THE BANGLADESH NATIONAL COOLING PLAN UP TO 2035

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1 Introduction

1.1 Overview

Bangladesh's cooling needs are rising rapidly, driven by both developmental progress and climatic changes. Cooling is no longer a luxury but a development necessity to protect public health, ensure food security, and sustain economic productivity. The country has a subtropical monsoon climate with hot, humid summers and mild winters, and climate change is exacerbating extreme heat conditions. Since 1980, average maximum temperatures have climbed by over 1°C nationally (and by 1.6°C in Dhaka over 2000–2019). Bangladesh now ranks among the world's hottest countries in terms of cooling degree days, with its capital Dhaka experiencing one of the highest urban heat exposures globally. This intensifying heat has tangible impacts: a recent World Bank analysis found that in 2024, heat-related illnesses and lost workdays cost the economy 0.4% of GDP (≈$1.78 billion). As temperatures increasingly exceed 35°C well beyond the traditional summer season, the urgency for sustainable cooling solutions becomes paramount.

At the same time, socio-economic growth is dramatically boosting cooling demand. Bangladesh is the world's eighth-most populous country (~170 million people in 2022), with a large young population and a high population density. Steady economic growth – averaging around 6–7% annually pre-pandemic – has raised per-capita GDP to around $2,600 (2024)[i]. Rapid urbanization (about 32% family living in urban area as of 2022, which was 23% in 2011)[ii] is leading to denser cities and increasing incomes, which in turn drive greater ownership of cooling appliances. Air conditioner (AC) and refrigerator uptake has accelerated exponentially over the past decade. Yet overall penetration of cooling appliances remains relatively low (only 2.4% percent of households have AC, and ~53.4% had refrigerators as of 2022), indicating enormous latent demand as the middle class expands. In short, Bangladesh faces a surging cooling demand in the coming years due to the confluence of economic growth, demographic trends, urbanization, and climate change.

This **Bangladesh National Cooling Action Plan (BNCAP) up to 2035** is introduced against that backdrop. It aims to provide an integrated policy framework to sustainably meet Bangladesh's current and future cooling needs while minimizing environmental impacts. Bangladesh joins a growing number of nations formulating dedicated cooling action plans. **BNCAP** similarly takes a holistic, cross-sectoral approach to cooling as a development priority, aligned with international best practices and tailored to national context. The Plan recognizes that sustainable cooling is essential for public health (e.g. heat stress relief, vaccine cold chains), food security (cold storage for agriculture),

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i World Bank Group

ii Population and Housing census 2022, Bangladesh Bureau of Statistics (BBS) economic productivity (comfortable workplaces), and environmental goals (energy efficiency and emissions reduction).

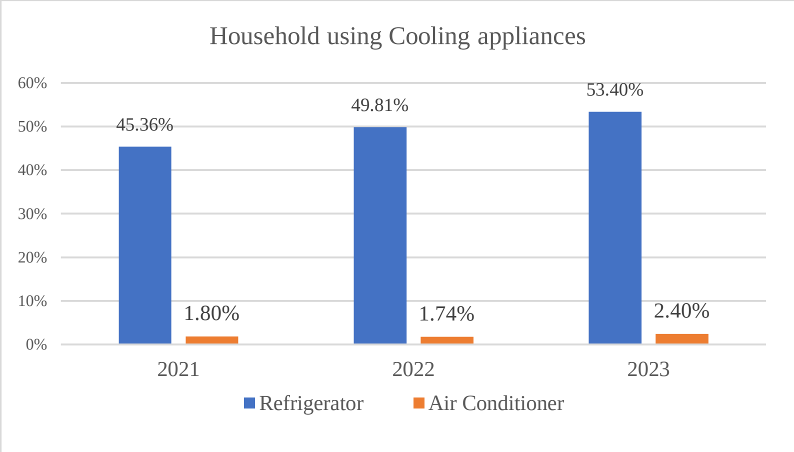

Figure 1-1: Cooling Appliance penetration percentage to the household[iii]

1.2 Rationale of the Bangladesh National Cooling Action Plan

Bangladesh's rationale for developing and updating its BNCAP is underpinned by urgent needs and strategic opportunities:

- **Protecting Citizens and Productivity in a Warming Climate:** With climate change causing more frequent and intense heatwaves, cooling is critical for public health, safety, and productivity. High wet-bulb temperatures already surpass safe thresholds in summer, straining vulnerable communities and workers. Studies show that a mere 2°C rise in workplace temperature can double productivity losses (from ~254 to 573 lost work hours per worker annually) due to heat stress. Lack of cooling leads to fatigue, illness, and lower economic output. By implementing cooling interventions (e.g. ventilation, spot cooling, heat-aware scheduling), Bangladesh can safeguard the well-being of its labor force and avoid substantial economic losses.

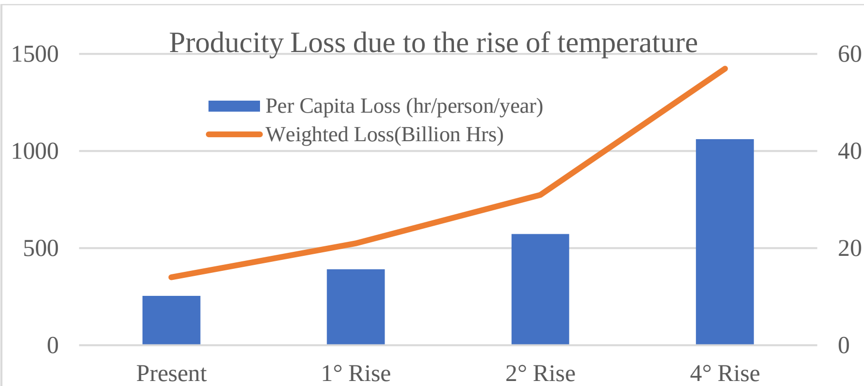

Figure 1-2: Productivity Loss due to the rise of the temperature[i]

[iii] Bangladesh Sample Vital Statistics 2023 (Bangladesh Bureau of Statistics)

- **Meeting Explosive Growth in Cooling Demand Sustainably:** As noted, cooling demand is projected to skyrocket. Without interventions, cooling-related electricity consumption could triple to ~72,834 GWh by 2035 (from current levels). Peak power loads in the hot season are rising due to air-conditioning uptake, causing stress on the national grid. Unplanned growth of inefficient cooling devices would significantly increase greenhouse gas (GHG) emissions and local air pollution. The BNCAP provides a proactive strategy to steer this demand growth onto an energy-efficient and climate-friendly path. By promoting high-efficiency equipment, passive cooling in building design, and better operational practices, studies estimate Bangladesh can cut projected 2035 cooling energy use by ~20%, saving over 14,566 GWh annually. This would avoid unnecessary power generation costs, improve energy security, and help meet climate targets.
- **Aligning with Climate and Environmental Commitments:** Bangladesh has made important international commitments that intersect with cooling. It is party to the Paris Agreement and submitted updated Nationally Determined Contributions 3.0 (NDCs) aiming to reduce Green House Gas (GHG) emissions by 20.31% in 2035 from a 2022 baseline. Although the NDC mitigation targets (such as a 5% unconditional and 15% conditional emission reduction from business-as-usual) mostly pertain to the power, transport, and industry sectors, efficient cooling offers a key "energy efficiency" wedge to achieve these goals. Moreover, Bangladesh ratified the Kigali Amendment to the Montreal Protocol in 2020, committing to phase down high-GWP HFC refrigerants by 80% by 2045 (with a freeze on HFC consumption from 2024). The BNCAP is a vehicle to integrate these Kigali goals with energy efficiency improvements, maximizing climate benefits. By transitioning to climate-friendly refrigerants and cooling technologies, Bangladesh can tap into Multilateral Fund support and avoid up to 0.4°C of global warming by century's end. Additionally, sustainable cooling contributes to several Sustainable Development Goals (SDGs) – SDG7 (energy access and efficiency), SDG3 (health and well-being), SDG13 (climate action), and SDG11 (sustainable cities). Thus, a coordinated cooling plan helps fulfill international obligations while advancing national development priorities.
- **Capitalizing on Economic Opportunities:** A national plan enables Bangladesh to harness opportunities in the emerging "cooling economy." Efficient cooling can spur **green industries and jobs**, from manufacturing of energy-efficient appliances to construction of climate-smart buildings and cold-chain logistics. Bangladesh already has a growing domestic appliance industry (e.g. local companies producing refrigerators, air conditioners, chillers etc). An BNCAP with supportive policies (like standards, incentives, and R&D) can boost local manufacturing of efficient, low-GWP cooling technologies, potentially creating skilled jobs and fostering export opportunities. Likewise, expanding cold storage capacity for agriculture can reduce food waste and increase farmers' incomes
- **Coordinating Fragmented Efforts into One Strategy:** Prior to the BNCAP, cooling-related policies and programs in Bangladesh were scattered – e.g. an Energy Efficiency and Conservation Master Plan (EECMP) with appliance efficiency initiatives, an

Ozone Depleting Substances (ODS) phase-out program by the Ozone Cell, ad-hoc health sector programs for heatwaves, etc. The BNCAP provides a **holistic umbrella framework** to coordinate these efforts across sectors. It brings together stakeholders from environment, energy, industry, health, agriculture, Fishery, and urban development to identify synergies and avoid counterproductive overlaps. This integrated approach ensures that measures like building code improvements, refrigerant regulations, and power sector planning all align toward a common cooling strategy. For Bangladesh, BNCAP institutionalizes a cross-cutting vision of "sustainable cooling for all" and establishes governance mechanisms to implement and monitor progress.

In summary, the rationale for BNCAP is compelling. It is **imperative** to develop a strategic, well-coordinated response to the rapidly growing cooling demand in order to protect people from heat, support economic growth, and achieve environmental targets. The NCP serves as that response – a blueprint to deliver cooling when and where it is needed (from homes and offices to factories, hospitals, and food supply chains) in an energy-efficient, affordable, and climate-friendly manner. This updated 2025 plan builds on the initial 2020 National Cooling Plan (which focused on Montreal Protocol compliance) and broadens the scope to fully integrate cooling into Bangladesh's sustainable development agenda.

1.3 Methodology for Data Collection and Future Projection

Approach to Developing the Plan: The National Cooling Plan has been formulated through a rigorous, evidence-based process following the holistic NCAP methodology framework. This involved both quantitative data analysis and qualitative stakeholder inputs, carried out in several phases:

- **Thematic Scoping:** The team first defined key cooling sectors and themes to be examined, ensuring all major cooling needs are covered. Consistent with international best practice, four sectors were identified: (1) Space Cooling in Buildings, (2) Refrigeration & Cold Chain, (3) Mobile Air conditioning (MAC), (4) Industrial Processing Cooling. The scope included current status, growth projections, technologies, and policy/regulatory context.
- **Data Collection:** A comprehensive data gathering exercise was undertaken to establish a **baseline** of cooling demand and usage across sectors, and to enable future projections. The consultants collated the **best available data** from a wide range of sources: government publications and statistics, industry surveys, academic research, and international databases. Key national sources included the **Bangladesh Bureau of Statistics (BBS)** for demographic and economic data, the Bangladesh Energy Regulatory Commission and Power Division for energy supply data, the **Sustainable and Renewable Energy Development Authority (SREDA)** for appliance and efficiency data, and the Department of Environment's **National Ozone Unit (NOU)** for refrigerant consumption figures. Historical data on installed appliances were gathered from industry associations like the Bangladesh Refrigerator & Air-Condition

Merchant Association (BRAMA), Bangladesh Refrigerator and Air conditoner Manufacturing and Exporting Association(BRAMEC), Bangladesh Cold Storage Association, Bangladesh Frozen Foods Exporters Associating (BFFEA), Bangladesh Marine Fisheries Association (BMFA) and the Cold Storage Association. Customs import data for refrigerants and cooling equipment were collected from the National Board of Revenue to quantify current consumption and cross-verify industry-reported figures. Where digital records were lacking (especially in the informal servicing sector), field surveys and interviews were used to fill gaps. Past studies, such as the ODS Alternatives Survey (UNDP 2019) and HFC Survey 2023, were leveraged to supplement data. Notably, collecting reliable data was a challenge in some areas due to fragmented record-keeping; the methodology therefore triangulated multiple sources to improve accuracy. In general, a top-down analytical approach (using national-level statistics) was combined with bottom-up cross-checks from sector-specific data whenever available.

- **Stakeholder Consultation:** Recognizing that cooling spans many stakeholders, the process emphasized consultation and validation. An inclusive stakeholder mapping was done (as detailed in Chapter 2.8), and relevant entities were approached for data and insights. These consultations with stakeholder served to (a) obtain expert judgments where data was scarce (e.g. estimating current stock and growth rate or forecasting market saturation points), (b) identify practical challenges and opportunities (such as barriers to adopting efficient technologies), and (c) build consensus on proposed actions. Input from experienced professionals – for instance, RAC engineers, cold-chain operators, and Fishery sector expert – enriched the qualitative understanding behind the numbers.
- **Modeling and Future Projections:** With a baseline established, the team developed **scenario projections** for cooling demand up to 2030 and 2035, incorporating socio-economic and climate trends. Using collected data on current appliance/equipment stock, growth rates, refrigerant nature and energy consumption, Business-as-Usual (BAU) scenarios were first constructed for each major sector. These BAU projections assumed continuation of current patterns – e.g. population growth, urbanization, rising incomes leading to higher appliance penetration, and warming temperatures increasing cooling degree days. Then, intervention scenarios were modeled to assess the impact of BNCAP measures. These included improvements like stricter building codes (reducing cooling load growth), higher appliance MEPS (lowering per-unit energy use), and refrigerant transitions (reducing GWP impact), introducing refrigerant recovery recycling program etc. Given data uncertainties, a conservative approach was taken. Kigali SIM Simulation software is used to simulate the BAU and the intervention sceniao. This simulation software was initiated through dialogue between the Schmidt Center for Data Science and Environment at the University of California Berkeley and the Multilateral Fund for the Implementation of the Montreal Protocol.
- **Report Formulation and Validation:** Finally, the findings from data analysis and stakeholder inputs were synthesized into this structured report. Chapter 2 provides the **Country Mapping** – a high-level context assessment covering drivers of cooling

demand, climate profile, energy grid, policy landscape, etc., as recommended by the BNCAP data framework. Subsequent chapters (beyond the scope of this draft) delve into sector-specific assessments and action plans. Before finalization, the draft Plan was reviewed by the multi-stakeholder steering committee for feedback and endorsement, ensuring the strategies are realistic and owned by implementing agencies.

Data Quality and Limitations: It is important to note that data limitations were encountered in developing the BNCAP. Cooling-related statistics are not routinely collected in national surveys, so the Plan had to rely on fragmented datasets and expert estimations. For example, exact numbers of the chiller bank operating in the field had to be approximated from import records and industry sales data. The projections thus provide indicative trends rather than precise figures, and assume no major unforeseen shifts (like technological breakthroughs or drastic economic changes). The BNCP methodology acknowledges these uncertainties. Despite limitations, the methodology employed is robust by triangulating multiple information sources and aligning with global methodologies, giving confidence that the identified strategies are based on the best available evidence.

2 Country Context Mapping

This chapter presents a high-level mapping of Bangladesh's context relevant to cooling, following the **holistic BNCAP data assessment framework**. It examines the drivers of cooling demand, climate conditions, energy infrastructure, policy commitments, and other key factors. This "country context mapping" analysis provides the backdrop for sector-specific assessments and action plan recommendations in subsequent chapters. The structure of this chapter corresponds to the modular categories of data considerations for national cooling action plans.

2.1 Socio-Economic Growth Drivers for Cooling Demand

Bangladesh's robust socio-economic growth is a fundamental driver of increasing cooling demand. **Population growth** and urbanization are expanding the base of people requiring cooling, while rising incomes and development ambitions are boosting expectations for thermal comfort.

- **Population and Demographics:** Bangladesh's population, currently about **170 million** (2022 census), continues to grow around 1.2% per year. Although the population growth rate has slowed compared to previous decades, the absolute number of people entering the middle class is large. Bangladesh's population will reach ~186 million by 2030 and over 195 million by 2035 if current trends hold[iv]. A growing and youthful population translates to **millions of new households** that will seek access to cooling – whether electric fans, refrigerators, or air conditioners – especially as electrification is now nearly universal. The average household size is shrinking and housing stock is increasing, which also raises the number of dwellings that may install cooling devices. Household number is very useful statics to estimate the overall penetration of a certain cooling equpment in the houeshold.

Table 2-1: Population and Household statistics (Source: BBS)

	Population and Housing Census 2022	Population and Housing Census 2011
Total Population	165,158,616	144,043,607
Household	41,010,051	32,173,630
Household size	4.0	4.5

- **Economic Growth and Rising Incomes:** Bangladesh has been one of the fastest-growing economies in Asia in the past decade. GDP growth averaged ~6–7% annually from 2010–2019, enabling the country to achieve lower-middle-income status. Even with a pandemic-related dip, growth has rebounded from 2020~2021 and continued in the following years. The government targets becoming an upper-middle-income country by 2031. Per-capita GDP (in current USD) rose from $2122 in FY 2018~2019 to ~$2,525 in FY 2023~2024. This rising **purchasing power** has profound implications for cooling demand: as disposable incomes increase, more families can afford fans,

[iv] World Health Organization (WHO)

refrigerators, and eventually air conditioners. Indeed, the past decade's income growth has coincided with an **exponential rise in appliance ownership**. For example, domestic refrigerator penetration grew from ~12% of households in 2011 to an estimated 53.4% by 2022[v].

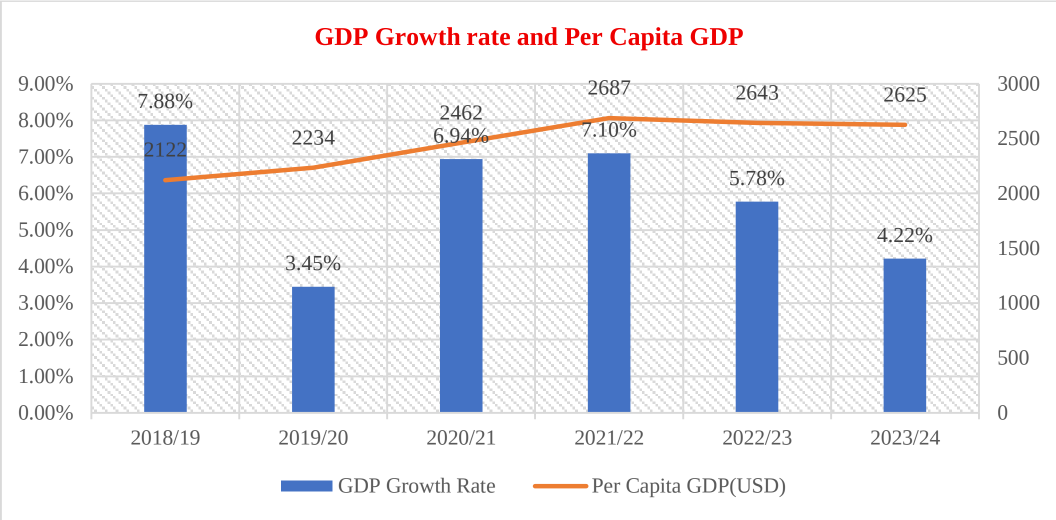

Figure 2-1: GDP Growth and Per Capita Information

- **Industrialization and Cold Chain Development:** Alongside income growth, Bangladesh's development priorities (food security and preservation, export diversification) are driving specific cooling needs. The country is investing in agro-processing and aims to reduce food waste – this requires expansion of **cold storage and refrigerated transport** for fish, meat, dairy, fruits, and vegetables. Already, cold storage capacity (mainly for potato) increased significantly in the last decade. As agriculture modernizes and supermarket/retail chains emerge, cold chain logistics demand is rising. Similarly, the pharmaceutical industry and healthcare sector growth call for more reliable medical cold chains (for vaccines, medicines). The government's focus on value-added exports (like frozen fish, fruite, vegetagles) and year-round food availability means cooling infrastructure is a strategic need. These development drivers are relatively new and contribute to the multi-fold growth of industrial and commercial cooling demand beyond just air conditioning.
- **Electrification and Energy Access:** A notable macro-driver is Bangladesh's success in expanding electricity access to over **99.44% of the population**. Rural electrification (through grid and off-grid solar home systems) means millions of new consumers can now use electrical cooling appliances. As recently as 2000, only 31% had access to power; by 2023, access is nearly universal. This forms the foundation for cooling adoption in villages and secondary towns – e.g. fans are often the first appliance people buy once they have electricity. Government programs for "Electricity for All" by 2021 have effectively removed a major barrier to cooling uptake (lack of power).

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[v] BBS

- **Urbanization and Real Estate Boom:** Bangladesh is witnessing a construction boom – new apartments, offices, shopping malls, and infrastructure – spurred by urban population growth and economic development. The built environment expansion inherently raises cooling requirements. Modern high-rise buildings in Dhaka, Chattogram, etc., are often designed for air-conditioning. The **floor area** requiring cooling (in m²) is rapidly increasing. Additionally, urban heat island effects make cities hotter, further necessitating cooling for comfort and productivity. The real estate sector's sustainable growth (contributing ~7.86% to GDP, in 2023/24) means more commercial space with cooling, more air-conditioned vehicles (cars, buses for urban transport), and generally a lifestyle shift towards conditioned environments in cities. This urban structural change is a powerful underlying factor for rising cooling demand.

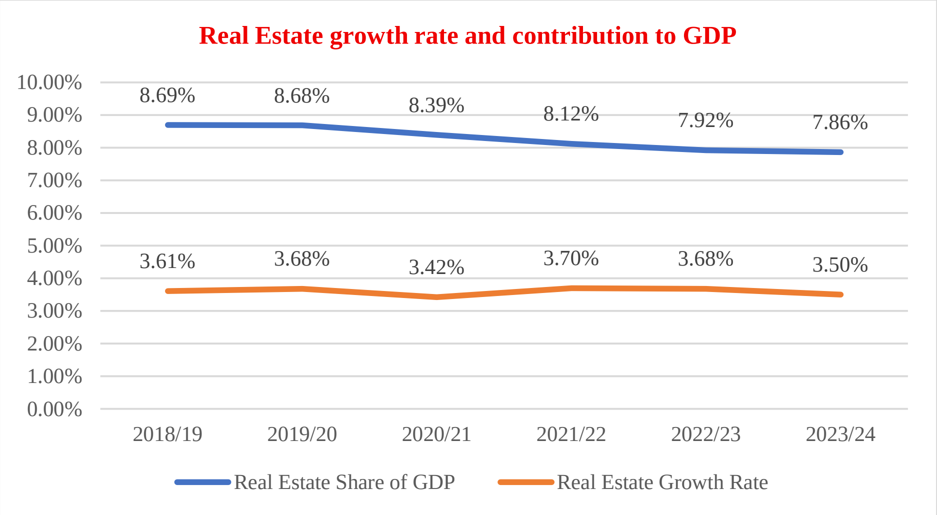

Figure 2-2: Real estate growth rate and share of GDP

In summary, Bangladesh's demographic and economic trajectory is creating a fertile ground for soaring cooling demand. More people, higher incomes, and urban development collectively mean that without strategic interventions, the country will see an unabated increase in cooling appliances and energy use. These socio-economic drivers underscore the importance of planning for sustainable cooling now. The National Cooling Action Plan takes these drivers into account, projecting that cooling demand will grow multi-fold in the next 10–15 years "due to global warming, the rapid pace of economic growth, increasing per capita income, population growth and rapid urbanization, particularly given the currently low penetration of air conditioning". Recognizing these drivers allows the NCAP to tailor solutions (e.g. leveraging local manufacturing for affordable efficient devices to meet new consumer demand, or guiding urban growth with climate-smart design).

2.2 Climate Mapping

Bangladesh's climate is a major factor influencing cooling needs. The country experiences a **tropical monsoon climate** characterized by high temperatures, high humidity, and significant seasonal variation in rainfall. Understanding the prevailing and changing climatic conditions – especially heat patterns – is critical for mapping current cooling demand and anticipating future needs.

- **Climate Zones and Seasons:** Broadly, Bangladesh's climate can be described as hot and humid for much of the year. There are three main seasons: a hot summer (March–June), a rainy monsoon (July–October), and a cool, dry winter (November–February). During summer and parts of the monsoon, large swathes of the country experience daily high temperatures in the mid-30s °C, with humidity often above 70–80% – creating uncomfortable heat indices. In these periods, the need for cooling (fans or AC for thermal comfort, refrigeration for food preservation) is greatest. Winters are relatively mild (average temperatures can drop to 10–15°C in the north in January), and space cooling needs are minimal then, though refrigeration remains needed year-round. Bangladesh is mostly a flat deltaic plain with small hilly regions in the northeast and southeast; thus, there is not a wide variation of climate by geography (unlike some larger countries with distinct zones). However, coastal areas experience more humidity and slightly tempered peaks due to sea breeze, whereas inland and urban areas (like Dhaka) see intense heat buildup. High Ambient Temperature conditions prevail in summer across the country, classifying Bangladesh among nations with moderate cooling requirements for human comfort and productivity.
- **Temperature and Humidity Characteristics:** The average temperatures in the hottest months (April–June) range from about 30°C (average daily mean) with daily maximums often reaching 36–40°C in many districts. Combined with humidity, the "feels-like" temperature (heat index) can be extreme – Dhaka's heat index has been recorded at ~65% higher than the national average on certain day[vi]. According to the Bangladesh Meteorological Department (BMD), the long-term trend shows significant warming: for instance, the average monthly maximum temperature in Dhaka increased by ~1.6°C over the last 20 years. Likewise, mean temperatures nationwide have risen ~1.1°C since 1980. Humidity is high year-round, especially in monsoon when relative humidity often stays above 85%, meaning even slightly elevated temperatures feel oppressive. Cooling Degree Days (CDD) – a measure of cumulative heat above a comfort baseline – are very high in Bangladesh. In fact, Bangladesh currently ranks around 7th globally in total CDDs (an indicator of cooling demand potential). Dhaka specifically endures a massive CDD burden, ranking as the 3rd highest city worldwide in cooling degree days. These metrics confirm that the climatic baseline itself creates intense cooling needs for much of the population, particularly in urban centers. Nights remain warm (high minimum temperatures) during summer, underscoring the need for cooling even beyond daylight hours.

[vi] World Bank Group

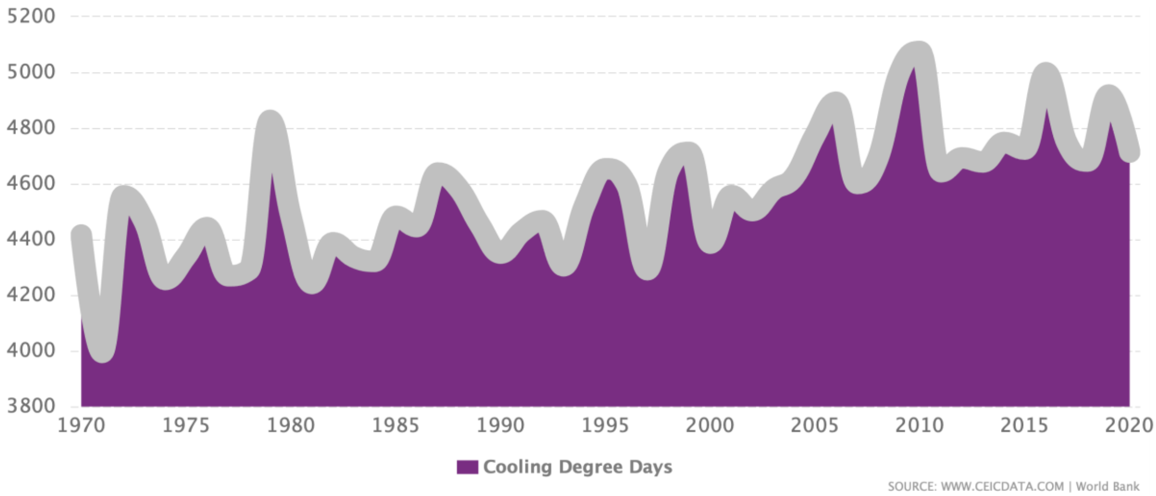

Figure 2-3: Bangladesh's cooling degree days from 1970 to 2020[vii]

- **Seasonal Variations and Heatwaves:** The hottest period is typically April and May, sometimes extending into June until monsoon rains bring slight relief. However, with climate change, heatwaves are becoming more frequent and prolonged. Bangladesh defines a heatwave as periods when temperatures exceed certain thresholds (e.g. >36°C mild heatwave, >40°C severe). BMD has observed an increasing trend in the number of heatwave days per year. For example, a global study noted Bangladesh experienced an additional +44 extreme hot days in a recent year compared to baseline expectations. In 2023, several regions saw record-breaking pre-monsoon heat (with some stations hitting 42–43°C). The monsoon season is marked by high humidity and temperatures in the low 30s°C – while cloud cover can reduce peak solar gain, the sultry conditions continue to drive fan/AC usage. Notably, climate change is causing higher temperatures even in shoulder seasons: it is no longer uncommon to have 35°C days in October or March. This effectively lengthens the cooling season, meaning reliance on cooling appliances is needed for more months of the year than before. Winters remain short and mild.
- **Cooling Degree Days and At-Risk Populations:** By rough estimates, many parts of Bangladesh experience well over 2,500–3,000 cooling degree days (base 18°C) per year, among the highest globally. The population "at risk" from heat due to lack of cooling access is huge. A report by Sustainable Energy for All identified Bangladesh as one of the top nine countries with the largest populations facing significant cooling risks. This includes both urban poor (crowded informal settlements in cities where indoor temps soar and AC is unaffordable) and rural poor (farmers or outdoor workers facing extreme heat without cooling refuges). Heat stress mortality and morbidity is an emerging concern; hospitals report spikes in heat-related illnesses during summer. High nighttime temperatures in urban areas (urban heat island effect) also reduce rest and recovery, impacting health. Climate projections indicate that by mid-century, average temperatures could rise by 1.5°–2.0°C (under moderate emission scenarios)

[vii] CEIC, World Bank Group

and up to 3°–4°C by 2100 under high emissions. This would dramatically increase CDDs, making cooling absolutely critical to prevent heat-related deaths and productivity losses.

- **Geographical and Seasonal Disparities:** While generally hot across the country, some variations exist. The northwestern districts (Rajshahi, Rangpur divisions) often register the highest temperatures in heatwaves (due to continental conditions) – they are sometimes called the "heat zone" of Bangladesh. Coastal areas (Khulna, Chittagong divisions) face high humidity and in summer can also be very uncomfortable, though max air temperatures there might be 1–2°C lower than inland peaks. The capital Dhaka suffers from a combination of factors – high density, concrete infrastructure, air pollution – leading to particularly high heat indices and poor air circulation, which increases cooling demand in Dhaka beyond what the temperature alone would suggest. The Sylhet region (northeast) has slightly more moderate climate due to rains and elevation but still experiences high humidity. The hilly southeast (Chittagong Hill Tracts) can have cooler nights. Recognizing these micro-climates is useful: for instance, building design solutions for Dhaka (where night temperatures remain high and high-rises dominate) may differ from those for rural Rajshahi (where enhancing natural ventilation might be viable at night when temperatures drop a bit more). However, broadly, all regions require significant cooling interventions, with priority on the hottest, densest urban and industrial areas.
- **Climate Hazards and Resilience:** Bangladesh is highly vulnerable to climate change impacts like flooding, cyclones, and rising temperatures. While this Plan focuses on cooling, it's noteworthy that reliable cooling (especially for cold-chains and healthcare) is a resilience measure in disasters (e.g. ensuring vaccine refrigeration during heatwaves or power outages with backup systems). Additionally, passive cooling (like planting trees, cool roofs) can improve urban resilience by lowering ambient temperatures. The climate mapping underlines that Bangladesh's cooling challenge is as much about adaptation as it is about mitigation – coping with existing high heat and future increases. It also justifies the emphasis on passive cooling and nature-based solutions in the BNCAP, since reducing heat loads can be an efficient way to alleviate some cooling demand.

This climate mapping informs the BNCAP by highlighting *when* and *where* cooling is most needed (e.g. pre-monsoon urban heat) and by underscoring the importance of designing cooling solutions that can operate under Bangladesh's hot-humid conditions (e.g. AC units need to be efficient at high ambient temperatures, cooling technologies must handle high moisture loads, etc.). It also reinforces the need for integrating cooling with climate adaptation efforts (cool roofs, urban greening to cool cities, early warning for heatwaves with community cooling centers, etc.).

2.3 Power Grid Parameters

Cooling demand in Bangladesh is predominantly met by electricity – from fans and residential ACs to commercial chillers and industrial cold storage. Therefore, the characteristics of the power grid and energy supply are crucial in assessing cooling's viability and environmental impact. Key power grid parameters include generation capacity and efficiency, transmission/distribution losses, grid reliability, and the carbon intensity of electricity. These factors determine how increased cooling loads will be served and what secondary effects (e.g. emissions, blackouts) might arise.

- **Electricity Generation Capacity and Fuel Mix:** Bangladesh's installed generation capacity has expanded rapidly to roughly 28,359 MW (as of December 2025). The power mix is dominated by natural gas-fired power plants (which account for about 41.59% of generation), followed by oil-based plants (diesel and furnace oil, ~25.13%), with a healthy share of coal (two new coal plants contributing 25.31%). Renewable energy (solar, hydro, others) remains modest – around 3.73% of capacity. This generation mix implies that electricity supply is relatively carbon-intensive (natural gas is cleaner than coal but still a fossil fuel). The grid emission factor for Bangladesh 0.62 ton CO_2/MWh for the year 2021/2022[viii]. This is important for cooling: unless the grid becomes greener, powering more ACs will increase GHG emissions significantly. It also suggests that any improvements in cooling energy efficiency directly avoid emissions (each kWh saved avoids ~0.62 kg CO_2).

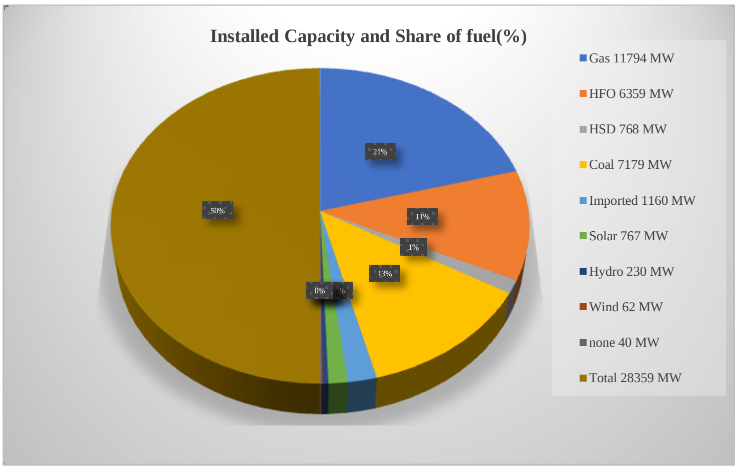

Figure 2-4: Electricity Install Capacity and Share of Fuel[ix]

- **Transmission and Distribution (T&D) Losses:** The power grid has historically suffered from high losses, but Bangladesh has made progress in reducing them. Transmission losses are now around 3.04%, while distribution losses vary by utility but have come down to around 7.38% on FY 2024~2025[x]. Overall, total T&D losses was

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viii Department of Environment (DoE)

ix Bangladesh Power Development Board (BPDB)

x Power Cell, Bangladesh

11.23% in FY 2019~2021, down to 10.13% in FY 2024~2025. This improvement means a greater fraction of generated power actually reaches consumers – critical as cooling loads rise. However, 10% loss is still higher than global benchmarks (single digits), implying that a portion of electricity for cooling is effectively wasted in the network. High cooling demand, especially during peak hours (daytime for commercial, evening for residential AC use), can strain distribution feeders and transformers. Upgrading these to handle new loads (sometimes very localized, e.g. many ACs in one apartment block) is a challenge for utilities. The BNCAP will need to coordinate with power sector planning to ensure distribution infrastructure keeps up, so that voltage fluctuations or overloads do not damage cooling equipment or cause outages. Notably, a widespread adoption of efficient cooling can help the grid too – e.g. if all new ACs are high-efficiency and having low staring voltage, the peak load addition from cooling will be lower than otherwise, easing the need for expensive grid capacity upgrades.

- **Grid Reliability and Peak Demand:** Bangladesh has achieved near-universal electrification, but reliability issues persist. Many areas experience load shedding (rolling blackouts) during peak demand periods, particularly in hot season evenings when AC and fan use is at its maximum. In recent years, peak electricity demand in summer has reached ~15,000 MW, at times outstripping available generation due to fuel or capacity constraints. For instance, in July 2022 and again in 2023, severe heatwaves led to record electricity demand and the grid faced shortfalls, resulting in planned outages that affected millions. Unreliable power supply can be devastating for cooling: even those with ACs or refrigerators suffer if power is off during the hottest hours. It also forces critical facilities (hospitals, vaccine stores) to rely on diesel generators for backup, which is costly and polluting. The power sector is working to improve reliability – adding capacity, improving maintenance, and cross-border power imports (from India and hydro from Bhutan in future). By 2030, Bangladesh aims for a stable surplus generation. However, the NCP must consider scenarios of "peak coincidence": a very hot day's peak cooling demand could stress the grid if not managed (e.g. through demand response or thermal storage). Therefore, part of the Plan's strategy is to encourage off-peak cooling (pre-cooling buildings, thermal energy storage for cold storages), and possibly smart grid measures to shave peaks. Grid reliability is gradually improving, but ensuring reliable cooling might also involve promoting distributed energy solutions – solar plus battery systems to power fans or critical cooling during outages, especially for vulnerable areas.
- **Electrification of Cooling vs. Other Energy Sources:** Currently, most cooling in Bangladesh is electric-driven. There are some non-electric cooling usages (like diesel-powered transport refrigeration units or vapor-absorption chillers in a few industries using waste heat), but these are niche. One notable sector is transport: mobile air conditioning in vehicles is powered by vehicle fuel (petrol/CNG for cars, diesel for buses/trucks). As vehicle ownership grows and more cars have AC, fuel consumption rises; this is indirectly a grid issue if electric vehicles become common (future EVs would make transport cooling an electric load). For now, from the grid perspective, the majority of new cooling demand will be on electricity. This underlines the importance

of power sector decarbonization as a complement to efficient cooling. The government of Bangladesh has set a target of covering 40% of its power generation with clean energy by 2041 (including 10% of renewables in power generation) and to import around 9 GW under regional and sub-regional cooperation. The Ministry for Power, Energy and Mineral Resources aims to reach an installed capacity of 40 GW by 2030 and 60 GW by 2041. If achieved, the grid's carbon factor will drop significantly (from ~0.6 to maybe 0.3 kg/kWh or lower), making electric cooling much cleaner. Therefore, the NCP and power master plan should be synergistic – expanding solar (including rooftop on commercial buildings, cold storages and industrial buildings), exploring utility-scale renewables, etc., which can during daytime meet AC loads (solar output aligns well with daytime AC use). Already, some large garment factories and potato cold storages have installed solar to help run cooling systems.

In summary, Bangladesh's power grid is in a transition phase – expanding and improving, but still carbon-intensive and occasionally strained. The cooling sector's growth will be both a challenge and an opportunity for the grid. A challenge, because meeting rising cooling electricity demand will require significant generation capacity (potentially an extra several gigawatts by 2030 and 2035) and robust distribution networks; an opportunity, because aggressive efficiency improvements in cooling can become a major strategy for the energy sector to avoid capacity shortages and reduce emissions. The BNCAP's country mapping underscores that power grid readiness is integral to sustainable cooling. Coordination with energy planners is needed to ensure that peak cooling loads are accounted for in the Power System Master Plan, and that the grid's decarbonization aligns with shifting more end-uses (like cooling) to electricity (which is preferable over, say, using inefficient diesel gensets or other off-grid fuels). In the context of the NCAP framework, the grid carbon intensity (currently ~0.62 kg/kWh) and T&D loss rate (~10.23%) are key parameters – improvements in these over time (through more renewables and grid upgrades) will directly enhance the sustainability of cooling.

2.4 International Commitments

Bangladesh's development of a National Cooling Plan is situated within the context of several international commitments and agreements. These commitments provide both motivations and guiding frameworks for the country's cooling strategy. The primary international drivers are the Paris Agreement (NDCs), the Kigali Amendment to the Montreal Protocol, and the Sustainable Development Goals, among others. This section outlines how each influences the cooling agenda:

2.4.1 Paris Agreement and NDC:

Bangladesh is a signatory to the Paris Agreement on climate change and has submitted its Nationally Determined Contribution (NDC) outlining GHG mitigation targets. In its updated NDC 3.0 (2025), Bangladesh committed to an unconditional reduction of GHG emissions by around 6.39% below business-as-usual by 2035, and up to 13.92% reduction conditional on international support. These targets focus on the power, transport, and industry sectors primarily. While the NDC did not explicitly quantify cooling sector emissions, the cooling plan serves as a mechanism to contribute to the NDC goals through energy efficiency. Energy-related CO_2 emissions (from electricity generation) will be curbed by efficient cooling, and HFC refrigerant emissions can be curbed by Kigali implementation – both are aligned with achieving NDC targets. Moreover, Bangladesh's NDC includes adaptation components where cooling is relevant: e.g. addressing health impacts of heat and ensuring sustainable cities. The BNCAP can be seen as an implementation tool for the NDC in the cooling domain – delivering mitigation (through avoided power emissions and HFC phasedown) and adaptation (cooling for resilience to heat). Additionally, as parties regularly update NDCs, Bangladesh could in future NDC submissions incorporate specific cooling-related pledges.

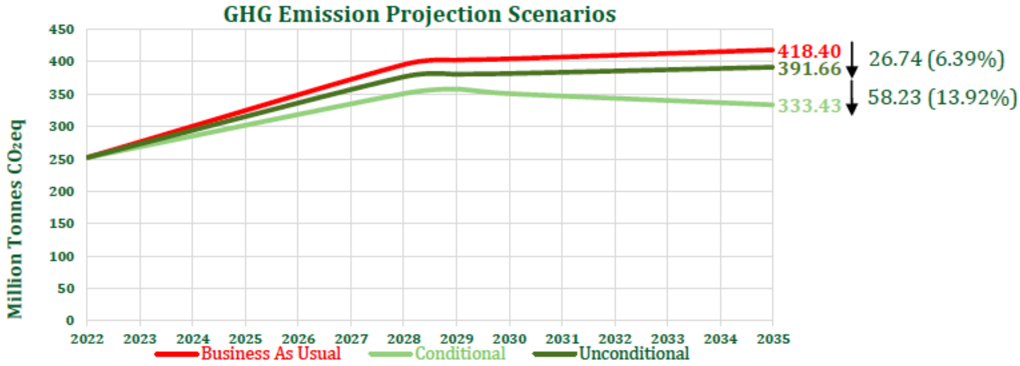

Figure 2-5: GHG Emission Projection Scenarios

2.4.2 Kigali Amendment to the Montreal Protocol:

Bangladesh ratified the Kigali Amendment in June 2020, joining the global effort to phase down hydrofluorocarbon (HFC) refrigerants. Under Kigali, Bangladesh, as an Article 5 Group 2 country has obligations including: establishing HFC consumption baseline (average of 2020–22), freezing HFC consumption in 2024, and then reducing HFC consumption by 80% by 2045. The HFC phasedown schedule is fixed: 10% reduction by 2029, 30% by 2035, 50% by 2040, 80% by 2045 from the baseline. This is a major driver for the cooling sector, as many current refrigerants in ACs and fridges (like HFC-134a, R-410A, R-404A) will need to be replaced with low-GWP alternatives. Compliance with Kigali is non-negotiable and is backed by the support of the Montreal Protocol's Multilateral Fund (MLF) for developing countries. BNCAP explicitly integrates Kigali targets – one of its core pillars is to manage the refrigerant transition alongside energy efficiency. Already, Bangladesh has an HCFC Phase-out Management Plan (HPMP) that successfully phasing out HCFCs by 2030. Kigali extends these efforts to HFCs, requiring policy measures (import controls, quota systems for HFCs), industry conversion (helping manufacturers shifting to technology for using alternatives refrigerant), and training of technicians in safe use of new refrigerants. Achieving Kigali targets will also reduce GHG emissions significantly .

Table 2-2: Reduction step for HFC Phase-down for Bangladesh

Steps	1st January of the Year	Max. Allowable Consumption Baseline 5,473,532 ton CO2e
Freeze	2024	5,473,532
10% Reduction	2029	4,926,179
30% Reduction	2035	3,831,472
50% Reduction	2040	2,736,766
80% Reduction	2045	1,094,706

In essence, Bangladesh's international commitments create an impetus and framework for the NCP. The Paris Agreement NDC provides the overarching climate target timeframe (2035) – the BNCAP's interventions can contribute to meeting those targets and will be monitored in that context. The Kigali Amendment provides specific phased targets for refrigerants (2024 freeze, 80% cut by 2045) – the NCP details how to achieve those in tandem with efficiency. Together, these ensure the NCP is not a standalone national endeavor but part of a global effort to promote clean and sustainable cooling. Aligning with these commitments also means Bangladesh can leverage international support (technical expertise, funding mechanisms like Green Climate Fund for cooling projects, etc.) and demonstrate leadership among developing nations in addressing the "cooling challenge

2.5 Key Stakeholders

Implementing the National Cooling Plan requires coordinated action among a wide array of **stakeholders from the public sector, private industry, and civil society**. This section identifies the key stakeholders in Bangladesh's cooling landscape and their roles, essentially mapping who needs to be involved through a multi-stakeholder governance approach:

2.5.1 Government Ministries and Agencies (Public Sector):

Several line ministries have mandates touching on cooling:

- **The Ministry of Environment, Forest and Climate Change (MoEFCC),** is a lead agency via its Ozone Cell (National Ozone Unit, NOU) which spearheaded the Montreal Protocol implementation and NCP formulation. It will continue to oversee refrigerant policies and overall coordination of the NCP as a national strategy (possibly housing the NCP Secretariat).
- **The Ministry of Power, Energy and Mineral Resources (MPEMR),** particularly through SREDA (Sustainable & Renewable Energy Development Authority) and the Power Division, is crucial for energy efficiency and demand-side management policies. SREDA is responsible for appliance standards & labeling and promoting energy conservation – a key implementing arm for efficiency measures in cooling.
- **The Ministry of Industries (MoInd**), oversees industrial policy, including local manufacturing of cooling appliances. The ministry and its bodies (like BSTI –

Bangladesh Standards and Testing Institution) set product standards and certification. They will ensure quality and efficiency standards for ACs/fridges are enforced in production/import.

- **The Ministry of Housing and Public Works,** has influence via building codes (BNBC enforcement through Public Works Department (PWD) and Rajdhani Unnayan Kartripakkha (RAJUK) in Dhaka). They need to incorporate cooling efficiency in public building projects and ensure new constructions follow energy provisions.
- **The Ministry of Agriculture and Ministry of Fisheries/Livestock**, are stakeholders for cold-chain expansion (as they run projects on food storage, and the Department of Agricultural Marketing often supports cold storages). They will be involved in planning and subsidizing rural cooling facilities.
- **The Ministry of Health,** – responsible for vaccine cold chain and hospital cooling. They need to coordinate with NCP to improve hospital HVAC systems and ensure resiliency during heatwaves (e.g. backup cooling in community clinics).
- **The Ministry of Transport (Road Transport & Highways) and BRTA (Road Transport Authority)** , relevant for transport AC regulations (like vehicle standards). Also the Ministry of Railways for cooling in railway services, and Ministry of Civil Aviation for airport cooling (airports are heavy AC users).
- **The Ministry of Finance and Bangladesh Bank**, stakeholders for financing and incentives, as they control subsidies, taxes, and green financing guidelines. Their buy-in is needed to implement fiscal incentives or credit lines for cooling.
- **The Ministry of Education**, indirectly involved since technical training institutions under them can incorporate RAC servicing training upgrades; also schools and colleges need cooling improvements for better learning environments.

These public stakeholders will likely form the **Technial Committee or Coordination Committee** for the BNCAP, as was recommended in the initial plan. High-level support ensures each ministry integrates BNCAP actions into their programs.

2.5.2 Private Sector – Manufacturers and Industry Associations:

The success of efficiency and refrigerant transition efforts heavily relies on the private sector:

- **Appliance and equipment Manufacturers/Importers:** Refrigerator and air contion manfuacturing companies could be the part of the technical committee. They are often represented by associations (e.g. Bangladesh Refrigerator Air-condition Marchent asocation, Bangladesh Refrigerator and Air condition Manufacturer and Exporters Assocation).
- **Commercial/Industrial End-Users:** Large companies that operate cooling systems – e.g. owners of cold storage warehouses (there is a Cold Storage Association in Bangladesh), the Bangladesh Supermarket Association (for commercial refrigeration),

Hotel and Hospitality associations (for commercial AC use), Garment Manufacturers (BGMEA/BKMEA) for factory cooling, etc. Their role is to adopt best practices, invest in upgrades, and provide industry insight. For instance, BGMEA (garment association) can champion cooling improvements as part of their sustainability drive. The Cold Storage Association can help implement standard operating procedures to save energy. Large quantity of absoption chiller are using in Textile industries, could be good partnership for promoting Not In Kind of cooling techology.

- **Real Estate Developers:** Under REHAB (Real Estate & Housing Association of Bangladesh), they influence building design. Their adoption of energy-efficient building designs, provision of central AC vs. individual units etc. can shape urban cooling demand. Engaging them to promote green building concepts (perhaps via incentives like Floor Area Ration (FAR) relaxation for green buildings) is important.
- **Industry Bodies and Think Tanks:** Groups like Federation of Bangladesh Chambers of Commerce & Industry (FBCCI) and specialized think tanks (e.g. Bangladesh Centre for Advanced Studies (BCAS), Centre for Energy Research at BUET) can support with research, pilot projects, and advocacy in the private sector.

2.5.3 Civil Society, Academia, and NGOs:

These stakeholders can provide neutral expertise, public awareness, and grassroots implementation:

- **Academic Institutions:** e.g. BUET (Bangladesh Univ. of Engineering & Technology) – its Mechanical Engineering and Architecture departments have experts in thermal engineering and building physics; they often consulted on building code, AC standards. Engaging universities for research (like modeling cooling demand, innovating passive cooling designs suited to local context, training programs) is valuable. Other universities (DUET, CUET, RUET) also have engineering faculties that can propagate curriculum on HVAC efficiency.
- **NGOs and International Organizations:** Groups like the UNDP (which supported the NCP), UNEP, GIZ etc., operate projects on energy, environment, and can provide technical assistance or pilot funding. Local NGOs focusing on urban issues (e.g. those working on slum upgrading could incorporate cool roofs), or those on agriculture (like NGOs assisting farmers with storage) become partners to implement cooling solutions at community level. Civil society organizations can also help raise awareness on the importance of cooling for all and act as watchdogs for policy implementation.
- **Professional Societies:** The ASHRAE Bangladesh Chapter (American Society of Heating, Refrigerating, AC Engineers) represents HVAC professionals. They are key for technical standards, training and promoting best practices within the engineering community. Similarly, the Institute of Architects Bangladesh (IAB) can influence building design approaches (encouraging passive cooling considerations).

- **Media and Consumer Groups:** While not typically listed, they are vital for outreach. Media can highlight heat risks, promote energy-saving tips, and report progress or gaps in NCP actions, building public support. Consumer rights groups might push for labeling transparency and quality.

2.5.4 Steering and Working Groups:

The plan envisions a governance structure with a national Steering Committee (policy level) and technical Working Groups (sector/theme level). These groups formalize stakeholder involvement. For instance, separate working groups could handle (1) Residential/Commercial Cooling, (2) Cold Chain and Refrigeration, (3) Servicing and Training, (4) Policy and Standards, etc., each comprising relevant experts from above stakeholder categories. Bangladesh's initial NCP suggested such multi-stakeholder committees and indeed set one up during drafting; continuing that for implementation will institutionalize stakeholder input and monitoring.

2.5.5 Stakeholder collaboration status:

Historically, Bangladesh has successfully run such multi-stakeholder processes for ODS phase-out (with strong industry-government collaboration) and for energy efficiency (SREDA often consults industry). The BNCAP looks to strengthen these ties: e.g. formal MoUs between DoE (ozone cell) and SREDA to jointly pursue cooling efficiency + refrigerant goals, or partnerships between government and industry associations to run voluntary programs (like an award or recognition for companies doing exemplary cooling efficiency work).

In summary, the stakeholder mapping underscores that cooling is a cross-cutting issue requiring "all hands on deck". From high-level policy makers to on-the-ground technicians, each has a role:

- Government sets regulations, provides incentives, leads by example.
- Industry innovates and implements solutions in manufacturing and usage.
- Academia and experts provide knowledge and capacity building.
- Financiers enable investments.
- Civil society ensures inclusivity and accountability.
- International partners bring in resources and global best practices.

The NCP's inclusive stakeholder engagement approach is intended to ensure buy-in and smooth implementation – everyone sees their interest in making cooling sustainable, whether it's a factory owner saving electricity costs or a city authority improving livability. Such broad engagement also helps identify and overcome practical barriers (for example, if a certain regulation is hard to comply with, industry feedback can lead to a more workable approach).

3 Refrigerant Pathway

3.1 Overview of Refrigerant Demand Trends in Bangladesh

Bangladesh's refrigerant consumption has evolved significantly over the past five years, driven by both market growth and the phase-out of ozone-depleting substances. Hydrochlorofluorocarbon HCFC-22 (R-22), once the dominant refrigerant in air-conditioning, has been steadily declining due to the ongoing phase-out under the Montreal Protocol. R-22 consumption fell from roughly 865 metric tons (MT) in 2019 to about 472 MT in 2024, as new equipment shifted away from HCFCs. In contrast, hydrofluorocarbon (HFC) usage has surged – especially high-global-warming-potential (GWP) HFCs used in air conditioners and commercial refrigeration. For example, imports of HFC-410A (GWP 2088) used in room AC grew from ~207 MT in 2020 to a peak of 751 MT by 2023. Similarly, HFC-134a (GWP 1430), historically used in refrigerators and other applications, has remained high at 600–800 MT per year in recent years. Meanwhile, Bangladesh has begun adopting lower-GWP alternatives. Notably, use of HFC-32 (GWP 675) – a medium-GWP refrigerant for AC – rose dramatically from near zero in 2020 to about 580 MT in 2024, as manufacturers transitioned to this option. Also, natural refrigerants (hydrocarbons) like R-600a (isobutane, GWP 3) now dominate the domestic refrigeration sector, with demand for R-600a climbing from 152 MT in 2020 to 355 MT in 2024. Throughout 2019–2024, total refrigerant consumption grew and then plateaued – peaking around 3,220 MT in 2023 before a slight dip in 2024 as HCFC usage dropped. This reflects a shift in the refrigerant mix: HFCs have rapidly replaced HCFC-22 in most new cooling equipment, causing a rise in HFC consumption (and associated CO_2-equivalent emissions) even as HCFC-22 use declines.

Table 3-1: Import statistics of the Major refrigerant used for cooling purpose[xi]

Summary of Total Refrigerant Import (tonne)							
Refrigerant	GWP	2020	2021	2022	2023	2024	2025(until Oct)
R-600a	3	152	241	195	337	355	377
R-290	3	0	0	0	0	0	26
HFC-134a	1,430	577	660	570	676	799	663
HFC-410a	2,088	207	232	338	751	641	619
HFC-32	675	2	0	59	434	580	711
HFC-404A	3,922	5.60	0	41.85	93.89	72.55	126.17
HFC-407C	1,774	0	0	17.59	50.78	148.28	239.00
HFC-507A	3,985	0	0	0	0	0	6.44
HFC-23	14,800	0	0.009	0.000	0.580	0.000	0.000
HCFC-22	1,810	682.17	666.67	837.22	876.52	472.26	16.93
Total		1,626	1,801	2,058	3,220	3,068	2,784

Major application sectors drive these trends. In the room air-conditioning (AC) sector, older units charged with R-22 are being replaced or retrofitted with HFC alternatives; concurrently, local AC manufacturers now largely use HFC-410A and HFC-32 in new

[xi] Import statistics from National Board of Revenue (NBR)

products. The domestic refrigeration sector has transitioned from HFC-134a to R-600a refrigerant in new refrigerators (nearly all household refrigerators produced locally now use R-600a, which has an ultralow GWP of ~3). Figure: 9 outline the growth of HFC (R32 and R410a) using by the unitary air conditiona manufacturer where as R-22 growth in the manufacturing sector is only at a minimum level. Commercial refrigeration and cold-chain applications historically used a mix of R-22, R-134a, HFC-404A (GWP ≈3922), and other HFC blends; these remain in use, but historically natural refrigerants (e.g. ammonia) has been using in large cold storage to reduce GWP. Transport air-conditioning (vehicle AC) predominantly uses HFC-134a (though a global shift to HFO-1234yf is on the horizon). Notably, a unique sector in Bangladesh is medical/pharmaceutical use of HFC-134a – local Metered Dose Inhaler (MDI) manufacturing uses HFC-134a as a propellant, accounting for a significant portion of national HFC-134a demand. Table 3 below summarizes the recent demand of key refrigerants and their GWPs, illustrating the overall transition away from HCFC-22 toward higher-GWP HFCs (with nascent uptake of low-GWP alternatives).

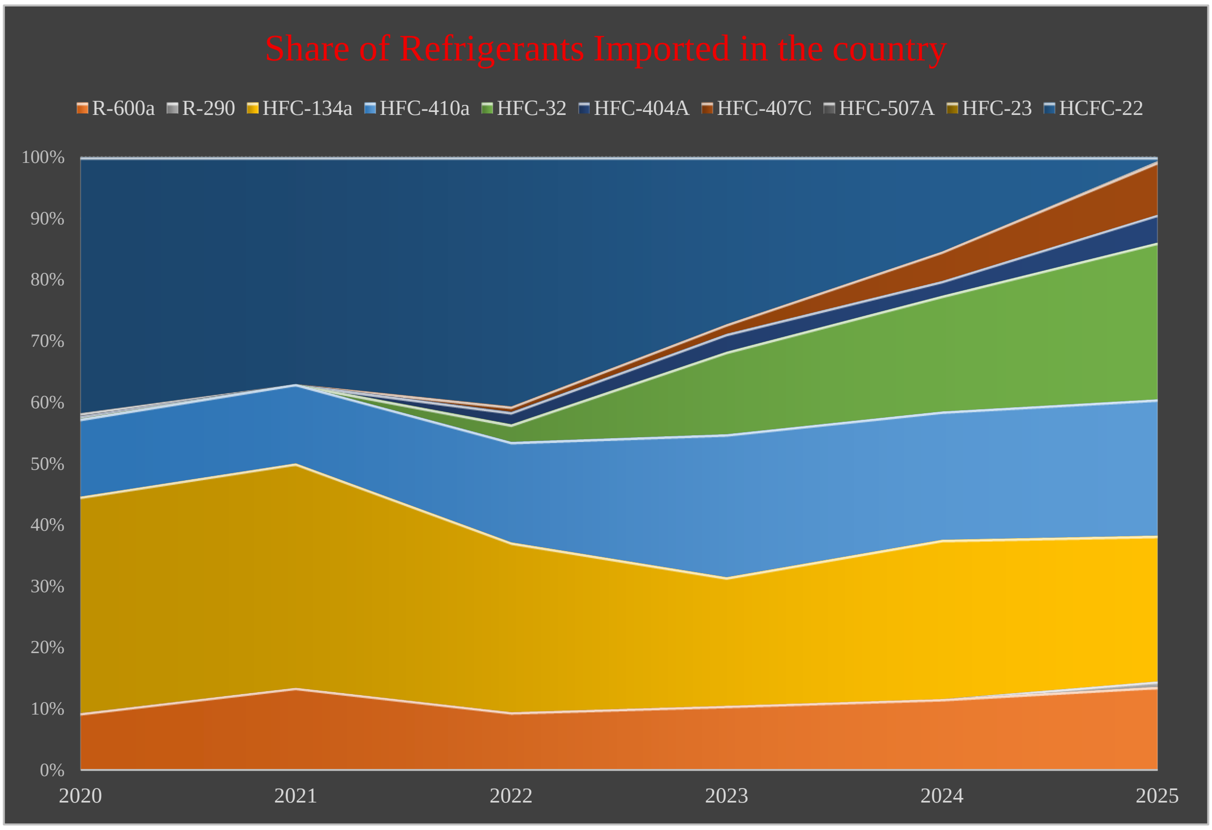

Figure 3-1: Share of refrigerant imported to the country during 2020 to 2025

As shown above, Bangladesh's refrigerant profile is currently a mix of high-GWP HFCs and residual HCFCs, with a small but growing fraction of low-GWP natural refrigerants. The steep rise of certain HFCs (notably R-410A and R-32) versus the phase-out of HCFC-22 is clearly evident. Overall, the past five years indicate growing total refrigerant demand, aligned with Bangladesh's expanding cooling needs, but also a transition in refrigerant types. The national strategy is now focused on managing this transition – replacing high-

ODP and high-GWP gases with climate-friendlier alternatives – without impeding the growth in cooling access.

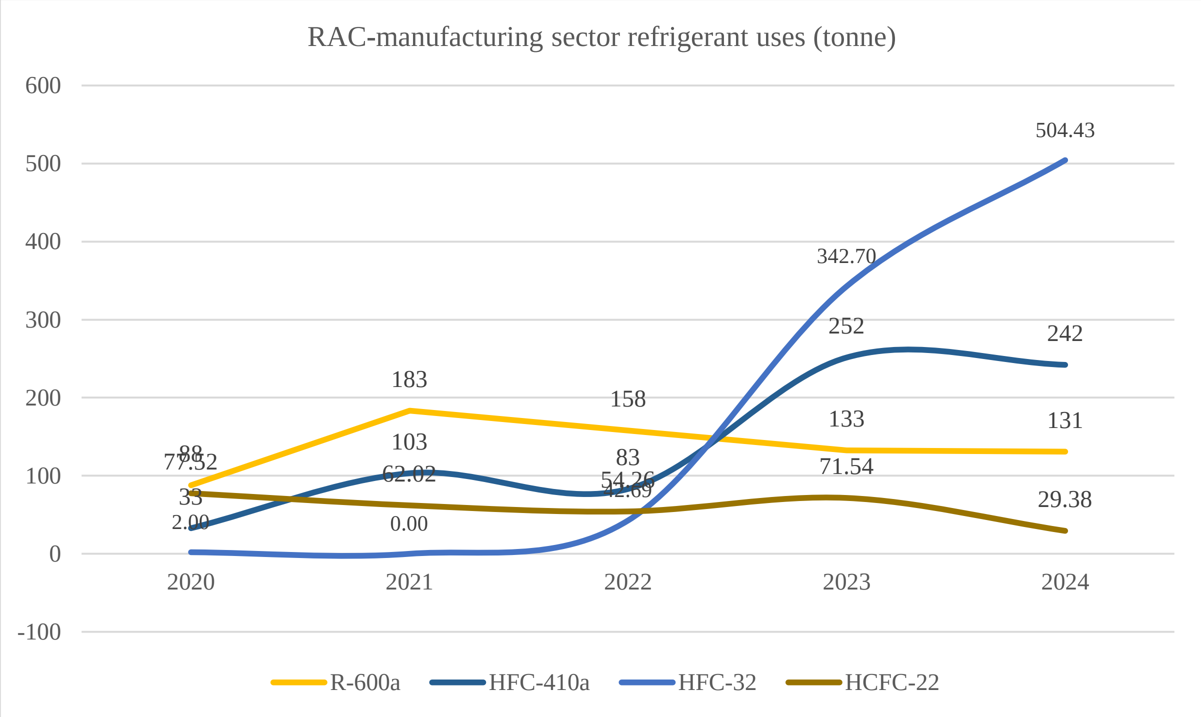

Figure 3-2: RAC manufacturing sector refrigerant transition

In summary, sector-wise refrigerant usage in 2019–2025 can be characterized as follows: the RAC manufacturing sector has switched to non-ODP refrigerants – predominantly HFC-32, HFC-410A, and R-600a – with R-290 just starting to enter in 2025 (Few companies launched R-290-based AC models in 2025, indicating future growth of R-290 use). The servicing sector still absorbs large quantities of high-GWP HFCs (and residual HCFC-22) to maintain existing equipment. This servicing demand will gradually decline or shift as old equipment is retired or retrofitted, but in the near term it remains substantial – e.g. over 62% of HFC-410A and 78% of HFC-134a consumed in 2024 went into servicing existing units, not new manufacturing. The data underscores the importance of managing legacy equipment banks and refrigerant recovery, as discussed later. It also highlights the opportunity for leapfrogging to natural refrigerants in sectors like domestic and commercial refrigeration to avoid HFC growth.

3.2 Proposed Refrigerant Transition Pathway

Bangladesh's refrigerant transition pathway is guided by its obligations under the Montreal Protocol's HCFC Phase-out Management Plans (HPMP) and Kigali HFC Phase-down (KIP), as well as national cooling priorities. The proposed pathway can be summarized as follows, aligned with HPMP Stage III (2026–2030) for HCFCs and Kigali Implementation Plan (Stage I 2024–2030, Stage II 2031–2035) for HFCs:

3.3 Complete HCFC-22 Phase-Out by 2030:

Under HPMP Stage III, Bangladesh will eliminate all remaining HCFC-22 consumption. This involves *banning R-22 in new equipment by 2026* (already effectively achieved – no local manufacturer uses R-22 anymore), and steadily reducing servicing imports to reach only a minimal "service tail" by 2030. The target is a 97.5% reduction of HCFC baseline by 2030, with at most 2.5% of baseline allowed for servicing needs until 2040. Given that Bangladesh's HCFC-22 import in 2025 is already down to ~17 MT, the country is on track to exceed these requirements. The pathway for the AC sector is to retrofit or retire remaining R-22 equipment by 2030 and replace them with low GWP altnatives. This will ensure *2.5% R-22 usage* beyond 2030, fulfilling Stage III of the HPMP.

3.3.1 Freeze and Reduce HFC Consumption (Kigali Stage I):

Having ratified the Kigali Amendment in 2020, Bangladesh's baseline for HFCs is the average consumption of 2020–2022. The first commitment is to freeze HFC consumption at the baseline level starting 2024, and then achieve a 10% reduction from baseline by 2029. The National Cooling Plan's refrigerant strategy embraces this by prioritizing low-GWP alternatives and improved refrigerant management this decade. During KIP Stage I (2024–2030), the focus will be on *avoiding growth* in high-GWP HFC use despite rising cooling demand. Key actions include:

- **Transition in the AC sector:** Replacing HFC-410A (GWP 2088) with lower-GWP refrigerants. Few local manufacturers are already moving from R-410A to HFC-32 (GWP 675) and even introducing R-290 (GWP 3) models. By 2030, the majority of new AC sales are expected to use refrigerants with GWP <750 (e.g. R-32, R-290, or new A2L blends like R-454B if introduced), drastically cutting the average GWP of the AC stock..
- **Transition in refrigeration:** Phasing out HFC-134a, R-404A, etc. in favor of naturals and very low-GWP alternatives. By 2030, new domestic refrigerators will continue to use R-600a exclusively (already in place), and the plan to introduce hydrocarbon (R-290) in commercial refrigeration. Bervegae cooler and the ice cream freezer currently manufacturing by R143a and R600. Local refrigerator manufacturing are selling R600 and R290 based beverage cooler and ice cream freezer to the local marke. Some demonestration project could encourage large supermarkets and cold stores to adopt CO_2 cascade or ammonia/CO_2 systems instead of R-404A; promote R-290 in bottle coolers, commercial freezers, and small cold rooms. Any interim use of HFC/HFO blends (like R-448A, R-449A) will be monitored, but the preference is natural refrigerants to avoid future transitions.
- **MDI sector:** Bangladesh is a one of the high number global producer of MDI. Until new alternatives are proven specail allocation of R134a should be allocated for this sector as while allocating the yearly HFC quota.

- **Improved equipment and standards:** Implement standards and codes that facilitate the above transitions (e.g. updated safety standards for flammable refrigerants in AC and refrigeration, building codes promoting efficient cooling, etc.).

These measures are intended to cap HFC use and enable the 10% reduction by 2029. BNCAP's pathway is designed to not only meet but potentially exceed these cuts through aggressive adoption of alternatives.

3.3.1 Deep HFC Cuts (Kigali Stage II & Beyond):

Beyond 2030, Kigali calls for a **30% reduction by 2035, 50% by 2040, and 80% reduction by 2045** (from the baseline). Bangladesh's Stage II KIP (2031–2036) will outline specific steps for these deeper reductions. The broad vision in the NCP is to **leapfrog to ultra-low GWP refrigerants wherever possible by 2040**. This means by the mid-2030s:

- **Room AC and commercial AC** should transition from HFC-32 to next-generation refrigerants (like R-290, HFO blends or future refrigerants with GWP <150). If any HFCs like R-32 remain in use, they would be phased down by 2040 in favor of naturals or zero-GWP options.
- **Large chillers** would shift from HFC-134a to HFOs (e.g. R-1234ze) or to natural options (ammonia, hydrocarbons) as technology permits.
- **Commercial refrigeration** would see widespread use of CO_2, ammonia, and hydrocarbons – eliminating R-404A/R-507A entirely well before 2040.
- **Mobile AC** in vehicles likely will transition to HFO-1234yf (GWP <1) by the 2030s, in line with global automotive trends.
- **Any remaining HFC use** would be restricted to applications where no viable alternatives exist, and even there, reclaimed or recycled HFCs should be used to the extent possible.

By 2045, the aim is to achieve the 80% reduction in HFC consumption, effectively meaning only a small fraction of current HFC use (perhaps for critical uses like some medical or aerospace applications) would continue, that too managed with recycling programs. This transition will be supported by capacity building and technology transfer under the Kigali Amendment's financial mechanism.

In summary, the proposed refrigerant transition pathway for Bangladesh is a structured phase-down: first exit HCFCs completely by 2030; concurrently freeze HFC growth and promote available low-GWP options by 2030; then systematically retire high-GWP HFCs from 2030–2045 in favor of naturals/HFOs. This will be accomplished through a combination of regulatory measures (import/export controls, standards), industry initiatives (manufacturing sector conversion project, like 4 AC manufacturer move to R-32/R-290 under HPMP Stage II), and supporting programs under the Multilateral Fund.

The pathway is designed to meet international obligations while also catalyzing domestic innovation (e.g. becoming proficient in hydrocarbon Referigerator and AC manufacturing). A summary of the refrigerant roadmap and the target milestones:

1. By 2025: No new HCFC-22 equipment;
2. By 2030: No more HCFC import and 50% new AC with low GWP (less than 700) refrigerant;
3. By 2035: 30% reduction in HFC use; 100% of the AC using low GWP refrigerants
4. By 2040: 50% reduction (with naturals widespread in all sectors);
5. By 2045: 80% reduction (minimal residual HFC use)."

3.4 Introducing Recovery, Recycling, and Reclamation

Managing refrigerants at end-of-life and during servicing is a critical component of the refrigerant pathway. In Bangladesh, refrigerant recovery, recycling, and reclamation (RRR) practices are still in nascent stages. Currently, the majority of servicing operations in the country are done by a highly fragmented network of small technicians, many of whom do not have equipment for proper recovery. It is common that when an air conditioner or refrigerator is repaired, the remaining refrigerant charge may be vented to the atmosphere rather than recovered. Under earlier stages of the HPMP, Bangladesh undertook some training programs on good servicing practices – technicians were trained in recovery and reuse techniques and a number of recovery machines and cylinders were distributed to service workshops. However, adoption remains limited due to challenges such as equipment cost, lack of enforcement, and low awareness.

3.4.1 Current initiatives:

The Department of Environment's National Ozone Unit (NOU) has been planning a more robust refrigerant management system as part of Kigali implementation. This includes establishing a formal refrigerant reclamation center and a program for returned refrigerant. An inventory of contaminated or surplus refrigerants in various sectors was proposed to understand the potential for reclamation. Additionally, two AC manufacturing industries were financed umder HPMP Stage II set up the recovery and reclaimation center which will be in operation from 2026. This support will boost up the industry stakeholders (such as large chiller service companies) have begun using recovery units for high-value refrigerants – for example, some commercial HVAC service providers do recover HFC-134a or R-410A during maintenance of chillers/VRF systems, storing the gas for reuse.

The refrigerant pathway described in this chapter provides the foundation for Bangladesh's cooling sector transformation. It diagnoses where we are (the trends and data) and outlines where we need to go (the transition timeline and practices). Ultimately, by following this pathway, Bangladesh aims to ensure its growing cooling needs are met in an environmentally sustainable manner, decoupling cooling growth from ozone depletion and climate change.

3.4.2 Opportunities and plans:

The National Cooling Plan identifies strengthening RRR practices as a key opportunity. By instituting proper recovery and recycling, Bangladesh can **reduce the need for new imports** (helping meet HFC phase-down targets) and prevent direct emissions. Some opportunities and steps forward include:

- **Policy and Regulation:** Introducing regulations that mandate refrigerant recovery during servicing and at equipment end-of-life. This could include certification requirements for technicians to ensure they have the capability to recover refrigerant, and penalties for venting. For instance, enforcement of rules that no refrigerant can be knowingly released and that recovered refrigerant must be sent to an authorized facility for recycling or destruction would change the industry norms.
- **Reclamation Facilities:** Setting up one or more central reclamation centers (possibly in collaboration with RAC manufacturer or large HVAC installation firms). These centers would take back recovered refrigerant, purify it, and then offer it for resale at lower cost than virgin product. Given the considerable servicing demand for HFCs up to 2040, a reclaim system could be economically viable. The Multilateral Fund can support the initial capital for such facilities. Reclaimed HCFC-22, for instance, could service the remaining R-22 equipment without requiring new imports, and reclaimed HFCs can help during the phase-down period.
- **Recovery Equipment and Training:** Scaling up distribution of recovery units, vacuum pumps, and cylinders to technicians nationwide. This may involve subsidized provision of equipment to certified service centers. Coupled with this must be training and certification: ensure technicians are taught not only how to use recovery machines, but also the importance of doing so for safety and environmental reasons. Incorporating RRR modules into vocational training and strengthening the certification process (perhaps making certification mandatory for servicing certain equipment) are strategies highlighted in the plan. Technicians also need to be trained on handling flammable refrigerants (like R-290, R-600a) safely, as those become more common – safe recovery of hydrocarbons is a new skill set to develop.
- **Incentive Programs:** To encourage reclamation, Bangladesh could implement a buy-back or deposit system. For example, importers of refrigerant cylinders could charge a small levy that is refunded when used refrigerant is returned. Or technicians could be paid a nominal amount per kg of used refrigerant they turn in for recycling. These incentives, funded perhaps through environmental levies on refrigerants, would motivate the extra effort required for recovery.
- **Public-Private Partnerships:** Engaging industry associations (e.g. BRAMA – Bangladesh Refrigerator & Air Conditioner Merchants Association) and large service companies in building the reclamation network is vital. They can help aggregate

recovered refrigerant and manage logistics. Some large air-conditioning manufacturers/service providers might even reclaim refrigerant for their own servicing operations if given the right support.

As of 2025, refrigerant recovery and recycling in Bangladesh remains at a pilot/demo scale – the National Cooling Plan aims to elevate it to a mainstream practice by the end of this decade. By 2030, the goal is to have an operational refrigerant management system such that a significant portion (e.g. 20% or more) of refrigerant used for servicing comes from reclaimed sources instead of new imports. This will not only reduce emissions but also save costs and relieve some pressure on the HFC quota.

In conclusion, while Bangladesh has made strides in reducing the use of harmful refrigerants through transitions in manufacturing, the servicing sector and end-of-life management are the new frontiers. Strengthening recovery, recycling, and reclamation will complement the refrigerant transition pathway – ensuring that even as we phase in better refrigerants, we minimize emissions from the ones already in circulation. The next chapter will delve into the policies and interventions planned to achieve these outcomes, tying together energy efficiency measures with refrigerant management to deliver sustainable cooling for Bangladesh.

4 Cold chain & refrigeration

The cold chain refers to a temperature-controlled supply system that ensures the quality, safety, and integrity of perishable products—from production and harvesting through transport, storage, distribution, and final consumption. For Bangladesh, an effective and climate-friendly cold chain is essential to protect the quality of agricultural produce(potato, onion, fruite, species etc), fisheries, livestock products, pharmaceuticals(vaccine, insuline etc), and other temperature-sensitive goods that contribute significantly to the national economy and public welfare.

Bangladesh's economy is highly dependent on agriculture and fisheries, sectors that are extremely vulnerable to post-harvest losses. It is estimated that a substantial portion of fruits, vegetables, fish, and livestock products is lost due to inadequate refrigeration and poor handling practices. Strengthening cold chain infrastructure offers a transformative opportunity to reduce these losses, increase farmers' incomes, stabilize market supply, and enhance food and nutrition security—especially for low-income and climate-vulnerable communities.

Cold chains also play a critical role in healthcare delivery**.** Bangladesh's pharmaceutical and public health sectors rely heavily on efficient cold storage and distribution systems to maintain the potency of vaccines, biologics, and other essential medicines. Lessons from the COVID-19 pandemic highlighted the country's growing need for reliable, energy-efficient refrigeration solutions to support resilient health systems.

According to the Food and Agriculture organization (FAO), globally, the agriculture sector contributes nearly one-third of total greenhouse gas emissions, and an estimated 30–40% of food produced is lost or wasted. Food loss and waste alone account for roughly 8–10% of global GHG emissions[xii]. In Bangladesh, most food losses occur during post-harvest handling, processing, transportation, and inadequate refrigerated storage—areas where modern cold chain solutions can significantly reduce waste and associated emissions.

At the same time, Bangladesh is highly susceptible to the impacts of climate change**,** including higher ambient temperatures, extreme weather events, and increased electricity demand for cooling. Rising temperatures are already driving higher demand for refrigeration and cold chain services across agriculture, food processing, pharmaceuticals, and retail sectors. This rapid expansion, if not managed sustainably, could lead to increased GHG emissions from both energy use (indirect emissions) and refrigerant leakage (direct emissions). With Bangladesh committing to climate mitigation under the Montreal Protocol, Kigali Amendment, and its NDC, the transition to low-GWP refrigerants and energy-efficient cold chain technologies has become an urgent national priority.

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xii UNEP2021

Despite progress, challenges remain. Bangladesh's cold chain landscape is fragmented, with limited rural cold storage coverage, inadequate refrigerated transport, insufficient technical capacity, and high energy costs. Knowledge gaps in safe food handling, poor maintenance practices, and the heavy reliance on conventional high-GWP refrigerants continue to impede sectoral development.

Bangladehs National Cooling Action Plan (BNCAP) provides a strategic framework to address these challenges and guide investments, policies, and technologies that will shape the country's cooling sector in the coming decades. It emphasizes the need for energy-efficient, climate-friendly, and financially accessible cold chain solutions that align with national development priorities and global environmental commitments.

4.1 Overview of Cold-chain infrastructure

Bangladesh's cold-chain network is dominated by refrigerated warehouse storage for agricultural produce, especially potatoes. Accordingly to the NCP 2020, there are about 427 cold storage facilities nationwide, providing roughly 5.5 million tonnes of storage capacity. These units mainly stock a single commodity (mostly potatoes, including seed potatoes, and occasionally vegetables or spices) under long-term, low-temperature conditions. Modern pack-houses and ripening facilities are largely absent, so cold storage is used for bulk seasonal preservation rather than smooth farm-to-market distribution. Due to the limited reach of cold-chain services beyond potatoes, many fruits, vegetables, and dairy products do not benefit from temperature-controlled handling – leading to significant post-harvest losses. A few multi-purpose cold storages have begun operating in the country, indicating potential to diversify beyond single-crop use and better support farmers and retailers.

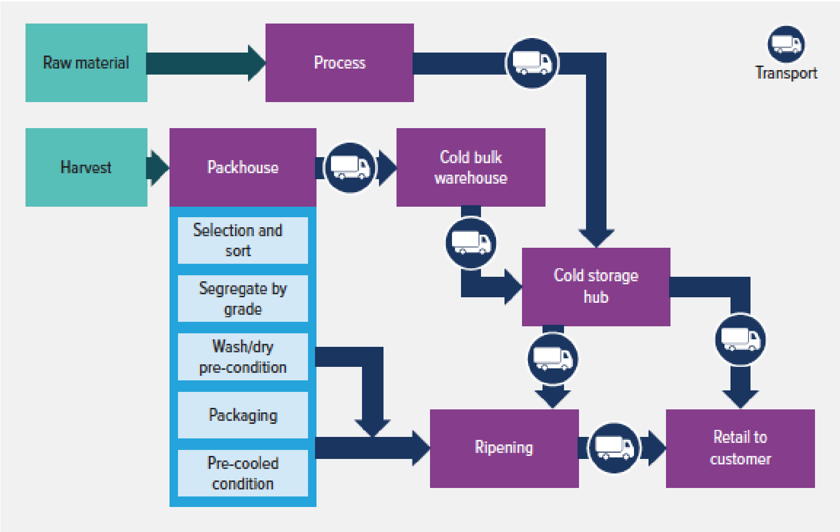

Figure 4-1: Cold Chain components[ii]

The cold-chain for frozen and high-value perishable foods – such as fish, meat, and dairy – is gradually expanding, primarily driven by industry initiatives. Bangladesh's seafood sector now operates around 280–300 fish freezing units for processing and export, utilizing ammonia-based refrigeration systems. To keep fish fresh from catch to market, many fishing communities and wholesalers rely on ice-making plants that supply crushed or block ice, given the shortage of refrigerated trucks in rural areas. Use of refrigerated transport (reefer trucks, vans, and cold boxes) is on the rise in Bangladesh, mainly for delivering frozen foods, icecream and pharmaceuticals to urban centers. The growth of modern retail *"super shops"* (supermarkets) in cities is also boosting demand for reliable cold logistics, as these outlets require steady supplies of chilled and frozen goods. Current study outline that around 1077 super shops (estimated 3.2million square feet floor space) are operating in all over the country where commercial refrigerators dominantly used for the food preservation and display. The market survey during the NCP preparation has estimated that in Bangladesh, about 31 million domestic refrigerator and freezer were locally manufactured or importing since 2010, about 228,000unit of beverage cooler (stand-alone equipment) are installed by several beverage drink brands.

Temperature control is the most critical factor affecting the shelf life of perishable products. Different categories of fresh and frozen foods require specific temperature ranges to maintain quality and minimize spoilage. Refrigeration technology based on a vapor-compression cycle is dominant in cold chain equipment for food processing, storage, transportation, retail stores and households at the temperatures listed in table 1.

Table 4-1: Temperature requirements for food and pharmaceutical products

Temperature Requirements	**Products**
Ultralow(-70°C)	Vaccine, parthmaceutical products, some marine products
Frozen(<-18°C)	Ice cream, frozen meats (fish, poultry, livestock), frozen ingredients, some frozen processed commodities
Chilled (0-10°C)	Fresh fruits and vegetables(potato), fresh meats, milk butter, confectionary, some pharmaceuticals
Mild Chilled (10-20°C)	Fresh frutis and vegetables, chocolates seeds, and some milk products
Normal(>20°C)	Onion, dehydrated foods, pickle, jams and oils extracts

Historically, fluorocarbon refrigerants, namely chlorofluorocarbons (CFCs), (already phased out in new equipment), hydrochlorofluorocarbons (HCFCs), and hydrofluorocarbons (HFCs) have been widely used in cold chain refrigeration equipment except for large and medium-sized cold stores/ warehouses, where ammonia is the refrigerant of choice. Small domestics refrigerator currently using Hydrocarbon (R600a). These fluorocarbons are controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer because they deplete the ozone layer and are significant contributors to global warming.

4.2 Growth Drivers

Bangladesh's large and growing population (about 180.60 million in 2025[xiii]) and steady economic growth are fundamental drivers of cold chain expansion[xiv]. Rising incomes and a

[xiii] BBS, Projected Population at 2025

growing middle class are increasing the demand for temperature-sensitive goods, from fresh produce to frozen foods. Rapid urbanization – with the urban population projected to reach ~86.5 million by 2030 (nearly half of all citizens) – is concentrating consumer markets in cities and straining existing food supply systems[xv]. These trends, combined with a warming climate, are driving up cooling needs. This confluence of economic growth, urban density, and higher heat stress is sharply boosting the need for refrigerated storage and transport to ensure food and medicine reach consumers in good condition.

Increasing Farmers' Income through Preservation: As the cost of farming rises in Bangladesh, there is a growing focus on improving preservation and storage techniques to boost farmers' net incomes. Lacking adequate cold storage or processing facilities, many farmers are forced to sell their harvest immediately at low prices or even discard unsold crops, which undermines their earnings. By investing in modern preservation methods (such as on-farm cooling, cold storages, and food processing), Bangladesh can extend the shelf life of produce and reduce post-harvest losses. This ensures farmers have more time and options to sell their goods – including off-season or distant markets – allowing them to fetch better prices and ultimately increase their income.

Rural Infrastructure Development: Improvements in road infrastructure are making it easier to move crops from farms to markets and storage hubs. Rural roads are considered the *"lifelines"* of Bangladesh's villages, directly contributing to higher agricultural incomes by connecting farmers with buyers and services. Recognizing this, the government's 7th Five Year Plan set an ambitious target to upgrade a majority of rural roads to all-weather standards – raising the share of roads in **good or fair** condition from only 43% in 2016 to 80% by 2020[iii]. Better road connectivity means farmers can transport perishable produce to markets faster and with less spoilage, while also accessing cold storage or processing facilities in nearby towns. This enhanced connectivity not only reduces post-harvest losses during transit but also encourages farmers to scale up production knowing they can reliably get their goods to market.

Growth of Agro-Based Industries: Bangladesh's agro-processing sector has expanded rapidly, creating new demand for farm produce and adding value to agricultural outputs. Over **1,000** food processing enterprises (including more than 250 that export) now operate in the country[xvi], turning crops, dairy, fish, and meat into products like packaged foods, frozen vegetables and fish, fruit pulps, spices, and snacks. The industry has been growing at roughly **13%** per year, with processed food exports climbing about **16.6%** annually– a strong momentum backed by rising domestic demand and government support. Even so, more than **75%** of Bangladesh's harvest is still sold in raw form without processing, which means huge potential remains for further value addition. The proliferation of food

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[xiv] Bangladesh Cold chain investment option analysis, 2024 (USDA)
[xv] The future of Bangladesh's new frontier cities, 2021 (UNDP)

[xvi] The Delta of agro-investment opportunities, Bangladesh Investment development authority

processors from fish and shrimp freezing plants to fruit canneries and spice grinding/packaging units gives farmers more avenues to sell their produce beyond traditional wet markets. This agro-industrial growth in turn spurs investment in supporting infrastructure such as pack-houses (for sorting and pre-cooling), cold storage warehouses, and quality control laboratories. A stronger network of agribusinesses thus acts as a backbone for innovation in logistics and preservation, ensuring farm outputs can be aggregated, stored, and processed efficiently.

Expanding Exports of Frozen Foods & Fish: Global demand for Bangladesh's agricultural products – especially seafood, frozen foods, and tropical fruits – is a major driver for modernizing the supply chain. Bangladesh today ranks among the top global producers of many foods (e.g. 2nd in jackfruit, 3rd in rice and in inland fish) and is a **major exporter** of items like shrimp, frozen fish, vegetables, and dry foods. Agricultural exports have been rising and recently **crossed $1 billion** in annual revenue[xvii] (in fact, combining raw and processed agricultural goods, exports reached *over $1.5 billion* in FY2024). However, to tap into lucrative markets abroad, Bangladeshi producers must meet strict international standards for quality, safety, and consistency. This necessity is pushing investments in cold-chain logistics (from modern frozen fish and foods processing center to cold chain trasnport and shipping container) and in compliance with global food certifications. In short, the pursuit of export opportunities is incentivizing improvements at every step – from farm-level handling to storage, transportation, and processing – thereby driving growth and innovation in the country's agri-logistics and cold-chain infrastructure.

4.3 Cold Chain & Refrigeration Components

4.3.1 Packhouses and ripening chambers:

Packhouses and fruit ripening chambers are relatively new storage concept in Bangladesh's horticulture cold chain. A packhouse is a facility where harvested fruits and vegetables are consolidated and prepared for transport and distribution. Packing is the main activity, but a range of packhouse operations occur before and after packing – including cleaning, sorting/grading, pre-treatments (like washing or hot water treatment), packaging, cooling, and temporary storage. These activities ensure produce quality and shelf-life by quickly removing field heat and culling damaged items, thereby reducing post-harvest losses. Ripening chambers**,** on the other hand, are specialized cold rooms used to induce and control the ripening of fruits (especially climacteric fruits that are harvested mature-green). They allow fruits to be ripened uniformly in a safe, controlled environment – avoiding the harmful chemical methods once common in informal markets. Packhouse Capacities and Technologies in Bangladesh.

In Bangladesh, packhouse infrastructure remains in an early stage of development, with a mix of small pilot facilities and a few larger centres. Typical throughput and capacity vary by scale:

[xvii] https://www.investbangladesh.gov.bd/investment-sector/agribusiness#:~:text=Expanding%20Export%20Markets

- **Small-scale packhouses** – often simple sheds or collection centres for farmer groups – may handle only a few tonnes of produce per day. These usually operate at ambient or near-ambient conditions with basic shade and ventilation, and limited equipment. Some have begun adopting low-cost cooling solutions to provide a small cold storage (often <10 tonne capacity) for short-term holding of produce. For example, the Department of Agricultural Extension (DAE) has piloted several *"mini cold storage"* units of about **10 tonnes capacity** each in mango-growing areas. These small packhouse-linked cold rooms can preserve fruits like mangoes for 2–3 weeks, allowing farmers to delay sales and reduce spoilage.
- **Medium-scale packhouses** – including some public-private ventures – might handle on the order of 10–30 tonnes per day. They typically feature dedicated pre-cooling units (to rapidly remove field heat) and insulated cold rooms for storage. Storage systems in these facilities range from simple refrigerated rooms kept at appropriate temperatures (depending on the crop) to more advanced setups. Controlled atmosphere (CA) storage (where oxygen, CO_2, and humidity are regulated) is still very rare in Bangladesh's fruit/veg sector – most packhouse cold stores use conventional refrigeration (chilled air at produce-specific temperatures) rather than true CA. In the southwest, Jessore – a hub for vegetables and flowers – hosts a BADC Horticulture Center that includes a 50-tonne cold storage for fruits, vegetables, meat and fish. These medium facilities often include all key packhouse activities: receiving crops from farms, sorting and grading by size/quality, cleaning (e.g. removing field dirt or hot-water treatment for disease control), packing into crates or cartons, pre-cooling produce to the cold chain temperature, and finally dispatch to market or airport in insulated/refrigerated vehicles.
- **Large-scale packhouses** – capable of >50 tonnes/day throughput – are still very limited in Bangladesh. There is effectively only one sizable government-operated packhouse facility (near Dhaka). This central packhouse (managed by Hortex Foundation/BADC) is used for inspecting and packing export-bound produce, but it lacks sufficient capacity and modern equipment to handle the growing export volume. Notably, at Hazrat Shahjalal International Airport (HSIA) in Dhaka, there is a dedicated perishable cargo handling area with a 420 m^2 cold storage facility operated by BADC for preserving fresh produce prior to export. Overall, the vast majority of Bangladesh's cold storage capacity (estimated 2.7 million MT across 300+ sites) is devoted to single-commodity bulk storage (primarily potato) rather than multipurpose horticulture packhouses. This leaves a gap in packhouse infrastructure for fruits and vegetables – most domestic markets and collection points do not yet have integrated cold chain facilities.

4.3.2 Potato and Potato Seed Cold Storages:

Potato cold storages in Bangladesh are typically large, insulated warehouses designed for long-term bulk storage of harvested potatoes. Most facilities are single-crop storages dedicated to potatoes, with chambers maintained at chilled conditions (~2–5 °C and high relative humidity ~90%) to prevent sprouting and dehydration during the 6–9 month storage cycle. Warehouses are constructed with thick insulation panels (commonly polystyrene Sheet, ~100 mm) on walls, roof, and floors to minimize heat gain. Chambers are equipped with evaporator cooling coils and powerful axial fans to maintain uniform temperature and humidity. Ventilation control is also provided – e.g. 2–6 air changes per day – to purge CO_2 produced by potato respiration while minimizing warm air infiltration.

Refrigeration systems in Bangladeshi potato storages are predominantly vapor-compression chillers using ammonia (R-717) as the refrigerant. Large facilities typically employ multi-stage reciprocating or screw compressors and evaporative condensers to handle the substantial cooling load. A typical design strategy is to have at least two compressor units – one sized for the steady "holding" load and another to handle the peak load during initial pull-down when fresh potatoes are loaded. To avoid thermal shock to the crop, potatoes are pre-cooled gradually at ~0.5 °C per day from ambient (~20–25 °C) down to the storage temperature around 3 °C. This slow pull-down over ~1–2 weeks reduces stress on both tubers and cooling systems. Each day of the loading period introduces a batch of warm produce (often ~4% of total capacity per day), so the refrigeration plant must be sized for this worst-case heat load. For example, a 5,000 MT store (divided into 4 chambers) may require on the order of 100–120 TR (tons of refrigeration) total cooling capacity to meet peak demand. In practice, the cooling load components include heat gain through the insulated structure, produce respiration heat, sensible heat removal during cooling, infiltration of warm air, plus internal loads from fans, lights, and workers. Modern facilities address these loads with efficient design – high R-value insulation, insulated doors/vestibules, scheduled loading, and proper equipment sizing – to ensure stable storage conditions.

4.3.3 Cold Storage Capacity vs. Potato Production

Bangladesh is a major potato producer – in the 2024–25 season, national potato production is targeted at 12.99 million metric tons (MT). However, cold storage infrastructure falls far short of this volume. As of 2025, the country's total cold storage capacity is only about 3.15 million MT, spread across roughly 384 facilities[xviii]. In other words, only about one-quarter of the annual potato crop could be accommodated in cold storage, leaving the remainder to be sold immediately, stored in traditional/on-farm methods, or risk post-harvest losses. Table 4-2 illustrates the regional breakdown of potato cold storage versus production. The northwestern divisions (Rangpur and Rajshahi) are the potato heartland and accordingly host the bulk of storage capacity. For example, Rangpur alone produces about 25% of Bangladesh's potatoes and has over 1.11 million MT of cold storage space – roughly one-third of the nation's capacity. Rajshahi Division similarly has about 1.19 million MT capacity. The stark gap between production and storage is a critical issue:

[xviii] Department of Agreecultural Marketing (DAM)

farmers often cannot store their surplus, leading to seasonal gluts and distress sales after harvest.

Table 4-2: Regional Potato Production and Cold Storage Capacity in Bangladesh (2025)

SN#	Division Name	Storage Number	Storage Capacity (MT)	Pototo for Consumption(MT)	Potato for Seed(MT)	Total (MT)
1	Dhaka	81	6,19,390	4,46,928	1,30,461	5,77,389
2	Rajshahi	116	11,87,984	8,22,769	3,42,070	11,64,839
3	Khulna	25	1,04,890	72,484	20,829	93,313
4	Chittagong	34	2,02,005	1,33,880	39,521	1,73,401
5	Barishal	2	8,200	2,797	2,662	5,459
6	Rongpur	116	11,18,046	6,27,674	4,81,994	11,09,668
7	Sylhet	4	5,300	1,352	1,635	2,987
8	Mymensingh	6	24,342	16,250	8,092	24,342
	Total	384	32,70,157	21,24,134	10,27,264	31,51,398

Nationally, only about **24%** of the potato harvest can be stored in cold facilities, underscoring the need for expanded and modernized storage infrastructure. The Government's National Cooling Plan under the Montreal Protocol framework highlights opportunities to increase storage capacity – e.g. through **multipurpose cold stores and solar-powered mini-units** – to improve food security and farmer incomes.

4.3.4 Energy Consumption and Seasonal Demand

Potato cold storage is an energy-intensive segment of Bangladesh's food cold-chain. Electricity is used year-round for refrigeration, with a sharp seasonal peak during the post-harvest loading period (typically February–May for potatoes). As new crops fill the stores and are cooled from ambient to 3 °C, refrigeration systems run at maximum capacity and electrical demand spikes. Grid supply in rural areas is often unreliable at these peak times, so many large cold stores rely on diesel generators to maintain cooling, adding to costs and emissions.

BNCAP calcuate the specific energy consumption of storing each ton of potato with the help of the sector expert. On average, storing 1 ton of potatoes for a full season consumes roughly **80–85 kWh of** electricity (depending on storage duration and facility efficiency). For the current sector scale, this translates to an annual electricity usage of about 260 GWh to operate all potato cold storages (for ~3.15 million MT stored). By comparison, this demand – concentrated over a few months – can significantly strain local distribution grids. A typical large cold storage (capacity ~5,000 MT) might have an installed cooling power on the order of 300–400 kW and draw several hundred kWh per ton over the season. Figure 1 below illustrates recent estimates of the sector's energy use and projected growth. As potato production and storage volumes gradually increase, energy consumption is expected to rise 13% from 261 GWh in 2025 to 295 GWh by 2030 further 342 GWh by 2035 under business-as-usual (BAU) practices. This trajectory reflects both higher throughput (more tonnage stored) and the aging, inefficient equipment stock in many existing cold stores. Without intervention, peak electrical demand during the post-harvest period will likewise increase, potentially exacerbating grid stress in agricultural regions.

Table 4-3: Energy consumption and emission from Potato Cold storages

Year	Storage Cap (MT)	Potato Storage Amount(MT)	Cooling Requirment (TR)	Energy Consumption GWh	Emission MtCO2e
2025	32,70,157	31,51,398	1,09,30,202	260.91	0.171
2030	35,14,467	35,68,692	1,23,77,529	295.45	0.193
2035	37,80,717	41,33,323	1,43,35,878	342.20	0.224

To manage seasonal peaks and energy costs, the National Cooling Plan recommends demand-side management and efficiency upgrades. For example, some facilities are exploring thermal energy storage or precooling at night when grid power is more stable. The government (through SREDA and other agencies) is also piloting solar-powered mini cold storages (8–10 MT each) to provide off-grid cooling in rural areas. Over the longer term, replacing outdated compressors and improving insulation/sealing in older large cold stores could significantly reduce the specific energy consumption (kWh/ton). Such measures not only lower operating costs for cold store owners but also shave peak loads – a key co-benefit for the electric grid.

4.3.5 Greenhouse Gas Emissions and Climate Considerations

Potato cold storage contributes to greenhouse gas (GHG) emissions both **indirectly** (through electricity/fuel use) and **directly** (if refrigerant leakage occurs). The indirect emissions are most significant: based on Bangladesh's grid emission factor (~0.62 t CO_2 per MWh), the sector's electricity consumption (~261 GWh in 2025) translates to **roughly 0.17 million tons of CO_2** per year. Direct emissions from refrigerants are comparatively minor in potato storages since most large facilities use ammonia, a zero-GWP refrigerant.

Figure 4-2: Refrigerant Free Potato Cold Storage by Natural Cooling

4.3.6 Not In-Kind cooling technology for potato storage

The *"Alur Bahumukhi Byabohar, Sangrokkhon o Biponon Unnayan Project"* has introduced a cost-effective, non-refrigerated household-level potato storage model to reduce post-harvest losses and improve farmers' income in major potato-producing districts. Under the project, 450 refrigerant free storage houses—constructed using locally available materials such as bamboo, wood, tin roofing and RCC (Reinfoced concrete cement) pillars—have been established to provide approximately 30-ton capacity units capable of safely storing potatoes from February to June. These structures are designed to maintain partial temperature moderation and adequate ventilation through raised bamboo platforms, insulated roofing, and improved lattice walls, enabling farmers to avoid high cold-storage fees and minimise 15–20% losses typically seen in household-level storage. Beyond potatoes, the model houses can also store pumpkin, groundnut, maize cobs, onion and garlic during the off-season, thus enhancing year-round utility. By enabling farmers to hold produce longer and sell at better prices, the project contributes directly to post-harvest loss reduction, increased profitability and improved resilience in Bangladesh's potato value chain.

Table 4-4: Not In Kind Potato Storage capacity

Division Name	Storage No	Storage Capacity (MT)	Storage Qty (MT)
Dhaka	21	630	476
Rajshahi	200	6,420	2,651
Rongpu	318	11,820	6,755
Total	539	18,870	9,882

4.3.7 Cold storage diversification trends

Bangladesh's cold storage sector is gradually diversifying beyond its traditional focus on potatoes, as entrepreneurs and investors turn to multi-purpose cold storage facilities for a wider range of perishables. According to recent data, there are now approximately 52 such cold storages operating across the country, with a combined capacity of around 150,000 metric tons (based on the attached survey of non-potato cold storages). These facilities are used to preserve imported and locally produced fruits – for example, apples, oranges, grapes, and dates – as well as vegetables like carrots, (a significant portion of which are imported), omatoes, onions, and other high-value crops. Betel nut and dry chilies are also recently practiced to store in these units, reflecting a marked shift toward more diversified uses of cold chain infrastructure. This trend is particularly important for fruit importers and other agri-food businesses, who rely on these storages to extend shelf life and stabilize the supply of perishable commodities year-round. By accommodating produce beyond potatoes, the growing network of multi-purpose cold storages is strengthening Bangladesh's food supply chains and demonstrating to policymakers and development partners the critical role of refrigeration infrastructure in reducing post-harvest losses and supporting market linkages for farmers

4.4 Commercial refrigeration

4.4.1 Overview of Super Shops in Bangladesh

Bangladesh's modern supermarket sector (locally known as "super shops") has expanded rapidly over the past decade. There are now roughly 1,077 super shop outlets nationwide**,** operated by about 7–9 major retail chains**.** The largest player**,** Shwapno, alone runs around 800 stores across the country as of 2025, giving it more than 50% of the market share. Other notable chains include Agora, Meena Bazar, Unimart, Daily Shopping, among others. Collectively these supermarkets cover an estimated 3.2 million square feet of floor space nationwide, indicating the substantial footprint of organized retail in Bangladesh's urban and semi-urban areas. This rise of super shops – from virtually none two decades ago to over a thousand outlets today – reflects changing consumer habits and the growing demand for convenient, hygienic food retail options in an urbanizing Bangladesh.

4.4.2 Commercial Refrigeration Technologies in Use

Super shops rely on a range of commercial refrigeration equipment to store and display perishable goods. As per the supershop business owen current 60~55% of the supershop are selling the parishable protein (fresh fish and meat) These technologies can be classified by their temperature regime or purpose (frozen, chilled, or ambient-controlled storage). Typical cooling and freezing equipment installed in Bangladeshi superstores include:

- **Fish and meat display freezers** – low-temperature display freezer for fish and meats display and cooling. To keep the parishiable protiens more fresh they are displayed over the ice flake bed. These are factory sealed item usually operated by R-404A refrigerant.
- **Vegetable and fruit display refrigerators** – medium-temperature coolers keeping fresh vegetables and fruites predominantely operated by R-134a refrigerant.
- **Frozen food display units** – freezers for packaged frozen items (processed foods, ready-to-cook products).
- **Dairy and beverage coolers** – refrigerators for milk, yogurt, cheese, and cold drinks, maintaining chill conditions above freezing. R-134a still dominant refrigerant in this section.
- **Ice cream display freezers** – specialized freezers holding ice cream at less than -20C temperatures, factory sealed unit using R-600a.
- **Ice flake machines** – equipment producing flaked ice on-site, often used for keeping fish or meat products cool in open displays, spcially using R-404A.
- **Cold Room**-singe and double door cold room are installed in comparatevely biggers sizes supers where parishable protien are selling. This units are using R-134a or R404A refrigerant.

In addition to product-specific refrigeration, ambient cooling (air conditioning) is ubiquitous to maintain a comfortable shopping environment and protect temperature-sensitive goods on the shelves. On an average each 100 square feet super shop floor space consume 2TR of air conditioning unit. In practice, each outlet operates in different combination of these equipment to meet different temperature needs – from frozen storage to chilled display – alongside HVAC systems for overall climate control.

Table 4-5: Estimated commercial equipment stock set up in the retail sales network

Types of equipment	Estimated stock	Dominant Refrigerant	Annual Energy consumption/unit KWh
Beverage Cooler	228,000	R-134a	1,000
Icecream freezer	271,000	R-600a	800
Cold room	550	R-404A	10,200
Ice making machine	101	R-404A	5,510
Dairy Product Ref.	248	R-134a	1,500
Fish/meat display	439	R-404A	2,520
Veg./Fruit Display	102	R-134a	2.160

4.4.3 Beverage Cooler and Ice cream display commercial refrigerator:

Beverage coolers and ice cream freezers make up a significant portion of Bangladesh's commercial refrigeration stock, serving vital roles in retail beverage distribution and frozen dessert storage. Recent national surveys estimate (through discussion with the cooling equipment manufacturers, beverage and ice cream producer) about 228,000 beverage coolers are installed across the country, each typically in the 300–500 liter size range, found in restaurants, markets, and convenience outlets. The ice cream freezer stock is similarly large at roughly 271,000 units, predominantly chest-type freezers of 180–380 liters capacity (with ~70% of units between 260–380 L). Historically, both appliance types relied on high-GWP HFC refrigerants – beverage coolers mostly using HFC-134a and older ice cream freezers often built with R-134a as well. However, the sector is now pivoting towards low-GWP alternatives. Isobutane (R-600a) trials in beverage coolers began in 2023 under initiatives by Coca-Cola and local manufacturer Akij, aligning with Coca-Cola's global commitment to HFC-free refrigeration. Meanwhile, most new ice cream freezers in Bangladesh have transitioned to hydrocarbon refrigerants like R-290 (propane) or R-600a, in line with international trends phasing out HFC-134a in small commercial freezers.

The **manufacturing landscape** for these cooling units has evolved considerably in the past five years. Bangladesh's **local production capacity** for beverage coolers and glass-door freezers has expanded, now supplying the majority of domestic demand. Industry data indicate that roughly **60,000 glass-door freezer and baverage cooler units** are domestically manufactured at each year, supplemented by an additional ~**30,000 units** imported to meet remaining demand – a distribution consistent with the high local manufacturing share. The Average life time of the beverage cooler ranging from 5 to 8 years.

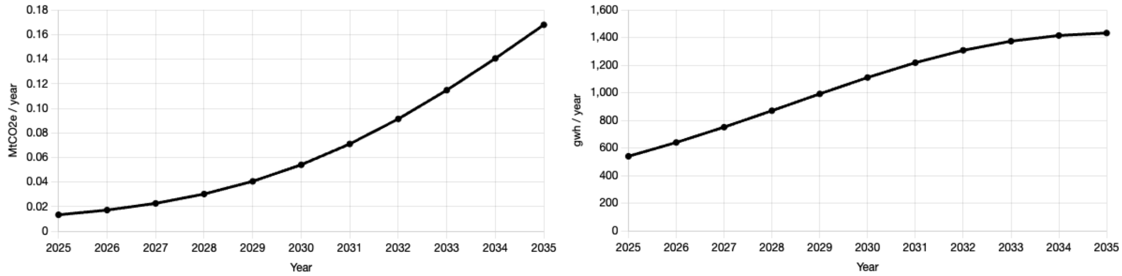

Figure 4-3: Yearly Energy consumption and Direct Emission from the Commercial refrigeration Banks (by Kiali SIM)

Beverage cooler is the dominating energy consumption in the commercial refrigeration segment. The current stock of the commercial equipment specially installed in the retail sales network are estimate over 5million units. The adjust number of cold room could be more operating in different sectors (like fishery, froze food) with other than this retail sales network. Estimated 539GWh electricity is consumed by the commercial equipment why will be 2.65 times higher in next 10 years and hence once of the high emission growth sector need to address by different types of interventions.

3.1 Domestic and household refrigerator

Household refrigerators are now a common fixture across Bangladesh, playing a vital role in the cold chain by preserving food and medicines at the household level. In 2011, only about 12.4% of households owned a refrigerator (around 3.98 million units). Over the past decade, rapid economic growth, rural electrification, and affordable local manufacturing have driven an explosive increase in refrigerator ownership. By 2019, the refrigerator stock was estimated at roughly 28.5 million units, and as of 2023 more than 53.4% of households have at least one refrigerator.[xix] This surge means refrigerators can be found in virtually every corner of the country, including rural areas that were once untapped markets. Annual sales have reached about 2.6 million units in recent years, though growth rates have begun to moderate to 4.7% as the market nears saturation.

Domestic production now dominates the sector. Whereas a decade ago most refrigerators were imported, today Bangladeshi companies supply *95%* of the annual demand. Major local manufacturers have invested in large-scale production, offering competitively priced models tailored to local needs. It has also enabled technological improvements: inverter compressor technology (variable-speed drives) has been introduced in domestic models to improve efficiency. The prevalent refrigerant in Bangladeshi fridges was historically HFC-134a, but manufacturers are now transitioning to environment-friendly refrigerants like isobutane (R-600a) in line with Montreal Protocol goals. All refrigerators must comply

[xix] BBS house hold survey

with national quality standards and carry a BSTI certification mark to ensure safety (electrical and mechanical) and performance in Bangladesh's hot climate.

Energy efficiency of the household refrigeration stock is improving but still has large room for gains. Many older or low-cost units use fixed-speed compressors and standard insulation, consuming on the order of 300–400 kWh per year (for a typical ~200 L fridge). In contrast, modern efficient models with inverter compressors and high-performance insulation can cut consumption by half. According to the refrigerator industry expert, the refrigerator/freezer sector in Bangladesh has the technical potential to **save about 30~40%** of its energy use by adopting these best-available technologies. Recognizing this, the government has introduced an Energy Efficiency & Conservation labeling program for appliances, and refrigerator manufacturers are now beginning to produce higher-rated (e.g. 3-star, 4-star) models. The shift is still in progress – many appliances in use remain relatively inefficient – but the trend is toward lower energy consumption per unit in new sales. Notably, even as efficient technology penetrates, the *total* energy consumption from household refrigeration is rising due to the rapid growth in the number of units. With over half of all households now running refrigerators, this appliance class represents a significant share of residential electricity demand. Improving efficiency across the stock will be critical to limit strain on Bangladesh's power system and reduce emissions from the cooling sector.

4.4.4 Projected Refrigerator Demand and Energy Use to 2030 and 2035

The trajectory of refrigerator adoption indicates that Bangladesh is on course for near-universal access to domestic cooling in the next decade. **Market saturation** is expected by -2035s, as most households that can afford a refrigerator will have obtained one. **By 2030**, experts anticipate on the order of **80–85%** of households owning refrigerators, and by 2035 the figure could approach **near-100%** coverage in electrified areas. In absolute terms, this means the **stock of household refrigerators** will roughly 1.58 times more from current levels.

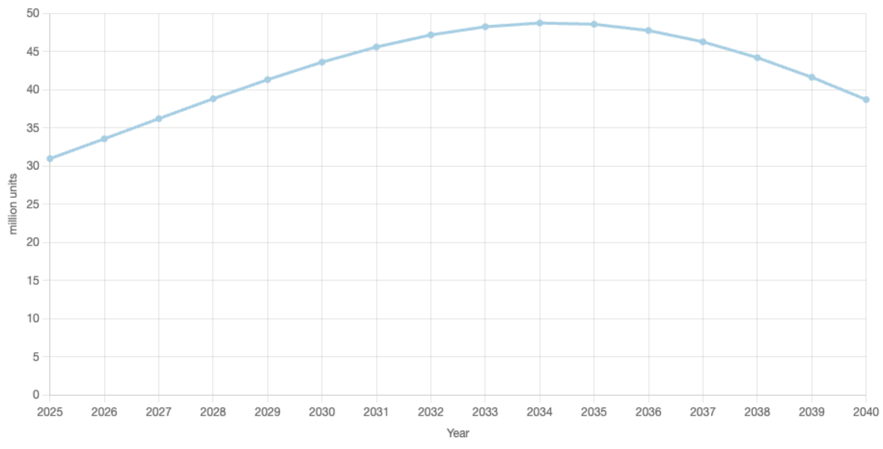

Figure 4-4: Domestic refrigerator Bank projection until 2040 (by Kigali SIM)

During 2035 the numer of refrigerator stock will exceed the total household number, this is because of the penetraion of the domestic refrigeator in the commercial actitives like restaurent, retail shops, hospitals, instittutional house hold. As per the Fast manufacturing and consuming goods(FMCG) manufacture, it is estimated that arround 1.8million retail outlet are operating in bangladesh which are also consuming the domestic refrigerator for storing the beverage and dairy products. Pharmacy sector also using hosehold refrigerator to storing the medicine (insuline, suppositor, injections etc). arround 155,000 pharmacy are registerd by the approval from Directorate General of Drug Administration (DGDA). Recent Hotel and resturent survey 2021 by the BBS shows that total 436,274 hotesl, restaurants and teas stall across Bangaldesh. Of the Total some 344,687 are road side tea stall and 159,393 are in cities and the remainning in the village area. Besides, there are 67,991 fast food shops, 19,637 restaurants and mobile food shops, and 126 catering services across the country. Hotel resturents are consuming big quantity of chest freezers and house hold refrigerators.

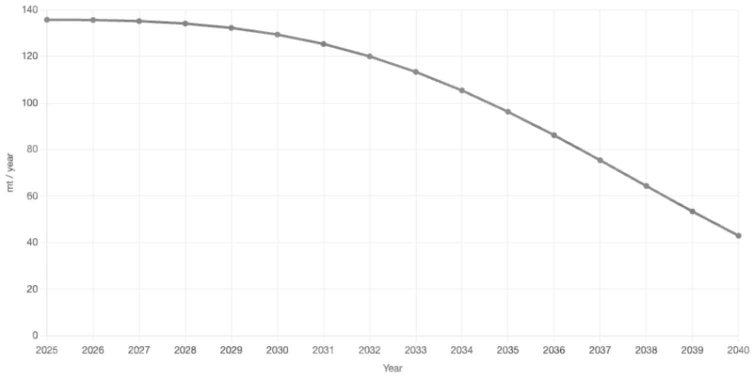

Figure 4-5: Refrigerant required for Servicing the current banks

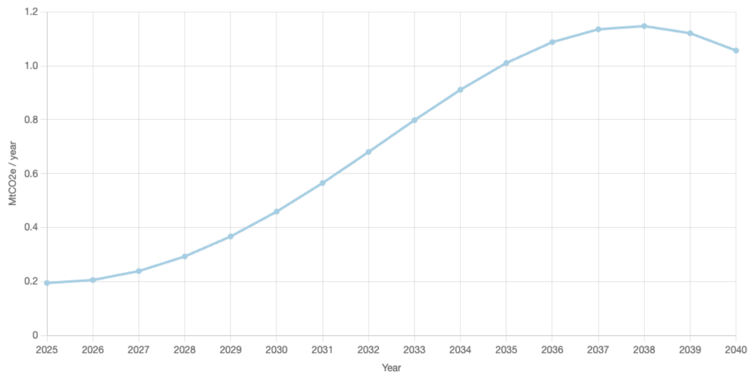

Figure 4-6: Direct Emission from the refrigerant

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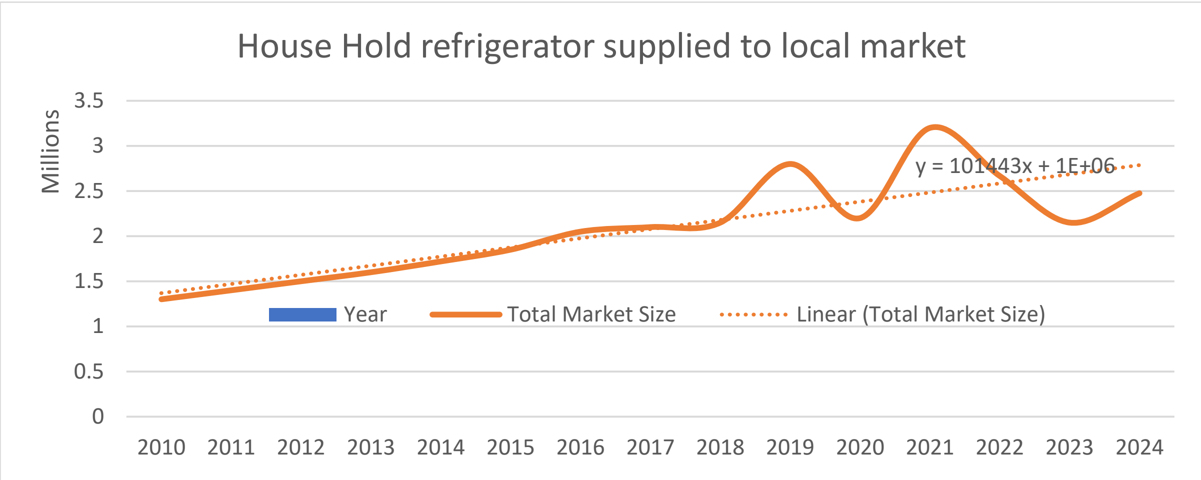


Figure 4-7: House Hold refrigerator supplied to Bangladesh market

Annual sales demand for refrigerators were likely peak in 2021s and then stabilize or slightly decline. In the near term, a few more years of high sales (2.2~2.6) million units per year) are expected as the remaining households purchase their first refrigerator. By 2030, however, sales will be largely driven by replacements and population growth rather than new adoption. Industry projections show yearly refrigerator sales leveling off once saturation is reached – possibly around **3–3.5 million units/year** by 2035 (to replace aging units and supply new households). Notably, Bangladeshi manufacturers like are exploring **export markets** to sustain production growth once domestic demand plateaus. If successful in exports, local production may continue to expand, but domestic **ownership is expected to plateau** at close to full coverage by 2035.

Table 4-6: Export of domestic refrigerator from Bangladesh

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025
Export	512	2308	2787	3181	139602	146,658	37,740	32,884	46,963

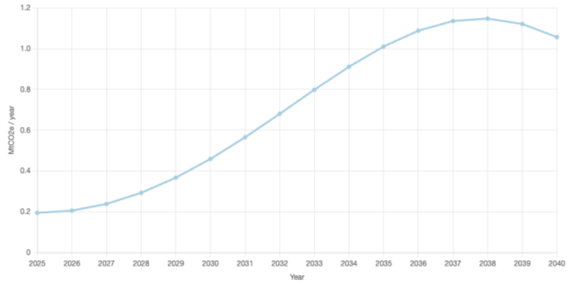
The implications for **energy consumption** are significant. Energy concusmption data are collected from one of the major equipment manufacturer and shown in the table:4-7.

Arround 30~35% of the refrigerator from this sample manufacturer are using inverter compressor which is 25~35% more energy efficient.

Table 4-7: Energy consumption from a major refrigerator manufacturer as per BDS 1850:2024

Refrigerator Volume Liter	Product mix	Yearly energy Consumpption (KWh/year)
125~180	25%	218.74
190~250	60%	318.35
250~660	15%	407

Similar energy consumption test also conducted in another 31 refrigerator(run by induction compressor) from different brands and found that on an average 485 KWh/year energy are consumed. Based on the study it is assemed that an an average R600a base refrigeator consumed 350 KWh/year and R-134a base refrigerator will consume arround 410KWh/year.



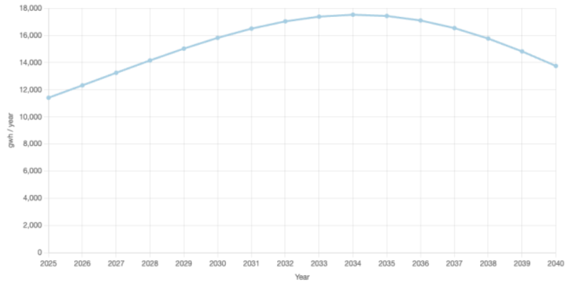


Figure 4-8: Energy consumption and direct emission form the domestic refrigerator project upto 2040

In a business-as-usual scenario with current efficiency levels, the dramatic increase in refrigerator stock would greatly boost residential electricity use. Current refrigerator bank consume arround 11.48 TWh/ year electrocity and projected to 12 and 13.71TWh in 2030 and 2035 . In practice, such an extreme rise will be mitigated by newer appliances being more efficient and by policy interventions. Many of the refrigerators added from 2020 onward are inverter-based or at least moderately efficient, and the oldest, most power-hungry units will gradually retire.

	Unit	2025	2030	2035
Refrigerator Bank	Million unit	30.96	43.40	48.57
Energy Consumption	GWh	11,411	15,823	17,434
Direct emission*	MtCO$_2$e	0.194	0.459	1.0
Indirect emission	MtCO$_2$e	7.07	9.81	10.81
Total Emission	MtCO$_2$e	7.26	10.27	11.81

* *Direct emission from refrigerator leakage and end of life emission. It is reducing during the reduction of R134a base refrigerator banks. Emission from the export refrigerators are not counted here.*

With aggressive efficiency intervention, the energy demand of refrigeration can be curbed even as the stock grows. BNCAP analysis indicates that introducing the new equipment which is 30% more energy effieincent (variable-speed compressors, improved insulation, etc.) should cut energy consumption by 4000GWh in 2030 translating into huge aggregate savings.

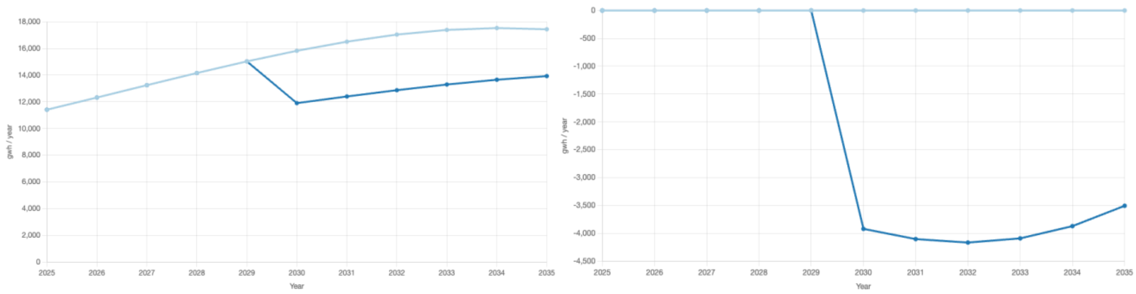


Figure 4-9: Energy efficiency intervention scenario (absolute and relative measurement)

Simulation Condition:

- *50% chance that within 8 years R134a based old stock will be phase out*
- *50% Chance that R600a based equipment stock will be stay in the market for next 12 years*
- *Average Energy consumption of R134a based stock is 429KWh and R600a is 350KWh*
- *Refrigerant Charge in R600a refrigerator is 60gm and R134a 130gm*
- *Refrigerator market growth rate is 5% per year*
- *Export market growth is 20%/ year from 2026 to 2029 and 10% from 2030 to 2035*
- *Expected production in 2025 is 2.5million pcs refrigerator*
- *Intervention scenario: 100% of the new refrigerator will be made by inverter compressor reduce 30% energy consumption*

Minimum Energy Performance Standard:

Critically, **standards and labeling** have been upgraded to lock-in these efficiency improvements. The Bangladesh Standards and Testing Institution (BSTI) introduced an updated refrigerator energy performance standard **BDS 1850:2024**, effective from September 2024. This new standard (which supersedes the 2012 version) defines improved testing methods and more stringent energy efficiency labeling requirements for household fridges. Under the revised BDS 1850:2024, manufacturers must meet **Minimum Energy Performance Standards (MEPS)** and affix energy labels indicating consumption in kWh/year, enabling consumers to compare efficiency. The enforcement of this standard is expected to push manufacturers to optimize insulation, compressor efficiency, and thermostat controls to achieve better ratings. In parallel, initiatives to train technicians in proper refrigerator servicing (e.g., correct refrigerant charging and minimizing energy-wasting faults) are underway as part of broader cooling sector capacity building by

National Ozone Unit. Overall, due to technology changes and standards, **today's new refrigerators are about 40–50% more energy-efficient than those a decade ago**, a remarkable improvement.

4.5 Fish Processing Industry and Ice block production:

4.5.1 Cooling requirement in the fishery sector:

All species of fish, when properly chilled, will stay fresh for longer periods than those that are not preserved in any way. The use of chilling techniques such as ice, therefore, effectively prolongs the length of time available for fishing trips and makes it possible to increase the catch with economic benefits for the vessel and crew. It might be assumed that all types and sizes of fishing vessels would benefit from the use of ice for catch preservation. However, in practice there are limitations. On the smallest types of vessels, such as traditional artisanal boats (like Dinghinaoka, Chandi nauka and Balam nauka) there is no space to keep ice until it is needed. However, this may not be a problem as the fishery undertaken by these very small craft usually only lasts a few hours and fish is consumed or sold on a daily basis.

Many large vessle capable of spending a day or more in fishing oprations will benefit from the use of ice block. Other catagory migh include motorized artisanal fishing vessels and capable for staying as long as two weeks in a single voyage. On small boats portable insulated boxes made of various materials are often used to carry ice to the fishing grounds. Ice is then transferred to the catch in suitable ratios until either all the ice is used, or there is no more space aboard for more fish. Larger boats are able to carry more ice, which allows them to make longer fishing trips, generally with better economic returns for the vessel and crew.

4.5.2 Chilling versus freezing of fish

The use of temperature reduction as a means of preserving fish and fishery products is very important worldwide both for local and export markets. There are many factors to be taken into account when considering the differences between chilling and freezing of fish products for various markets. Both chilling and freezing operations can produce stable products and the choice of one or the other depends on many factors.Chilling is the process of cooling fish or fish products to a temperature approaching that of melting ice. Following table lists some of the advantages and disavantages of the two methods.

Table 4-8: Table 5 1: Difference between chilling and freezing fishery products

Chilling	Freezing
Short-term storage (up to one month maximum for some species, only a few days for others)	Long-term storage (a year or more for some species)
Storage temperature 0 °C	Storage temperature well below zero, e.g. -30 °C
Relatively cheap	Relatively costly
Product resembles fresh fish	If poorly done can badly affect quality
Relatively low-tech	Relatively high tech
Low skills required	High skills required

Low skill required	High skill required
Portable refrigeration	Generally static operations

4.5.3 Use of ice if fish value chain:

In case of fish, cold chain starts from fishing though all sorts of distributions steps and ends to consumers hand, that involves handling, preservation, processing, reprocessing and storage. Cold chain never allows the body temperature to rise beyond 5°C at any cost. Ice is the most important component of cool chain management. Different types of ice are used to cool fish. Ice makers in Bangladesh mainly produce three types of ice, viz., block ice, flake ice and tube ice.

For preservation of fish, mainly block ice is used in domestic distribution chain. Fish and shrimp processing factories need to cool down their raw materials and products promptly. So they generally use fake ice inside the factory. There are more than 400 ice factories in the country producing different sizes of ice block-20kg, 40kg, 80kg, etc. The traditional production of block ice is a batch operation and, once emptied, the cans are refilled with water and replaced in the brine tank for a further freezing period. The cooling's system in most case run by Ammonia system and the tanks containing circulating sodium or calcium chloride brine. The dimension of the can and the temperature of the brine are usually selected to give a freezing period of between 8-24hours.

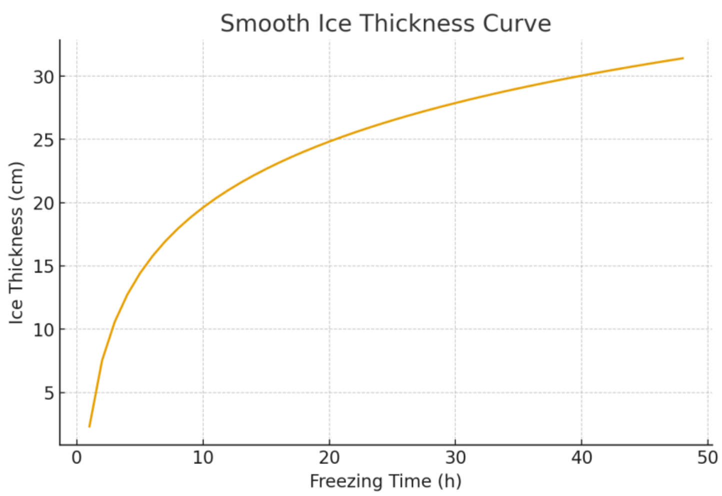


Figure 4-10: Relationship between the thickness of ice produced and the freezing time required, in a typical production of traditional refresh water block ice[xx]

4.5.4 Utilization of fish:

Table shows the utilization status of fish in Bangladesh. Based on findings from "Post-harvest Loss Reduction in Fisheries in Bangladesh: A Way Forward to Food Security" developed under National Food Policy capacity strengthening programme, presently, about

[xx] FAO

55 to 65 % of the fish are consumed fresh as wet fish in Bangladesh. Out of which 20-25% are without ice and 35-40% are with partial icing. Adequate icing is not practiced in fishes except in some value-added items like prawn, shrimp, ilish and other species. A 15-20% fish, mostly low-cost marine, with a few minor carps and small freshwater fish are sun-dried. Calculating the approximate value from export statistics and from the rapid market appraisal of the current study, a 10% fish (including shrimp/prawn) was found to be exported as well as frozen for long time duration consumption.

Table 4-9: Utilization of fish in the country[iv]

Fish and Products	Utilization(%)
Fresh fishwitout ice	20-25
Fresh fish with ice(partial icing)	35-40
Sun dried	15-20
Frozen for export or long duration consumption	10%
Salted, fermented, smoked, fish meal production etc	7-10

The research work by the Department of Fishery explore that 88% fishermen, 77% fish farmer, 27% retailers and 47% fish vendors do not use ice in fish. Among the wholesalers/transporters, 12% use a ice-fish ratio of 1:1 and 44% use a ratio of 1:2. Most of wholesalers, retailers and vendors use a ice:fish ratio of 1:3 to 1:5, which is quite negligible. In case of shrimp value chain, on the other hand, a 80% of the depot holders use a shrimp - ice ratio of 1:1 and 10% of the depot holders/transporters use a shrimp:ice ratio of 5:1. Base on the research finding we could estimate the ice requirement for the chilled fish value chain is arround 702,500MT

Table 4-10: Yearly Ice block consumption estimation

Fish Production (MT) in 2023-2024	
Inland Fisheries	43,89,860
Marine Fisheries	6,28,623
Total Fish Production	50,18,483
Dry Fish Production	67,296
Fish Export	77,407
Fresh Fish direct consumption without Ice (25%)	12,54,620
Fresh Fish with Ice(Partial Icing) (35% of the production)	17,56,469
Frozen Fish (less than -18°C), MT	5,01,848
Estimated yearly ice consumption (considering 40% ice with 60% of fish), MT	7,02,587

4.5.5 Energy Consumption in ice making

Ice has a large cooling capacity per weight, is relatively cheap, prevents drying by keeping the fish moist, is easily portable, and maintains a temperature slightly above freezing point of fish without the need for sophisticated temperature control. Block ice is the type most commonly produced in Bangladesh, using simple, accessible technologies. Cooling capacity of different types of ice is similar in weight terms but differs by ice volume owing to density differences. The cooling and melting rate varies with type, depending primarily on surface area, which for flake ice is over four times that of tube ice, weight for weight. This is advantageous for rapid cooling of fish but disadvantageous for losses during transport and storage. For this reason also, block ice is normally transported whole, and only at point of application is it crushed or chipped to smaller pieces. For bulk and boxed stowage, an ice to fish ratio varies between 1:2 and 1:1 depending on climate and intended keeping time. Energy use for ice production depends on ambient conditions and feed water temperatures. Table shows approximately energy use per tonne of ice produced. When running to capacity, large plants are more efficient than small plants, although this also depends on the refrigeration technology, refrigerant and the age and maintenance level of the plant. For greatest efficiency, continual ice production is desirable but the demand may fluctuate daily or weekly, and some storage is usually required.

Table 4-11: Energy consumption and recommended use of differen[xxi]t types of ices

Type of Ice	Specific energy consumption KWh/ MT	Recommended ice use per MT fish
Flake	70-85	1.7
Plate	60-75	1.7
Tube	60-75	1.9
Block	55-70	2.0

Electricity consumption in the ice making plan verifies significantly based on the production capacity and the insulation of the brine storage tank. Also in Bangladesh used scrap ship compressor is used for the cooling generation by using ammonia. Ice factory in Bangladesh required licensing from Fishery quality and inspection Department under Department of fisheries. In 2024 total 58 ice making plant license holding enterprise were running their business in Chittagong region. Production capacity study based on the data collected from 38 ice block making factory are shown in the following tables

Table 4-12: Ice block Production capacity classification located in Chittagong division

Daily Production Capacity	No of Factories	Percentage
Less than 20MT/day	24	63%
21-30 MT/day	2	5%
31-40MT/day	4	11%
More than 40MT/day	8	21%

Based on the reference study from Bureau of energy efficiency (BEE), Ministry of power, India[v] specific energy consumption per ton of ice manufactured for each category is presented in the Table 4-13

Table 4-13: Specific Energy consumption pattern of ice factories

Daily Production Capacity	Specific Energy Consumption (KWh/ton)
Less than 20MT/day	83
21-30 MT/day	102
31-40MT/day	114
More than 40MT/day	118
Weighted average	94.63

[xxi] FAO

The specific energy consumption in ice plan depends upon operational parameters, percentage utilization with respect to installed capacity. It is estimated that on an average 94.63KWh/ton of electricity in required in a typical ice block making factory.

Table 4-14: Emission estimation from ice block production sector

	2024	2030	2035
Total Fish Production (MT)	50,18,483	57,79,597	64,13,859
Estimated Ice Consumption(MT)	7,02,588	8,09,144	8,97,940
Energy Consumption (GWh)	66.49	76.57	84.97
Emission (KtCO2 equivalent)	0.041	0.047	0.053

4.6 Frozen Fish processing industry

Bangladesh's fish and seafood processing industry – especially frozen shrimp and fish for export – is a vital part of the national economy. It supports hundreds of thousands of livelihoods in coastal regions (Khulna, Bagerhat, Satkhira, Chattogram) and remains among the country's top export earners. In FY2024-25, exports of frozen shrimp and fish rebounded to USD 388.7 million, a 19% increase after several years of decline. Shrimp dominates these exports (23,238 tons worth USD 296 million in FY25), with frozen fish contributing USD 92.4 million.[xxii] This growth has been credited partly to investments in modern processing and cold-chain facilities meeting strict EU, US, and Japanese standards. Only 30–40 of 110 licensed processing facilities are currently active, and barely 10 operate at full capacity. Limited financing, aging technology, and inadequate cold-chain infrastructure have left many plants underutilized.

4.6.1 Key Freezing and Cold Storage Equipment for Fish and Shrimp Processing plant:

Seafood processors in Bangladesh (especially export-oriented shrimp plants) employ a range of freezing systems to rapidly chill and freeze products while preserving quality. The main equipment includes blast freezers, spiral freezers, plate freezers, cold storage rooms, **and** IQF (Individual Quick Freezing) systems. Each serves different purposes:

Blast Freezers (Air Blast Freezing): A blast freezer (or shock freezer**)** uses powerful cold air circulation to rapidly freeze products. In a typical air-blast freezer, food is exposed to very cold air (often –35 °C to –40 °C) blown at high velocity by fans. This quick chill prevents large ice crystals from forming, thus protecting texture. Blast freezers come in various configurations: batch cabinets (small rooms or cabinets where racks of product are placed and blast-chilled), or continuous tunnel freezers where products move on belts or trolleys through a freezing chamber. They are very versatile – able to freeze seafood in boxes, trays, or even unpackaged (e.g. whole fish). In Bangladesh, many older plants had

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[xxii] Bangladesh Frozen Food Exporters Association

blast freezers for shrimp and fish fillets. They typically freeze product to –18 °C core temperature within a few hours. Blast freezers usually use ammonia evaporator coils.

Spiral Freezers: A spiral freezer is a continuous system where products are conveyed on a spiral-tiered belt inside an insulated chamber with cold air. The belt winds upward (or downward) in a spiral stack, maximizing product dwell time in a compact footprint. Spiral IQF freezers are widely used for seafood like fillets, shrimp (especially when individually quick frozen), and prepared foods. Spiral freezers are prized for energy efficiency and gentle handling. In Bangladesh, a few large shrimp processors have begun installing spiral freezers (particularly for IQF shrimp or breaded shrimp production), but they are still less common than plate or blast freezers in older plants. Spirals typically require a central refrigeration system (often ammonia-cooled evaporator coils) due to their large capacity.

Plate Freezers: A plate freezer uses direct contact between the product and metal plates cooled by refrigerant to freeze food rapidly and uniformly. In Bangladesh's shrimp industry, horizontal contact plate freezers are widely used to make 2 kg or 5 kg frozen blocks of shrimp or fish fillets. A modern plate freezer can freeze a 2 kg block of shrimp in ~2–4 hours at –40 °C plate temperature, producing high-quality frozen blocks. In practice, many Bangladeshi plants have several plate freezer units, each with maybe 200–500 kg per batch capacity, cycling a few batches per shift. A notable advantage is energy efficiency: Plate freezers can use up to 40% less energy than equivalent blast freezers for the same loa. Bangladesh historically exported a lot of block frozen shrimp (mostly to Japan and other markets) using plate freezers. Even as IQF grows, plate freezing remains important for certain products and for cold storage of raw materials. Most plate freezers in Bangladesh's industry are ammonia-cooled, hooked to central refrigeration plants.

IQF Systems: Individual Quick Freezing (IQF) refers to freezing products as separate small pieces, so they do not clump together. This is crucial for products like peeled shrimp, where end-users want to defrost only what they need. IQF is achieved by freezing items individually and rapidly, often on a moving belt or in a fluidized bed of cold air. Typical IQF tunnel freezers can achieve core temperatures of –18 °C in well under 30 minutes, even for small shrimp. IQF freezers in Bangladesh are found in most large export plants now – often a 1–2 ton/hour capacity IQF line for shrimp.

Cold Storage Rooms: Cold storage rooms are large refrigerated warehouses (or chambers) where frozen products are stored at a stable low temperature (usually –18 °C to –25 °C for seafood). In an export plant, after shrimp or fish are frozen (by blast, plate, or spiral), they are moved to on-site cold storage holding rooms until shipment. These rooms are typically well-insulated and equipped with evaporator fan-coils to keep air at freezing temperature. Cold storage doesn't freeze product (that should already be frozen); it maintains frozen stock often for weeks or months. Seafood export plants usually have their own cold rooms sized to their throughput (some large plants have 1,000+ ton capacity on-site). Cold stores in fisheries often use ammonia refrigeration (large systems) or sometimes Freon (HFC) systems for smaller rooms.. Key challenges for cold rooms are to minimize temperature fluctuations, ensure reliable power (diesel backup generators are common), and avoid overloading beyond capacity. Properly maintained, cold storage at –20 °C can keep fish quality high for many months.

Overall, each of these equipment types plays a role in Bangladesh's seafood cold chain. Blast freezers and plate freezers have been the backbone of the industry for decades (block frozen shrimp and fish), while IQF spiral/tunnel freezers represent modern advancements catering to market preferences for quality and convenience. Cold storage links it all, enabling stockpiling and steady supply to markets.

4.6.2 Energy consumption in fish processing sector:

Expect some exception most of the frozen fish processed in Bangladeh is export oriented. The study survey in India and pakistan found that the power load of a fish processing plant varies from 300 to 550 kW.[vi] Disussion with the major fish processing industries in Bangladesh also suggest that on an average of 600KWh/MT electricity is required to process and stroge different types of frozen shrimp and fish dedicated for export.

Table 4-15: Emission from the Frozen Fishery production and export

Year	Frozen Shrimp/ Prawn (MT)	Frozen Fish (MT)	Energy (GWH) Consumption	Emission (MtCO2 equ)
2019	30,036	10,008	24.03	14.90
2020	30,615	13,022	26.18	16.23
2021	30,571	8,797	23.62	14.64
2023	25,143	9,289	20.66	12.80
2024	19,131	8,909	16.82	10.43
2030 (est)	25,000	10,000	21.00	13.02
2035(est)	30,000	13,000	25.80	16.00

4.6.3 Refrigeration systems energy improvement potential

The proposed measures to improve energy efficiency in block ice block plants and fish product processing plants include using variable speed compressors, electronic expansion valves, premium efficiency motors, and variable speed motors for fans. Other measures include wall insulation for cold stores inside processing plants and the insulation of brine solution tank and pipelines. The proposed measures are for the upgrade of the equipment to a better performance based on the full-load capacity of the equipment. The equipment presently installed will work at full capacity irrespective of the actual refrigeration load. The proposed changes using variable speed drives will use less energy to run the equipment if it is not required to deliver full load refrigeration capacity. Energy can be savee by adopting certain technologies:

Table 4-16: Energy efficiency improvement scope for fish and ice processing industry

Component	Impact
Variable speed drive (VFD) compressors	10% energy efficiency improvement for fish processing plants and 22% for ice block plants
Expansion valves	About 5% reduction in power consumption can be achieved

	using electronical expansion valves
Premium efficiency motors	3-4% reduction in power can be achieved by using premium efficiency motors
Variable Speed Drives (VFDs) for evaporators & condenser Fans, and water pump of ice machines	2-4% reduction in power can be achieved by installing VFDs for evaporator and condenser fans
Wall Insulation Additional	15% in energy efficiency can be achieved by replacing conventional insu
Insulation of Brine Solution Tank and Pipelines	Additional 5% energy efficiency can be achieved by proper insulation
Use of Renewable Energy for Power Generation	Using roof top solary and net metering in fish processing and ice plan can reduce demand on the grid by 20%

Energy efficiency of refrigeration systems depends on the choice of refrigerant and the choice of components, while the application of energy efficiency is supported by the proper standards. Guidelines on refrigerants, components, and standards were developed.

- Low GWP refrigerants used in the cold chain include ammonia, which is almost exclusively used in the ice and fish processing sector in Bangladesh, making a transition to other refrigerants unnecessary. Considering that future expansion of the use of mechanical refrigeration might include other refrigerants, an exposé of climate-friendly, high-efficiency refrigerants like carbon dioxide, hydrocarbons, and low GWP halogenated refrigerants was prepared listing their advantages and their applicability to the different parts of the cold chain i.e., vessels, ice plants, processing plants, cold storage, transportation, and commercial refrigeration.
- The choice of components contributes to energy efficiency. Screw compressors are generally more efficient than the reciprocating compressors, which are mainly used in Bangladesh's fisheries sector. Components that enhance energy efficiency like variable speed drives and dedicated controls can be applied as upgrades to existing systems. Other components and measures include introducing mechanical or vapor injected subcooling, variable capacity, compressors, evaporative condensers, and heat recovery systems.

4.7 Industrial Fishing Vessels:

4.7.1 Stock and Role of Onboard Refrigeration

Bangladesh's industrial marine fishing fleet consists of roughly 230–250 steel-hulled trawlers equipped with mechanical refrigeration systems[xxiii]. These vessels undertake multi-day voyages in the Bay of Bengal, catching fish (and shrimp) in offshore waters and relying on onboard cooling to preserve the catch. Unlike the numerous small wooden boats that use ice for fish preservation, industrial trawlers carry built-in freezers or chillers to rapidly cool and store fish at sea. This capability allows higher-quality fish preservation (often for export), enabling longer trips and maintaining freshness that would be impossible with ice alone. For example, modern Bangladeshi trawlers have integrated

[xxiii] Bangladesh Marine Fishery Association

slurry ice machines, chillers, and blast freezers that can bring fish core temperatures down to –50 °C, ensuring premium quality upon landing. In recent years these industrial vessels have contributed around 20–22% of the marine fish catch (about 116,000–146,000 tons annually in FY2023–25)[xxiv], making them a critical component of the cold chain for seafood despite being far fewer in number than artisanal boats.

Refrigerant Types, System Sizes, and Transitions

Onboard refrigeration in these vessels historically relied on ozone-depleting HCFCs (primarily R-22), and many older systems still use R-22 for fish hold chillers or plate freezers. However, the dominant refrigerants in newer or retrofitted fishing vessels are high-GWP HFCs. In particular, HFC-404A is widely used for low-temperature freezers and cold storage on trawlers. Surveys show a steady rise in R-404A use in Bangladesh's marine vessels, from ~4 MT in 2020 to ~8 MT in 2022, reflecting a transition away from R-22. Some vessels may also use HFC-134a in auxiliary chilling systems or air-conditioning, but R-404A remains the workhorse for freezing due to its suitability for –20 °C to –40 °C ranges. A few legacy systems used R-502 (an obsolete CFC/HCFC blend) in the past, now largely phased out. Ammonia (R-717), a zero-GWP refrigerant common in shore-based fish processing freezers, is not used onboard due to toxicity and safety concerns. Instead, all **280–300** coastal fish freezer installations in Bangladesh (mostly onshore) use ammonia for main refrigeration and R-22 for pre-cooling, whereas on vessels HFCs prevail. The typical refrigeration capacity of industrial trawlers ranges from tens to hundreds of kW. For example, a mid-size 56 m fishing vessel can have over **100 TR** (~350 kW) of total cooling capacity spread across multiple compressors. Refrigerant charge volumes per vessel vary with system size – a smaller trawler's chill store might hold on the order of 50 kg of refrigerant, while a large deep-sea freezer trawler could require a few hundred kilograms in a cascade of compressors and brine coolers (meaning leaks from these systems can be very consequential). There is an emerging trend toward lower-GWP alternatives: the national HFC survey recommends promoting refrigerants like HFC-452A (which has about half the GWP of R-404A) or even CO_2-based systems in new fishing vessels. In practice, adoption of such alternatives is still nascent – most existing vessels continue to operate on R-22 or R-404A – but future new-build trawlers are expected to consider natural refrigerants or HFO blends as technology becomes available.

Energy Consumption of Onboard Cooling

Mechanical refrigeration on fishing vessels is energy-intensive. Freezing and chilling equipment run off diesel-driven generators onboard, drawing substantial power especially during active freezing of catch. A newly-built 42 m deep-sea trawler, for instance, is outfitted with an **800 kW** generator set largely to support its refrigeration and processing systems. Typical mid-size trawlers (40–60 m) may have refrigeration compressor motors totaling 50–300 kW in capacity, depending on whether they only chill fish in ice/slurry or

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[xxiv] Department of Fishery

blast-freeze large volumes. As a result, the fleet's aggregate energy use for cooling is significant. Based on industry benchmarks, roughly **380 kWh of electricity** is required to freeze and store each tonne of fish product[vii]. Using this metric, the current industrial fleet – which landed on the order of **0.12–0.15 million tonnes** of fish per year in recent seasons – would consume on the order of **45–55 GWh** of energy annually for onboard refrigeration. (In other words, each large fishing trawler may use several hundred megawatt-hours per year for its cooling systems.) This energy demand is additional to the vessels' propulsion fuel use and is a key component of the cold-chain energy footprint in the fisheries sector.

Table 4-17: Overall fish holding and cooling capacity of the industrial fishing vessel in Bangladesh

Net Capacity	Ship Number	Total Storage Capacity(MT)	Average Cooling Capacity (KW)	Refrigerant (Kg)
Less than 100Ton	55	3819	28.57	14
100-200Ton	94	13360	58.48	28
200-300Ton	26	6614	104.66	51
300Ton Above	4	1596	164.16	80
Total	179	25389		173

4.7.2 GHG Emissions from Vessel Refrigeration

Direction emission from the fishing vessel is compartievely high compare with the other equipment. Maring equipment are continuely operating in high vibration and sea rolling condition as in salty weather condition. The factory continutes higher leakage rate from the equipment. The estimation is based on 10% leakage rate per annum, how ever in actual practice this amoung may be signifantly very based on the sea voyage duration and the quatity of fishing, storage and run time of the equipment. Indirect emission is calcuated based on 0.70kg/KWh energy consumption due to the electrcity generation by marine desel generator.

Table 4-18: Energy consumption and emission from the industrial fishing vessel in Bangladesh

		2025	2030	2035
Fishing Qantity	MT	1,34,242	1,47,150	1,60,058
Energy Consum.	GWh	51.01	55.92	60.82
Indirect Emission	MtCO2e	0.036	0.039	0.043
Direct Emission	MtCO2e	0.012	0.013	0.014
Total Emission	MtCO2e	0.048	0.052	0.057

5 Space Cooling

5.1 Background

Bangladesh’s demand for space cooling is rising rapidly due to a confluence of factors: a hot and humid tropical climate, economic growth, urbanization, and global warming trends. This surge is driven by rising living standards and expanding infrastructure: as incomes grow and electrification reaches virtually all communities, more households are acquiring cooling appliances for the first time. Several drivers are propelling this rapid expansion of the AC sector:

- **Rising Incomes and Urbanization:** Bangladesh’s sustained economic growth has expanded the urban middle class, many of whom are now able to afford ACs for the first time. AC ownership is seen as both a comfort upgrade and a status symbol for upwardly mobile families. Continued urban population growth (and higher urban heat island intensity) is boosting AC demand in cities.
- **Increasing Hot Seasons and Heatwaves:** Higher average temperatures and more frequent extreme heat events have made cooling a necessity rather than a luxury for many. Households that previously managed with fans are finding electric fans insufficient during hot spells >35 °C, leading to greater AC adoption for health and comfort. The Bangladesh Meteorological Department projects more frequent heatwaves extending beyond the traditional summer, which is likely to further increase seasonal demand for ACs.
- **Improved Electricity Access:** Near-universal electrification and more reliable power in both urban and rural areas have created the enabling environment for AC usage. By eliminating the barrier of power availability, rural and peri-urban households are now entering the market for cooling appliances, especially as grid upgrades reduce voltage fluctuations that could damage AC units.
- **Local Manufacturing and Lower Costs:** Importantly, over 95% of ACs sold in Bangladesh are now assembled or manufactured domestically. Major local brands (e.g. Green, Walton, Medea, Haier, Samsung, LG, Singer, Marcel, Vision, Jamuna etc) have entered the AC market, benefitting from tariff protection and growing local component assembly. This has driven down retail prices making ACs more affordable to middle-income consumers. Local production has also improved after-sales service networks, boosting consumer confidence.
- **Consumer Credit and Marketing:** Appliance financiers and retailers are increasingly offering installment payment plans (EMIs) and aggressive marketing, which lower the upfront barrier for consumers. This, combined with aspirational advertising, has spurred more families to consider AC purchases to improve living standards.

5.2 Residential sector Air Conditioning

The domestic air conditioning (AC) sector, while still in a nascent stage in terms of household penetration, is poised for significant growth. Both the split types and window types within 5 Ton cooling capacity are referred as Unitary Air conditon. Recent study illustrate how quickly Unitary AC ownership is expanding: in 2020 total unitary air condition total bank was 2.35 million, whereas by 2025 this had risen to 4.59 million unit.

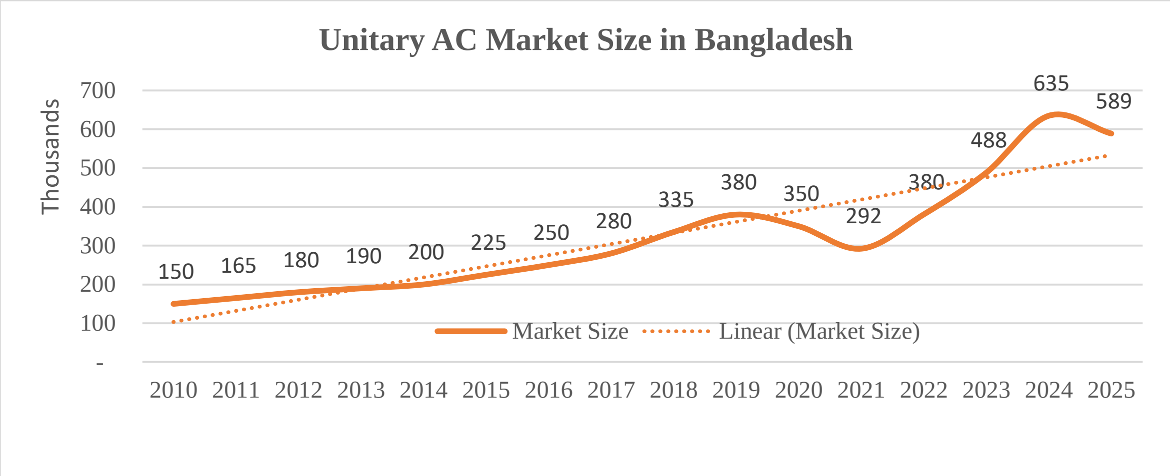

Figure 5-1: Unitary AC Market Trend in Bangladesh

This growth, however, brings policy challenges. Space cooling already contributes substantially to peak electricity loads, and its expansion could strain generation capacity and increase greenhouse gas (GHG) emissions. Without interventions, space cooling by unitary AC- electricity use is projected to about 25.76 TWh by 2030. Such an outcome would drive up indirect emissions (from power generation) and exacerbate fiscal pressures through higher energy imports or subsidies. In parallel, increased use of vapor-compression ACs risks a rise in direct emissions from refrigerant leaks, if high GWP gases remain prevalent

5.2.1 Market Trends and Growth Drivers

The residential AC market in Bangladesh has been experiencing double-digit annual growth, albeit from a low base. Annual unit sales have surged in recent years, reaching approximately 635,000 AC units sold in 2024, up sharply from ~488,000 units in 2023**.** This momentum briefly tapered in 2025 due to economic headwinds, but the underlying trajectory remains upward. Industry reports project continued growth of over 8% per year in the near term. Under such growth, the installed stock of ACs could approach 10 million units by 2035 (equivalent to ~17–18 million TR of cooling capacity) – a transformative increase in the span of a decade.

Table 5-1: Unitary AC bank and production in 2025

	HCFC-22	R-32	R-410a	Total
Equipment Bank	2,205,335	804,281	995,644	4,005,260

Production in 2025		453,378	135,424	589,000

A few number of AC has been exporting to the global market since 2020. The progress of the export is quite optimistics.

Table 5-2: Export of Unitary Air Condition from Bangladesh

Year	2025	2024	2023	2022	2021	2020
Export	2,159	1,130	411	1,952	6,073	6,514

The growth of domestic AC ownership has a direct impact on electricity consumption. Although current residential AC usage contributes a modest portion of total national power demand, it is growing rapidly. Consultation with the major air conditon manufacturer in Bangladesh, it could be estimate the energy consumpiton and market share of different types of untiary AC are shown in Table 5-2

Table 5-3: Market Share among different Capacity Unitary AC

Capacity	Energy Consumpiton(KWh)	Market Share
12000BTU	2022	22%
18000BTU	3170	55%
24000BTU	4023	20%
36000~60000BTU	6000~8,000	3%

Energy effieincy awarness by the upper middle income and high income level customers boost up the demand of the inverter AC. After discussion with the market expert it could be estimated that the ratio of inverter vs induction AC is 1:1. However the price of the inverter AC is 15~20% higher than the current induction compressor. This extra price gap will cause the slow penetration of the inverter AC to the market.

5.2.2 Current Technologies and Emissions

Presently, there is a wide range of AC energy performance in the market. Locally produced or imported economy models may have an Energy Efficiency Ratio (EER) on the order of 2.5–3.0 (i.e. relatively high electricity use per unit cooling), whereas modern inverter models can achieve EERs of 3.5 or higher. Bangladesh has developed Minimum Energy Performance Standards (MEPS) and a labeling program for appliances including room ACs, led by the Sustainable and Renewable Energy Development Authority (SREDA). These standards – still being finalized and implemented – aim to remove the least efficient AC models from the market and guide consumers toward higher efficiency options. The Energy Efficiency & Conservation Master Plan (2015) estimated large efficiency improvement potentials in cooling: for instance, typical AC systems could achieve 50% energy savings by using high-efficiency components like micro channel heat exchangers, variable-speed drives, electronic flow control valve etc.

Room air conditioners in Bangladesh historically used HCFC-22 (R-22) as the refrigerant – . Under the Montreal Protocol**,** Bangladesh is obligated to phase out HCFC-22 by 2030 (with interim reduction targets of 35% by 2020 and 67.5% by 2025). Accordingly, the market has been transitioning to alternative refrigerants. Many newer AC models, especially those assembled domestically in the past few years, use HFC blends like R-410A or lower-GWP HFCs such as R-32 Table 5-3 below summarizes common refrigerants in the Unitary AC sector manufacturing sector:

Table 5-4: Share of refrigerant in Unitary AC manufacturing Sector

Year	R22	R410a	R32
2020	66%	29%	5%
2021	28%	62%	10%
2022	30%	46%	24%
2023	25%	23%	52%
2024	4%	31%	65%
2025	0%	23%	77%

In summary, the current domestic AC sector is characterized by rapidly improving technology (with efficiency gains and refrigerant transitions underway), but also legacy inefficiencies and practices that heighten its emissions profile.

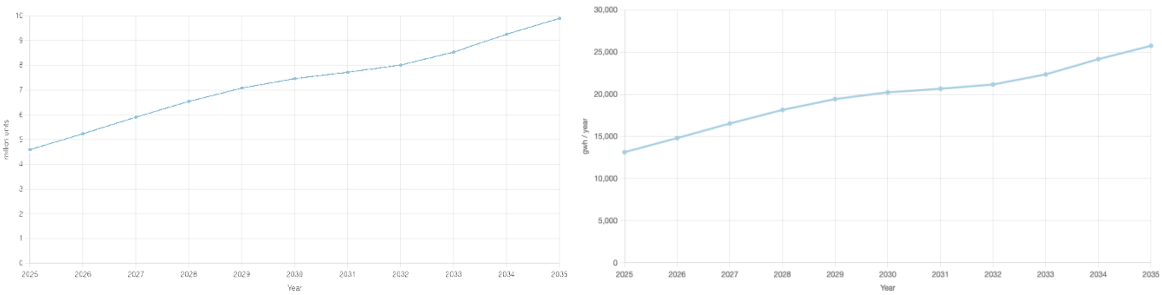

Figure 5-2: Energy Consumption and Bank Projection of the Unitary AC (Kigali SIM)

Emissions Scenarios and Mitigation Impact: Policy modeling in the cooling plan outlines two contrasting scenarios for the domestic AC sector: a “Business-as-Usual (BAU) scenario” versus a “Mitigation scenario” with interventions. Under BAU (high growth, no additional efficiency improvements), the GHG emissions from residential AC would double by 2035. Direct HFC emissions would grow as the stock of ACs grows, even as R-22 is replaced by HFCs.

Table 5-5: Energy Consumption and emission from the unitary AC at BAU condition

	UOM	2025	2030	2035
Bank	Millon	4.59	7.98	10.52
Energy Consumption	GWh	13,131	21,768	27,636
Direction Emission	MtCO2e	0.36	1.07	2.33
Indirect Emission	MtCO2e	8.14	13.50	17.13
Total Emission	MtCO2e	8.50	14.57	19.46

In the mitigation scenario, a suite of measures bends this curve downward. On the refrigerant side, adherence to Kigali schedules and adoption of low-GWP refrigerants could avoid the majority of direct emissions growth. For example, phasing down HFCs from the Unitary AC manufacturing sector could reduce 0.5MtCO2e emission from this sector in 2035. Another

Table 5-6: Potential of Emission Reduction after manufacturing line conversion under KIP Stage I

KIP Manufacturing Line Conversion Project (2027-2030)				
	UOM	2025	2030	2035
Energy Consumption	GWh	13,132	21,768	27,387
Direction Emission	MtCO2e	0.363	1.077	1.978
Indirect Emission	MtCO2e	8.14	13.496	16.98
Total Emission	MtCO2e	8.504	14.274	18.96

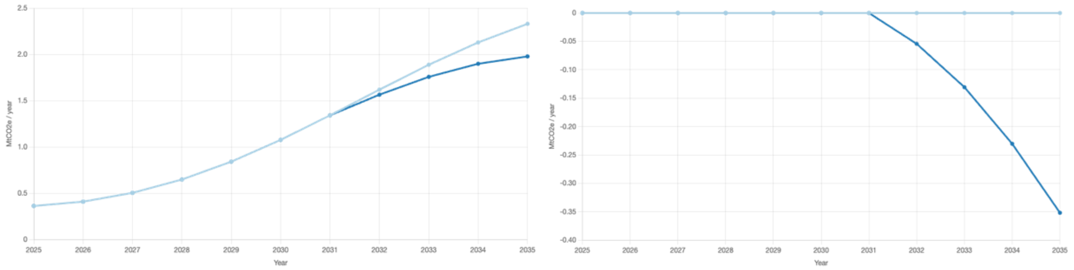

Figure 5-3: Reduction of Direct Emission through phasing out of R-410 from Air condition manufacturing sector (Kigali SIM)

5.3 Commercial Space Cooling: VRF, Chillers, and DX Systems

Bangladesh's commercial building sector spans diverse segments – offices, retail stores, hospitals, hotels, educational institutions, assembly venues, transit hubs, warehouses**,** etc. – all requiring cooling for occupant comfort and equipment protection. Compared to the residential sector, penetration of air conditioning in commercial buildings started from a low base but is rising fast. In 2008, Bangladesh had only 1.51 million total air conditioners (including residential and commercial); by 2019 this grew to 3.5 million units (about 6.0 million tons of refrigeration (TR) of cooling capacity). A significant share of this growth comes from the commercial sector**,** where larger cooling systems are being adopted to meet increasing floor space and cooling load.

5.3.1 Variable Refrigerant Flow (VRF) Systems

Technology overview: VRF systems are a type of advanced **multi-split air conditioning** that use one or more modular outdoor units connected by refrigerant piping to multiple indoor air handling units. They continuously modulate refrigerant flow to each indoor unit using inverter-driven compressors, allowing precise temperature control in different zones. Key features of VRFs include:

- **Flexible capacity and zoning:** A single VRF system can connect many indoor units (often 10–40 or more) of varying styles, serving multiple rooms or areas with independent control. Outdoor units come in various sizes (e.g. 5–25+ TR per module), and modules can be combined to achieve large capacities (up to ~60–80 TR in some designs) to cover medium-sized commercial buildings.
- **High efficiency:** By varying compressor speed and refrigerant flow, VRFs achieve high part-load efficiencies. They typically have high EER/COP ratings and perform well under partial cooling loads, reducing energy use compared to numerous individual unitary ACs. In tropical climates like Bangladesh, VRFs can significantly save energy when properly designed and operated.
- **Building integration:** VRF systems use small-diameter refrigerant pipes instead of bulky ducts or water piping, which simplifies retrofits and high-rise installations. They are well-suited to offices, hotels, hospitals, and retail buildings where different zones have different cooling needs. VRFs avoid the need for a centralized chiller plant and cooling towers, making installation faster in many cases. However, they are generally optimal up to a certain building size; very large facilities may still require chiller systems for economy of scale.

Market trends: VRF technology is gaining rapid traction in Bangladesh's commercial cooling market. Majority of the VRF units to date have been imported (primarily from China, Thailand, Malaysia, and South Korea), since 2020 local manufacturer (Walton) start producing the VRF system. In 2025, the installed base of VRF systems was estimated at 0.40–0.45 million TR of cooling capacity. Adoption has accelerated in new constructions – for example, many modern supermarkets and shopping malls now install VRF central AC systems instead of numerous split units. A conservative CAGR of 5~7% is anticipated over the next 10 years, as VRFs become increasingly popular for their efficiency and flexibility. This implies a rise from around 0.91 million TR in 2025 to approximately 1.158 million TR by 2030**,** 1.2 million TR by 2035**.**

The table below summarizes the stock and emissions projections for VRF systems under a business-as-usual scenario, based on NCP analyses and growth assumptions:

Table 5-7: Energy consumption and the Emission from the VRF and Chiller Bank

	UOM	2025	2030	2035
Bank	Million TR	0.91	1.16	1.2
Energy Consumption	TWh/year	2180	2779	2881
Direct Emission	MtCO2e	0.089	0.164	0.338
Indirect Emission	MtCO2e	1.352	1.723	1.786
Total Emission	MtCO2e	1.441	1.887	1.786

Emissions implications: As shown above, the rapid growth of VRF cooling capacity could increase annual GHG emissions from this segment more than 1.23 times from 2025 to 2035. Indirect emissions from electricity generation (to run compressors and fans) dominate the total, comprising roughly 90–85% of VRF's climate impact under current grid conditions. This priorotise the importance of **improving energy efficiency** (to curb indirect emissions) and **using lower-GWP refrigerants** (to curb direct emissions) in VRF systems.Without intervention, by 2035 VRF ACs alone might be responsible for on the order of **1.8 million tonnes CO_2-equivalent** annually.

Refrigerant usage: VRF systems in Bangladesh presently rely on HFC refrigerants**,** predominantly R-410A . R410A enabled the efficiency gains of VRF technology but contributes high direct emissions if leaked. To address this, the market is beginning to pivot to lower-GWP alternatives. There are R-32 based VRF systems now introducing in the global market, which have about one-third the GWP of R410A and comparable (even improved) efficiency. The barrier is that R32 is mildly flammable (A2L), so safe handling and updated standards are needed – but many countries are successfully adopting R32 in both residential AC and some VRF applications

5.3.2 Chiller Systems

Technology overview: "Chillers" are large centralized cooling systems that chill water (or other fluid) which is then circulated through air-handling units or fan-coil units around a building. They are the backbone of HVAC in many sizable commercial and institutional buildings. Chillers come in various designs: centrifugal chillers (high-capacity, typically **2**00 TR and above**),** screw chillers (medium capacity, ~50–200 TR), scroll or reciprocating chillers (smaller, ~20–50 TR) among others. Chillers can be water-cooled (using a cooling tower for heat rejection, common in large installations) or air-cooled (incorporating outdoor condenser coils/fans, often for smaller units or where water is unavailable). In Bangladesh's commercial sector, chiller-based central AC is used in high-rise office buildings, shopping malls, hotels, hospitals, universities, and similar large facilities. Key technical points include:

- **High cooling capacity:** Single chiller units can range from tens of TR up to well over 1,000 TR for the largest centrifugal chillers. This makes them suitable for cooling whole buildings or campus-scale systems. In many modern high-rise complexes, multiple chillers are installed for redundancy and load management (e.g. N+1 configurations).
- **Efficiency and maintenance:** Chillers are often more efficient (in kW/TR) than equivalent DX or VRF systems when operated near full load, especially water-cooled centrifugal types which can achieve very high COPs (6.0 or more under rated conditions). They do however require significant supporting infrastructure (pumps, cooling towers, insulated piping) and skilled maintenance. Screw chillers are becoming preferred over older scroll types due to easier maintenance and higher efficiency, gradually displacing scroll chillers in the market. Modern chillers also often include variable-speed drives and advanced controls to improve part-load efficiency.

- **Application scale:** Chiller systems are generally economical for large floor areas (typically above ~5,000–10,000 m² or where cooling loads exceed a couple hundred TR). For smaller commercial buildings, the capital and space requirements of a chiller plant may not be justified, in which case multiple splits or a VRF system is chosen. But for big commercial complexes or industrial facilities**,** chillers remain the go-to solution. In Bangladesh, an estimated 80% of chiller sales serve commercial buildings (offices, retail, hospitality, etc.), with the remaining ~20% used in industrial process cooling.

Market trends: Despite a lack of comprehensive official data on cooling floor space, every segment of the commercial building sector has grown in AC usage over the past decade. Small sizes chillers currently assembled in Bangladesh. Most of the big size Chiller systems are 100% imported into Bangladesh, so import data and industry intelligence were used to gauge the market size. In 2025, the total installed stock of chillers (including historically installed units) was estimated at 1.076 million TR of cooling capacity. It is expected to import and install arround 70,000TR of Chiller in 2025.Projections in the BNCAP suggest an average growth rate of around 6~8% per year in chiller capacity over the next 10 years. Using a conservative 5% CAGR, the chiller installed base would roughly 1.47 million Ton by 2030 and by 2035 approach to 1.77 million TR**.** Drivers for this growth include the expansion of shopping malls, high-rise office towers, hotels, airports and other large infrastructure projects, all of which require central cooling plants. Chillers will thus remain a critical part of Bangladesh’s cooling landscape in the coming decades, even as newer technologies emerge.The following table summarizes the projected growth of the chiller stock and the associated emissions in 2025, 2030, and 2035 (business-as-usual scenario):

Table 5-8: Energy consumption and Emission from Chiller bank

	UOM	2025	2030	2035
Bank	Million TR	1.076	1.47	1.774
Energy Consumption	GWh	2065.59	2822.45	3494.51
Direct Emission	MtCO2e	0.072	0.116	0.206
Indirect Emission	MtCO2e	1.28	1.75	2.17
Total Emission	MtCO2e	1.35	1.87	2.38

Emissions implications: Energy consumpiton per TR of Chiller is 10~15% lower than the current market avalable VRF system. As in the Chiller system refrigerant are not flowing throgh a long pipe like the VRF system which reduces the number of joints in the refrigerant flowing tube. As a Chiller systems tend to have lower both the direct and indirect emissions per TR compared to many similar DX and VRF system. It’s noteworthy that commercial chillers often operate at higher efficiency than many small AC units – but any efficiency gains per unit are being outpaced by the sheer growth in number and capacity of chillers in service. Therefore, improving chiller efficiencies (through better design, controls, and maintenance) and managing refrigerants are both crucial. This highlights that efforts like energy-efficient building design, retro-commissioning of cooling plants, and use of climate-friendly refrigerants in chillers can yield large emissions savings in the commercial sector.

Refrigerant usage: Historically, many large chillers in Bangladesh used **HCFC-22 (R22)** as the refrigerant, especially older screw and scroll chiller models. New chiller installations have shifted to R134a in centrifugal and screw chillers, and sometimes R-410A or R-407C in smaller packaged chillers. This suggests the chiller stock today is a mix of aging R22 units and newer HFC units. Moving forward, Bangladesh is transitioning to lower-GWP refrigerants in the chiller sector as part of its compliance with the Kigali Amendment. Recently R290 base chiller is popular globally due to low GWP and better energy efficiency. Additionally, next-generation refrigerants **such as** HFOs (hydrofluoro-olefins) are emerging for large chillers – for example, HFO-1233zd(E) and HFO-1234ze(E) are now used in some high-end centrifugal chillers.

BNCAP and related strategies (like the Energy Efficiency & Conservation Master Plan) encourage the uptake of such alternatives. The government has signaled that wherever possible, new AC systems should use the lowest-GWP refrigerants available – for instance, R290 (propane, GWP ~3) for small appliances and R32 or other low-GWP fluids for larger systems. By 2030, one can expect R22 to be largely retired from commercial chillers (replaced via retrofit or natural attrition), and a mix of R134a and R410awill be populating the market. Some large organizations may even opt for ammonia (R717) chiller systems for industrial cooling applications – ammonia has zero GWP and high efficiency, though its toxicity/flammability restrict broader use to specialized settings. Overall, the chiller sector is at the cusp of major refrigerant changes that, if coupled with better containment and leak management, will significantly curb direct emissions in line with Bangladesh's cooling and climate commitments.

5.3.3 Packaged DX Air Conditioners

Besides VRF and chiller systems, a portion of commercial cooling in Bangladesh is served by packaged direct-expansion (DX) air conditioners. These are factory-assembled unitary AC units where the refrigerant directly cools the air supplied to the space, without an intermediate chilled water loop. Common examples include rooftop packaged units**,** ducted split systems**, and** cassette or ceiling units deployed in commercial settings. They essentially scale up the refrigeration cycle found in room ACs to serve larger zones.

Technical overview: Packaged DX units typically range from small (~5 TR) to moderate (~30–50 TR) capacities per unit. They are usually installed on rooftops or building exteriors, blowing cooled air through ductwork into interior spaces. Many fast-food restaurants, retail stores, and low-rise commercial buildings use one or several packaged units for cooling. They offer a simpler plug-and-play solution compared to chiller plants (no water piping or separate indoor coils needed) and can be easier to maintain than many split ACs scattered throughout a building. However, their efficiency can be somewhat lower than a purpose-built chiller or VRF system at similar load, especially in very hot climates or if not properly sized. Packaged units also concentrate a large refrigerant charge in one system, which, if leaked, can cause significant direct emissions.

Market status: In Bangladesh's current cooling market**,** packaged DX ACs occupy a relatively small niche – roughly 2–3% of the total air conditioning market by capacity. This low share is in part because many small-to-medium commercial buildings have so far relied on multiple residential-type split AC units (which are cheap and readily available) rather than investing in dedicated packaged units. At the larger end, once cooling needs surpass a certain threshold, VRF or chiller systems become more cost-effective or functional, leaving a narrow middle range where packaged units compete. Nonetheless, there is a steady (if modest) demand for packaged DX systems, particularly for single-story large halls, midsize office buildings, banquet halls, and telecom or server rooms**,** where a self-contained cooling unit is convenient.

5.4 Precession Air Conditioning: Data Center Application

5.4.1 Introduction and Growth Drivers

Bangladesh's data center industry is expanding rapidly, propelled by surging data processing needs and digitalization across government and businesses. Increased internet penetration, 4G/5G rollout, and cloud adoption are driving demand for reliable data services. Both government initiatives and private sector investments have spurred a boom in data center development. Foreign and domestic investors are building advanced facilities (including Tier III and Tier IV centers) to meet growing needs for local data storage and 24/7 online services. This growth reflects the rising reliance on digital finance, e-commerce, and cloud computing, all of which require continuous uptime and robust cooling infrastructure.

5.4.2 Installed Cooling Capacity and Infrastructure

Based on the latest data, Bangladesh's operational data centers (over 30 facilities) have a combined installed cooling capacity of roughly 112,700 TR**.** These cooling capacities span both public and private centers, from telecom and bank server rooms to large Tier IV campuses. For example, a major new Tier IV campus in Kaliakair is planned with 40,000 kW (~11,370 TR) of cooling using a chilled-water system with AI control. By contrast, smaller enterprise data rooms might have only a few hundred kW of DX (direct expansion) cooling. This indicates a significant scaling-up: new hyperscale facilities are an order of magnitude larger in cooling demand than earlier data centers.

5.4.3 Cooling Technologies and Redundancy

Cooling Methods: A variety of cooling technologies are used. Large Tier III–IV facilities predominantly use chilled-water systems (central chillers with cold water circulated to computer room air handlers), often coupled with modern controls (AI optimization). Many data centers rely on precision CRAC units (Computer Room Air Conditioners) – either chilled-water CRACs or DX CRACs – to maintain strict temperature/humidity in server rooms. In-row cooling (row-based air conditioners close to racks) and cold-aisle containment are deployed in some facilities to improve efficiency by isolating hot and cold air streams. Advanced cooling approaches are emerging: at least one live site uses immersion cooling with dielectric fluid, and others are exploring direct-to-chip liquid cooling for high-density racks. Although Bangladesh's humid climate limits the use of outside-air free cooling**,** future designs are considering indirect evaporative cooling and "hybrid" systems to economize during cooler hours. Notably, a planned "solar pre-chill" system will integrate solar energy to precool or power chillers (reducing grid demand during peak sun hours) – an example of innovative renewable integration in cooling.

Redundancy: Given the 24/7 uptime requirements, nearly all data centers have redundant cooling configurations. Typical setups are N+1 (one extra cooling unit for every N needed) in Tier III facilities, ensuring maintenance or a single failure doesn't interrupt cooling. For instance, many sites use N+1 CRAC or chiller units. Higher-tier centers employ 2N **or** 2N+1 redundancy – completely duplicate cooling systems, sometimes with an extra backup on top. The national Tier IV facility and upcoming hyperscale campuses feature 2N or 2N+1 designs (e.g. dual independent chiller plants plus a spare) to guarantee fault-tolerant continuous cooling. This means even if one entire cooling system fails, an equivalent system instantly handles the full load. Such configurations align with Uptime Tier IV requirements for continuous cooling with no single points of failure. In practice, smaller data centers (e.g. bank or telecom data rooms) often implement N+1 CRAC units, while the new large data centers (some co-developed with foreign firms) boast fully redundant 2N infrastructure for both cooling and power.

5.4.4 Refrigerants and Environmental Considerations

The cooling systems in Bangladeshi data centers predominantly use HFC refrigerants, similar to global trends. **R410A** (a high-GWP HFC) is especially common in DX CRAC units and VRF systems, and **R134a** (HFC) is widely used in large chillers Older or smaller installations may use **R407C** or legacy HCFC-22 in air conditioners, but these are being phased out under the Montreal Protocol. There is a nascent shift toward lower-GWP alternatives: for instance, at least one new data center project is using **R32 or R454B** (medium-GWP HFO/HFC blends) in its cooling units.

Notably, some advanced facilities avoid traditional refrigerants entirely for the IT cooling loop – **i**mmersive cooling with dielectric fluids or mineral oil (a few installations use these for high-density servers) does not require compressors or HFC refrigerants in the server bath. However, even these setups ultimately reject heat via chillers or cooling towers that may use refrigerants upstream. Natural refrigerants like ammonia or hydrocarbons are not yet in use in this sector in Bangladesh, given safety and design constraints, but global trends toward low-GWP cooling may inspire future adoption (e.g. large ammonia chillers or HFO-based centrifugal chillers for big campuses). Overall, HFCs remain dominant in data center cooling today, but the national HFC phase-down strategy and corporate sustainability goals are pushing designers toward climate-friendlier refrigerants and cooling methods.

6 Transport Air-Conditioning

6.1 Overview

The transport sector in Bangladesh is diverse, encompassing all vehicles under the jurisdiction of the Bangladesh Road Transport Authority (BRTA), Bangladesh Railway, Dhaka Metro Rail, water-based modes such as launches and steamers, and air transport. Over the past decade, Bangladesh has witnessed a significant expansion in its road network, including the construction of new expressways. These developments have resulted in a rise in car ownership and faster travel speeds.

Rail infrastructure has also expanded with the addition of new railway lines. Meanwhile, the commissioning of the Padma Bridge has reduced reliance on launch services for southern Bangladesh, shifting a substantial share of travel demand to buses and trains. The launch of the Dhaka Metro Rail marks the beginning of a new era of high-capacity mass transit systems in urban centers.

6.2 Methodology

Through available BRTA vehicle database and consultations with relevant experts, agencies and authorities, refrigerant demand, in-use refrigerant banks, and leakage rates in the transport air-conditioning (MAC) sector are estimated. This data enables us to estimate the direct greenhouse gas (GHG) emissions from refrigerant use.

- MAC stock estimates for road transport are derived from the BRTA database, which records vehicle registrations by type. Growth projections are based on historical registration trends.
- Consultation with sector experts suggests that all BRTA-registered vehicle categories, including private cars, jeeps, microbuses, and a significant portion of commercial vehicles, contain MAC systems.
- The number of air-conditioned buses is validated through direct engagement with AC bus operators.
- Bangladesh Railway's 2023 official information booklet provides data on AC coach count, passenger data and travel frequency for AC train compartments were used to forecast future MAC demand in the railway sector.

6.3 MAC in Road Vehicles (BRTA-Registered Fleet)

6.3.1 Cooling Demand and Energy Use in Road Transport

The demand for mobile air conditioning in Bangladesh’s road sector is rising rapidly, now comprising a significant share of overall cooling needs. Until Jun 2025, total 2,270,630 number of different types vehicals are registered under BRTA. It is estimated **~517,000** road vehicles (cars, jeeps, microbuses, buses, etc.) are equipped with mobile air conditoning systems, a number projected to grow to **~631,000** by 2030 and **~744,000** by 2035 (Business-as-Usual scenario). This reflects increased vehicle ownership and urbanization-driven comfort demand. The prevalence of MAC varies by vehicle type – nearly all private cars and urban buses have AC, while some older or commercial vehicles may not. Future cooling requirements will depend on transport modality shifts (e.g. greater public transport usage could moderate private vehicle AC growth). The table below presents a breakdown of different types of road vehicles in terms of their total numbers and the percentage equipped with mobile air conditioning (MAC) systems. This data highlights the prevalence of MAC across various vehicle categories, which has significant implications for energy consumption and emissions in the transport sector.

Table 6-1: Table 0 1: Estimated number of road transport MAC vehicles registered under BRTA

Sl. No	Type of Vehicles	Grand Total	Est. % MAC	CAGR	2025	2030	2035
1	Ambulance	6,141	90%	5.08%	5,527	7,358	9,075
2	Bus	43,398	3%	4.22%	1,302	1,652	1,968
3	Cargo Van	9,063	1%	11.20%	91	114	263
4	Covered Van	42,968	1%	5.32%	430	577	722
5	Delivery Van	27,365	5%	3.81%	1,368	1,699	1,989
6	Jeep(Hard/S0ft)	86,163	90%	5.24%	77,547	102,407	129,220
7	Microbus	103,591	80%	3.47%	82,873	99,439	116,561
8	Minibus	10,291	5%	1.33%	515	552	588
9	Pick Up (Double/Single Cabin)	124,086	30%	4.91%	37,226	49,074	60,097
10	Private Passenger Car	353,539	80%	3.34%	282,831	339,687	392,944
11	Special Purpose vehicle	2,620	10%	5.88%	262	373	464
12	Taxicab	30,136	80%	0.05%	24,109	24,180	24,233
13	Others	34,985	10%	5.21%	3,499	4725	5816

From the data, it is evident that certain vehicle types, such as ambulances, jeeps, microbuses, private passenger cars, and taxicabs, have a high proportion of MAC-equipped units, with percentages ranging from 80% to 90%. In contrast, other categories like buses, cargo vans, covered vans, and minibuses show much lower MAC adoption rates, typically below 5%. The overall distribution underscores the varied adoption of MAC technology across the road vehicle fleet.

Running MAC in vehicles imposes a substantial energy penalty. In hot, congested conditions in the metropolitan cities air-conditioning can consume up to 15–20% of a vehicle's fuel on average and even over 40% under extreme heat or idling[xxv]. A UNEP study in India observed that 20% of total transport energy consumption can be attributed to mobile air-conditioning. Although Bangladesh lacks a direct national study on MAC energy usage, a conservative estimate using a 10% energy share for cooling was used for the analysis. As per the National Energy Balance 2021-2022 published by SREDA,

[xxv] Cooling on the Move – Analysis - IEA

Bangladeh’s total final energy consumption reached 40.193 million tons of oil equivalent (Mtoe), transport sector consumed 885 ktoe of natural gas and 4017 ktoe of oil. The transport sector accounted for 4.902 Mtoe of energy consumption, with petroleum products constituting 82.85% of this figure. Additionally, natural gas, particularly in the form of compressed natural gas (CNG) for motor vehicles, contributed to the remainder of the sector's energy usage.

Over the last 10–15 years, Bangladesh’s primary energy consumption has grown at about 4–6% per year, depending on the exact period and dataset. Power-sector and energy master plans (PSMP, EECMP, IEPMP) typically assume around 5%/year growth in total energy demand in their BAU or “middle” scenarios. In 2025, trasport sector is estimated to consume on the order of 0.57 Mtoe (10% of the energy uses and considering 5% yearly growth in the transport sector energy consumption) of energy for cooling purposes. According to the Energy Efficiency & Conservation Master Plan (EECMP), primary energy demand in Bangladesh is projected to exceed 72 Mtoe by 2030 under a BAU scenario. By 2030 energy uses for the trasport cooling purpose could rise to ~0.88 Mtoe, and by 2035 around ~1.12 Mtoe, absent efficiency improvements. This additional fuel consumption contributes to indirect GHG emissions from the transport sector.

Table 6-2: Table 1: Road Vehicle MAC Stock, Energy Use, and Emissions (2025–2035)

Metric (Road MAC)	2025	2030	2035
MAC-equipped vehicles (units)	517,578	631,836	743,940
Refrigerant bank in vehicles (MT)	301	370	437
Fuel energy use for MAC (Mtoe)	0.57	0.88	1.12
Indirect GHG emissions ($MtCO_2$)	0.48	0.74	0.94

As shown above, the MAC refrigerant **bank** (total HFC charge in all vehicles) is on the order of **300 MT** in 2025 (mostly HFC-134a), growing to over **437 MT** by 2035 as the fleet expands.

6.3.2 Refrigerant Use and Transition to Alternatives

Refrigerant Types: Virtually all mobile AC units in Bangladesh’s road fleet use high-GWP HFC refrigerants today. HFC-134a is the dominant refrigerant in car, van, and bus AC systems. As a result, demand for HFC-134a for MAC servicing has surged in recent years – the national survey data confirm exponential growth in MAC refrigerant use in the last decade. Few brand new imported car comes with HFO-1234yf MAC systems. A small number of refrigerated transport trucks use HFC-404A in their cooling units for cargo; however, refrigerated trucks are still very limited in number and are considered under cold-chain sector in the broader NCP context.

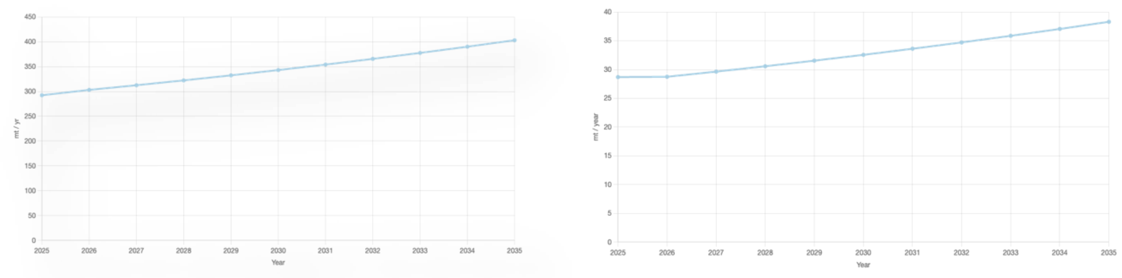

Figure 6-1: R134a bank and refrigerant year consumption in the MAC sector

Bangladesh is currently in a transition from import-dependent to assembler / light manufacturer, predominantly CKD/SKD assembly of foreign brands (cars, SUVs, pickups, buses, trucks). Government goal (Automobile Industry Development Policy 2020/2021) is to move from assembly → progressive localization → full manufacturing & exports, supported by tax holidays and duty rebates for local plants. Still now HFC-134a is used in local assembly facilities.60-70% of the AC bus area assembled in Bangladesh with the air conditoniong unit imported as assembled locally. Currently 35KW cooling load system is installed in the AC bus with 8kg of inetial gas(HFC-134a) charge. On an average each of the passenger car charge with 0.5kg of HFC-134a where as for big size of passenger vehicals like microbus, double cabin pick up this amount goes to 0.65kg per unit.

6.3.3 Low-GWP Alternatives:

The transition to next-generation low-GWP refrigerants in MAC has been very slow in Bangladesh to date. Globally, automobile manufacturers have begun shifting to HFO-1234yf (GWP <1) in place of HFC-134a – this is mandatory in the EU, adopted in the US/Japan, and increasingly common in new cars in many markets. Using hydrocarbon (R-290) in the MAC sector is quite challenging and gobal autmobiles company (The pilot project, ‘A Greener Auto Air Conditioner to Save the World’, has been successfully developed and validated on a TATA Motors Utility Vehicle, with a dual AC system in 2019.) are reasarch on using hydrocarbon in the passanger car. In Bangladesh, however, HFO-1234yf based transport import is minimal so far. The primary barriers are high cost and limited availability of HFO-1234yf refrigerant and compatible components. No domestic car assembly is yet charging HFOs, and parallel-imported reconditioned vehicles mostly still contain HFC-134a. If all new cars from 2030 onward use HFO-1234yf, the direct GWP impact of their refrigerant would be near-zero, significantly bending down the MAC emission curve by 2035. Policy measures can accelerate this transition.

6.3.4 GHG Emissions and Environmental Impact

The greenhouse gas emissions from road MAC come from two sources: **(1) direct refrigerant leaks** of high-GWP gases, and **(2) indirect emissions** from fuel/electricity used to power AC. Direct emission from MAC equipment causing from the leakage (considering 10% per year) and end of the life cycle emission. In Bangladesh private car are usally running in the road for a long time, as a result 4% stock replenishment is considered in the simulation model. In 2025, direct MAC emissions (mostly HFC-134a) are estimated at 61.08 **KtCO$_2$-e**, Without interventions, these could reach 82 **KtCO$_2$-e** by 2035, as shown in Figure 3. While MAC currently represents only a few percent of Bangladesh's total GHG inventory, its growth rate and mitigation potential are noteworthy. The **direct emissions** will decline substantially if low-GWP refrigerants are adopted (since a shift from GWP 1300 to GWP <1 can nearly eliminate direct CO$_2$-e emissions per unit).

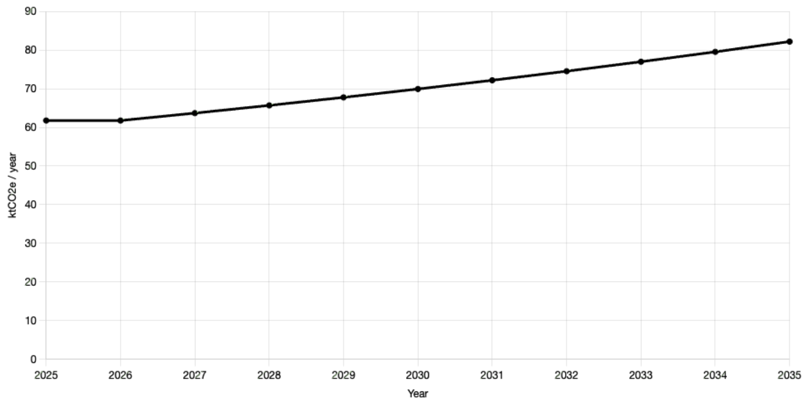

Figure 6-2: Direct Emission from Road transported MAC sector (Simulation by: Kigali SIM)

6.3.5 Refrigerant Recovery and Servicing Practices

Improving servicing practices is critical to reduce refrigerant leakage (direct emissions) and to ensure safety with new refrigerants. In Bangladesh, the MAC servicing sector is largely informal, with thousands of roadside or small garage technicians who often lack proper tools and training. At present, refrigerant recovery during repairs is minimal – it is common for mechanics to simply vent the remaining gas when opening AC systems, then recharge with new refrigerant. This leads to substantial avoidable emissions and wastage of high-GWP gases. The ODS/Kigali survey identified major gaps: no certified reclamation facilities for used refrigerant, limited recovery machine use, and low awareness of good servicing practices.

The NCP calls for strengthening the MAC servicing sector through several measures:

- **Training and Certification:** Launching nationwide training for MAC technicians on good refrigeration practices, safe handling of flammable alternatives (like HFOs or hydrocarbons), and recovery techniques. By 2030, a significant fraction of the ~50,000+ AC service technicians should be reached with certification programs (leveraging ongoing HPMP/KIP initiatives). This is a priority "no-regrets" intervention, as it both reduces emissions and improves livelihoods by introducing professionalism. NCP highlights the twin benefits of training in the servicing sector for environmental protection and employment generation.
- **Recovery & Reclamation Infrastructure:** Establishing refrigerant recovery and reclamation centers or incentivizing refrigerant suppliers to offer buy-back of recovered HFCs. This could be done via public-private partnership – e.g. equipping

large vehicle service centers or vocational institutes in major cities with reclamation units to recycle HFC-134a. Recovered refrigerant can be purified and reused, reducing import demand. Policies may mandate that end-of-life vehicles have their AC refrigerant recovered (during scrappage) and not simply released. Developing a formal system for refrigerant waste management is recommended in the KIP Stage I.

- **Regulatory Measures:** Updating rules (via the Environment/Ozone Regulation) to prohibit intentional venting of refrigerants during MAC servicing. Implement and enforce requirements that MAC servicing shops have basic recovery equipment. Additionally, when low-GWP (and potentially flammable) refrigerants come into use, safety standards and protocols must be in place – e.g. training on HFO-1234yf which, while mildly flammable, requires care in handling. The government can also explore incentives for proper practices, such as refrigerant subsidies or credits for workshops that return recovered gases.

By improving servicing, Bangladesh can reduce the annual refrigerant leakage rate (thus direct emissions) and over time shift the MAC service sector onto a more sustainable footing. The Data Assessment Framework for MAC in BNCAP methodology specifically emphasizes "refrigerant-handling during recharging and end-of-life" as a key intervention area. It also notes tracking refrigerant consumption by the service sector as an important data point, given that most HFC use in MAC is for servicing existing vehicles. Through the National Cooling Plan, mechanisms will be introduced to monitor and reduce these service-related losses – for example, annual reporting of HFC-134a sales to MAC servicing, and integration of MAC servicing training under the national skills development programs.

6.4 MAC in Rail Systems (Bangladesh Railway and Metro Rail)

Bangladesh's rail systems contribute to cooling demand through air-conditioned passenger coaches on intercity trains and the new Dhaka metro system. While smaller in scale than road MAC, rail cooling is important for public transport comfort and has grown with recent investments in railway modernization. This section examines Bangladesh Railway (intercity trains) and Dhaka Metro Rail MAC, using 2025 as baseline and projections for 2030/2035.

6.4.1 Bangladesh Railway (Intercity) Air-Conditioned Coaches

The Bangladesh Railway operates a fleet of long-distance intercity trains, many of which include air-conditioned (AC) coaches (first-class cabins, AC sleeper and chair cars). In 2025, there are roughly 400 AC coaches in service (across broad-gauge and meter-gauge lines). This number is expected to increase to support growing ridership and network expansion – projected AC coach count is 600 by 2030 and 800 by 2035 as new coaches are procured and older non-AC stock is retrofitted or replaced. Notably, gauge conversion and new lines (Padma Bridge route, etc.) will likely all use modern AC coaches, raising the share of cooled rail travel.

Each AC coach has a significant cooling load due to passenger capacity (often 50+ passengers per coach) and harsh summer temperatures. A typical broad-gauge intercity AC coach has 14 TR (50 kW) cooling capacity and uses about 22 kW of electrical power for air-conditioning under peak load, while a meter-gauge AC coach is 12 TR (40 kW, 20 kW input) according to railway specifications. Utilization is high – coaches operate on multiple trips per day. An average AC coach may run its AC 16 hours per day, 6 days a week, with around 80% utilization (accounting for maintenance downtime) – this yields on the order of 80,000–88,000 kWh per coach per year in electricity consumption for cooling (for BG and MG respectively). Given the 2025 fleet, the total cooling energy consumption for intercity rail coaches is estimated at 34 GWh/year. By 2030, with more than 1.5× the coaches, this could rise to 66 GWh/year, and by 2035 to 84 GWh/year (assuming similar technology; efficiency improvements could moderate this).

6.4.2 Refrigerants in Railway AC

Traditionally, railway AC systems in Bangladesh (as in many countries) used HCFC-22 as the refrigerant. Many older coaches (especially meter-gauge ones over 15 years old) still have R-22 in their cooling chamber. However, R-22 is being phased out, and interim retrofits to R407C have occurred. By 2025, it is estimated that about 250 rail coaches (≈80% of older stock) still use R-22, while others have been converted to HFC-407C or built with HFC-410A. For example, newer broad-gauge coaches imported in the 2010s use HFC-410A in roof-mounted package AC units. Some retrofits of older units have used HFC-407C as a replacement for R-22. Based on railway records and maintenance practices: roughly 20% of refurbished coaches have been filled with HFC-407C, and the remaining older ones with R-22. By 2030, Bangladesh Railway plans to eliminate R-22 from passenger coaches – projections indicate only a handful (5%) of the 2025 R-22 coaches might still be using it by 2030 (and zero by 2035 as R-22 supply ends). The fleet in 2030–35 will thus use a mix of HFC-407C and HFC-410A. It's assumed that by 2035 about 700 coaches (mostly retrofitted older stock and some new) use HFC-407C, and around 100 newest coaches use HFC-410A. No transition to HFO or natural refrigerants in railway AC is yet planned, so the GWP of rail refrigerants will remain moderately high (1770–2088). However, the total charge is relatively small: each coach carries about 8–10 kg of refrigerant. The total refrigerant bank in 2025 is 3.6 tonnes across all intercity coaches, growing to 5.7–7.6 tonnes by 2030–35 in line with the number of coaches. Annual refrigerant consumption for railway AC servicing is on the order of a few hundred kilograms per year (due to 15% leakage rates). This corresponds to a direct emission of about 1.0 kton CO_2-e per year in 2025 from rail AC (primarily R-22, R-407C leaks), rising to ~2.0 kton CO_2-e by 2035 as the AC stock grows (even as R-22 is phased out) – the increase is moderated by the somewhat lower GWP of HFC-407C compared to R-22.

Table 6-3: Table 4 1: Emission from the intercity Railway Coaches

	Unit	2025	2030	2035
No of AC Coaches	Nos	401	600	800
Total Refrigerant bank in the coaches	MT	3.56	5.7	7.6

Refrigerant yearly leakage amount	MT	0.55	0.86	1.14
Direct Emission	MtCO2e	.001	0.002	2.07
Indirect Emission	MtCO2e	.025	0.040	0.053
Total Emission	MtCO2e	.026	0.041	0.055

In summary, by 2035 Bangladesh Railway will have a fully HFC-based AC coach fleet (no ODS), with better cooling technology and larger capacity. The focus will be on managing the higher refrigerant bank and energy use efficiently.

6.4.3 Dhaka Metro Rail AC Systems

The Dhaka Metro (Mass Rapid Transit) is a new addition to Bangladesh's transport and cooling landscape. Line 6 began operations in 2022–2023, featuring modern fully air-conditioned trains and stations. For NCP 2025 baseline, only MRT Line-6 is operational (around 24 train sets, 144 coaches, serving 17 stations). By 2030, multiple lines (Line 1, 5, etc.) are expected to be operational – the network could have 100+ stations and ~120 trains (800+ coaches). By 2035, all 6 planned MRT lines should be running at full capacity, totaling ~130 trains and ~900 coaches in service. This rapid transit system is entirely electric, and both the train cars and many station facilities are air-conditioned for passenger comfort.

Cooling Systems and Refrigerants: Each metro train coach is equipped with compact HVAC units. Notably, the Dhaka Metro uses two kinds of refrigerants in its cooling systems: the train AC units use HFC-407C, and the station air-conditioning systems use HFC-410A. each station has a signalling and telecommunication room where 3 ducted ac(12.5 ton each) are installed. On an average each metro station installed with 29nos of split type of room ac (1 ~1.5 ton each). Line-6 data indicate ~2,160 kg of R-407C (each coach charge with 15kg of refrigerant) is charged across all the trains, and ~848 kg of R-410A in all the stations in 2025. As the metro expands to all lines, the total refrigerant charge will increase roughly proportionally to the number of trains and extent of station cooling. By 2030 and 2035, the combined refrigerant bank in the metro system is expected around 21.83 MT – this assumes all lines use similar technology and refrigerant types as Line-6, and no transition to lower-GWP refrigerants in the interim.

Table 6-4: HFC banks and total emission from Metro Rail system

	UOM	2025	2030	2035
MRT Line		Line 6	Line1 and 5.1	Line 5.2, 2 and 4
No of Coach	Unit	144	504	1,128
No of Station	Unit	17	50	104
HFC Bank	MT	2.96	9.9	21.83
Direct Emission	MtCO2e	0.001	0.0023	0.005
Indirect Emission*	MtCO2e	0.017	0.058	0.127
Total Emission	MtCO2e	0.018	0.060	0.133

Annual leakage rates in such systems are relatively low (the metro's new equipment likely has tight seals) but some losses occur via maintenance. If we assume 10-12% annual leak for train units and 5-8% for station ac. These above estimates assume HFC-407C (GWP 1774) and HFC-410A (GWP 2088) continue to be used; switching to lower GWP refrigerants in future trains (e.g. HFO blends) could reduce this direct impact. It is noteworthy that by 2030 the metro's refrigerant bank and emissions will dwarf that of the intercity rail (simply due to scale of the metro network and higher cooling load per km).

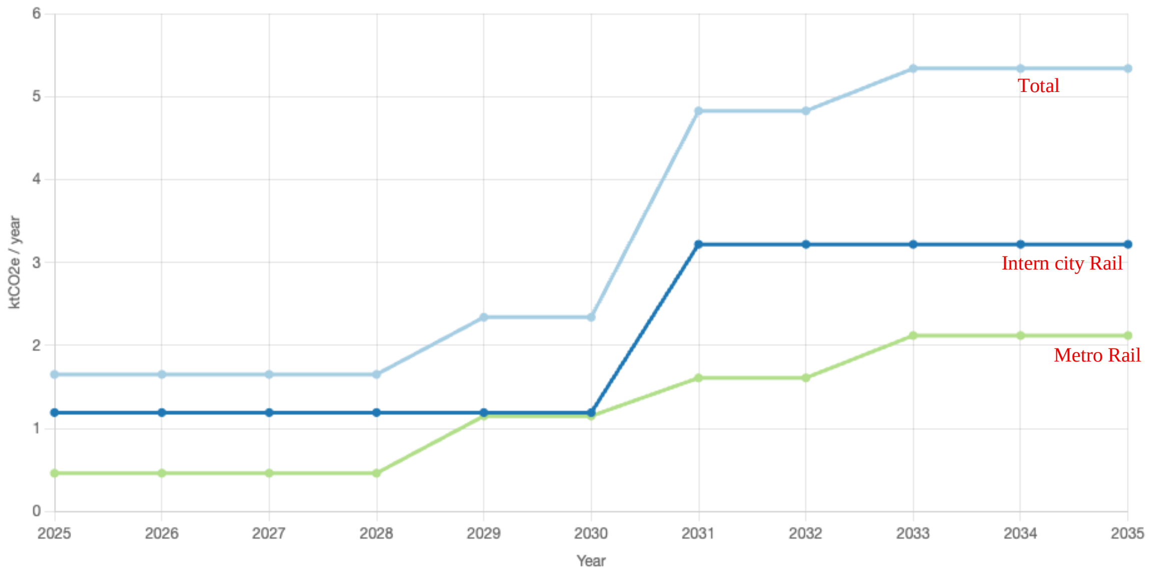

Figure 6-3: Direct emission from the total Rail transport Sector (Metor+Intercity)(Kigali SIM)

Energy Use and Indirect Emissions: The metro rail's AC systems are powered by grid electricity. For Line-6 in 2025, the cooling demand (trains + stations) consumes about 27.50 GWh/year, corresponding to roughly 17.05 $KtCO_2$/yr indirect emissions (using grid emission factor 0.62 tCO_2/MWh). By 2030, with several new lines operating, the annual cooling energy consumption is projected to reach 93 GWh/year (for trains and stations combined). By 2035, further ridership growth and line additions raise this to about 205 GWh/year for cooling. The metro's indirect emissions illustrate the importance of efficient cooling – they dominate the metro's cooling footprint. However, because the metro is moving large numbers of passengers, on a per-passenger-km basis the cooling energy/emissions are more efficient than an equivalent number of cars or buses with AC. This supports the climate co-benefit of shifting commuters to mass transit, as highlighted in NCAPs (reducing *aggregate* cooling demand even if metro AC use grows).

6.5 Summary of the emission from MAC sector

The table below summarizes the key emission from the railway and road transported the MAC systems:

Table 6-5: yearly Emission break down from overall MAC sector

Yearly Emission (KtCO2/year) in BAU Senerio

Transport Type	Emission Type	2025	2030	2035
Road Transport MAC	Direct	61.08	70	82
	Indirect	480	740	940
Rail Transport MAC	Direct	1.72	3.94	7.36
	Indirect	43.51	98.78	187.47
Total	Direct	62.8	73.94	89.36
	Indirect	523.51	838.78	1127.47
	Grand Total	586.31	912.72	1216.83

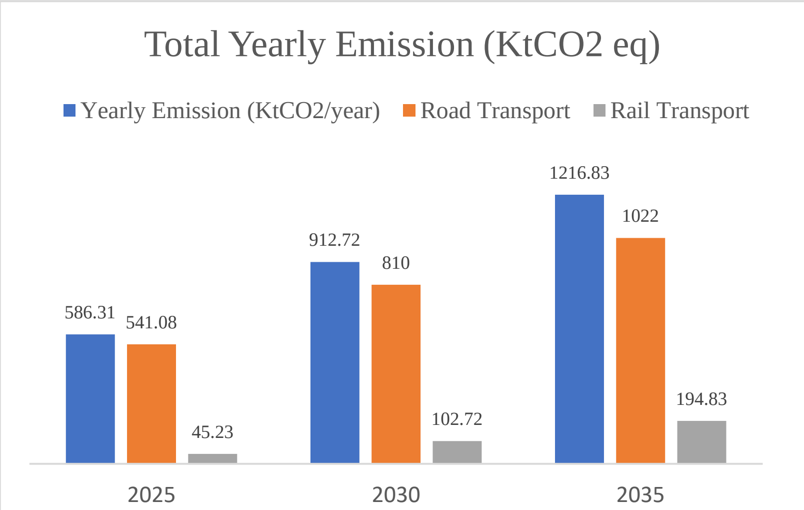

Figure 6-4: Total Emission from MAC Sector

In conclusion, the MAC chapter for Bangladesh's NCP (2025 baseline, projections to 2030/35) reveals a growing cooling demand in both road and rail transport, driven by rising vehicle numbers and expansion of AC public transit. Without intervention, energy use and HFC refrigerant consumption in this sector will increase substantially, with associated GHG emissions (direct and indirect). However, significant opportunities exist to bend this trajectory: transitioning to low-GWP refrigerants in vehicles, improving MAC energy efficiency through technology and design, enhancing servicing and refrigerant recovery, and encouraging a shift toward efficient public transport (thereby reducing the growth in number of individual AC units). These strategies, as detailed above, are in line with the Bangladesh National Cooling Plan (2021) recommendations and updated guidance from the Kigali Amendment implementation. By 2030 and 2035, with NCP measures in effect, Bangladesh can expect to see a MAC sector that meets the cooling needs of mobility while moderating energy use and emissions – contributing to climate goals, better air quality, and improved comfort for citizens in a sustainable way.

7 Cooling Action Plan

This chapter presents the proposed Cooling Action Plan for Bangladesh up to 2035. It begins with an overall cooling assessment based on the national cooling energy and emissions projections (Business-as-Usual, BAU) compiled in the "Overall Energy Consumption for Cooling in Bangladesh" dataset (years 2025, 2030 and 2035). The chapter then sets out a structured package of policy actions and interventions to meet growing cooling needs while minimizing impacts on the power system and greenhouse gas (GHG) emissions, and concludes with a monitoring and reporting framework aligned with national climate objectives (including the NDC 3.0 target year of 2035).

7.1 Overall cooling assessment (BAU baseline and projection)

Cooling already represents a major and rapidly growing component of national electricity demand. Under the BAU projection, total electricity consumption for cooling rises from 45,651 GWh (≈45.65 TWh) in 2025 to 63,206 GWh (≈63.21 TWh) in 2030 and 72,836 GWh (≈72.84 TWh) in 2035 (an increase of 60% over 2025–2035). Cooling-related GHG emissions (direct refrigerant emissions plus indirect emissions from electricity generation) increase from 29.65 $MtCO_2e$ in 2025 to 43.12 $MtCO_2e$ in 2030 and 50.21 $MtCO_2e$ in 2035 (a 70.% rise over 2025–2035) in BAU case. Indirect emissions dominate the profile, reflecting the carbon intensity of electricity supply and the fast growth of electrically driven cooling loads.

Table 7-1: National cooling electricity consumption and emissions (BAU projection)

Year	Cooling electricity consumption (GWh)	Direct emissions ($MtCO_2e$)	Indirect emissions ($MtCO_2e$)	Total emissions ($MtCO_2e$)
2025	45,651	0.81	28.84	29.65
2030	63,206	3.08	40.05	43.12
2035	72,836	3.91	46.30	50.21

7.1.1 Sectoral contribution and key demand drivers

The BAU projection indicates that space cooling in buildings and industry is the dominant driver of electricity consumption and emissions. By 2035, the space-cooling segment accounts for approximately 77% of cooling electricity demand and 75% of cooling-related emissions. Cold chain and refrigeration account for about 24% of electricity demand and 22.5% of emissions. Cold chain emission at 2035 is relatevely lower than 2030 figure, the reasong behind this reduced emission causing due the phasing out 7 million power hungry R-134a based refrigerator. During 2016-2020 with the help of Multilater fund the country biggest refrigerator manufacturer converted their 3 refrigerator and one compressor manufacturing line and swith to 15% more energy efficient and natural refrigerant(R600a). All the old R134a based refrigerator bank will be phased out and replace by energy R600a based products in next 10 years. The Mobile air-conditioning (road and rail) contributes an estimated 1.22 $MtCO_2e$ in 2035 (about 2.4% of total cooling emissions); however, electricity consumption for mobile AC is not directly represented in the dataset because much of the energy use occurs as liquid fuel consumption in vehicles.

Table 7-2: Table Cooling energy demand and emissions by major sector (BAU)

	Energy Consumption (GWh)			Total Emission (MtCO2e)		
Sector	2025	2030	2035	2025	2030	2035
Space Cooling	33,299	46,435	56,096	21.17	30.14	37.65
Cold Chain	12,351	16,771	16,740	7.89	12.06	11.34
Mobile AC				0.59	0.91	1.22

7.1.2 Key subsectors requiring priority attention

By 2035, three end-uses dominate cooling electricity consumption: domestic air conditioners, domestic fans, and household refrigerators. Together, these end-uses account for more than 95% of projected cooling electricity demand, indicating that appliance efficiency and building thermal-load reduction are the highest-impact policy levers for reducing both peak demand and associated emissions.

Table 7-3: Top cooling end-uses in 2035 by electricity demand (BAU)

End-use	Sector	2035 Energy (GWh)	2035 Emissions ($MtCO_2e$)
Domestic Air Condition	Space Cooling	27,636	19.46
Domestic Fan	Space Cooling	22,174	13.75
House hold Refrigerator	Cold Chain	14,784	9.93
Commercial Air Condition	Space Cooling	6,286	4.4
Commercial Refrigeration	Cold Chain	1,434	1.06

7.1.3 Cooling emissions in the national climate context (NDC 3.0)

Bangladesh's NDC 3.0 adopts 2022 as the base year for GHG projections and 2035 as the target year, with total national emissions estimated at 252.04 $MtCO_2e$ in 2022 and a Business-as-Usual (BAU) level of 418.40 $MtCO_2e$ in 2035. In this context, cooling-related emissions are already material: the estimated cooling emissions of 29.65 $MtCO_2e$ in 2025 correspond to approximately 11.8% of the 2022 national total, and BAU cooling emissions of 50.21 $MtCO_2e$ in 2035 correspond to about 12% of the projected 2035 national BAU level. Therefore, improving cooling efficiency and managing refrigerants is a meaningful mitigation wedge for achieving national climate targets, while also supporting adaptation objectives linked to heat stress, health and resilient services.

7.1.4 Regional comparison with climate peers

Bangladesh shares a hot-humid climate profile with several South and Southeast Asian countries, where rapid increases in air-conditioning and refrigeration are driving power demand growth and emissions. While country circumstances differ (size of economy, baseline emissions, grid mix, appliance penetration and data scope), international experience provides useful benchmarks for the cooling challenge and for policy responses.

Table 7-4: Cooling-related emissions context in selected countries (illustrative benchmarks)

Country	Climate context (high-level)	Cooling-related emissions	Share of national emissions	Notes on scope / source
Bangladesh	Tropical monsoon (hot-humid)	50.21 $MtCO_2e$ (2035 BAU)	≈12% of 2035 BAU total	BNCAP projection; national BAU total from NDC 3.0
Viet Nam	Tropical monsoon (hot-humid)	91.7 $MtCO_2e$ (2030 BAU)	≈9.9% (2030)	Viet Nam National Cooling Plan policy brief; indirect dominates through 2030
India	Multiple zones incl. large hot-humid population	208.7 $mtCO_2e$ (2017)	≈8% of national GHG	World Bank cooling-sector assessment summarizing space cooling, MAC, refrigeration, cold chain, industrial
Thailand	Tropical (hot-humid)	(not reported in this benchmark)	≈20% of national GHG	UNFCCC NAMA registry notes RAC sectors account for ~20% of Thai emissions; emissions dominated by energy use

Note: Values are drawn from publicly available national or international assessments with differing base years and sector coverage; they are presented as indicative benchmarks rather than fully harmonized comparisons.

7.2 Proposed Cooling Action Plan: actions and interventions

The proposed Cooling Action Plan combines demand reduction (passive measures), improved efficiency of active cooling technologies, and lifecycle refrigerant management. Actions are grouped as (i) cross-cutting enabling measures and (ii) sector-specific interventions.

7.2.1 Improve energy efficiency of cooling appliances and equipment

- Strengthen and expand Minimum Energy Performance Standards (MEPS) and energy labelling for high-impact products: room air-conditioners, fans, refrigerators, commercial refrigeration equipment, chillers and cold storage systems.
- Adopt a regular MEPS “ratcheting” schedule (e.g., every 2–3 years) to keep pace with global best-available technology and to avoid market lock-in of inefficient products.
- Use public procurement and government-funded programs to create demand for high-efficiency cooling equipment (e.g., hospitals, schools, public offices, cold chain facilities).
- Introduce targeted financing and incentives (rebates, concessional credit, on-bill financing) for high-efficiency products, focusing on low-income households and SMEs to improve access while reducing long-term electricity costs.
- Promote maintenance and correct installation practices (proper sizing, refrigerant charge, airflow management) as a low-cost pathway to reduce energy use and peak demand.

7.2.2 Accelerate passive cooling and climate-responsive buildings and cities

- Integrate passive cooling requirements in building codes and urban planning: shading, natural ventilation, insulation, reflective (cool) roofs, improved glazing, and heat-resistant materials.
- Promote enforcement and scaling of building energy codes for residential and commercial buildings, with special attention to new urban developments and public buildings.
- Scale "cool roof" and urban greening programs (trees, parks, nature-based solutions) to reduce urban heat island effects and lower cooling loads.
- Promote thermal comfort standards and occupant-focused design that can reduce unnecessary mechanical cooling demand (including appropriate thermostat settings and ventilation strategies).

7.2.3 Transition to low-GWP refrigerants and strengthen refrigerant management

- Implement the Kigali Amendment HFC phase-down through import controls, quota systems and market guidance to enable the 30% reduction milestone by 2035.
- Promote adoption of low-GWP alternatives across sectors (e.g., hydrocarbons such as R-290/R-600a, ammonia, CO_2 and HFOs where appropriate), supported by updated safety standards and training for flammable/toxic refrigerants.
- Scale technician training, certification and accreditation programs for installation and servicing, including good practices to reduce leakage and venting and to maintain efficiency.
- Establish refrigerant recovery, recycling and reclamation (RRR) systems and end-of-life protocols for cooling equipment, including incentives and regulation to prevent refrigerant release at disposal.
- Strengthen data systems for refrigerant import, sales and use, including tracking of servicing sector consumption and recovered volumes.

7.2.4 Sector-specific interventions

Space cooling in buildings and industry

- Prioritize high-efficiency room AC and fan markets (the largest drivers of cooling electricity demand), including market transformation programs and consumer awareness on efficient use.
- Promote efficient commercial cooling systems in large buildings (e.g., high-efficiency chillers, variable-speed drives, building management systems) and consider district cooling where suitable (dense commercial zones and new developments).

- Promote energy audits and retrofits of large cooling systems in industry and commercial buildings to reduce peak loads and operating costs.

Cold chain and refrigeration (food, agriculture, fisheries and healthcare)

- Upgrade cold storage and refrigeration systems through improved insulation, high-efficiency compressors, optimized control systems and correct sizing, with a focus on high-growth segments (e.g., food processing and commercial refrigeration).
- Encourage adoption of natural refrigerants in cold storage and industrial refrigeration (ammonia, CO_2, hydrocarbons) where feasible, with appropriate safety and training.
- Promote renewable energy integration and load management solutions (solar PV, thermal storage, hybrid systems) for rural cold storage facilities to reduce grid stress and diesel backup dependence.

Mobile air-conditioning (road, rail and emerging urban transit)

- Strengthen servicing practices and enforcement to reduce leakage and venting in mobile AC systems, including adoption of recovery equipment in workshops.
- Promote transition to low-GWP refrigerants in vehicles (aligned with global automotive technology trends) and prepare safety standards and training for new refrigerants.
- Support broader transport efficiency and electrification strategies that can reduce the indirect emissions associated with vehicle cooling.

7.2.5 Cross-cutting enabling measures

- Institutional coordination: establish or strengthen an inter-ministerial mechanism to coordinate cooling actions across environment, energy, industry, urban development, agriculture, health and transport.
- Financing: develop a national cooling investment pipeline and mobilize public, private and climate finance (including concessional credit, risk-sharing instruments and green bonds) for efficiency upgrades and low-GWP technology transitions.
- Awareness and behaviour: implement national communication campaigns on efficient cooling practices (e.g., temperature set-points, maintenance, shading) to deliver low-cost savings and peak reduction.
- Data and research: institutionalize regular data collection on cooling equipment stock, performance, refrigerant flows and sectoral electricity use to improve projections and track progress.

7.3 Achieving targets and monitoring framework

A monitoring, reporting and verification (MRV) approach is required to track implementation and link cooling interventions to national energy planning and climate commitments. The following framework is proposed for BNCAP implementation up to 2035.

7.3.1 Proposed targets and milestones

- By 2026–2028: MEPS and energy labelling in force for the highest-impact products (room AC, fans and refrigerators), with strengthened compliance monitoring and market surveillance.
- By 2030: building energy code and/or cooling-relevant provisions integrated into national building regulations for new large buildings; scaled programs for passive cooling (e.g., cool roofs) implemented in major cities.
- By 2030: national technician training and certification program scaled, including safe handling of low-GWP refrigerants and recovery practices.
- By 2035: Kigali milestone achieved (30% reduction in HFC consumption from baseline), supported by import controls and sector conversion programs.
- By 2035: measurable reduction of cooling electricity demand and emissions relative to BAU through combined efficiency and passive interventions, with attention to peak demand management.

7.3.2 Key indicators for monitoring

Recommended indicators include:

- Cooling electricity consumption (GWh) by sector (space cooling, cold chain, industrial process cooling) and associated peak-demand contribution, where data are available.
- Market share of high-efficiency appliances (e.g., proportion of room ACs, fans and refrigerators meeting top efficiency tiers).
- Number of buildings complying with cooling-relevant building code provisions; area of buildings adopting passive cooling measures.
- HFC consumption (CO_2e tonnes) and progress against Kigali control schedule; adoption rates of low-GWP refrigerants by sector.
- Quantity of refrigerants recovered, recycled or reclaimed; number of certified servicing technicians and equipped workshops.
- Number and scale of financed cooling-efficiency and refrigerant-transition projects (public and private).

7.3.3 Reporting and institutional responsibilities

Cooling MRV should be integrated into existing national systems for energy statistics, appliance standards enforcement and Montreal Protocol reporting. An annual implementation progress report can consolidate data from relevant agencies (e.g., environment/ozone unit for refrigerants, energy authority for electricity and standards, and line ministries for sector programs). A mid-term review around 2030 is recommended to recalibrate targets and update data, consistent with the NDC target timeline and Kigali milestones.

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