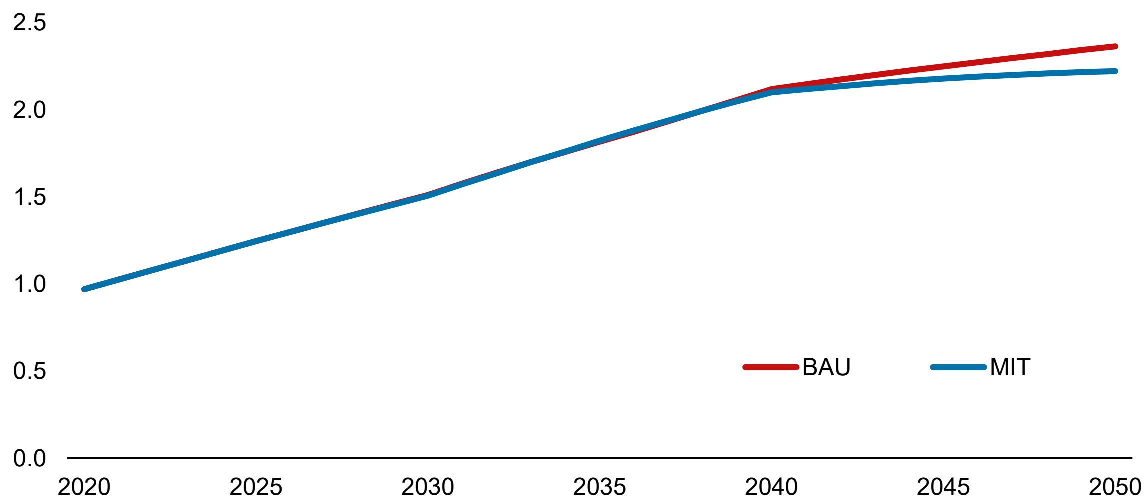

Figure 17: AC Chillers projected emissions in the BAU and the MIT scenarios (Source: HEAT Analysis).

As with UAC, technically speaking, there is potential for further gains in the sector as top-performing equipment can reach

3.3.6. Mobile air emissions analysis

For MAC, the fleet of vehicles continues to increase, and while the overall fuel efficiency of vehicles has been under scrutiny, the performance of the AC systems in them has not, at least at a policy level. Similarly, as AC units in vehicles can vary significantly, it is difficult to isolate their individual performance and difficult to address them as part of a RAC initiative. As such, this section focuses on the direct emissions of the MAC sub-sector only.

The MAC direct emissions in the Philippines are projected to increase by 87% between 2025 and 2050 as the total vehicle fleet in the country increases to almost 12 million units by 2050, up from 5.2 million in 2025. The more than doubling of the fleet is somewhat offset by the beginning of a transition to R290 in MAC applications, but it is not enough.

In the MIT scenario, the sector achieves a significant reduction in emissions of 31% as R290 increases its penetration in MAC applications, led by international efforts in the automotive industry[15] and the assumption that country policies will back such efforts.

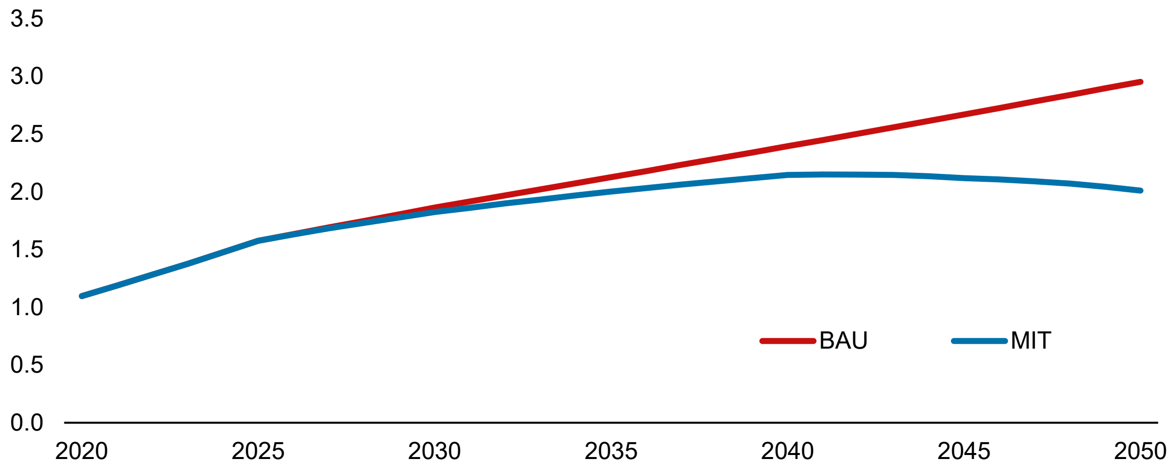

Figure 18: MAC projected emissions in the BAU and the MIT scenarios (Source: HEAT Analysis).

Further gains are possible in the event that R290 becomes the standard refrigerant in the automotive industry within the assessment period. With its superior thermodynamic properties, low cost, and ultra-low GWP, this is not a high bar.

3.3.7. Domestic refrigeration emissions analysis

Domestic refrigeration is the third-largest RAC sub-sector emitter as it is a widespread application with a projected stock of almost 21 million units by 2050. However, the growth in emissions in the modelling period is limited to 20% (from 4.5 to 5.4 $MtCO_2eq$) as it is believed that the 2025 levels are close to market saturation levels of refrigerator ownership.

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[15] Naturalrefrigerants.com

In the MIT scenario, the projected savings are limited to 8% (0.4 MtCO2eq) (Figure 19), for two key reasons:

- The majority of the market (94%) is already using natural refrigerants, limiting further emissions reduction to energy efficiency gains.
- The implementation of MEPS in the Philippines and worldwide has already resulted in significant gains.

While there is still technical potential for further gains in energy efficiency, policy has not kept up with technical development with over 54% of registered models in the PELP[16] classified as 4 or 5 stars. With this level of loading at the top end of the energy efficiency scheme, it is recommended to increase the MEPS and rebalance the rating scales to support further gains in energy efficiency.

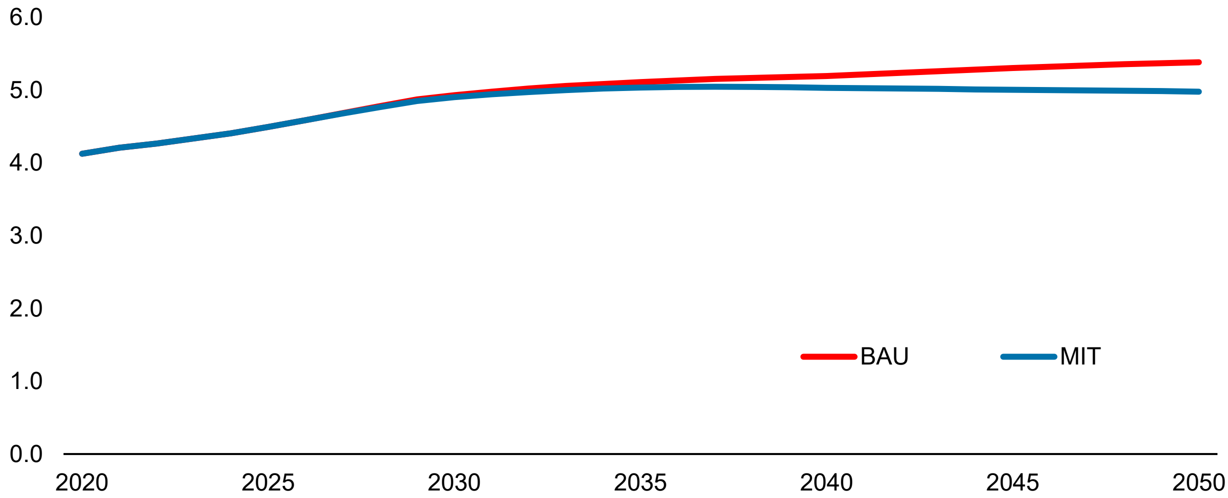

Figure 19: Domestic refrigeration projected emissions in the BAU and the MIT scenarios (Source: HEAT Analysis).

3.3.8. Commercial refrigeration emissions analysis

The commercial refrigeration sector is the second largest source of emissions during the period, reaching 16.1 $MtCO_2eq$ in 2050, up from 9.5 $MtCO_2eq$ in 2025. This is a 70% increase as the food retail industry and the related supply chains grow with the demand of a growing population and a developing economy. Importantly, this sub-sector causes the single largest absolute addition of emissions to the total with over 6.6 $MtCO_2eq$. This includes growth in all three components of this subsector: stand-alone units, condensing units, and centralised systems for supermarkets.

Aside from the industry growth, this sector is not currently subject to regulatory requirements in energy efficiency; most of its systems still rely on high-GWP refrigerants, limiting the potential for emissions reductions in the country.

As such, the MIT scenario estimated an 11% reduction in emissions by 2050 compared to the BAU scenario. However, this still allows a growth in demand of over 50% by 2050 and adds nearly 5 $MtCO_2eq$ of emissions to the country.

[16] Sourced from the PELP in 2024.

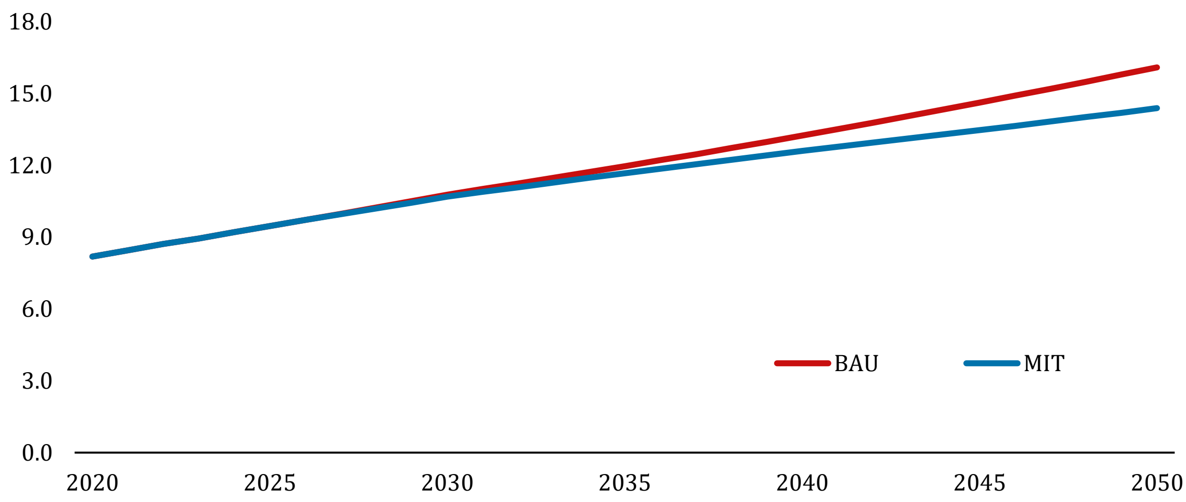

Figure 20: Commercial refrigeration projected emissions in the BAU and the MIT scenarios (Source: HEAT Analysis).

Despite these results, technical options are available to the sector to improve its energy performance if MEPS and/or design requirements are enforced on commercial refrigeration applications. This also applies to its direct emissions as the industry is not only producing stand-alone units using R600a, which, as with domestic refrigeration, should become the norm, but also there are centralised systems for supermarkets that operate with natural refrigerants such as ammonia.

4. Annex A: Detailed modelling parameters

For this analysis and projections, HEAT's proprietary model was used. The model uses a standard stock and flow methodology to estimate total annual sales and operating stocks of appliances for each sub-sector for each year in the estimation period. In this case, from 2025 to 2050. For this, the model requires a starting point that is exogenously estimated, that is, historical and/or projected figures for either sales or operating stock that are sourced from outside of the model. This involves data collection, including but not limited to:

- Primary data collection from sources such as manufacturers, distributors, retailers, industry bodies, etc, to obtain up-to-date figures on annual sales, technical specifications of units sold, and more. This process tends to generate high-quality and up-to-date data, but it is also expensive, and the data has limited longevity.
- Mining secondary data sources is an increasingly desirable method as the data is usually collected for alternative administrative purposes, such as regulatory enforcement. This means that the data already exists, and the added uses increase its value. In the case of this report, the PELP provided an excellent source of secondary data for two key subsectors.
- Carrying out a robust literature review of academic research, one-off studies, government reporting, corporate reporting, etc, for related data that would enable estimation of relevant numbers for the model. For example, statistics on the residential ownership of appliances enable estimations of operating stock.

The methodologies for estimating future sales/stock vary depending on the available data and the subsector. This can include:

- Extrapolation of historical sales/stock figures.
- Extrapolation of levels of appliance ownership up to an assumed saturation rate. This method requires the use of population/household growth rates and focuses on residential appliances.
- Estimation of appliances or stock pegged to economic growth figures. This is for subsectors that are more linked to economic growth than population, such as commercial cooling.
- Complex algorithmic extrapolations using quadratic regressions or multi-variate analysis. These tend to be limited to more academic environments as they require more data, more expertise, and more time for calibration.

Key assumptions needed for these projects include:

- GDP growth is key as it usually indicates a growth in the number of businesses demanding energy as well as wealth available in the economy, to increase the demand for energy services. At the same time, GDP growth indicated increasing affordability of energy services for the residential sector.
- Population growth is another key driver as an increasing population (and increasing number of households) purchases and uses more appliances, requires more living space, and drives demand for certain commercial services such as food retail.

- Household size is an important indicator to estimate the total number of households in a country. Demand for many appliances in an economy is driven more by households than population at large. Also, there is a general global tendency for reduced household sizes as countries develop, which compounds demand for energy services and appliances beyond what could be expected by population growth alone.
- Average useful lifetime of the appliances indicates how long appliances remain in service and the number of units that are retired each year. This is essential to determining how many appliances are operating each year. A high assumption can inflate total operating stocks, while a too low assumption may result in smaller than realistic stocks.

Once the model generates figures for sales and operating stocks, the model estimates annual energy demand, direct emissions, and indirect emissions from each appliance, and this is aggregated at a subsector level in the first instance and then aggregated to the entire RAC sector. For this, the model applies assumptions of energy demand for different levels of energy efficiency, levels of energy efficiency prevalent, refrigerant type and level of charge, annual refrigerant leak rates, end-of-life refrigerant leak, and a grid emissions factor for electricity at a national level that is relevant to each country.

In terms of energy demand, some subsectors have strong data available on energy performance, particularly those focused on consumer appliances such as AC and domestic refrigerators. For other subsectors, it is necessary to estimate annual energy demand based on information available, such as average equipment capacity (kW of cooling), usage patterns (in hours per day or year), and energy efficiency (COP or CSPF).

For direct emissions, the model requires information on the prevalent refrigerant gases, as each refrigerant has a different GWP, and how the refrigerant mix will change over time. At the same time, it is known that refrigerants leak from appliances to the atmosphere during their lifetimes as a regular part of their operation and maintenance. For this, internationally accepted assumptions are used in the model.

Finally, indirect emissions estimates refer to the emissions resulting from the use of energy products to power the refrigeration and cooling appliances. In this inventory, the focus is on the emissions produced in the generation of electricity for the national grid (GEF). For this, a national average is used. Electricity covers the indirect emissions from the majority of the subsectors, except mobile applications (on vehicles). In the Philippines, there are several separate grid sections with separate GEF values, and no unified GEF was found for the country as a whole. For this reason, the IGES value of 0.636 kg of CO2eq per kWh, as the average operating margin, was used.

In the following sections, an explicit description of the macro assumptions used to determine general activity levels is presented, followed by a detailed description of the assumptions in each of the subsectors.

4.1. Macro assumptions

The macro assumptions related to the wider socio-economic drivers in the country. For this inventory, this includes a measure of GDP and a measure of population growth as the key drivers for RAC sector activity.

4.1.1. GDP

Gross Domestic Product (GDP) is a central driver in modelling future RAC service demand because it strongly correlates with economic growth, urbanisation, and consumer purchasing power, all of which influence the adoption and intensity of cooling technologies. As GDP increases, especially in emerging economies like the Philippines, the demand for cooling services in residential, commercial, and industrial sectors rises sharply due to greater income, infrastructure development, and improved living standards. Higher GDP typically leads to increased construction of air-conditioned buildings, expanded cold chains for food and medicine, and rising ownership of household cooling appliances. In RAC demand models, GDP projections are used to estimate future stock growth, usage intensity, and energy consumption of RAC equipment[17].

For this report, the key measure used was GDP per capita, sourced from the World Bank[18]. Considering that much of the RAC sector activity is directly linked to residential consumers, this indicator was considered to be more relevant. As no long-term GDP estimates were found, a 5-year moving average of past figures was assumed as a reasonable, yet conservative, assumption for this inventory (Table 3).

Table 3: Summary of GDP assumptions for HEAT model.

Indicator	2015	2020	2025	2030	2035	2040	2045	2050
GDP per Capita (%)	4.6	-11	1.2	2.8	3	3	3	3

4.1.2. Population

Alongside GDP, population is the other fundamental driver in modelling future RAC service demand, as it directly affects the scale of residential, commercial, and public sector cooling needs. A growing population leads to increased construction of housing, schools, hospitals, and commercial buildings. For example, more people typically mean more households with air conditioners and refrigerators, and higher food demand requiring expanded cold chain infrastructure. This demographic factor is especially relevant in countries like the Philippines, where population growth and urban migration are expected to significantly boost cooling demand in the coming decades.

As indicated before, the total number of households was used as a measure of population, as it can evolve differently due to changes in household size. Total population figures were sourced from the World Bank Data Centre, while household size was sourced from the Philippines Statistics Authority. A conservative assumption of a continued decrease in household size to reach 3.5 by 2050. It is reasonable that the reduction will be more significant, but a conservative assumption provides a robust and defensible option.

[17] IEA, (2018). The Future of Cooling. Available online: Link.

[18] World Bank Data Centre. Available online: Link.

Table 4: Population statistics and assumptions used in the HEAT model.

Indicator	2015	2020	2025	2030	2035	2040	2045	2050
Population (million)	103	112	119	122	126	130	134	137
Household size	4.4	4.1	4	3.9	3.8	3.7	3.6	3.5
Household numbers (million)	23	27	30	31	33	35	37	39

4.2. Unitary AC

4.2.1. Activity

The key activity indicator is assumed to be the number of households. As such, sales growth is assumed to follow HH numbers growth, increasing from the actual data obtained from the PELP for 2021 and 2022.

4.2.2. Refrigerant and technical assumptions

The key technical assumptions for UAC projection include the assumed average lifetime (in years) to determine how long units stay in service. The other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 5). The numbers in Table 5 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 5: Technical assumptions for AUC.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak factor (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
UAC	10	R410A, R32, R290	0.875	2%	10%	95%

4.2.3. Energy assumptions

Estimating energy consumption for this sub-sector requires two key inputs: the annual consumption of each unit at different levels of energy efficiency. A total of 10 energy efficiency brackets are present in the model based on the existing PELP levels as well as on the potential for efficiency improvements over the modelling period. The other data input requirement refers to the proportion of units in the market that fall within each efficiency bracket. The annual consumption for each bracket was estimated using the United for Efficiency (U4E) AC Model Regulation methodology for the climate zone relevant to the Philippines (0A).

Table 6: Annual energy consumption and proportion of units in the market at each level of EE.

EE Level (CSPF)	Annual EC (kWh)	Proportion of units in the market for each EE level (%)							
		2015	2020	2025	2030	2035	2040	2045	2050
3.00	2,533	15%							
3.20	2,375	30%	23%	10%					
3.40	2,235	15%	13%	20%	10%	10%			
3.65	2,082	20%	6%	10%	20%	10%	10%	5%	
3.90	1,948	20%	2%	10%	20%	20%	20%	10%	10%
4.35	1,747		56%	30%	20%	20%	20%	20%	20%
5.10	1,490			20%	20%	20%	20%	30%	30%
6.00	1,267				10%	20%	30%	25%	25%
6.90	1,101							10%	15%
7.60	1,000								

4.3. AC Chillers

4.3.1. Activity

The key activity indicator is assumed to be GDP growth. As such, the growth in sales is assumed to follow GDP growth. As data for this subsector was not collected directly for this inventory, the initial number of sales was sourced from the 2019 Inventory.

4.3.2. Refrigerant assumptions

The key technical assumptions to make market projections include an average lifetime (in years) to determine how long units stay in service. Other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 7). The numbers in Table 7 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 7: Technical assumptions for AC Chillers.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak EF (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
AC Chillers	20	R134a, R290, HFO1234yf, R123	35	1%	22%	95%

4.3.3. Energy assumptions

The estimation for commercial AC chillers assumes a capacity of 250 kW to power HVAC systems for larger commercial buildings in urban areas. The annual energy demand assumes an 8-hour daily use cycle, and the stated COP values in Table 8.

Table 8: Annual energy consumption and proportion of units in the market at each level of EE.

EE Level (COP)	Annual EC (kWh)	Proportion of units in the market for each EE level (%)							
		2015	2020	2025	2030	2035	2040	2045	2050
2.75	212,364	85%	80%	70%	50%	30%	10%		
2.85	204,912	15%	20%	20%	30%	35%	50%	50%	40%
3.05	191,475			10%	20%	20%	20%	20%	20%
3.25	179,692					10%	20%	20%	20%
3.50	166,857							10%	20%
3.80	153,684								
4.10	142,439								
4.40	132,727								
4.80	121,667								
5.20	112,308								

4.4. Mobile AC (incl. large vehicle AC)

4.4.1. Activity

The key activity driver is assumed to be the number of households. As such, sales growth is assumed to follow HH numbers growth. The original activity data (number of vehicles on the road) was obtained from the Department of Transportation's vehicle registration database.

4.4.2. Refrigerant assumptions

The key technical assumptions to make market projections include an average lifetime (in years) to determine how long units stay in service. Other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 9). The numbers in Table 9Table 7 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 9: Technical assumptions for Mobile AC units.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak EF (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
MAC	15	R134a, R290, HFO1234yf	0.6	1%	2%	100%
Large Vehicle MAC	20	R134a, R290, HFO1234yf	8	2%	30%	80%

4.4.3. Energy assumptions

As indicated before, emissions from the MAC come from vehicles' engines, which are usually accounted for in the transport sector emissions, have been excluded from this inventory. Further, estimating energy consumption and emissions from MAC is difficult to do with accuracy, as there is very little reporting regarding the capacity, energy efficiency, and usage statistics. This would result in estimates with wide margins for error.

4.5. Domestic refrigeration

4.5.1. Activity

The key activity driver is assumed to be the number of households. As such, sales growth is assumed to follow household numbers growth derived from the total population and the total people per household obtained from Census data, as per **Fehler! Verweisquelle konnte nicht gefunden werden.**.

4.5.2. Refrigerant assumptions

The key technical assumptions to make market projections include an average lifetime (in years) to determine how long units stay in service. Other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 10Table 7). The numbers in Table 10Table 7 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 10: Technical assumptions for domestic refrigerators.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak EF (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
Domestic refrigerators	15	R134a, R600a	0.175	1%	2%	80%

4.5.3. Energy assumptions

Domestic refrigeration has a variety of Energy Efficiency Factor (EEF) measures for different types of refrigerators, such as "Single door direct cooling", "two direct cooling", and "frost-free refrigerator". Also, sales per category of label were not obtained for this analysis. As such, an average consumption was estimated from the data provided for the PELP registration for all models in the 400L capacity range. This size was selected as there is a general global tendency for increased refrigerator capacity as incomes grow.

The proportional increases in the energy efficiency categories reflect the general improvements across the different levels in the PELP for the different refrigerator types. For the BAU scenario, the distribution units across the different EEF categories over time assume that improvements to the MEPS will not be a priority, with only sporadic and unambitious increases to the MEPS and labelling requirements.

Table 11: Annual energy consumption and proportion of units in the market at each level of EE.

EEF	Annual EC (kWh)	Proportion of units in the market for each EE level (%)							
		2015	2020	2025	2030	2035	2040	2045	2050
1.50	426	100%	100%	90%	80%	60%	40%	20%	
1.60	399			10%	20%	30%	40%	40%	40%
1.70	376					10%	20%	40%	40%
1.80	355								20%
1.90	336								
2.00	320								
2.10	304								
2.20	290								
2.30	278								
2.40	266								

4.6. Stand-alone equipment

4.6.1. Activity

The key activity indicator is assumed to be GDP growth. As such, the growth in sales is assumed to follow GDP growth. As data for this subsector was not collected directly for this inventory, the initial number of sales was sourced from the 2019 Inventory.

4.6.2. Refrigerant assumptions

The key technical assumptions to make market projections include an average lifetime (in years) to determine how long units stay in service. Other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 12Table 10Table 7).

The numbers in Table 12Table 10Table 7 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 12: Technical assumptions for stand-alone equipment.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak EF (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
Stand-alone equipment	15	R134a, R600a	0.8	1%	3%	80%

4.6.3. Energy assumptions

Self-contained refrigeration units for commercial use are a diverse category that ranges from simple display cabinets using under 100 kWh per year to larger island or horizontal open displays and freezers that can consume over 17,000 kWh per year. For this analysis, data on the make-up of this market has not been collected, and research revealed no insights. As such, an assumption that averages the market is needed to represent the entire range. Based on a review of multiple sources (United for Efficiency, United States Environmental Protection Agency, academic research) an average of 4,110 kWh per year was calculated to account for the mix of units.

Table 13: Annual energy consumption and proportion of units in the market at each level of EE.

EEF	Annual EC (kWh)	Proportion of units in the market for each EE level (%)							
		2015	2020	2025	2030	2035	2040	2045	2050
1.50	**4,110**	100%	100%	90%	80%	60%	40%	20%	
1.60	**3,853**			10%	20%	30%	40%	40%	40%
1.70	**3,626**					10%	20%	40%	40%
1.80	**3,425**								20%
1.90	**3,245**								
2.00	**3,083**								
2.10	**2,936**								
2.20	**2,802**								
2.30	**2,680**								
2.40	**2,569**								

4.7. Condensing units

4.7.1. Activity

The key activity driver in this sub-sector is assumed to be GDP growth. As such, the growth in sales is assumed to follow GDP growth. As data for this subsector was not collected directly for this inventory, the initial number of sales was sourced from the 2019 Inventory.

4.7.2. Refrigerant assumptions

The key technical assumptions to make market projections include an average lifetime (in years) to determine how long units stay in service. Other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 14Table 7). The numbers in Table 14Table 10Table 7 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 14: Technical assumptions for stand-alone commercial refrigeration units.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak EF (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
Domestic refrigerators	15	R134a, R407C, R290, GWP150	4	5%	30%	85%

4.7.3. Energy assumptions

Condensing units for commercial refrigeration will typically be used to run a relatively small set of display cabinets in smaller commercial locations, or walk-in coolers/freezers ranging from 4kW to more than 20kW (UNIDO, 2017)[19]. For this, an average size of 8 kW was used, indicating a bias towards medium and smaller units but still presenting a realistic perspective.

The EE progression over time mirrors that observed in the other commercial refrigeration applications, as it is believed that improvements in these sectors respond to the same drivers for EE improvements.

Table 15: Annual energy consumption and proportion of units in the market at each level of EE.

EE Level (COP)	Annual EC (kWh)	Proportion of units in the market for each EE level (%)							
		2015	2020	2025	2030	2035	2040	2045	2050
2.00	**11,680**	100%	100%	90%	80%	60%	40%	20%	
2.15	**10,865**			10%	20%	30%	40%	40%	40%
2.30	**10,157**					10%	20%	40%	40%
2.45	**9,535**								20%
2.60	**8,985**								
2.75	**8,495**								
2.90	**8,055**								
3.05	**7,659**								
3.20	**7,300**								

[19] UNIDO, (2017). Philippines Stage II HCFC Phase-out Management Plan. Available online: Link.

3.35	**6,973**

4.8. Centralised units for supermarkets

4.8.1. Activity

The key activity driver in this sub-sector is assumed to be GDP growth. As such, the growth in sales is assumed to follow GDP growth. As data for this subsector was not collected directly for this inventory, the initial number of sales was sourced from a market research report by Euromonitor International from 2024, which indicated the total existing number of larger supermarkets active in the Philippines. It is assumed that each of these supermarkets will have one centralised chiller to run refrigeration.

4.8.2. Refrigerant assumptions

The key technical assumptions to make market projections include an average lifetime (in years) to determine how long units stay in service. Other assumptions refer to the refrigerant specifications that include the type of refrigerants present in the latest data, the total amount of refrigerant present in each unit at the beginning of operation (initial charge), the annual leak rates as a percentage of the initial charge, and the amount of refrigerant emitted to the atmosphere upon the disposal of the units at the end of their lifetime as a percentage of the initial charge (Table 16Table 14Table 7). The numbers in Table 16Table 10Table 7 (except for the refrigerants) come from internationally accepted defaults as indicated in the IPCC 2006 manual, as there has been no comprehensive data collected on these variables.

Table 16: Technical assumptions for stand-alone commercial refrigeration units.

Equipment	Lifetime (years)	Refrigerants	Initial charge (IC) (kg)	Annual leak EF (% of IC)	Service EF (% of IC)	Disposal EF (% of IC)
Domestic refrigerators	20	R22, R134a, R717, R290, R1234yf	230	5%	38%	85%

4.8.3. Energy assumptions

For the initial energy demand, sources indicated that large supermarkets would consume in the range of 2 to 3 million kWh per year, or even more in tropical climates (CCI, 2020)[20] (Baxter, N.D)[21]. Of this consumption, refrigeration applications account for around two-thirds, making it the single largest energy use. The assumption for this study uses the range of consumption above, but also realises that aside from the centralised systems, supermarkets also make use of numerous stand-alone units in places out of the reach of the centralised system.

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[20] Cold Chain Innovation Hub, (2020). Evaluating the Philippines' Food Cold Chain, Energy Efficiency and Environmental Impact. Available online: Link.

[21] Baxter, V.D (N.D), Advances In Supermarket Refrigeration Systems, Oak Ridge National Lab. Available online: Link.

The EE progression over time mirrors that observed in the other commercial refrigeration applications, as it is believed that improvements in these sectors respond to the same drivers for EE improvements.

Table 17: Annual energy consumption and proportion of units in the market at each level of EE.

EE Level (COP)	Annual EC (kWh)	Proportion of units in the market for each EE level (%)							
		2015	2020	2025	2030	2035	2040	2045	2050
1.70	**1,023,333**	100%	100%	90%	80%	60%	40%	20%	
1.74	**999,808**			10%	20%	30%	40%	40%	40%
1.78	**977,341**					10%	20%	40%	40%
1.82	**955,860**								20%
1.86	**935,034**								
1.90	**915,614**								
1.94	**896,735**								
1.98	**878,619**								
2.02	**861,221**								
2.06	**844,498**								

4.9. Mitigation scenario assumptions

For the mitigation scenario, the key assumptions centre on a more rapid progression to high energy efficiency equipment and low GWP refrigerants. The assumptions will express themselves in higher percentages of units in each subsector present at higher levels of EE. Similarly, the refrigerant mix will increasingly migrate to lower GWP options.

These transitions are largely in response to a more ambitious approach from the government, delivering more interventions with increasingly ambitious emissions reduction targets. This could mean MEPS, technology and capacity transfers, refrigerant bans, demonstration projects, etc.

In the following sections, the energy efficiency progression for all subsectors is presented from 2025 until 2050.

4.9.1. Energy efficiency of UAC – Mitigation Scenario

Table 18: Energy efficiency progression of UAC in the Mitigation Scenario.

EE Level (CSPF)	Proportion of units in the market for each EE level (%)					
	2025	2030	2035	2040	2045	2050
3.00						
3.20	10%					
3.40	20%	5%				
3.65	10%	15%	5%	5%		
3.90	10%	20%	20%	10%	10%	5%
4.35	30%	20%	20%	20%	10%	10%
5.10	20%	25%	35%	20%	25%	20%

6.00		15%	25%	35%	25%	25%
6.90				10%	30%	40%
7.60						

4.9.2. Energy efficiency of AC chillers – Mitigation Scenario

Table 19: Energy efficiency progression of AC chillers in the Mitigation Scenario.

EE Level (COP)	Proportion of units in the market for each EE level (%)					
	2025	2030	2035	2040	2045	2050
2.75	70%	40%	20%			
2.85	20%	30%	30%	20%		
3.05	10%	30%	30%	30%	20%	
3.25			20%	30%	30%	20%
3.50				20%	30%	30%
3.80					20%	30%
4.10						20%
4.40						
4.80						
5.20						

4.9.3. Energy efficiency of domestic refrigerators – Mitigation Scenario

Table 20: Energy efficiency progression of domestic refrigerators in the Mitigation Scenario.

EEF	Proportion of units in the market for each EE level (%)					
	2025	2030	2035	2040	2045	2050
1.50	90%	60%	30%			
1.60	10%	20%	30%	30%		
1.70		20%	30%	30%	30%	
1.80			10%	20%	30%	30%
1.90				20%	20%	30%
2.00					20%	20%
2.10						20%
2.20						
2.30						
2.40						

4.9.4. Energy efficiency of stand-alone equipment – Mitigation Scenario

Table 21: Energy efficiency progression of stand-alone equipment in the Mitigation Scenario.

EEF	Proportion of units in the market for each EE level (%)					
	2025	2030	2035	2040	2045	2050
1.50	90%	60%	30%			
1.60	10%	20%	30%	30%		
1.70		20%	30%	30%	30%	
1.80			10%	20%	30%	30%
1.90				20%	20%	30%
2.00					20%	20%
2.10						20%
2.20						
2.30						
2.40						

4.9.5. Energy efficiency of condensing units – Mitigation Scenario

Table 22: Energy efficiency progression of condensing units in the Mitigation Scenario.

EE level (COP)	Proportion of units in the market for each EE level (%)					
	2025	2030	2035	2040	2045	2050
1.50	90%	60%	30%			
1.60	10%	20%	30%	30%		
1.70		20%	30%	30%	30%	
1.80			10%	20%	30%	30%
1.90				20%	20%	30%
2.00					20%	20%
2.10						20%
2.20						
2.30						
2.40						

4.9.6. Energy efficiency of centralised units for supermarkets – Mitigation Scenario

Table 23: Energy efficiency progression of centralised units for supermarkets in the Mitigation Scenario.

EE level (COP)	Proportion of units in the market for each EE level (%)					
	2025	2030	2035	2040	2045	2050
1.70	90%	60%	30%	20%		
1.74	10%	20%	30%	30%	20%	
1.78		20%	30%	30%	30%	20%
1.82			10%	20%	30%	30%
1.86					20%	30%
1.90						20%
1.94						
1.98						
2.02						
2.06						

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