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Final Report

National Cooling Action Plan

Developing the National Cooling Programme in Viet Nam

JULY 2025

UNOPS

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DEVELOPING THE NATIONAL COOLING PROGRAMME IN VIET NAM

DELIVERABLE 4 - FINAL REPORT

National Cooling Action Plan

July 2025

Colophon and disclaimer

Beneficiaries

Southeast Asia Energy Transition Partnership

14th Floor, 208 Wireless Road Building Lumphini, Bangkok 10330, Thailand | +669 8832 1614 | etp@unops.org

Department of Climate Change, Ministry of Agriculture and Environment, Viet Nam

10 Ton That Thuyet, Nam Tu Liem, Ha Noi, Viet Nam | +8424 3775 9430 | info@dcc.gov.vn

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List of Abbreviations

AC	Air Conditioning
BAU	Business as usual
CFC	Chlorofluorocarbon
COP	Conference of the Parties
CSPF	Cooling Seasonal Performance Factor
DCC	Department of Climate Change
EE	Energy Efficiency
ESCO	Energy Service Company
ETP	Southeast Asia Energy Transition Partnership
EV	Electric Vehicle
EVN	Viet Nam Electricity
GEF	Grid Emission Factor
GGGI	Global Green Growth Institute
GHG	Greenhouse Gas
GSO	General Statistics Office of Viet Nam
GWP	Global Warming Potential
HC	Hydrocarbon
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
ICE	Internal Combustion Engine
IPCC	Intergovernmental Panel on Climate Change
ITMO	Internationally Transferred Mitigation Outcome
JETP	Just Energy Transition Partnership
LEEE	Law on Economical and Efficient Use
MAC	Mobile Air Conditioning
MAE	Ministry of Agriculture and Environment
MEPS	Minimum Energy Performance Standards
MOC	Ministry of Construction
MOET	Ministry of Education and Training
MOF	Ministry of Finance
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology

NCAP	National Cooling Action Plan
NDC	Nationally Determined Contribution
NGCP	National Green Cooling Program
NZT	Net Zero Target
O&M	Operation and Maintenance
ODS	Ozone Depleting Substances
PAC	Packaged AC
PAMS	Policy Analysis Modelling System
GCP	Global Cooling Pledge
PDP8	Viet Nam's Eighth National Electricity Development Plan
QCVN	Viet Nam Technical Regulations
RAC	AC and Refrigeration
RE	Renewable Energy
TCVN	Viet Nam Technical Standards
UCAP	Urban Cooling Action Plan
UHI	Urban Heat Island
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNEP	United Nations Environment Programme
UNOPS	United Nations Office for Project Services
VNEEP	the National Programme on Economical and Efficient Use of Energy
VRV/VRF	Variable Refrigerant Volume/Flow

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1 Introduction and national context

1.1 Background

Cooling activities play an important role in modern life, ensuring food and pharmaceutical preservation, enhancing industrial processes, and maintaining the functionality of critical infrastructure such as healthcare facilities and data centres. They also contribute significantly to providing comfortable living and working environments, crucial for health and productivity in increasingly global warming climates. In recent decades, the demand for cooling solutions has surged, not only to enhance comfort but also to safeguard essential services. At the same time, cooling remains a major driver of global electricity consumption, accounting for 20% of the world's electricity use (Cool Coalition, 2023), making it one of the largest contributors to rising energy demand and greenhouse gas (GHG) emissions.

Viet Nam, a densely populated and rapidly urbanising country, faces significant challenges due to its warm climate and increasingly hot days. The combined effects of rising temperatures, urbanisation, and higher incomes are sharply boosting the demand for cooling, especially in urban areas with hot and humid climates in the country. This is particularly evident in buildings where cooling is crucial for indoor comfort, health, and well-being. Various factors, including demographics, urban development and environmental impacts, are intensifying this trend.

The economic impact of climate change is already significant. According to the World Bank, Viet Nam suffered losses exceeding 10 billion USD in 2020 (3.2% of GDP), with 518 million USD (4.7% of the total) directly attributed to increased cooling costs (World Bank, 2022).

Recognising the need for sustainable cooling[1] solutions aligning with international efforts to reduce cooling-related GHG emissions, Viet Nam has integrated cooling management into its national climate and energy policies that reflect the country's commitment to achieving net zero emissions by 2050 declared at the 26th Conference of the Parties (COP26) in 2021, and its obligations to phase out ozone depleting substances (ODSs) under the Montreal Protocol on Substances that Deplete the Ozone Layer and the Global Cooling Pledge (GCP) that Viet Nam announced to join at COP28 on 5 December 2023. The updated Nationally Determined Contribution (NDC) 2022 outlines key mitigation measures related to air conditioning (AC), refrigeration, and refrigerants.

In line with these responsibilities and commitments, the Government issued Decree No. 06/2022/ND-CP on GHG mitigation and ozone layer protection (Decree No. 06/2022/ND-CP) dated 7 January 2022 and its latest Amendment, Decree No. 119/2025/ND-CP, dated 9 June 2025 (Decree No. 119/2025/ND-CP) alongside Circular No. 01/2022/TT-BTNMT detailing the Law on Environmental Protection regarding climate change response in 2022, which provides detailed guidance on climate change and ozone layer protection related provisions.

On 11 June 2024, the Prime Minister's Decision No. 496/QD-TTg to establish the National Plan for the regulation and phase out of ODSs and controlled GHGs was issued. The overall objective of the National Plan is to effectively manage and phase out controlled substances, including HCFCs (Hydrochlorofluorocarbons) and Hydrofluorocarbons (HFCs), in alignment with Viet Nam's commitments under the Montreal Protocol and deployment of passive cooling strategies to tackle extreme heat in cities, and equipment energy efficiency (EE) aligned with NDCs 2022, Climate

[1] The Government of Viet Nam defines that *"[S]ustainable cooling" refers to the implementation of climate-friendly cooling solutions to reduce GHG emissions, use energy efficiently and economically, and aim to use controlled substances with low or zero GWP in buildings and urban areas.* This definition was provided in the Decree No. 119/2025/ND-CP.

Change Strategy 2050 and PCG. The plan emphasises adopting low- or zero- global warming potential (GWP) substances, advancing technology conversion, and deploying sustainable cooling solutions. These efforts aim to reduce 11.2 million tons of CO_2 equivalent ($MtCO_2e$) emissions by 2045, contributing significantly to Viet Nam's climate and environmental protection goals.

The Ministry of Agriculture and Environment (MAE) is the designated national authority responsible for implementing international climate and ozone protection commitments, including the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement, PCG, the Vienna Convention and the Montreal Protocol as well as the Kigali Amendment to the Montreal Protocol.

As a direct response to these critical responsibilities, the MAE develops Viet Nam's National Cooling Action Plan (NCAP). This foundational blueprint is crucial for steering the nation towards a more sustainable cooling future. It aims to reduce energy and refrigerant-related emissions while expanding access to essential cooling services, thereby directly supporting Viet Nam's NDC commitments and net zero target (NZT). The NCAP provides a thorough sector assessment and outlines strategic interventions spanning regulation, technology, market development, and capacity-building.

1.2 National context

Viet Nam is a nation of significant standing in Southeast Asia, characterised by a large population and a rapidly developing economy that is deeply integrating into regional and global economic structures. In 2023, Viet Nam's average population was estimated at 100.3 million (GSO, 2024). Rapid socio-economic development, coupled with urbanisation and specific geographical and climatic features, presents increasing demands and challenges for cooling needs. In this context, the development and implementation of a strategic NCAP has become imperative. This plan aims not only to meet the essential thermal comfort needs of the population and economic activities but also to harmonise with objectives related to energy security, mitigation of negative environmental impacts, reduction of GHG emissions, and fulfilment of international commitments on climate change.

1.2.1 Geographical and climatic overview

Viet Nam is characterised by a humid tropical monsoon climate, ensuring high temperatures and substantial humidity year-round. This pervasive warmth, intensified by the East Sea's profound influence and consistent average monthly temperatures ranging from approximately 20.3°C in January to 27.7°C in June, inherently drives a significant and persistent demand for cooling solutions across the nation (World Bank, 2025).

While the country exhibits regional climatic variations, with a colder winter in the North compared to the more consistent temperatures in the South, the overall 1991-2020 climatology highlights thermal conditions that necessitate extensive cooling. Notably, average maximum temperatures consistently exceed 30°C from April through September (World Bank, 2025), coinciding with peak precipitation and high humidity. This combination of prolonged high heat and humidity creates significant thermal discomfort, underscoring the foundational and escalating need for cooling throughout much of the year.

1.2.2 Socio-economic landscape and urbanisation

Economic growth and structure

Viet Nam's economy continued its recovery trajectory in 2023, demonstrating resilience amidst global uncertainties. Gross Domestic Product (GDP) for the year increased by 5.05% compared to 2022. Within the overall economic expansion, the final consumption expenditure increased by

3.52% compared to 2022, and asset accumulation grew by 4.09%. GDP per capita at current prices reached approximately 4,282 USD in 2023, an increase from 2,320 USD in 2013 (World Bank, 2023). This continued economic development and rising per capita income are key factors driving increased energy consumption, including for cooling purposes (GSO, 2024).

Population and urbanisation dynamics

Viet Nam's average population in 2023 was 100.3 million people, an increase of 0.84% compared to 2022. Urbanisation remains a profound trend, with the urban population reaching 38.2 million (38.1% of the total) in 2023. Conversely, the rural population was 62.1 million people (61.9%) (GSO, 2024). This ongoing shift towards urban living, characterised by increasing population density and evolving building landscapes, significantly contributes to the growing demand for cooling solutions. This is evident in higher cooling appliance ownership rates: in 2022, nationwide, there were 95 refrigerators and 68 ACs per 100 households. These rates are considerably higher in urban areas, with 101 refrigerators and 94 ACs per 100 households, compared to 91 refrigerators and 51 ACs in rural areas. Notably, the Red River Delta recorded an AC ownership rate of 128 units per 100 households (GSO, 2023).

1.2.3 Climate-induced demand

Direct impact of rising temperatures and extreme weather events

Viet Nam is experiencing a discernible warming trend, with the average temperature in 2023 being 1.1°C above the long-term average and recorded as the second hottest year in history (NCHMF, 2024). Long-term projections also indicate a continued significant rise in temperatures. Research predicts that temperature rises of 2.18–3.88°C in Viet Nam's major cities could increase building cooling demands by 4.8% to 100.6%, depending on structural features (Luong & Phan, 2024).

Recent years have highlighted a clear warming trend and an increase in extreme heat events, directly fuelling a surge in cooling demand. The year 2023 saw a national record high temperature of 44.2°C (EFE, 2023), part of a trend escalating into 2024, which became the hottest year in the nation's instrumental history with numerous daily maximum temperatures surpassing historical records (NCHMF, 2023 and 2024). This persistently high heat, exacerbated by characteristic high humidity, dramatically accelerates the overall demand for cooling solutions across Viet Nam, which is critical for human well-being, productivity, and the stability of essential sectors.

Aggravation of the Urban Heat Island (UHI)

Rapid urbanisation in major cities like Hanoi, Ho Chi Minh City, Can Tho and Da Nang significantly exacerbates the UHI effect. This phenomenon occurs as natural surfaces are replaced by built structures, roads, and heat-absorbing materials (concrete, asphalt), combined with waste heat from human activities (transportation, industry, electricity use). Consequently, urban temperatures become significantly higher than surrounding rural areas, especially at night. Studies in Viet Nam document this, showing temperature differences that can reach several degrees Celsius (Phung et al., 2017; Dang et al., 2018). The UHI effect not only intensifies the sensation of heat but also prolongs cooling requirements, thereby driving more frequent and higher-capacity use of cooling equipment in urban environments. Viet Nam has been implementing an urban cooling program to tackle UHI in cities in partnership with UNEP Cool Coalition and Global Green Growth Institute (GGGI).

The confluence of economic prosperity, population growth, and accelerated urbanisation directly increases Viet Nam's overall energy consumption for cooling and will continue to drive demand for cooling appliances in the coming years (GSO, 2024).

2 Objective and scope of the NCAP

2.1 Objective

In recognition of the urgent need for comprehensive cooling strategies that balance cooling needs for socio-economic development, EE, emissions reduction, and climate resilience, the Government of Viet Nam, with the support of international partners, is actively supporting initiatives to enhance the nation's cooling sector. NCAP has been developed to provide a unified and strategic direction for these efforts.

The primary objective of the NCAP is to facilitate Viet Nam's transition towards sustainable, climate-friendly, and resilient cooling solutions. It aims to ensure that the country can meet its growing cooling needs while contributing effectively to its 2030 NDC targets, PCG, and Viet Nam's 2050 NZT.

This NCAP will serve as a cohesive national strategy and a roadmap for policymakers, industry stakeholders, and international partners, aligning their efforts towards sustainable cooling in Viet Nam. By presenting a comprehensive approach, the NCAP aims to position Viet Nam as a frontrunner in climate-friendly cooling solutions while effectively meeting the increasing cooling demand of its rapidly developing economy.

2.2 Scope

The strategic approach for NCAP is mainly built upon and integrated with data and outputs from the two most recent technical assistance initiatives that assisted MAE in developing effective, sustainable cooling solutions:

- **ETP/UNOPS Collaboration:** This initiative, through a Memorandum of Understanding of the Energy Transition Partnership (ETP) under the United Nations Office for Project Services (UNOPS) with the Department of Climate Change (DCC) under MAE, led to the development of the National Green Cooling Program (NGCP). The NGCP primarily focuses on improving the EE of active cooling technologies and enhancing refrigerant management (hereafter called ETP/UNOPS Technical Assistant).
- **UN ESCAP and UNEP Passive Cooling Support:** This initiative of the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) and United Nations Environment Programme (UNEP) Cool Coalition promotes the adoption of passive cooling solutions to inherently reduce cooling demand. Key strategies include climate-responsive building design, nature-based solutions, and effective urban planning.

The NCAP of Viet Nam leverages the Global NCAP Methodology and builds upon a comprehensive approach. By unifying active and passive cooling measures, the NCAP ensures that the deployment of efficient cooling technologies is complemented by design interventions that minimise the intrinsic need for mechanical cooling.

2.3 General approach and methodology

The NCAP of Viet Nam was developed using a structured, data-driven methodology, primarily consolidating the analytical work and findings from two technical assistance leveraging the global NCAP Methodology. This comprehensive approach was designed to support the delivery of energy-efficient, climate-friendly, and sustainable cooling solutions tailored to Viet Nam's specific context.

The approach and methodology to develop the NCAP were framed into three primary phases as outlined in Figure 1.

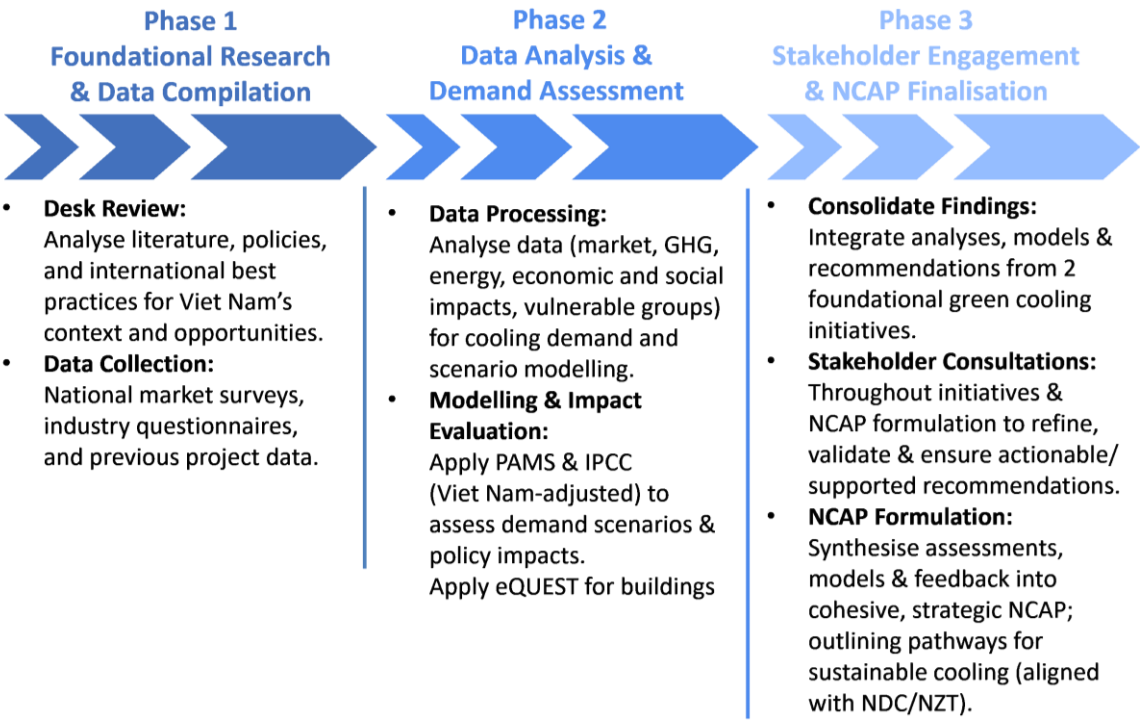


Figure 1: Summary of the approach and methodology to develop the NCAP

Phase I: Foundational Research and Data Compilation focused on establishing an evidence base by gathering comprehensive information important to Viet Nam's cooling sector.

- **Desk review:** A thorough examination of scientific literature, existing national policy frameworks, and international best practices in cooling technologies to extract valuable insights and identify opportunities relevant to the Vietnamese context.
- **Data collection:** Compiling extensive data through national market surveys, targeted questionnaires administered to manufacturers, importers, and distributors, and integrating relevant data from previous projects and studies.

Phase II: Data Analysis and Cooling Demand Assessment involved the systematic processing of the collected data and the quantitative assessment of current and projected cooling demand, along with its associated environmental and socio-economic impacts. Key activities were:

- **Systematic data processing:** Organising and structuring the compiled data into key analytical domains, including market analysis, GHG emissions inventories, energy consumption patterns, and social impact assessments, with a specific focus on vulnerable population groups. This ensured the data was robust and reliable for subsequent modelling.
- **Modelling and impact evaluation:** Applying the Policy Analysis Modelling System (PAMS) and established IPCC (Intergovernmental Panel on Climate Change) methodologies, with necessary adjustments to align with Viet Nam's specific socio-economic conditions and the unique characteristics of its cooling industry. This was used to evaluate current and future cooling demand scenarios and the potential impacts of various policy interventions.

Phase III: NCAP Synthesis, Stakeholder Engagement, and Finalisation, integrating all analytical findings, engaging with key stakeholders, and formulating the final NCAP document:

- **Consolidation of initiative findings:** Integrating the detailed analyses, modelling results, and preliminary recommendations from the two foundational green cooling initiatives.
- **Multi-level stakeholder consultations:** Conduct a series of consultations throughout the development of the foundational initiatives and during the specific NCAP formulation phase.

This iterative engagement served to refine analyses, validate findings, and ensure that the proposed recommendations were practical, actionable, and supported by key actors.

- **Formulation of science-based recommendations for sustainable cooling policies:** Synthesising all assessments, modelling outputs, and stakeholder feedback into a strategic and actionable national sustainable cooling strategy and plan.

2.4 Cooling sectors and sub-sectors under the NCAP

Under the NCAP, cooling is categorised into two sectors and seven sub-sectors in order to provide a clear framework for data collection, policy development, technology assessment, and to propose intervention strategies. The two cooling sectors and seven sub-sectors were defined and categorised based on international practice, national standards on EE, and industry practices, and are summarised in Annex 1.

Figure 1 below provides a schematic overview, offering an intuitive understanding of the NCAP's operational scope and the key domains for targeted interventions.

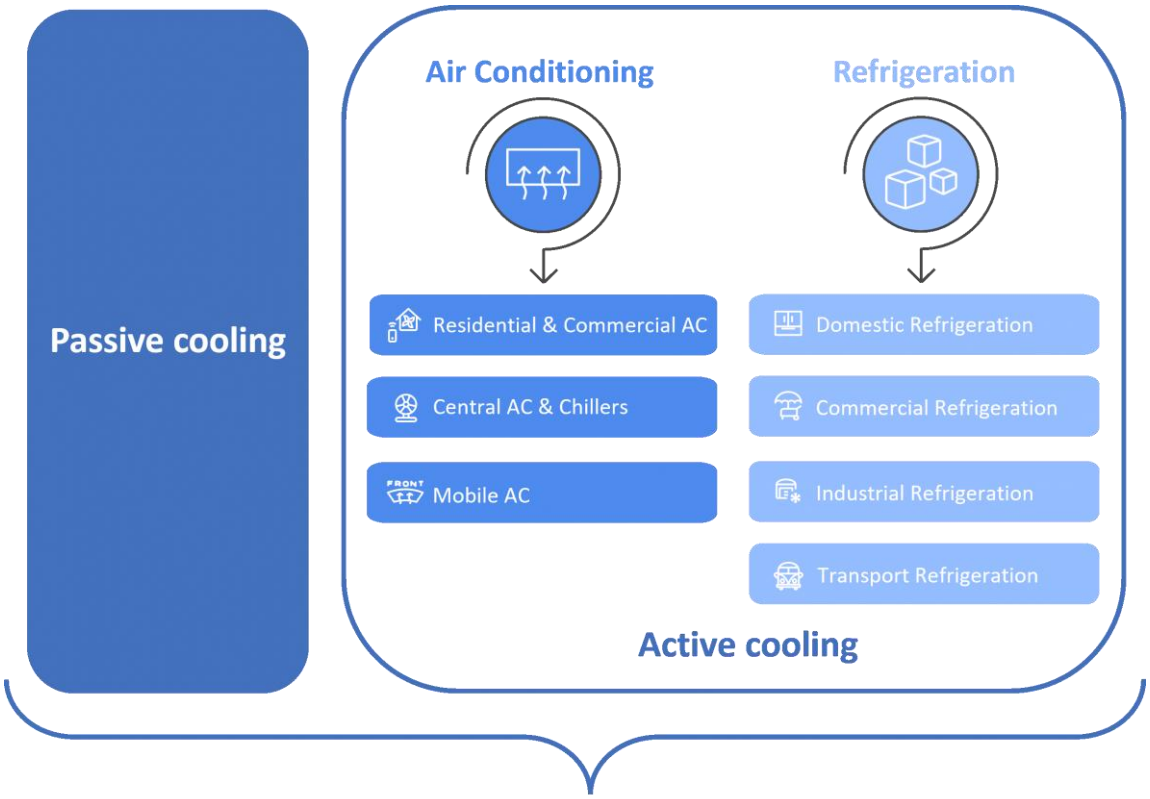


Figure 2: Overview of cooling sectors and sub-sectors under the NCAP

This delineation of cooling sectors and sub-sectors forms the foundational framework for all subsequent analyses, policy recommendations, and targeted actions detailed within this NCAP. By clearly defining these boundaries, the NCAP ensures a focused and systematic approach to addressing Viet Nam's cooling challenges and accelerating the transition towards sustainable cooling solutions across its diverse applications.

2.5 Scenario establishment

To assess the cooling sector's trajectory and identify the necessary interventions to achieve Viet Nam's climate objectives, two distinct scenarios have been developed: a Business-as-Usual (BAU)

scenario and an NZT scenario. These scenarios provide a comparative framework for evaluating the impact of current trends versus accelerated policy action towards national climate goals.

Scenario definitions:

- **BAU Scenario:** This scenario projects the future development of Viet Nam's cooling sector based on the continuation of current market trends, observed autonomous EE improvements, and the enforcement of policies and commitments established prior to 2022. It serves as a baseline representing a pathway without significant new national interventions beyond existing obligations.
- **NZT Scenario:** This scenario outlines an ambitious pathway for the cooling sector, strategically aligned with Viet Nam's commitments under the NDC 2022, PCG and the NZT. It models the impact of accelerated adoption of high-efficiency technologies, a faster transition to climate-friendly refrigerants, increased transport electrification, and the implementation of new strategic policies.

The key assumptions and differentiating parameters for each scenario are detailed in Table 2.

Table 1: Key assumptions and parameters for cooling scenarios

Parameter	BAU Scenario	NZT Scenario
Primary Objective	Projection of current market trends and development pathways, incorporating policies and commitments enacted before 2022.	Alignment of cooling sector development with Viet Nam's NDC 2022 and NZT through ambitious interventions.
EE of Cooling Equipment	Autonomous EE improvement trend (0-0.5% per year), based on the 2018-2022 market survey.	Accelerated EE improvement in line with targets in the NDC mitigation measures*, the Green Cooling Pledge and the National Programme on Economical and Efficient Use of Energy 2019-2030 (VNEEP3).
Refrigerants	HCFC phase-out by 2040 (Montreal Protocol). Continuation of current HFC reduction trend through replacement by natural refrigerants (e.g., R-600a, R-290, R-717) and Hydrofluoroolefins - HFOs (e.g., R-1234yf).	More ambitious HCFC phase-out and HFC phase-down pathways. Emphasis on natural refrigerants and HFOs. Target of 20% refrigerant recovery by 2030 (as per I5s measure) *.
Grid Emission Factor (GEF)	Annual reduction of 2% based on historical data (2015-2021).	GEF trajectory guided by Power Development Plan 8 (PDP8) and Viet Nam's Just Energy Transition Partnership (JETP) commitments.
Transport Sector	Continuation of the current market trend toward vehicle electrification. Consideration of existing fuel consumption limits (Decision 78/2013/QD-TTg & Decision 24/2018/QD-TTg).	Target of 30% electric vehicle (EV) penetration by 2030. Inclusion of relevant NDC mitigation measures: E17 (fuel consumption limits for new vehicles), E24 & E24s (use of electric cars), E26 & E26s (use of electric buses) *.
Key Policies & Commitments Considered	Pre-2022 policies and programmes: VNEEP1, VNEEP2, Standard adherence to the Montreal Protocol & Kigali Amendment.	National targets: NDC 2030, NZT 2050. Key programmes/plans: VNEEP3, PDP8, JETP. Global commitments: PCG.

** Note: The NDC mitigation measures listed under the NZT scenario are further elaborated in Table 2.*

Source: Developed under ETP/UNOPS Technical Assistance

3 Policy and regulatory framework

3.1 International commitments

3.1.1 Montreal Protocol and Kigali Amendment

As a Party to the Montreal Protocol since January 1994, Viet Nam has consistently adhered to its obligations, including all subsequent amendments. Most notably, the nation ratified the Kigali Amendment in September 2019, which incorporated HFCs as controlled substances under the Protocol.

The Montreal Protocol has been remarkably successful in facilitating the control and gradual elimination of ODSs. Currently, the focus is on phasing out the last major group, HCFCs. However, an unintended consequence of this transition was the increased adoption of HFCs. While HFCs do not deplete the ozone layer, they are potent GHGs, with GWPs ranging from several hundred to over 14,000 times that of CO_2.

HFCs were initially introduced as alternatives to ODSs like Chlorofluorocarbons (CFCs) and HCFCs, primarily within refrigeration and AC equipment and appliances. By acceding to the Kigali Amendment, Viet Nam has committed to a structured phasedown of HFC consumption and production, thereby addressing their significant impact on the climate. This commitment is particularly critical given the steep projected increase in demand for cooling across developing nations, especially in South and Southeast Asia. Unabated growth in HFC use could otherwise negate the climate benefits achieved through the earlier phase-out of CFCs and HCFCs within a few decades. Consequently, Viet Nam has commenced the phasedown of high-GWP HFCs alongside its ongoing efforts to achieve a near complete phase-out of all remaining ODSs.

3.1.2 Nationally Determined Contributions

As a signatory to the Paris Agreement, Viet Nam is committed to reducing its GHG emissions and adapting to the impacts of climate change through its NDCs.

Under the NDC 2022, the targets for the cooling sector are encompassed within the broader objectives of the energy sector. Specifically, the energy sector's emission reduction targets are set at 7% through domestic efforts (unconditional contribution) and up to 24.4% with international support (conditional contribution). The potential for emission reduction relative to the BAU scenario amounts to a cumulative 382.66 $MtCO_2e$ from 2021 to 2030, with a specific target of 64.78 $MtCO_2e$ by the year 2030.

The emission targets are in line with the energy saving of 5-7% of total energy consumption in the 2019 - 2025 period, and 8-10% in the 2019 - 2030 period indicated in VNEEP3. Targets related to the improvement of EE in cooling sectors are summarised in the Table below:

Table 2: Current NDC targets for energy efficiency in the cooling sectors

Cooling sector/ sub-sector	NDC measure	2030 Target
Residential and commercial AC	E1	• 85% of urban and 75% of rural households (≈11.4 M urban; 12.5 M rural) use high-efficiency AC (≥30% more efficient vs. 2014 baseline) • Cumulative reduction: 9.16 $MtCO_2e$ (2021–2030); 2.37 $MtCO_2e$ in 2030
Central AC and chiller	E27	• 15% reduction in energy demand vs. BAU through the deployment of high-efficiency equipment
MAC	E24, E26, E17	• 30% of buses and cars electrified by 2030

Cooling sector/ sub-sector	NDC measure	2030 Target
		• Fuel-efficiency limits for Internal Combustion Engine (ICE) vehicles: small ≤ 4.7 L/100 km; medium ≤ 5.3 L/100 km; large ≤ 6.4 L/100 km
Domestic refrigeration	E2	• 80% of urban and 75% of rural refrigerators (≈10.7 M urban; 12.5 M rural) are high-efficiency models (≥30% gain vs. 2014) • Cumulative reduction: 4.19 $MtCO_2e$ (2021–2030); 0.87 $MtCO_2e$ in 2030
Commercial refrigeration	E27	15% reduction in energy demand vs. BAU through high-efficiency equipment
Industrial refrigeration	E16	15% reduction in energy demand vs. BAU through the deployment of high-efficiency equipment
Transport refrigeration		No specific target
Refrigerant	I5s	20% of refrigerant will be recovered by 2030 with international support

Source: Compiled from NDC 2022 Technical Report

The emission reduction potential, costs, and financial needs of GHG emission reduction measures listed under the NDC for cooling for the period 2021 - 2030 are provided in the NDC Technical Report 2022.

3.1.3 Global Cooling Pledge

In 2023, at the COP28, Viet Nam reaffirmed its commitment to sustainable cooling by joining the PCG, alongside 63 other nations. This pledge binds signatories to reduce cooling-related emissions by 68% by 2050 compared to 2022 levels, further solidifying Viet Nam's leadership in green cooling and supporting the objectives of the Paris Agreement and the Kigali Amendment under the Montreal Protocol.

Following the launch of the PCG at COP29, Viet Nam, along with eight other countries, announced the intention to integrate cooling into its updated NDC, emphasising Viet Nam's commitment to addressing this pressing issue, recognising the transformative potential of sustainable cooling in mitigating climate change and enhancing EE (UNEP, 2024).

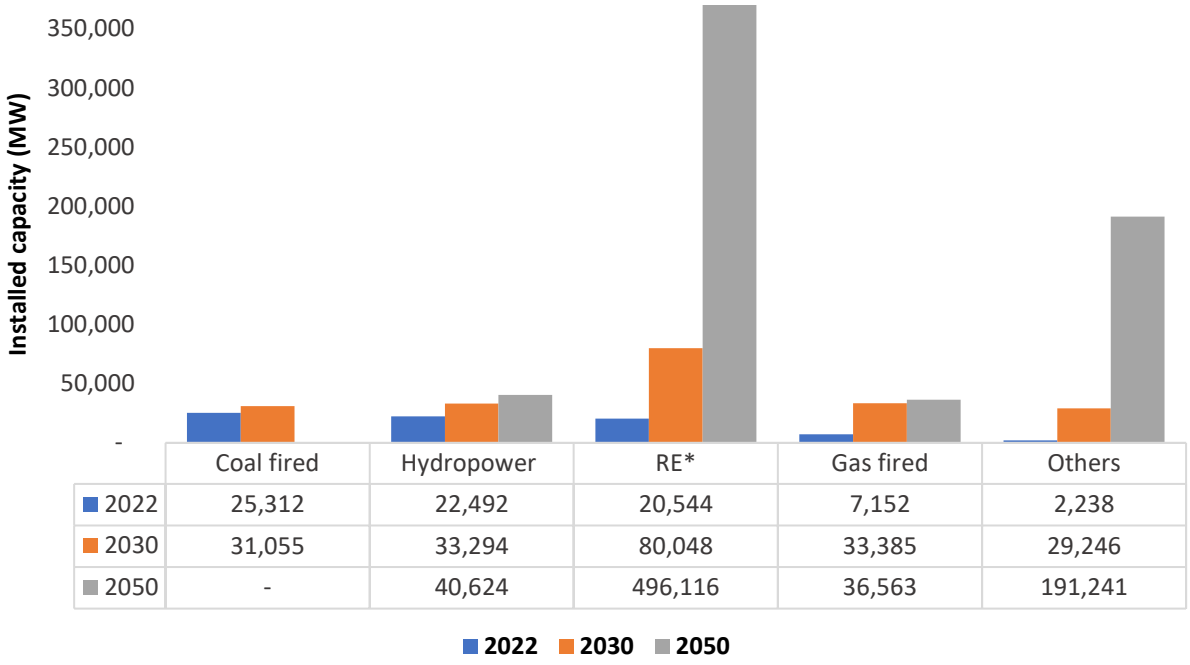
As part of the global movement, nations are preparing NCAPs to institutionalise green and sustainable cooling practices within their legal frameworks.

3.2 National policy framework

3.2.1 Power sector development and grid decarbonisation pathway

In April 2025, the Government of Viet Nam approved the revised National Electricity Development Plan for 2021 - 2030, with a vision to 2050 in 2023 (commonly known as the revised PDP8).

According to the projections in the revised PDP8, commercial electricity consumption is expected to grow substantially from 261.69 TWh in 2022 (EVN, 2023) and reach approximately 500.4 – 557.8 TWh by 2025 and around 560.4 – 624.6 TWh by 2030. By 2050, this figure is anticipated to increase to a range of 1,360.1 – 1,511.1 TWh. The energy system of Viet Nam by 2050 will change drastically with the transition towards renewable energy (RE), characterised by a remarkable 24-fold surge in RE installed capacity compared to 2022. This transformation aligns with plans for a complete phase out of coal fired power. Figure 3 shows the electricity system of Viet Nam in 2022 compared to the projections in the revised PDP8.



	Coal fired	Hydropower	RE*	Gas fired	Others
2022	25,312	22,492	20,544	7,152	2,238
2030	31,055	33,294	80,048	33,385	29,246
2050	-	40,624	496,116	36,563	191,241

**RE: includes solar energy, wind energy and biomass energy*

Figure 3: The electricity system of Viet Nam in 2022 compared to the projections in the revised PDP8

Source: Compiled from Viet Nam Electricity (EVN) Annual Report 2022 and the revised PDP8

Grid emission trend

Viet Nam's grid is steadily decarbonising as renewables scale up. DCC reports the national GEF fell from 0.6766 tCO_2/MWh in 2022 to 0.6592 tCO_2/MWh in 2023 (DCC, 2024), continuing a multi-year decline. Solar, wind and other renewables now supply about 13% of electricity, with hydro adding another 31%, displacing coal-fired output and pushing the emission factor downward.

The cooling sector, as a significant consumer of electricity, is directly impacted by the GEF. A lower GEF will result in lower electricity consumption, which will reduce indirect emissions from the cooling sector, offering an opportunity to align cooling-related activities with climate mitigation goals. The projected trends of the GEF under both the BAU and NZT scenarios are further illustrated in Figure 4.

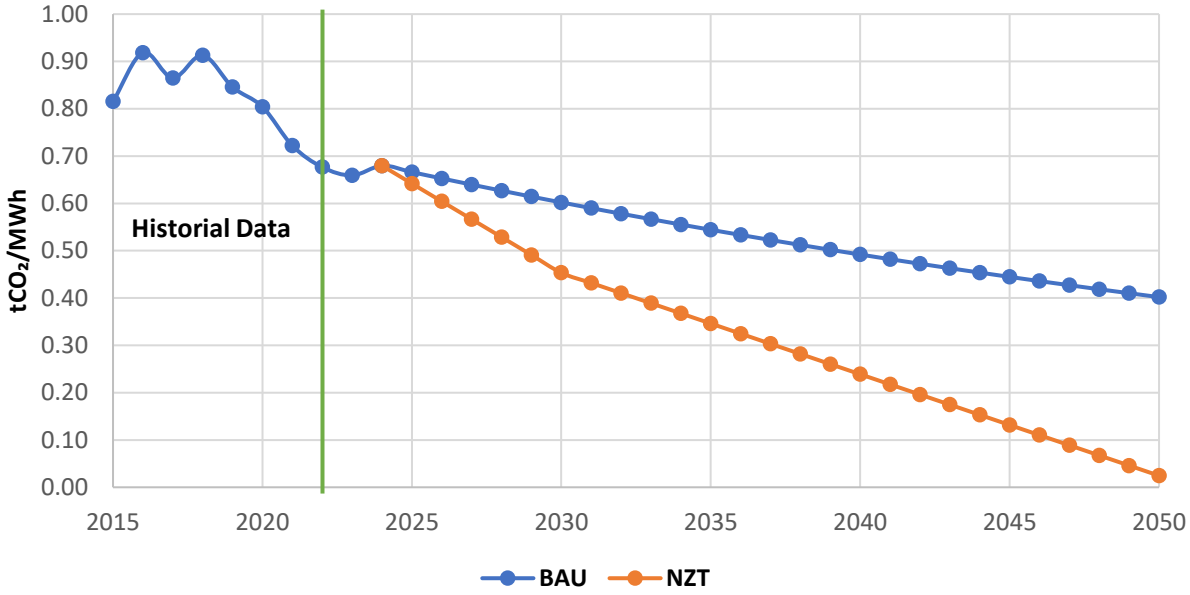


Figure 4: Grid emission factor trend under BAU and NZT scenarios

Source: Compiled from the revised PDP8 and GEF published by DCC

The trend of GEF in BAU and NZT scenarios is modelled and depicted in Figure 4. The chart shows that in the BAU case, incremental renewables and efficiency continue to cut the factor, but only to around 0.40 tCO_2/MWh by 2050. The NZT case doubles the pace: emissions dip below 0.60 by 2025, halve again to around 0.30 by 2035, and plummet to near-zero (around 0.02) by 2050, consistent with deep decarbonisation of the power mix.

3.2.2 Refrigerant management policies

Viet Nam's refrigerant management framework is built upon a foundation established between 2022 and 2024. The primary legal instrument is the Government's Decree No. 06/2022/ND-CP, which sets a new management system for importing controlled substances. From 2024 onwards, importers must apply for import quotas from MAE before applying for importing licenses from the Ministry of Industry and Trade (MOIT) in order to import controlled substances into Viet Nam. The Decree further details the rules for the allocation of the quotas and administration of quotas to ensure responsible usage and compliance with national consumption limits.

To operationalise this system, the Prime Minister of Viet Nam issued Decision No. 496/QD-TTg on 11 June 2024, approving the National Plan on the Management and Elimination of ODSs and Controlled GHGs. This National Plan is critical as it transforms obligations under the Montreal Protocol and Kigali Amendment into a national roadmap. The plan emphasises adopting low- or zero-GWP substances, advancing technology conversion, and deploying sustainable cooling solutions. It establishes a clear roadmap for implementation, assigning specific responsibilities to ministries, sectors, localities, organisations, businesses, and individuals. Furthermore, it outlines targeted solutions for strengthening management capacity, supporting enterprises in transitioning to alternative technologies, and monitoring annual consumption and reduction levels. The National Plan also introduces restrictions on products and equipment containing HCFCs and HFCs. This plan alone projects cumulative savings of approximately 11.2 $MtCO_2e$ by 2045, directly contributing to Viet Nam's conditional mitigation target in the 2022 NDC.

The technical basis for this plan was provided by Decision No. 4134/QD-BTNMT issued by the Minister of the Ministry of Natural Resources and Environment (MONRE), now known as MAE, on

28 December 2023, which announced the baseline production and consumption levels of HFCs for the 2024-2028 period.

Building on this foundation, a significant evolution of the framework occurred with the issuance of Decree No. 119/2025/ND-CP by the Government on 9 June 2025, amending Decree No. 06/2022/ND-CP. This new decree does not replace the existing framework but significantly enhances the operational details, strengthens enforcement mechanisms, and expands the scope of responsibility. Key amendments focus on several critical areas:

- **Strengthening the HCFC phase-out commitment:** The new decree elevates Viet Nam's commitment by changing the 2040 target from "banning import and export" to a "complete phase-out" of HCFCs. This change in terminology signifies a stronger pledge, moving beyond just controlling cross-border trade to aiming for the total elimination of these substances from the economy.
- **Expanding registration and strengthening quota management:** The decree significantly expands the scope of mandatory registration for equipment owners by removing the previous high total-capacity threshold (586 kW). Now, any organisation owning at least one AC unit of 26.5 kW or more must register, bringing numerous medium-sized facilities into the national management system for the first time. This expanded registry is then directly linked to the quota system, as the decree clarifies that this reported data is the basis for allocating import quotas. The system also gains flexibility, allowing re-exporters to have their quotas replenished.
- **Expanding scope to product manufacturers and importers' responsibility:** It extends the responsibility for collection, recycling, and disposal to manufacturers and importers of smaller appliances (under 26.5 kW) starting from 1 January 2028, strengthening the principle of Extended Producer Responsibility (EPR).
- **Clarifying ministerial roles in line with governmental restructuring:** A key update is the clarification and realignment of roles and responsibilities among key government ministries, especially reflecting Viet Nam's recent state apparatus restructuring.

3.2.3 Regulations and policies on energy efficiency of the cooling sector

The primary legal instrument governing EE in Viet Nam is the Law on Economical and Efficient Use of Energy, No. 50/2010/QH12, enacted by the National Assembly in 2010 (LEEE 2010). After 15 years of implementation, a landmark step was taken when the National Assembly passed the Amended Law on Economical and Efficient Use of Energy, No. 77/2025/QH15, on 18 June 2025, and will officially take effect on 1 January 2026 (LEEE 2025). This amendment represents a dynamic shift, moving from a focus primarily on the efficiency of individual equipment to a more holistic approach, particularly through the recognition of passive cooling solutions.

A core innovation of LEEE 2025 is its expanded definition of an "Energy-saving product," which now explicitly includes “building materials with good insulation properties that help reduce energy consumption.” This is the most impactful change for the cooling sector, as it officially acknowledges the fundamental role of the building envelope and passive cooling solutions. This policy shift paves the way for specific technical standards and regulations for insulating materials, which can directly reduce the cooling load on buildings. Furthermore, the amended Law establishes a new policy landscape by introducing key concepts such as "High Energy Performance Level," designed to encourage superior products, and formally defining the role of an "Energy Service Company (ESCO)." Together, these updates signify a strategic move towards a more comprehensive and integrated approach to EE.

While the amended Law marks a strategic shift by incorporating passive cooling solutions like building materials, its provisions regarding specific technical standards for active cooling

equipment are not yet detailed. Therefore, the subordinate legal documents and roadmaps issued under the LEEE 2010, which govern these specific appliances, remain the primary basis for implementation until new, detailed guidance is provided.

Following the enactment of the LEEE 2010, the implementation of an energy labelling scheme for various equipment categories has progressed from voluntary to mandatory.

- Prime Minister's Decision No. 51/2011/QD-TTg (November 2011): Initiated voluntary energy labelling for refrigeration equipment, specifically ACs, household refrigerators, and commercial refrigerators.
- Prime Minister's Decision No. 03/2013/QD-TT-g (Amending 51/2011/QD-TT-g): Transitioned to mandatory energy labelling, with compulsory requirements starting 1 July 2013, for ACs and 1 January 2014, for household refrigerators.

Subsequently, from 1 January 2015, a ban was imposed on the import and production of equipment that did not meet the stipulated minimum EE levels. This applies to non-ducted ACs, household refrigerators, and commercial freezers.

To specify the scope and implementation of EE measures, the Prime Minister issued Decision No. 04/2017/QD-TTg on 9 March 2017 detailing the equipment and vehicles that must adhere to mandatory energy labelling and Minimum Energy Performance Standards (MEPS) and outlining the roadmap for their application. Accordingly, ACs, refrigerators, and commercial refrigerated cabinets are subject to mandatory energy labelling.

Despite the established legal framework, the minimum EE levels defined through these regulations were introduced quite a long time ago. These standards may no longer reflect current best practices or technological capabilities, potentially hindering further energy savings.

Table 3 shows the applications of the current national standards for cooling equipment in each cooling sub-sector.

Table 3: List of existing national standards for cooling equipment

No	Sector	Applicable national standard
1	**AC**	
1.1	Residential and commercial AC	• TCVN 7830:2021 for non-ducted ACs - EE • QCVN 09:2017/BXD in National Technical Regulation on EE Buildings
1.2	Central AC and chiller	• TCVN 13256:2021 for VRV/VRF (Variable Refrigerant Volume/Flow) ACs – EE: This standard only includes VRF/VRV AC, which does not represent the whole sub-sector, and there is still no standard on EE for Chillers. • QCVN 09:2017/BXD for National Technical Regulation on EE Buildings
1.3	MAC	Not yet developed
2	**Refrigeration**	
2.1	Domestic refrigeration	• TCVN 7828:2016 for Refrigerator, Refrigerator-freezer, and Freezer - EE • TCVN 7829:2016 for Refrigerator, Refrigerator-freezer, and Freezer - Method for Determination of EE
2.2	Commercial refrigeration	• TCVN 10289:2014 for Commercial Refrigerated Cabinets - EE • TCVN 10290:2014 for Commercial Refrigerated Cabinets - Method for Determination of EE
2.3	Industrial refrigeration	Not yet developed
2.4	Transport refrigeration	Not yet developed

Source: Compiled under ETP/UNOPS Technical Assistance

3.2.4 Urban planning and building energy codes

Viet Nam's policy framework for urban planning and building design for EE is governed by a hierarchical system of technical instruments issued by the Ministry of Construction (MOC). This framework distinguishes between national standards (TCVN), which are recommended, and national codes (QCVN), which are legally binding. Key policy features include:

- **Building codes and EE:** The QCVN series of national codes, notably QCVN 09:2005/BXD, QCVN 09:2013/BXD, and QCVN 09:2017/BXD, provides a regulatory foundation for EE in buildings. These codes specify requirements concerning building envelope performance, thermal resistance of structures, and aspects of ventilation. They detail parameters for calculating thermal resistance and list the thermal characteristics of various materials.
- **Passive cooling elements in architectural regulations:** Certain architectural regulations issued by the MOC incorporate elements related to passive cooling design. For instance, TCVN 4252:2012 addresses the accommodation of regional particularities, including temperature, in design. TCVN 5687:2024 provides standards for ventilation and AC, including best practices for ventilation design. QCXDVN 09:2005/BXD includes specific requirements for building envelopes, roofs, and ventilation, with natural ventilation qualifying as a passive cooling design. QCVN 09:2013/BXD and QCVN 09:2017/BXD offer instructions on ventilation systems and the outer layers of buildings for EE.
- **Climate information integration:** QCVN 02:2022/BXD presents statistical data and information on climate conditions across different regions of Viet Nam, serving as a resource for creating regionally specific designs.
- **Material use standards:** Standards such as TCVN 7194:2002 categorise insulating materials based on various properties, and TCVN 7950:2008 provides detailed specifications for Calcium Silicate as an insulating material.
- **Urban planning directives:** Resolution No. 06-NQ/TW of the Politburo outlines Viet Nam's urbanisation strategy, emphasising green, intelligent, and sustainable urban development. Decision No. 11/QD-BXD from the MOC further supports scientific, technological, and innovative advancements in the construction sector, promoting sustainable and climate-adaptive urban areas and green construction materials. These policies encourage the preservation of nature, soil moisture, and forests, contributing to the reduction of the urban heat island effect through plant and tree growth.
- **Overall urban development** Goals: The MOC's initiatives include accelerating urban and rural system planning, developing a national urban planning database, and promoting green and climate-adaptive urban areas (2021-2030), alongside advancing smart sustainable urban models (2018-2025, vision to 2030). The national urbanisation rate is targeted to reach 53.9% by 2023, with urban planning identified as a key sectoral breakthrough.

Although urban planning policies prioritise environmental protection and climate adaptation, they rarely include specific directives on sustainable/urban cooling beyond tree planting targets; a direct and comprehensive vision specifically for urban cooling and detailed passive cooling strategies remains largely unarticulated within these policy documents. Achieving sustainability targets, including NZT by 2050, requires significant transformations in urban energy use and efficiency, particularly in buildings.

4 Country cooling profile

4.1 GHG emissions from the cooling sector

Between 2018 and 2022, Viet Nam's cooling sector expanded at an average of 2.3% a year, led by the Residential and Commercial AC sub-sector, which grew 7.6% annually; total units imported and manufactured climbed from 5.4 million to over 5.9 million. Successive record-hot years, alongside the country's push into digitalisation, smart manufacturing, and high-tech clean-room production, have reinforced demand, making Viet Nam the largest cooling market in ASEAN. At the same time, the COVID-19 pandemic highlighted how indispensable refrigeration is for food processing, storage, and distribution nationwide.

Cooling is one of Viet Nam's largest energy consumers: in 2022, it drew a total of 71.38 TWh, made up of 65.95 TWh of grid electricity plus fuel burned by MAC and transport refrigeration (0.71 million m^3 of diesel and 1.23 million m^3 of gasoline). That load alone represented 25.2% of the country's entire 261.686 TWh of generated and purchased power (EVN, 2023).

Recent surveys and modelling show a steady rise in both direct (refrigerant) and indirect (energy-related) emissions, putting the sector on a trajectory that could undermine the country's NDC by 2030 and 2050 NZT if no additional measures are taken.

Figure 5 shows the proportion of energy consumption of cooling sub-sectors in 2022 (converted to TWh for comparison).

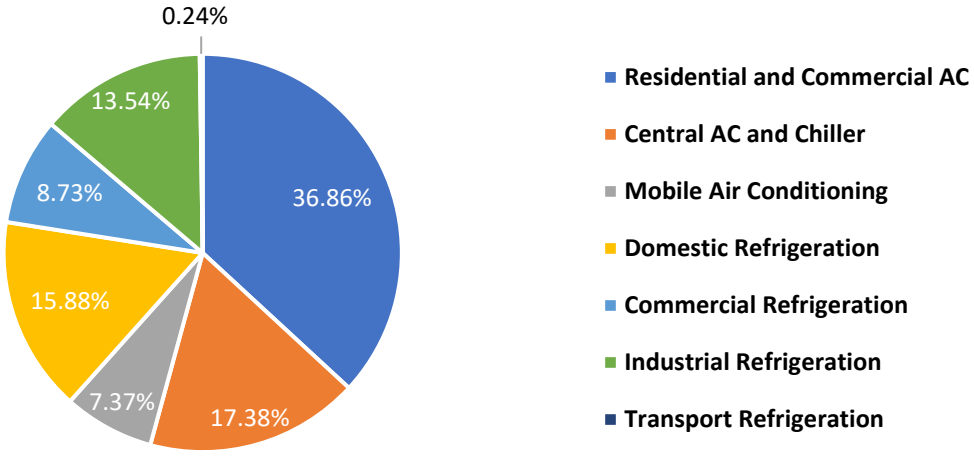


Figure 5: Proportion of energy consumption of cooling sub-sectors in 2022

Source: Compiled under ETP/UNOPS Technical Assistance

Viet Nam's cooling sector generated 64.68 $MtCO_2e$ in 2022, accounting for about 14% of the country's projected total emissions. Direct emissions contributed 10.16 $MtCO_2e$ (15.7%), while indirect, energy-related emissions added 54.52 $MtCO_2e$ (84.3%). Within the sector, Residential and Commercial AC dominated with 38% of the load, followed by Central AC & Chillers and Industrial Refrigeration, each at roughly 16% (see Figure 6).

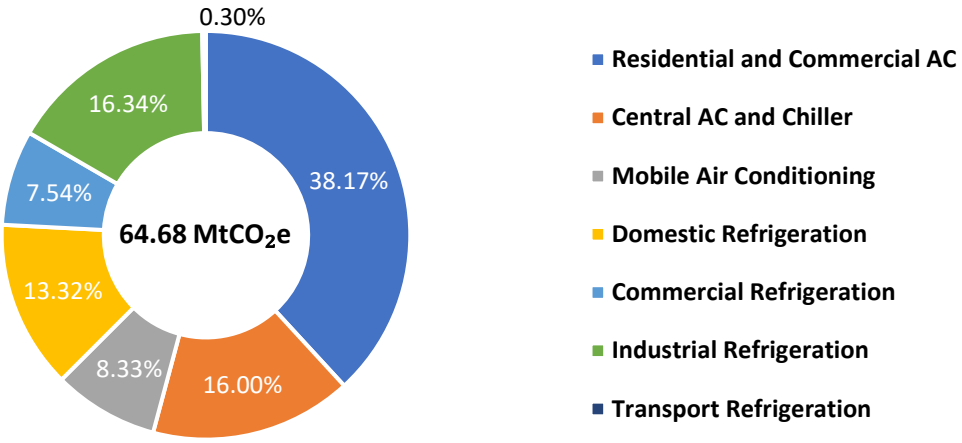


Figure 6: Total BAU GHG emission from the cooling sector and contribution by sub-sectors in 2022

Source: Compiled under ETP/UNOPS Technical Assistance

4.2 Energy efficiency status and refrigerant use in the cooling sector

A recent survey *under ETP/UNOPS Technical Assistance* confirms that Viet Nam's room AC stock is already operating well above the current MEPS. Actual average cooling seasonal performance factors (CSPF) sit between 3.26 – 3.71, depending on size, whereas the existing MEPS regulated CSPF is in the range of only 2.8 – 3.1. With the target of a 50% increment in average CSPF, the MEPS is estimated to increase by 35% by 2030 (3.8 to 4.2). With the 2030 target, a 50% lift in the fleet-average CSPF implies raising MEPS by roughly 35% to 3.8 – 4.2 as visualised in Figure 7.

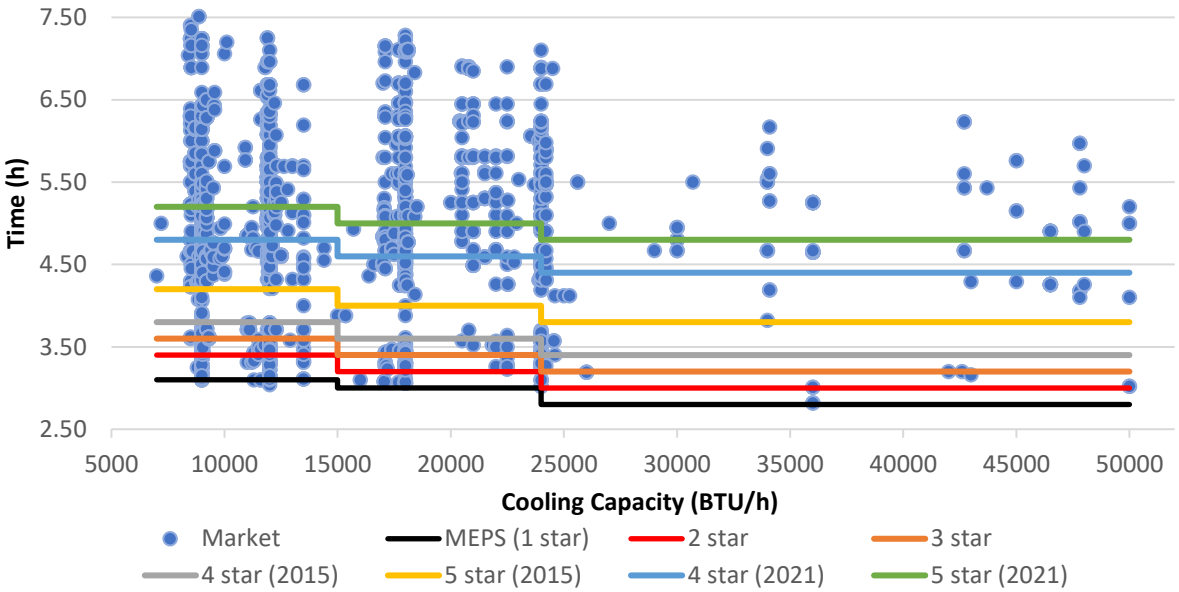


Figure 7: Cooling capacity vs. CSPF with MEPS line and star rating criteria in 2023

Source: Compiled under ETP/UNOPS Technical Assistance

In Viet Nam, a wide range of cooling equipment using different technologies is available on the market. With the recent EE policies and technology development, new, more efficient equipment has quickly penetrated the market. The survey under *ETP/UNOPS Technical Assistance* shows that by 2022, about 72% of new residential and commercial units already used inverter drives, delivering up-to-35% efficiency gains, and the share is still climbing.

Advanced technologies to improve performance and reduce system costs focus on options such as high-efficiency compressors, heat-transfer performance, and motors similar to the prominent global trend. Laboratory prototypes using magnetic or thermoelectric cooling are emerging but remain niche.

Refrigerant use is evolving rapidly in both AC and refrigeration (RAC), yet each sector is following its own distinct trajectory:

- **AC:** HCFC-charged units have almost disappeared from new sales, while the old products in which HCFCs are quickly removed from stock at the end of life. Under Decision 496/QD-TTg, HCFCs will be eliminated nationwide by 2040. The current market is led by HFCs of R-32, R-410A, and R-134a in room, central, and chiller equipment, while large chillers are switching to R-717 (NH_3) and luxury MAC models to R-1234yf. Natural options such as R-600a and R-290 are only just entering split systems.
- **Refrigeration:** Industrial cold storages still lean on HCFC-22 and HCFC-123, yet they too face the 2040 phase-out deadline. Conventional HFCs like R-134a and R-404A dominate mid-scale equipment, but the fastest growth is in natural refrigerants: R-717 remains the workhorse for large facilities, while R-290 and R-600a have swiftly become the default in domestic and small-commercial cabinets, signalling an accelerating shift away from high-GWP gases.

4.3 Integrated, sustainable, and climate-resilient cooling solutions for buildings & cities

Current building practices in Viet Nam have largely overlooked passive cooling strategies. In the last five years, 98% of all structures were built without insulation, 75% use single-layer glass, and 41% have a window-to-wall ratio (WWR) over 0.25. Additionally, 37% of these buildings are equipped with central AC systems, and 25% have variable speed fans and pumps (VNEEP, 2022). The prevalent use of glass in modern office buildings significantly increases heat load, up to 20 times with single-layer glass and 10 times with double-layered glass, compared to regular walls. This over-reliance on active cooling methods to compensate for inadequate passive design leads to higher energy consumption (Nguyen V.M., 2024).

For instance, a 2024 survey of 23 high-rise office blocks in Da Nang found that 100% lacked any façade insulation, 83% favoured fully rectangular forms, and many pushed the glass-to-wall ratio towards 100%; only one building provided external shading. Field measurements show that for such towers, 45 – 80% of unwanted heat now enters through glazing versus 10 – 45% through opaque walls, driving near-continuous ACs (Luong & Phan, 2023).

Policy is beginning to respond, but coverage is patchy. The MOC's Decision 385/QD-BXD (May 2022) commits the sector to ensure that more than 50% of publicly funded buildings satisfy green-building criteria by 2050 and emphasises passive-cooling design. Yet the dominant new-build segment, detached houses, which dominate the added floor space as presented in Figure 8, still sit outside any mandatory energy-use cap, so today's choices lock high cooling demand into the fabric for decades.

There are energy codes and no compulsory requirements of an upper energy consumption threshold for single detached houses, leading to high energy consumption over their lifecycle.

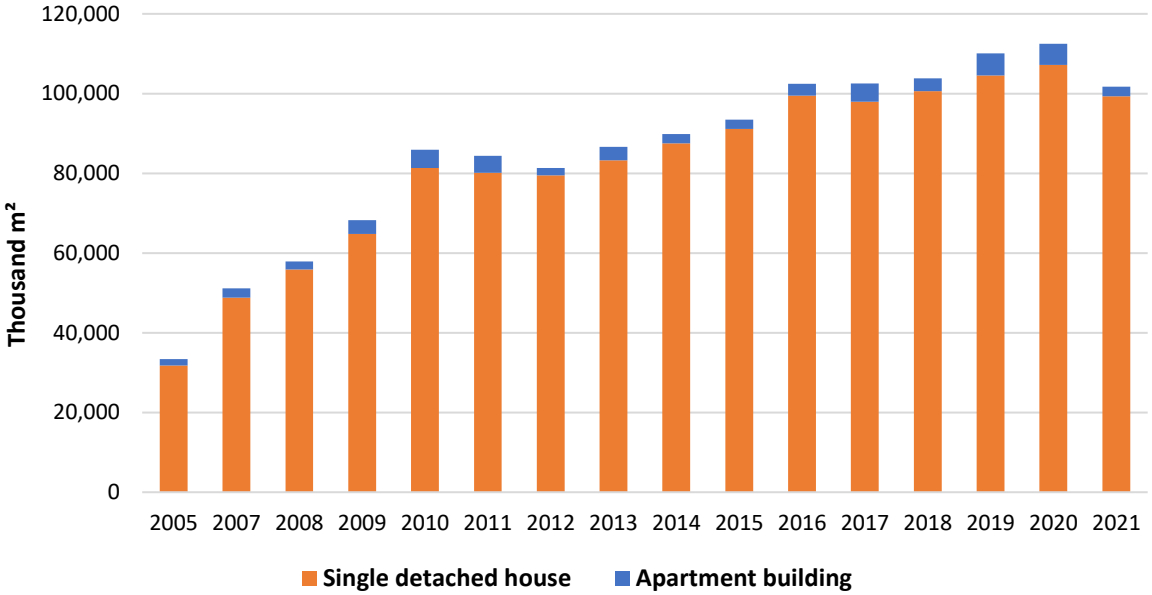


Figure 8: Constructed residential floor area additions, by housing type

Source: Compiled under UNEP Support

Urban growth amplifies the challenge. Over the past three decades, Viet Nam has undergone an extensive urban transformation that has leveraged economic development and a high density of population in many cities. Viet Nam had 37.4 million urban residents in 2022, and cities added more than 9 million people over the previous 10 years, with the urbanisation rate reaching 37.6%, up from 31.7% a decade earlier (GSO, 2024); projections show urbanisation topping 57% by 2050 (Open Development Mekong, 2024). The replacement of vegetation with concrete and glass intensifies the UHI effect, while a rapidly expanding stock of air-conditioners adds further waste heat to the street.

The health signal is unmistakable. A national multi-province study across eight ecological regions reports that each heatwave lifts all-cause hospital admissions by 7% (RR 1.07) and infectious-disease admissions by 27% (RR 1.27) within three days; the risk is even higher for the elderly and for respiratory cases in Ho Chi Minh City (RR ≈ 1.30) (Kadihasanoglu, 2022; Tran et al, 2019).

Taken together, these data underline the urgency of mainstreaming passive solutions, shading, insulation, natural ventilation, and urban greenery, so that Viet Nam can meet its cooling needs without multiplying energy use, emissions, and heat-related health risks.

5 Strategic interventions towards the 2030 NDC and 2050 NZT targets

The strategic interventions and quantifiable targets for Viet Nam's cooling sector are designed to align with the nation's 2030 NDC, the 2050 NZT, and relevant international commitments. These interventions are a synthesis of technical assessments, alignment with national and international policy drivers, consideration of technological advancements, and stakeholder consultations. The overarching aim is to transition the cooling sector towards sustainability, significantly reducing its energy consumption and GHG emissions.

5.1 Energy efficiency enhancement targets

Improving the EE of cooling equipment and promoting EE in buildings is the key measure to reduce indirect GHG emissions from electricity consumption by the cooling sector. The EE targets established under this NCAP are ambitious yet achievable, derived from an analysis of current market conditions, the potential of best available technologies, Viet Nam's national commitments and policies including the NDC 2022, VNEEP3, the regulatory direction provided by Decision No. 496/QD-TTg and international drivers such as the PCG.

The primary drivers for the EE enhancement target for the cooling sector include:

- **Alignment with PCG and national ambition:** Viet Nam's commitment to the PCG, which calls for at least a 50% improvement in the global average efficiency of new AC equipment sold by 2030 (from a 2022 baseline), is a primary driver for the NCAP's EE targets. This international pledge reinforces existing national momentum, where current NDC 2022 measures already target equipment significantly more efficiently than a 2014 baseline. The NCAP's targets, therefore, represent an accelerated and updated pathway.
- **Contribution to VNEEP3:** The EE improvement targets across all cooling sub-sectors are designed to contribute substantially to the overarching goals of VNEEP3. With VNEEP3 aiming for a national energy saving of 8-10% of total energy consumption by 2030 (compared to a BAU scenario of NDC), enhancing the efficiency of the rapidly growing and energy-intensive cooling sector is critical for Viet Nam to achieve this national objective.
- **Technological feasibility and market trends:** The specific EE improvement percentages for various sub-sectors are based on technical assessments of current average EE levels in the Vietnamese market, the availability and cost-effectiveness of best available technologies globally and locally and observed market penetration rates of more efficient equipment. Global trends indicate a continuous advancement in compressor technology, heat exchanger design, and smart controls, making these targets achievable with appropriate policy interventions and market support.
- **Long-term vision for EE (2050 targets):** The EE targets extend to 2050 and reflect a long-term commitment to maximising energy savings. As technologies mature and approach their thermodynamic efficiency limits, these sustained improvements are essential for Viet Nam to meet its ambitious 2050 NZT.

Table 4 provides a detailed breakdown of these EE targets by cooling sub-sector, including the implied average annual growth rate of efficiency.

Table 4: Energy efficiency targets for cooling sub-sectors with corresponding interventions

Cooling sub-sector	Period	Target for EE improvement	Average growth rate/year
Residential & Commercial AC	2022–2030	+50%	~6.25%
	2031–2050	+30%	~1.5%
Central AC & Chiller	2022–2030	+20%	~2.5%
	2031–2050	+30%	~1.5%
MAC	2022–2030	+15%	~1.8%
	2031–2050	+30%	~1.5%
Domestic Refrigeration	2022–2030	+50%	~6.25%
	2031–2050	+30%	~1.5%
Commercial Refrigeration	2022–2030	+20%	~2.5%
	2031–2050	+30%	~1.5%
Industrial Refrigeration	2022–2030	+15%	~1.8%
	2031–2050	+25%	~1.3%

Transport Refrigeration	2022–2030	+10%	~1.2%
	2031–2050	+20%	~1.0%

Source: Compiled under ETP/UNOPS Technical Assistance

The specific EE improvement targets for each cooling sub-sector by 2030 and 2050, benchmarked against a 2022 baseline, have been defined to ensure a targeted and impactful approach across Viet Nam's diverse cooling landscape. The following enlightens the rationale underpinning the EE ambitions for cooling sub-sectors:

- **Residential & Commercial AC and Domestic Refrigeration:**
    - **Target 2030 (+50% EE improvement):** This high-ambition target directly reflects Viet Nam's commitment to the PCG. It also builds upon existing national momentum where NDC measures (E1 for ACs, E2 for refrigerators) already aim for equipment significantly more efficient than a 2014 baseline. The NCAP's 50% target (from a 2022 baseline) represents an accelerated pathway, considering significant technological advancements (such as the high market penetration of inverter ACs) and the large contribution of these sub-sectors to national energy consumption. This aligns with VNEEP3's goal of substantial national energy savings.
    - **Target 2050 (+30% additional EE improvement, totalling +80% vs. 2022):** The continued EE improvement towards 2050 for these high-volume sub-sectors is crucial for achieving Viet Nam's 2050 NZT. This target anticipates continued technological advancements. However, the pace of innovation might gradually slow as technologies mature and near their inherent performance limits. It also assumes a complete replacement of older equipment with new-generation, highly efficient, and smart appliances. With continued implementation of strong MEPS and labelling programs, driven by the principles of Decision 496/QD-TTg, which emphasises deploying sustainable cooling solutions.
- **Central AC & Chiller Systems and Commercial Refrigeration:**
    - **Target 2030 (+20% EE improvement):** This target is strongly supported by NDC measure E27, which mandates a 15% reduction in energy demand by 2030 (compared to the 2014 NDC baseline) through high-efficiency equipment in these applications. The NCAP's +20% target for new equipment efficiency aims to enable and potentially exceed this NDC goal. It acknowledges the increasing availability of advanced technologies (Variable Speed Drive chillers, magnetic bearing compressors, advanced controls, EE designs for commercial refrigeration units). Global trends show significant advancements, providing a strong technological basis. This also contributes to VNEEP3 objectives.
    - **Target 2050 (+30% additional EE improvement):** For these larger, often longer-lifespan systems, the 2050 target anticipates deeper penetration of advanced technologies, widespread adoption of smart building management systems integrating cooling, and potentially new technological breakthroughs. It aligns with the long-term vision of NZT and the need for substantial decarbonisation in the commercial and industrial building sectors, supported by the lifecycle management approach for equipment implicitly encouraged by Decision 496/QD-TTg.
- **MAC:**
    - **Target 2030 (+15% EE improvement):** This target is linked to national transport sector goals. NDC measures E24 and E26 aim to increase EV penetration to 30% by 2030. Efficient MAC systems are critical for EV range. NDC measure E17 limits fuel consumption for new ICE vehicles, indirectly incentivising efficient MACs. The +15%

target reflects the potential of efficient components and systemic benefits from electrification and stringent fuel economy standards, contributing to VNEEP3's transport sector goals.

- **Target 2050 (+30% additional EE improvement):** With the anticipated full electrification of the vehicle fleet under the NZT pathway, MAC efficiency becomes even more paramount for overall energy system efficiency. This target reflects expected advancements in EV-specific MAC technologies and lightweight designs, driven by global automotive trends towards maximising efficiency.

- **Industrial Refrigeration:**
  - **Target 2030 (+15% EE improvement):** While specific NDC measures are not yet defined for this sub-sector, it is a significant energy consumer. VNEEP3 sets overall energy saving targets for the industrial sector, and improving refrigeration efficiency is key. The +15% target is considered achievable via the best available technology (high-efficiency compressors, optimised system design, insulation, advanced controls) and the use of low-GWP refrigerants like ammonia (R-717) and CO_2 (R-744), which can offer system efficiency benefits. Global trends in industrial refrigeration strongly focus on minimising energy consumption.
  - **Target 2050 (+25% additional EE improvement):** The long-term target reflects ongoing improvements, potential for innovative solutions (e.g., waste heat recovery integration, advanced thermal storage), and the sector's critical role in the NZT, especially as industrial output grows. This aligns with the sustainable cooling solutions principle in Decision 496/QD-TTg.
- **Transport Refrigeration:**
  - **Target 2030 (+10% EE improvement):** Similar to industrial refrigeration, specific NDC targets are not explicit. However, VNEEP3 encourages energy savings across all sectors. The +10% target for new transport refrigeration units is based on available efficient technologies (improved insulation, efficient small-scale compressors, better temperature controls). Global market trends show an increasing focus on reducing fuel consumption in refrigerated transport.
  - **Target 2050 (+20% additional EE improvement):** As the transport sector electrifies (encouraged by NDC E24, E26), electric transport refrigeration unit efficiency becomes vital. This target reflects further technological advancements, integration with evolving EV technologies, and the need for an efficient cold chain, supporting objectives implicitly covered by Decision 496/QD-TTg regarding sustainable solutions.

These sub-sectoral EE targets, while ambitious, are deemed essential for a holistic approach to EE in Viet Nam's cooling sector. They are grounded in the overall ambition of national energy policies, specific climate commitments, regulatory frameworks for controlled substances, observed technological potentials worldwide, and international best practices, ensuring that all significant areas of cooling demand contribute to national energy saving and emission reduction goals.

5.2 Climate friendly refrigerants targets

The transition to climate-friendly refrigerants and the effective management of existing refrigerant stocks are critically strategic interventions to mitigate direct GHG emissions from the cooling sector. The targets and objectives outlined in this section are designed to align with Viet Nam's international obligations under the Montreal Protocol and its Kigali Amendment, national phase down schedules stipulated in Decision No. 496/QD-TTg (2024), and the ambitions of the NDC 2022

that are also reflected the global technological advancements and best practices in refrigerant transition and lifecycle management.

The primary drivers for the climate friendly refrigerant transition targets for the cooling sector include:

- **Compliance with international obligations and national regulations:** The core of Viet Nam's refrigerant strategy is the legally binding phasedown schedules for HCFCs and HFCs mandated by Decision No. 496/QD-TTg. These schedules directly translate international commitments under the Montreal Protocol for HCFCs and under the Kigali Amendment for HFCs into national action, setting clear consumption caps and reduction milestones. The overarching goal of this decision is to reduce 11.2 million tons of CO_2e by 2045 from activities related to eliminating these controlled substances. Furthermore, recognising that emissions occur throughout a refrigerant's lifecycle in Decision No. 496/QD-TTg, this NCAP emphasises comprehensive management from production/import through use, servicing, and end-of-life, supported by technician training and certification programs.
- **Alignment with NDC 2022 and NZT by 2050:** Recovery, recycling, reuse and disposal, aiming for 20% by 2030, are directly responsive to NDC measure I5s (compared to the 2014 NDC baseline). Along with a high penetration rate of low-GWP refrigerants by 2030, including 90% for Residential AC, 50% for Commercial and Industrial AC, 60% for Domestic and Commercial, and 80% for Industrial Refrigeration. The NCAP's refrigerant targets are designed to operationalise and help achieve these NDC commitments.
- **Technological availability, global best practices and market trends:** The transition pathways and GWP conversion targets for various sub-sectors are informed by the global availability, technical viability, safety considerations, and market maturity of low-GWP alternatives. The NCAP promotes a shift consistent with global technological trends and successful transitions observed in other countries for similar applications.
- **Lifecycle management approach:** Recognising that emissions occur throughout a refrigerant's lifecycle in Decision No. 496/QD-TTg, this NCAP emphasises comprehensive management from production/import through use, servicing, and end-of-life. This includes targets for refrigerant recovery and recycling, as well as measures to reduce leakage through improved operation and maintenance (O&M), supported by technician training and certification programs.
- **Long-term vision for refrigerants (2050 targets):** This vision anticipates a comprehensive market transformation towards refrigerants with very low to zero GWP across all applications, underpinned by a fully operational circular economy approach that ensures 100% recovery and responsible lifecycle management of all controlled substances by 2050. As Viet Nam completes its HFC phasedown obligations beyond 2045, the cooling sector will predominantly rely on natural refrigerants and advanced low-GWP alternatives, supported by continuously improving O&M practices to minimise leakage.

Table 5 below summarises the specific targets for refrigerant transition and management within the NZT scenario for each cooling sub-sector, considering current policies, Viet Nam's NDC targets, and future HCFC Phase out Management Plan - HPMP III and Kigali HFC Implementation Plans Phase 1 - KIP I.

Table 5: Targets related to refrigerant use with corresponding interventions

Cooling sub-sector	BAU	NZT
General	• Limited refrigerant recovery, recycling, reuse and disposal and high leakage rates.	• Recovery, recycling, reuse and disposal: 20% by 2030; 100% by 2050.

Cooling sub-sector	BAU	NZT
	• HCFC/HFC management and phase out roadmap Decision No. 496/QD-TTg).	• Leakage reduction through enhanced O&M.
Residential and commercial AC	• In use: R-22, R-32, R-410A, R-134a, R-417A • Complete conversion to R-32	• Introduction of R-290 by 2025 • Penetration targets: 5% by 2030, 80% by 2050 • Low-GWP refrigerant adoption by 2030: 90% (Residential), 50% (Commercial)
Central AC and chiller	• Chiller: R-22, R-123, R-410A, R-407c, R-717 • Central AC: R-407c, R-32, R-410A, R-22 • Ongoing conversion to HFCs and available replacements (R-717)	• Chiller: Transition to R-717, R-1234ze, R-1233zd, R-290. • Central AC: Transition to R-1234yf, R-1234ze, HFOs/HFCs blends. • Low-GWP conversion by 2030: 50%
MAC	• In use: R-134a, R-1234yf, R-407c • Slow uptake of R-1234yf	• Accelerated transition to R-1234yf • Penetration targets: 25% by 2030, 100% by 2050
Domestic refrigeration	• In use: R-600a, R-134a • Ongoing transition to R-600a	• Full conversion to R-600a by 2029. • Low-GWP adoption by 2030: 60%.
Commercial refrigeration	• In use: R-600a, R-134a, R-290, R-404a, R-407c • Transition: R-290/R-600a for small equipment conversion by 2030.	• Standalone/Small remote: R-290/R-600a transition by 2030. • Large systems: Transition to HFOs/blends; eliminate HFCs by 2045. • Low-GWP conversion by 2030: 60%
Industrial refrigeration	• In use: R-134a, R-404A, R-407c, R-507A, R-410A, R-22, R-717. • Transition: R-717 for large and R-134a/R-404A for small equipment.	• Phase out new high-GWP HFCs (R-404A, R-507A, R-410A, etc.) from 2029 & R-134a from 2035 • Low-GWP conversion by 2030: 80%
Transport refrigeration	• In use: R-134a, R-404A • Transition: Not available	• Phase out new R-404A from 2029 & R-134a from 2035 • Transition to R-1234yf/blends GWP < 750

Source: Compiled under ETP/UNOPS Technical Assistance

The specific climate friendly refrigerant targets for each cooling sub-sector by 2030 and 2050, benchmarked against a 2022 baseline, have been defined with the following rationales to ensure a targeted and impactful approach across Viet Nam's diverse cooling landscape.

- **Residential and Commercial AC:** The transition is a direct response to the upcoming GWP > 750 restriction for these equipment types by 2029 under Decision No. 496/QD-TTg. R-290 is a globally recognised ultra-low GWP alternative for smaller AC systems, and achieving these targets will necessitate stringent safety standards, technician training, and market development efforts.
- **Central AC and Chiller:** This transition is driven by the restrictions in Decision No. 496/QD-TTg for equipment with GWP > 2,100 (for some chillers by 2029) and GWP > 750 or > 1,500 for other AC types and chillers by later dates. The choice of multiple refrigerants reflects the diverse applications and capacity ranges in this sub-sector and aligns with global technological availability.
- **MAC:** This accelerated transition is supported by global automotive industry trends where R-1234yf is becoming the standard low-GWP refrigerant for new vehicles. This also complements NDC measures related to transport electrification and fuel efficiency.

- **Domestic Refrigeration:** The transition leverages the already dominant global trend and successful adoption of R-600a in this sub-sector due to its excellent efficiency and very low GWP. This aligns with the rapid phase-out of HFC-134a in new domestic units as implied by equipment restrictions in Decision No. 496/QD-TTg (targeting GWP > 3 for household refrigeration).
- **Commercial Refrigeration:** The transition reflects the diverse range of equipment in this sub-sector and the availability of different low-GWP solutions. It is consistent with the GWP-based equipment restrictions outlined in Decision No. 496/QD-TTg and global supermarket and retail sector trends.
- **Industrial Refrigeration:** The transition aligns with Decision No. 496/QD-TTg's restrictions on high-GWP industrial equipment and the global industry's move towards these efficient and climate-friendlier solutions for large-capacity systems.
- **Transport Refrigeration:** The transition reflects the need to decarbonise cold chain logistics. These targets are consistent with the GWP-based equipment restrictions in Decision No. 496/QD-TTg and emerging global standards for refrigerated transport.

The refrigerant transition targets for each sub-sector under the NZT scenario are not set in isolation. The successful achievement of these targets is fundamental to minimising direct emissions and realising Viet Nam's long-term climate objectives.

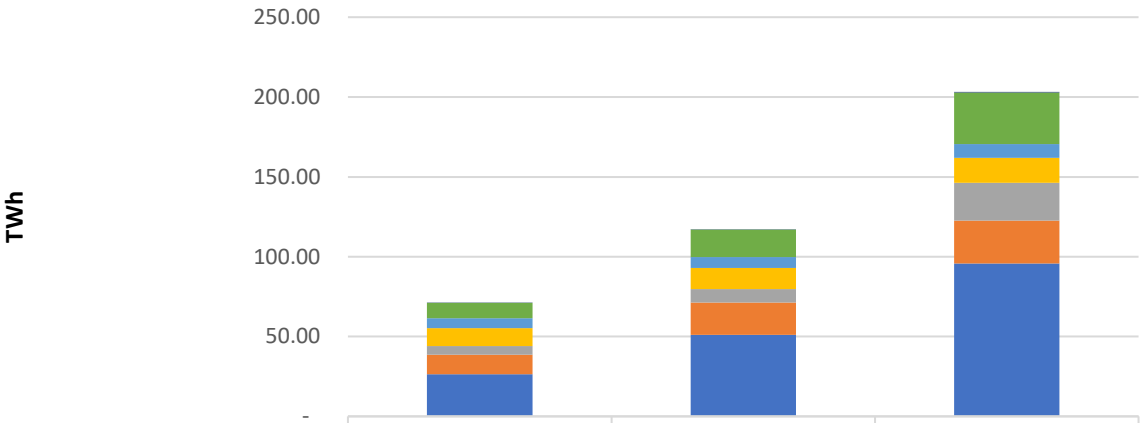
Furthermore, promoting sustainable cooling models and integrating UHI reduction measures into urban planning, as outlined in Decision 496/QD-TTg, will complement these technology-specific interventions.

- In terms of the lifecycle management of controlled substances:
    - Technicians who install, operate, maintain, and repair products and equipment containing controlled substances must have appropriate diplomas, certificates, and certifications as regulated.
    - Controlled substances must be collected, stored, transported, reused, and recycled, meeting technical requirements, and if not meeting technical requirements after recycling, they must be disposed of and destroyed as regulated.
    - Popularise and replicate models of carbon credit mechanisms from recycling and processing activities of controlled substances.
- Regarding sustainable cooling:
    - Requirements for reducing the urban heat island effect and resilience against extreme heat are researched and integrated into national and provincial urban development programs, national and local climate change action plans, provincial planning, and related sectoral transitions of the province.
    - Sustainable cooling activities are implemented in special urban areas, Type I and II cities.
    - New construction projects achieve green building certification, energy-efficient building certification in design, construction, and operation.
    - New buildings meet technical standards in design, construction, and achieve energy balance (NZEB), and increase the average green area per urban resident.
    - Popularise and replicate models of sustainable cooling and business models of cooling services in urban areas, residential areas, office buildings, commercial buildings, and public facilities.

6 National cooling demand projection

6.1 Projected cooling demand under the BAU scenario

Under the BAU outlook, the cooling sector's electricity draw is projected to rocket from 65.95 TWh in 2022 to about 200 TWh in 2050, a threefold jump that would make cooling one of Viet Nam's fastest-growing end-uses of energy. Residential and Commercial AC, already the largest load, is expected to keep driving the curve, but every sub-sector, from industrial refrigeration to MAC, rises steeply as incomes climb and urban heat intensifies (see Figure 9 for the detailed split).



	2022	2030	2050
Transport Refrigeration	0.17	0.22	0.30
Industrial Refrigeration	9.67	17.37	32.41
Commercial Refrigeration	6.23	6.81	8.52
Domestic Refrigeration	11.33	13.19	15.74
Mobile Air Conditioning	5.26	8.37	23.64
Central AC and Chiller	12.41	20.19	26.91
Residential and Commercial AC	26.31	51.12	95.69

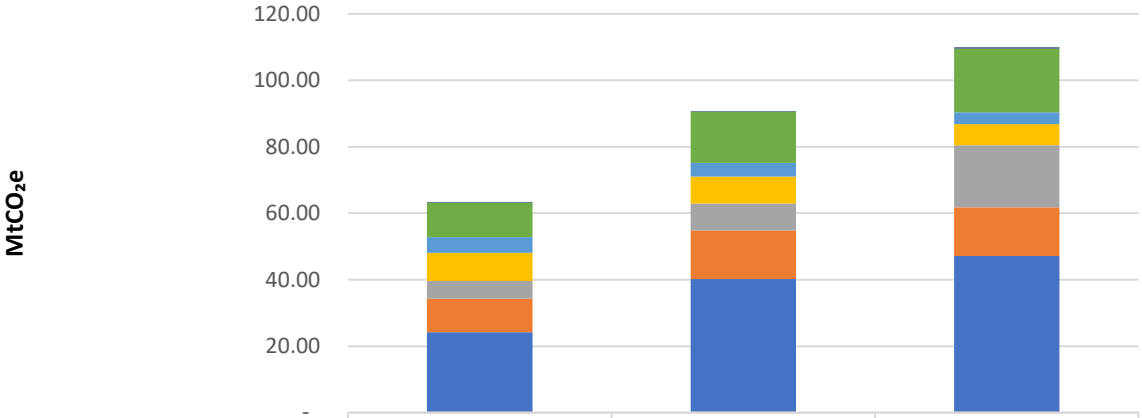
Figure 9: Energy consumption by sub-sectors

Source: Compiled under ETP/UNOPS Technical Assistance

Under the BAU outlook, cooling-related emissions keep climbing:

- **By 2030:** emissions reach 91.7 $MtCO_2e$, accounting for about 9.9% of the national total GHG emissions. Of which just 15.7% is from direct refrigerant emission, while the other 84.3% is indirect emissions. The share of indirect emissions is significant in this period due to the high national GEF.
- **By 2050:** emissions double from the 2022 level, peaking in 2045 with a total emission of 116.38 $MtCO_2e$ and then gradually falling to 112.32 $MtCO_2e$ in 2050 due to the effect of GEF reduction and EE improvement. A 2% annual decline in the GEF flips the mix to 83% direct and 17% indirect by mid-century.

Across the seven sub-sectors, Residential & Commercial AC dominates due to the quadrupling of the penetration of household AC, while Industrial Refrigeration remains the largest emitter on the refrigeration side. Figure 10 charts the full sub-sector breakdown.



	2022	2030	2050
Transport Refrigeration	0.19	0.24	0.33
Industrial Refrigeration	10.36	15.27	19.22
Commercial Refrigeration	4.78	4.21	3.53
Domestic Refrigeration	8.44	8.05	6.42
Mobile Air Conditioning	5.28	8.13	18.65
Central AC and Chiller	10.14	14.60	14.67
Residential and Commercial AC	24.19	40.21	47.09

Figure 10: GHG emissions from all sub-sectors under the BAU scenario

Source: Compiled under ETP/UNOPS Technical Assistance

6.2 Projected cooling demand under NZT scenario

This scenario models the impacts of accelerated EE improvements, a rapid transition to climate-friendly refrigerants, increasing transport electrification, and strategic policy implementation as outlined in Section 5.

6.2.1 Projected energy consumption and indirect emissions under NZT scenario

Under the NZT scenario, significant energy savings are anticipated across the cooling sector due to the widespread adoption of high-efficiency equipment and practices that could reduce electricity demand by 9.91 TWh in 2030 and 69.37 TWh in 2050. Table 6 breaks these savings down by sub-sector.

Table 6: Potential energy saving of the cooling sector under the NZT scenario

Cooling sub-sectors	Potential savings in 2030		Potential savings in 2050	
	Saving (TWh)	%	Saving (TWh)	%
Residential and commercial AC	6.55	66.12%	38.82	55.97%
Central AC and chiller	0.93	9.40%	7.12	10.27%
MAC	0.24	2.46%	4.68	6.75%
Domestic refrigeration	1.32	13.34%	5.97	8.60%
Commercial refrigeration	0.38	3.88%	2.54	3.66%
Industrial refrigeration	0.47	4.71%	10.17	14.66%
Transport refrigeration	0.01	0.09%	0.06	0.09%
Total Saving	**9.91**	**100%**	**69.37**	**100%**

Source: Compiled under ETP/UNOPS Technical Assistance

These energy savings become more pronounced in the longer term as interventions promoting high-efficiency equipment achieve wider market penetration. Figure 11 illustrates the projected

trend of total energy consumption by the cooling sector, comparing the significant reductions under the NZT scenario against the BAU scenario.

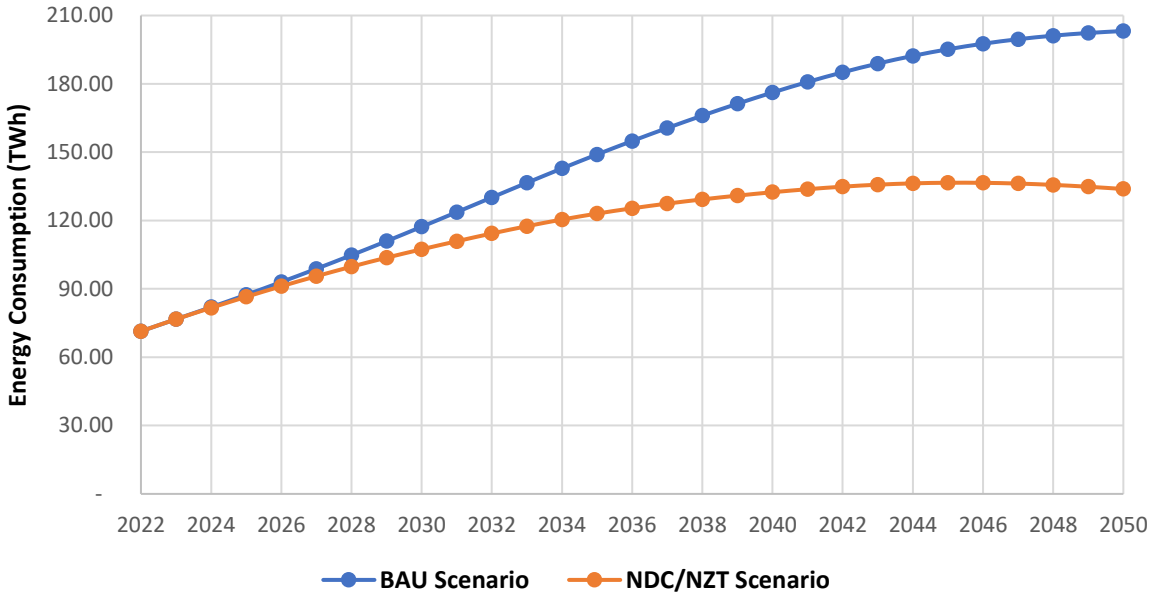


Figure 11: Total energy consumption by the cooling sector under the BAU and NZT scenarios

Source: Compiled under ETP/UNOPS Technical Assistance

The reduction in electricity consumption, coupled with the planned decarbonisation of Viet Nam's power grid, with a GEF approaching near-zero by 2050 as outlined in Figure 4, will lead to a substantial decrease in indirect GHG emissions attributable to the cooling sector under the NZT scenario. The indirect emissions from the cooling sector projected under the NZT scenario are presented in the figure below. Figure 12 illustrates the projected trajectory of indirect GHG emissions from the cooling sector, highlighting the significant mitigation achieved under the NZT scenario compared to the BAU pathway, primarily due to advancements in EE of cooling equipment and the greening of the electricity supply.

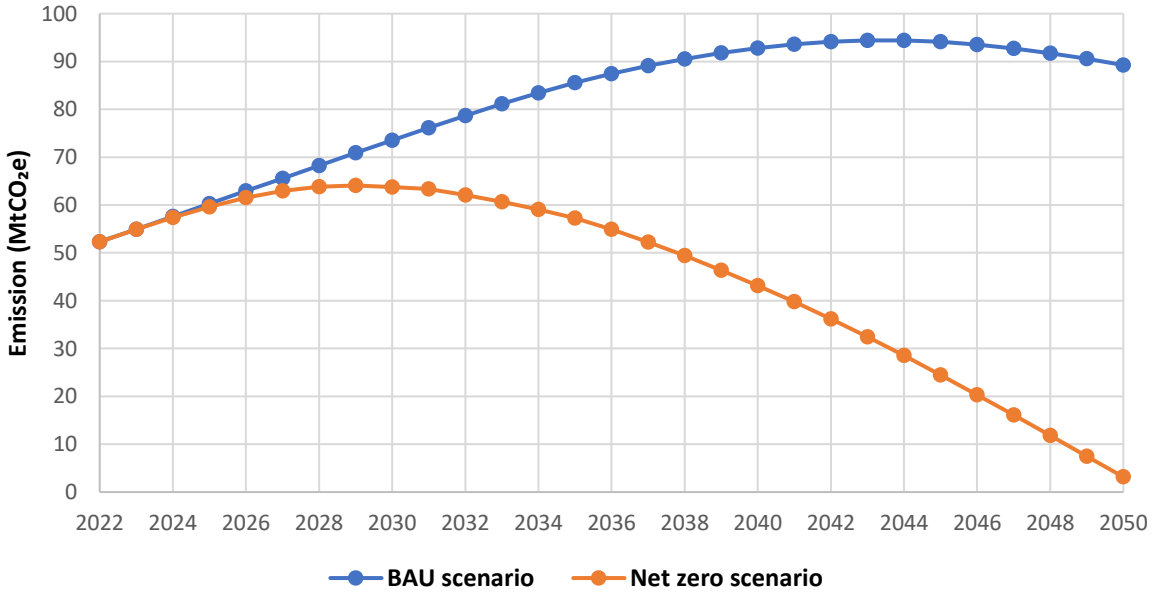


Figure 12: Total indirect GHG emissions under NZT scenario vs. BAU

Source: Compiled under ETP/UNOPS Technical Assistance

In 2022, indirect emissions from cooling-related electricity consumption were estimated at 54.52 $MtCO_2e$, largely driven by the then GEF of 0.7221 tCO_2/MWh. Under the NZT scenario, with the combined effect of consuming 9.91 TWh of electricity in 2030 and a significantly improved GEF of 0.45329 tCO_2/MWh indirect, emissions are projected to decrease to approximately 63.76 $MtCO_2e$.

By 2050, as the GEF approaches near-zero emissions (0.02449 tCO_2/MWh) and cooling sector electricity consumption under NZT is maintained at 69.37 TWh, indirect emissions from the cooling sector are anticipated to be drastically curtailed to merely 3.16 $MtCO_2e$.

6.2.2 Projected direct emissions from refrigerants under NZT scenario

Direct emissions, primarily originating from the leakage of high GWP refrigerants, are a key focus under the NZT scenario. Figure 14 depicts the projected direct emissions from the cooling sector in Viet Nam under the NZT scenario against the BAU scenario and the emission caps applied for Viet Nam under the Montreal Protocol and the Kigali Amendment.

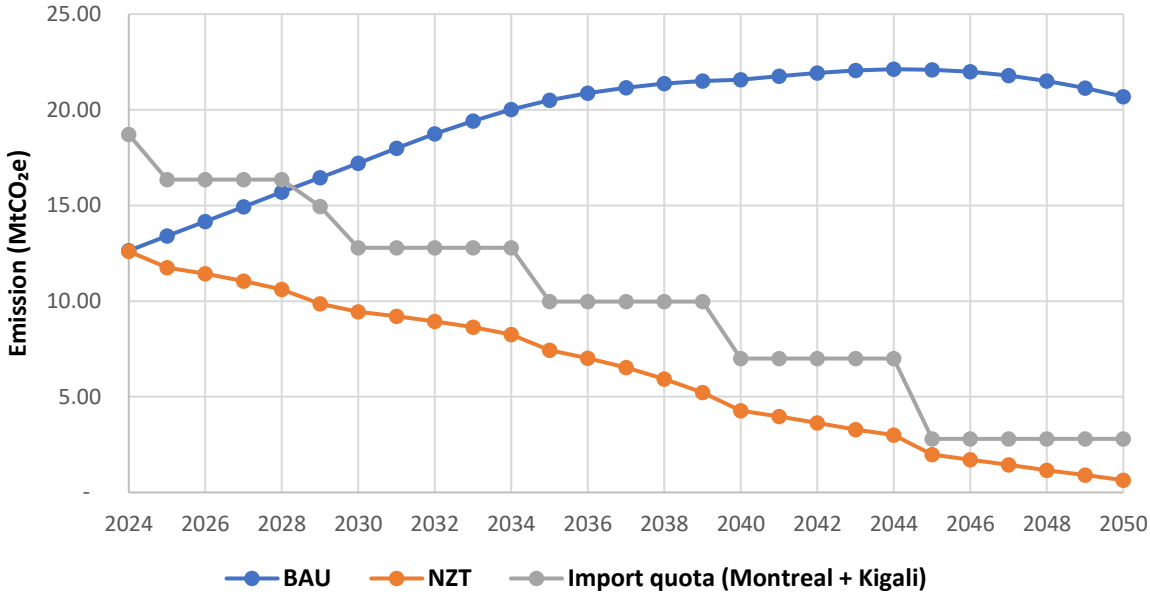


Figure 13: Total direct GHG emissions under NZT scenario, BAU and import quota following the Montreal Protocol and Kigali Amendment roadmap

Source: Compiled under ETP/UNOPS Technical Assistance

Table 7 summarises the potential for direct emission reductions by 2030 and 2050 across key cooling sub-sectors under the NZT scenario and indicates the alternative low-GWP refrigerants.

Table 7: Potential emission reduction of the cooling sector under the NZT scenario

Cooling sub-sectors	Reduction potential in 2030		Reduction potential in 2050		Alternative for HCFCs, HFCs with GWP < 150
	$MtCO_2e$	%	$MtCO_2e$	%	
Residential and commercial AC	4.26	54.86%	7.72	38.52%	R-290, R-1234yf, R-1234yf blend with R-32
Central AC and chiller	1.01	12.99%	3.45	17.23%	R-1234yf, R-1234ze, and other HFOs or HFOs blends with HFC
MAC	0.27	3.43%	2.74	13.69%	R-1234yf
Industrial refrigeration	2.21	28.46%	6.01	29.99%	HFOs, R-717, R-744 systems
Other sub-sectors	0.02	0.26%	0.11	0.56%	HFOs, Hydrocarbons (HCs)

Total emission reduction potential	**7.77**	**100%**	**20.04**	**100%**	

Source: Compiled under ETP/UNOPS Technical Assistance

Table 7 shows that the residential and commercial AC sub-sector presents the most significant potential for direct emission reductions, with the following details:

- **2030:** Projected to contribute 4.26 $MtCO_2e$ (54.86%) of the cooling sector's total direct emission reduction potential.
- **2050:** Expected to increase its absolute reduction contribution to 7.72 $MtCO_2e$ (38.52%).

Collectively, the cooling sector demonstrates a substantial direct emission reduction potential of 7.77 $MtCO_2e$ by 2030, escalating to 20.04 $MtCO_2e$ by 2050 under the NZT scenario. These figures highlight the cooling sector's important role in achieving Viet Nam's NZT.

6.2.3 Total projected GHG emissions under the NZT scenario

The combined effect of drastically reduced indirect emissions (due to energy savings and a near-zero GEF by 2050) and significant cuts in direct emissions (through HFC phase-down and transition to low-GWP alternatives) results in a profound overall reduction in the cooling sector's GHG footprint under the NZT scenario. Total GHG emissions from the cooling sector are projected to decrease to just 3.80 $MtCO_2e$ by 2050 in this scenario. This contrasts sharply with the BAU scenario, where emissions are projected to peak at 116.38 $MtCO_2e$ in 2045 before declining due to GEF improvements.

Figure 14 provides a comparative overview of the total CO_2e emissions from the cooling sector under both the BAU and NZT scenarios, illustrating the transformative impact of the NZT pathway.

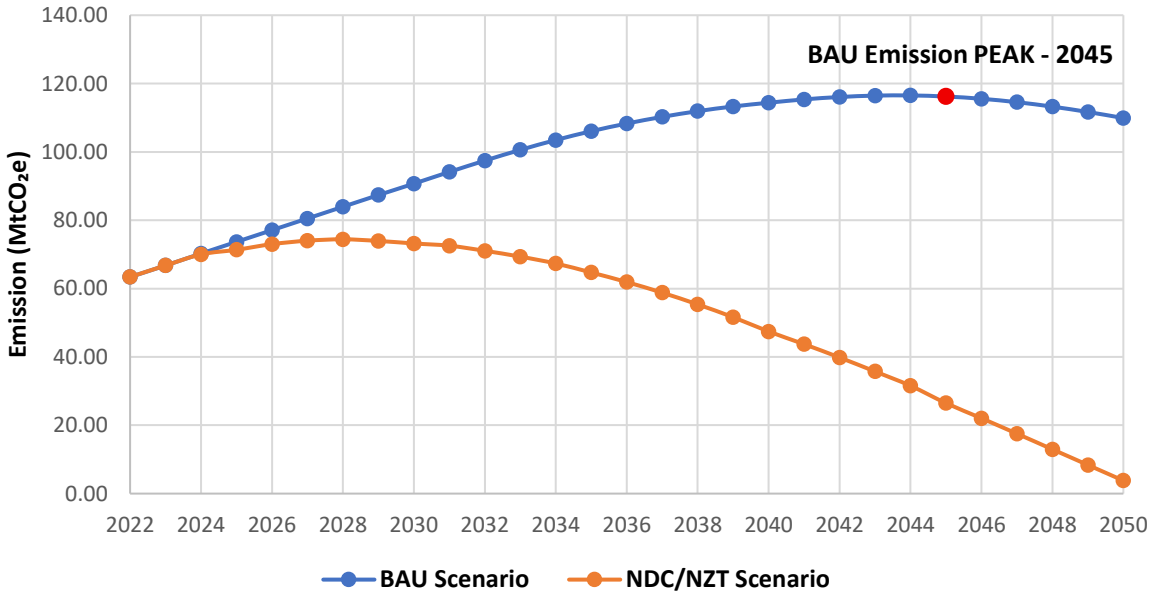


Figure 14: Total GHG emission from the cooling sector under the BAU and NZT scenarios

Source: Compiled under ETP/UNOPS Technical Assistance

Achieving these significant emission reductions underscores the critical importance of transitioning towards sustainable cooling solutions, encompassing both enhanced EE and the widespread adoption of low-GWP refrigerants that are envisioned in this NCAP.

7 Main challenges to achieve NZT

Viet Nam faces multifaceted challenges in transitioning towards sustainable cooling practices, underscoring the need for comprehensive policy revisions, enhanced training and awareness programs, and financial strategies that align with the sustainable cooling development and NZT goals.

7.1 Regulatory and policies on energy efficiency for cooling

The passage of the LEEE 2025 by the National Assembly in June 2025 is a landmark legal step. However, this does not eliminate the challenges but rather shifts their nature, from operating under an outdated law to implementing an ambitious new one. The main challenges now include:

- **Urgent need for implementing regulations:** The immediate challenge is issuing the detailed Decrees and Circulars required to implement the new Law. This is particularly critical for developing technical regulations and standards for insulating building materials, which are essential to fulfilling the Law's expanded scope.
- **Outdated EE framework:** The existing legal framework for EE in cooling is often outdated and does not fully align with recent technological advancements, hindering the effectiveness of EE measures.
- **Limited scope of standards:** Current national standards (TCVN) cover only a limited range of cooling equipment, high-growth segments such as VRV/VRF systems and commercial display freezers remain uncontrolled. It restricts the comprehensive application and effectiveness of mandatory MEPS.
- **Implementation lag:** There is a significant time gap between the issuance of TCVNs and their practical implementation. This delay poses a challenge to meeting ambitious targets, such as the projected 50% improvement in EE for air conditioners by 2030, as recent updates may still rely on older criteria, with the next update not scheduled until 2030.
- **Enforcement and monitoring deficiencies:** Limited market surveillance capacity allows non-compliant, lower-efficiency models onto the market, diluting the intended energy savings.

7.2 Regulatory and policies on refrigerant use for cooling

Although Kigali implementation has begun, the support systems for low-GWP alternatives, safety standards, technician up-skilling, and recovery networks lag behind, keeping high-GWP gases dominant.

- The new quota system (Decision 496/QD-TTg) will curb virgin HCFC and HFC imports, yet the supporting infrastructure for refrigerant recovery, recycling, and safe destruction is only nascent.
- Industry's transition to lower-GWP alternatives such as HCs (R-290/R-600a) and HFOs is slowed by legitimate concerns over flammability, toxicity, and higher first costs.
- Clear safety standards, technician training, and incentives for retrofit or replacement are not yet in place at scale, so most of the installed base continues to rely on high-GWP blends such as R-410A and R-404A.

7.3 Regulatory and policies on urban planning and building energy codes

Energy demand for space cooling is amplified by Viet Nam's rapid urbanisation, yet the urban-planning toolbox contains few measures that explicitly target passive cooling.

- **Narrow code focus:** Building Code QCVN 09:2017/BXD stresses envelope insulation and window-to-wall ratios but barely touches urban-heat-island mitigation (e.g., cool roofs, shading, ventilation corridors).
- **Capacity gap:** Provincial planning offices often lack the mandate, staffing, and modelling tools to embed passive-cooling targets in zoning or permit reviews, allowing new districts to lock in high loads for decades.

7.4 Quality and knowledge in operating and servicing

The performance gap between laboratory efficiency and real-world operation is widened by a fragmented, largely informal servicing sector.

- **Limited certification:** Of roughly 200,000 RAC technicians, most work without formal credentials; modern diagnostic or leak-detection tools are rare.
- **Hidden losses:** Poor charge control and casual handling of mildly flammable refrigerants lead to premature failures and significant refrigerant leakage, inflating operating costs and national emissions.

7.5 Quality and knowledge in passive cooling

Passive-cooling opportunities remain under-used because design disciplines seldom converge early enough.

- **Siloed design process:** Architects, engineers, and urban planners rarely co-design orientation, shading geometry, ventilation paths, or thermal-mass strategies.
- **Weak incentives:** Design competitions and public procurement seldom reward heat-resilient layouts or cool-roof materials, so promising low-tech solutions stay at the pilot stage.
- **Digital shortfall:** BIM (Building Information Modelling) based or "smart-building" tools that could optimise passive-active hybrids are not yet mainstream.

7.6 Financial barriers

Premium prices for high-efficiency equipment clash with tight lending conditions, high collateral, and double-digit interest rates, continue to deter investment in efficient equipment and low-GWP refrigerants and leave small and medium enterprises and low-income households locked into inefficient devices.

- **Price premium:** High-efficiency RAC units and safer refrigerants cost 15–40 % more upfront; pay-backs can outstrip typical small-business loan horizons.
- **Tough lending terms:** Banks often demand 100 % collateral and charge interest above 10 % p.a., discouraging small and medium enterprises and informal operators from EE retrofits.
- **Fragmented support:** Green credit lines, partial guarantees, and on-bill-financing pilots exist but remain small-scale, leaving low-income households locked into inefficient devices without concessional capital or risk-sharing mechanisms.

These six challenge areas are interlinked; tackling them in isolation risks rebound effects elsewhere. A coordinated package, tighter, faster-updating standards, robust enforcement, skill-building, passive-cooling requirements, and accessible finance will be required to set Viet Nam's cooling sector on a sustainable, net-zero-compatible trajectory.

8 Roadmap for sustainable cooling management

The Government of Viet Nam is committed to achieving its EE improvement and emissions reduction objectives within the cooling sector. This chapter outlines the detailed action plan and intervention measures, following a clear roadmap with key milestones leading up to 2030 and orientations towards 2045/2050. This plan leverages resources and expertise from government agencies, industry, academia, and international partners.

8.1 Management and phasing down of controlled substances

The schedules for controlling high-GWP and ODSs are aligned with the commitments under the Montreal Protocol and its Kigali Amendment, the PCG and the Paris Agreement.

8.1.1 HCFC phase-down schedule

- **By 31 December 2024:** A 35.0% reduction in national HCFC consumption from the baseline is targeted, with total consumption not to exceed 2,600 tons per year. This initial step marks a significant commitment to curtailing HCFC use.
- **From 2025 to 2030:** The phase-down accelerates, aiming for a 67.5% reduction from the baseline, limiting total national consumption to a maximum of 1,300 tons annually. This period will require substantial efforts to transition away from HCFC-dependent technologies.
- **From 2030 to 2040:** A near-total phase-down is planned, with a 97.5% reduction from baseline consumption. Average annual national consumption during this decade will not exceed 100 tons, primarily for servicing existing essential equipment where alternatives are not yet feasible.
- **From 1 January 2040 onwards:** Viet Nam commits to a 100% reduction in HCFC consumption from the baseline, effectively eliminating HCFC use in the country.

The key elements are summarised in Table 8.

Table 8: HCFC cap and phaseout schedule in Viet Nam

Period	Cap (%)	Import quota (tons/year)	Milestone
2022-24	≤65 %	2,600	35 % reduction
2025-29	≤32.5 %	1,300	67.5 % reduction
2030-39	≤2.5 %	100	97.5 % reduction
≥2040	0 %	0	Phase-out

Source: Compiled under Prime Minister's Decision No. 496/QD-TTg

8.1.2 HFC phasedown schedule

- **From 2024 to 2029 (baseline freeze):** National HFC consumption will be maintained at or below the established baseline level, capped at 14.0 $MtCO_2e$. This period focuses on preventing further growth in HFC consumption.
- **From 2029 to 2035 (first reduction step):** A 10% reduction in HFC consumption from the baseline is mandated, with total national consumption not exceeding 12.6 $MtCO_2e$.
- **From 2035 to 2040 (second reduction step):** Consumption will be further reduced by 30% from the baseline, capped at 9.8 $MtCO_2e$.

- **From 2040 to 2045 (third reduction step):** A 50% reduction from the baseline is targeted, limiting consumption to a maximum of 7.0 $MtCO_2e$.
- **From 1 January 2045 onwards (final target):** Viet Nam aims for an 80% reduction in HFC consumption from the baseline, with total national consumption not exceeding 2.8 $MtCO_2e$, aligning with long-term climate objectives.

The key elements are summarised in Table 9.

Table 9: HFC cap and phasedown schedule in Viet Nam

Period	Cap (%)	Cap ($MtCO_2e$)	Milestone
2024-28	100 %	14.0	Freeze
2029-34	90 %	12.6	–10 %
2035-39	70 %	9.8	–30 %
2040-44	50 %	7.0	–50 %
≥2045	20 %	2.8	–80 %

Source: Compiled under Prime Minister's Decision No. 496/QD-TTg

8.2 Managing products and equipment containing or manufactured from controlled substances

To support the phasedown of controlled substances, Viet Nam will implement restrictions on the manufacture and import of specific products and equipment, progressively targeting substances with higher GWP values. This ensures that new equipment entering the market aligns with the transition to more climate-friendly alternatives.

8.2.1 Initial restrictions (effective from 2025 and 2029)

- **From 2025**, measures will be initiated to restrict and gradually prohibit the manufacture and import of fire suppression products and equipment containing HFC-23 or other controlled substances with a GWP exceeding 4,000.
- **From 2029**, a ban on the manufacture and import will apply to:
    - Transport refrigeration equipment and water chillers containing HCFC-22, HFC-404A, or substances with GWP > 2,100.
    - Commercial and industrial refrigeration equipment containing HCFC-22, HFC-507A, HFC-404A, or substances with GWP > 1,800.
    - Hot water heat pumps and portable ACs containing HFC-410A, HFC-407C, or substances with GWP > 1,500.
    - Household ACs, packaged ACs (PAC), and VRV/VRF systems containing HCFC-22, HFC-410A, HFC-407C, HFC-134a, or substances with GWP > 750.
    - Household refrigeration appliances containing HFC-134a or substances with GWP > 3.

These initial restrictions target commonly used equipment and high-GWP refrigerants, signalling a clear market shift.

8.2.2 Mid-term restrictions (effective from 2035)

- The manufacture and import of the following will be restricted and subsequently prohibited:
    - Water chillers, commercial refrigeration equipment, and transport refrigeration equipment containing HFC-410A or controlled substances with a GWP > 1,500.

- Industrial refrigeration equipment and portable ACs containing HFC-410A, HFC-407C, HFC-134a, or substances with GWP > 750.

This phase tightens controls on a broader range of equipment, pushing the market further towards lower-GWP solutions.

8.2.3 Further restrictions (effective from 2040)

- Restrictions and prohibitions will extend to the manufacture and import of:
  - Transport refrigeration equipment, commercial refrigeration equipment, water chillers, and hot water heat pumps containing HFC-134a or controlled substances with a GWP > 750.

8.2.4 Long-term restrictions (effective by 2045)

- A comprehensive set of restrictions and prohibitions will be in place for the manufacture and import of:
  - Most AC types (household, PAC/VRV/VRF), all refrigeration sub-sectors (commercial, industrial, transport), and insulation foam manufacturing equipment containing HFC-32 or any controlled substances with a GWP > 150.
  - Fire suppression equipment and portable ACs containing HFC-32 or controlled substances with a GWP > 3.

These final measures aim to ensure that nearly all new cooling-related equipment utilises very low-GWP or zero-GWP alternatives.

8.3 Life cycle management of controlled substances

Effective management of controlled substances throughout their lifecycle – from installation and operation to end-of-life – is paramount to minimising emissions and ensuring a sustainable transition. This involves enhancing technical capacity, establishing robust recovery and recycling infrastructure, and promoting responsible practices.

8.3.1 Phase 1 (2024 - end of 2028): Building foundational capacity and infrastructure

- Develop and implement comprehensive training programs integrated into the vocational education system, leading to official certifications for technicians on the collection, disposal, and best practices for reducing leaks of controlled substances.
- Update and integrate content related to controlled substance management into the minimum knowledge and competency requirements for relevant technical fields and occupations.
- Support the establishment of at least three initial regional or national facilities that meet stringent technical requirements for the collection, transportation, storage, recycling, and environmentally sound disposal/destruction of controlled substances.

8.3.2 Phase 2 (2029 - end of 2034): Scaling up certification and recovery efforts

- Expand the network of qualified organisations to at least eight entities capable of assessing and issuing occupational skills certificates for technicians working with controlled substances.
- Target at least 8,000 technicians involved in the installation, operation, maintenance, and repair of household and portable air conditioners holding appropriate certifications.

- Implement and enforce regulations to ensure 100% collection of controlled substances from end-of-life large-scale air conditioners (nominal cooling capacity > 26.5 kW / 90,000 BTU/h) and industrial refrigeration equipment (electrical power capacity > 40 kW).
- Promote and ensure the effective reuse and recycling of HCFC-22 to meet ongoing societal demand during its final phase-out period, minimising the need for virgin HCFC-22.

8.3.3 Phase 3 (2035 - end of 2039): Enhancing technician proficiency and end-of-life management

- Aim for 70% of all technicians working in fields related to controlled substances to possess appropriate, officially recognised diplomas and certificates.
- Establish and enforce comprehensive regulations ensuring that controlled substances from all end-of-life household refrigeration and AC equipment are systematically collected and directed to certified recycling or destruction facilities.
- Ensure 100% of collected controlled substances that cannot be reused or do not meet technical requirements after recycling are treated for destruction according to national environmental standards and international best practices.

8.3.4 Phase 4 (2040 - end of 2044): Achieving comprehensive management and circularity

- Target 100% of technicians working in fields related to controlled substances holding appropriate diplomas and certificates.
- Maximise the recycling of collected controlled substances to meet technical requirements and societal demand for reclaimed refrigerants, promoting a circular economy approach.
- Maintain and enhance the effectiveness of existing or new mechanisms for exchanging and offsetting carbon credits derived from the certified recycling and environmentally sound disposal/destruction of controlled substances.

8.4 Promoting and applying sustainable cooling solutions

Beyond refrigerant management, the NCAP will actively promote the adoption of holistic sustainable cooling solutions, including passive design strategies, enhanced building EE, and innovative service models to reduce overall cooling demand and its environmental impact.

8.4.1 Phase 1 (2024 - end of 2028): Capacity building, research, and policy integration

- Develop and implement targeted training programs and capacity-building initiatives for architects, urban planners, and construction engineers on applying sustainable cooling solutions (including passive design, natural ventilation, and cool materials) in the planning, design, and construction of buildings and urban areas.
- Actively promote the adoption and use of climate-friendly alternative refrigerants and low-carbon cooling technologies through awareness campaigns and technical support.
- Conduct research and integrate specific requirements for sustainable cooling, UHI effect mitigation, and building resilience to extreme heat waves into national and provincial urban development programs, local climate change action plans, provincial master plans, and relevant provincial specialised development plans.
- Research, develop, and regularly update technical documents, guidelines, and standards for energy conservation, EE improvements, carbon emission reduction in buildings, and criteria

for achieving green building certifications for both new constructions and major renovations/upgrades.

8.4.2 Phase 2 (2029 - end of 2034): Piloting and regulatory development

- Research and develop specific regulations on energy consumption benchmarks (or performance targets) for various building typologies; pilot their application for new constructions, while strongly encouraging their voluntary application for renovated and upgraded buildings.
- Research and update public procurement practices and guidelines to prioritise refrigeration and air-conditioning equipment containing controlled substances with low GWP and high energy-saving cooling technology for agencies and units utilising the state budget, in accordance with the Law on Public Investment and Law on Bidding.
- Develop and pilot comprehensive technical guidelines and potential certification schemes for Net Zero Energy Buildings (NZEB), incorporating passive cooling and suited to Viet Nam's climatic and construction context.
- Implement demonstration projects for integrated sustainable cooling models that apply passive cooling solutions, utilise climate-friendly refrigerants, incorporate low-carbon technologies, and achieve high levels of EE.
- Pilot and evaluate "Cooling-as-a-Service" (CaaS) business models in suitable applications such as office buildings, commercial centres, or public facilities to promote access to efficient cooling without high upfront costs for end-users.

8.4.3 Phase 3 (2035 - end of 2039): Scaling up and mainstreaming

- Mandate and enforce energy consumption benchmarks for various building types for all new constructions and significant renovations/upgrades.
- Target ensuring that at least 50% of all new construction projects achieve recognised green building or energy-efficient building certification, which incorporate passive cooling in their design, construction, and operational phases.
- Actively disseminate and replicate successful models for sustainable cooling, including those applying passive cooling solutions, using climate-friendly refrigerants, employing low-carbon technologies, and significantly increasing EE.
- Promote and scale up successful cooling-as-a-service business models in urban areas, residential complexes, office buildings, commercial centres, and public facilities.

8.4.4 Phase 4 (2040 - end of 2044): Achieving widespread sustainable cooling and resilience

- Continue the comprehensive implementation and refinement of all sustainable cooling activities.
- Ensure that all special-class, class I, and class II cities have developed and are synchronously applying integrated solutions to reduce the urban heat island effect and build resilience to extreme heat waves.
- Mandate that 100% of new construction projects achieve recognised green building or energy-efficient building certification.
- Ensure new buildings are designed and constructed to meet high-performance technical standards, aiming to achieve a net zero energy balance, where feasible.

9 Implementation and governance framework for sustainable cooling

9.1 Institutional framework and coordination for implementation of the NCAP

The successful development and implementation of Viet Nam's NCAP hinges on two critical factors: active stakeholder engagement and a well-defined governance framework.

Engaging relevant stakeholders, including government agencies, the private sector, technical and research institutions, financial entities, and international development partners, is crucial. This ensures the NCAP aligns with national priorities, fostering a coordinated and multi-dimensional approach to address the challenges of controlling and mitigating GHG emissions in the cooling sector.

Ultimately, achieving ambitious targets for EE, refrigerant transition, and sustainable cooling practices necessitates a multi-sectoral and multi-level approach, integrating the efforts of all these key players.

Recently, the Government of Viet Nam undertook a significant restructuring of its ministerial framework (as of early 2025) to enhance administrative efficiency and foster greater synergy in national development priorities, including those critical to climate action and sustainable development as outlined in this NCAP. An overview of the primary stakeholder categories and their anticipated coordination for active and passive cooling initiatives under the new governmental structure is presented in Figure 15.

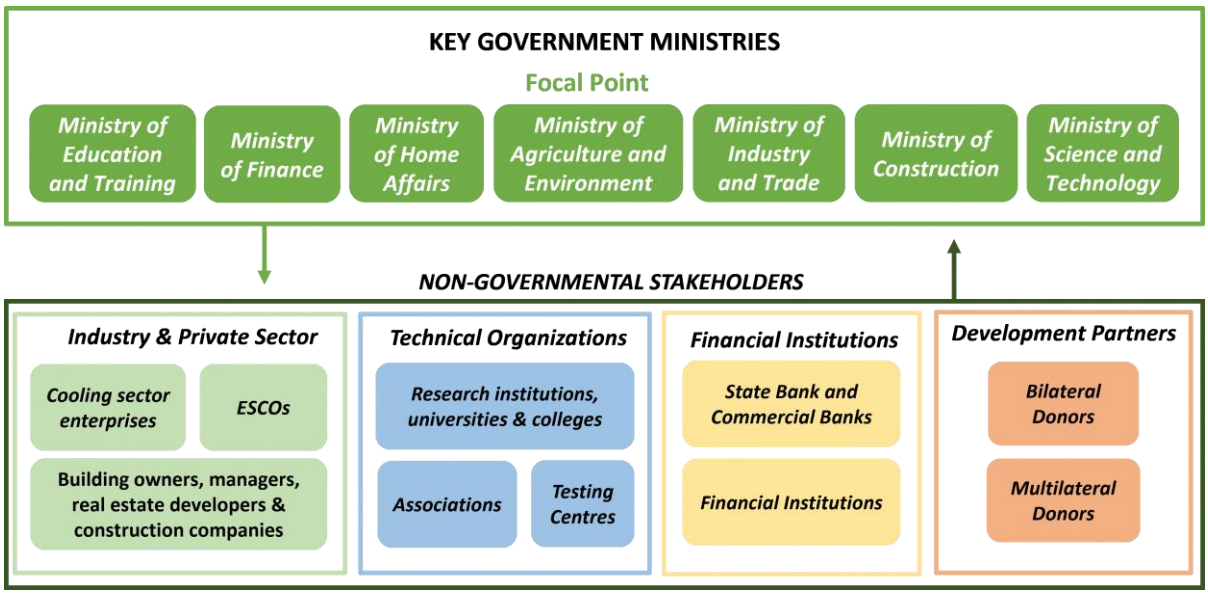


Figure 15: Institutional framework and stakeholder coordination for the cooling sector

Source: Compiled based on existing relevant regulations in the cooling sector

Viet Nam continues to refine its governmental structures and operational mechanisms, the specific delineation of responsibilities and coordination pathways outlined herein may be subject to further adjustments. Continuous adaptation and updating of this governance framework will be crucial to ensure its ongoing relevance and effectiveness.

9.1.1 Overall coordination mechanism

While specific high-level steering committees or dedicated NCAP implementation units may be formally established or further detailed by subsequent governmental decisions, the overall coordination for the NCAP is anticipated to be led by the MAE, which is responsible for climate action and environmental protection, and acts as the national focal point for the Vienna Convention and the Montreal Protocol. This will likely involve regular inter-ministerial dialogues, joint planning sessions, and potentially the formation of technical working groups focused on specific NCAP components (e.g., MEPS development, refrigerant management, passive cooling strategies, financing mechanisms) to ensure coherent and synchronised implementation.

9.1.2 Roles and responsibilities of key government ministries

In line with the recent governmental restructuring, the roles and responsibilities of key ministries in implementing the NCAP are envisaged as follows:

9.1.2.1 Policy, regulatory framework, and international cooperation

- **MAE:** As the newly consolidated ministry overseeing both environmental protection (including climate change and ozone layer protection, functions previously under MONRE) and agricultural development (functions previously under the Ministry of Agriculture and Rural Development), MAE holds the central and most comprehensive responsibility for managing controlled substances. This includes ensuring national targets for GHG emission reductions and ODS phase-out from cooling activities are met, in close collaboration with line ministries. Its key functions include:
    - Leading the allocation, adjustment, and supplementation of production and import quotas for all controlled substances, including HCFCs, HFCs, and Methyl Bromide.
    - Developing and operating the online public service system for registration, reporting, and quota management.
    - Leading inspections and supervising the implementation of regulations on the collection, reuse, recycling, and disposal of controlled substances.
    - Championing sustainable refrigeration practices within the agriculture and seafood industries, fostering an efficient cold chain to minimise food loss and waste, and leveraging its dual environmental and agricultural mandate.
- **MOIT:** Will continue its critical role in leading EE programs and regulations directly impacting the cooling sector. Key responsibilities include managing refrigerant licensing and overseeing the development, implementation, and enforcement of MEPS and energy labelling for cooling appliances. MOIT will also be central to integrating NCAP objectives into broader EE programs like VNEEP3 and future initiatives.
- **Ministry of Finance (MOF):** Will manage public financial resources for green initiatives, including potential budgetary allocations for NCAP programs. It will also play a key role in developing and implementing financial policies, incentives (e.g., tax benefits, subsidies), and supporting mechanisms to attract investment in EE and sustainable cooling solutions.
- **MOC:** With its expanded mandate, MOC will be pivotal in developing and enforcing building codes and urban planning regulations that promote EE building designs, integrate passive cooling strategies, and manage UHI effects. Its role would also extend to influencing EE related to transport infrastructure and potentially refrigerated transport through broader transport development policies and standards.

9.1.2.2 Technology, standards, research & development

- **Ministry of Science and Technology (MOST):** Will lead in conducting and managing research, promoting standardisation (including TCVNs), and fostering the development and adoption of technological innovations to enhance EE in cooling technologies and support the transition to climate-friendly refrigerants. Collaboration with MOIT on equipment standards and MOC on building-related standards will be crucial.
- **MOIT, MAE and MOC:** These ministries will collaborate closely with MOST in the development, dissemination, and enforcement of specific technical standards and regulations relevant to their respective domains (e.g., MOIT for cooling equipment EE, MOC for building EE and passive cooling materials/designs, MAE for environmental standards related to refrigerants and waste).

9.1.2.3 Sector specific implementation and integration:

- **MOIT:** Will continue to manage and promote EE within industrial and commercial sectors, where a significant portion of cooling demand resides.
- **MAE:** In its dual role, MAE oversees the implementation of sustainable cooling practices in agriculture, fisheries, and other rural development contexts, as well as manages the environmental aspects of refrigerant use and disposal across all sectors.
- **Ministry of Education and Training (MOET):** Will promote passive cooling across the building sector, developing and disseminating technical knowledge, initiating pilot demonstrations, and raising awareness of energy, climate, and thermal comfort benefits.

9.1.2.4 Workforce development, awareness, and social aspects:

- **MAE and MOET:** MAE is responsible for regulating the requirements for diplomas and certificates for technicians who install, operate, maintain, and repair equipment containing controlled substances. Building on these regulations, MOET then takes the leading role in developing and implementing the corresponding vocational training programs and issuing the final skills certificates for these technicians.
- **Ministry of Home Affairs (MOHA):** MOHA is assigned the responsibility to develop and issue national technical regulations on labour safety for refrigeration and AC systems.
- **MAE, MOIT and MOC:** Will coordinate in developing and implementing programs to raise awareness among communities and businesses about the benefits of sustainable cooling, EE, and climate-friendly solutions.
- **MAE,** in collaboration with social organisations: Will continue to promote the integration of gender equality and the inclusion of vulnerable groups in accessing sustainable cooling solutions.

9.1.3 Engagement of non-governmental stakeholders

The successful rollout of the NCAP will also heavily depend on the proactive engagement and contribution of stakeholders beyond government ministries:

9.1.3.1 Technical organisations

The technical entities play an important role in fostering innovation, setting industry standards, and advancing technical expertise in the cooling sector. Through research, knowledge-sharing, and professional performance and collaboration, they contribute to the development, standardisation, and promotion of EE and sustainable cooling solutions. They include:

- **Testing centres:** Facilitate the development of national technical standards and conduct technical testing and certification for construction materials and cooling equipment, ensuring compliance with MEPS and labelling requirements.
- **Associations: Bodies** like the Viet Nam Society of Refrigeration and AC (VISRAE), Viet Nam Automobile Manufacturers' Association (VAMA), and Viet Nam Association of Seafood Exporters and Producers (VASEP) serve as crucial platforms for representing industry experts, promoting innovation, disseminating best practices, and facilitating knowledge-sharing within the cooling sector.
- **Research institutions, universities & colleges:** Act as academic and technical hubs, conducting applied research, fostering innovation, and developing specialised expertise and human resources to support advancements in energy-efficient and sustainable cooling solutions and technologies.

9.1.3.2 Industry and private sector

Industry and private sector stakeholders are at the forefront of adopting new technologies, providing market insights, and contributing to sector-wide efforts to reduce GHG emissions. They include:

- **Cooling sector enterprises (manufacturers, importers, distributors, retailers, and service providers):** Are central to the transition towards energy-efficient products and low-GWP refrigerants. They provide vital data on market trends, drive technological adoption, and are key to implementing service best practices and end-of-life management schemes.
- **ESCO:** Can play a significant role by investing in EE projects under performance-based models, which can be critical in financing and scaling up the adoption of sustainable cooling technologies, particularly in the commercial and industrial sectors.
- **Building owners, managers, architecture and engineering firms, real estate developers and construction companies:** Are responsible for specifying, implementing, and maintaining passive cooling designs and energy-efficient active cooling systems in both new constructions and retrofits, influencing long-term operational efficiency and occupant comfort.

9.1.3.3 Financial institutions

These institutions are integral for providing the necessary capital to finance sustainable cooling initiatives, ensuring that the sector can transition toward more sustainable practices. They include:

- **State bank and commercial banks:** Integral for providing the necessary capital through green loans, credit lines, and financial products tailored to support investments in RE and EE cooling projects.
- **Other financial institutions (investment funds, microfinance institutions):** Can further diversify funding sources, investing in green energy projects and potentially offering targeted solutions for low-income households or specific vulnerable groups to access sustainable cooling.

9.1.3.4 Development partners

Development partners provide funding, technical assistance, capacity building, and expertise to support Viet Nam's efforts in implementing international climate agreements and advancing sustainable cooling technologies. They include:

- **Bilateral donors:** Provide direct support for sustainable cooling initiatives through funding and technical collaboration.

- **Multilateral donors:** Facilitate Viet Nam's compliance with international climate commitments, including support for energy-efficient technologies and climate change mitigation in the cooling sector.

The stakeholder mapping will be continuously updated and refined to ensure that the NCAP aligns with evolving sector needs, regulations, and international best practices. Effective engagement and collaboration with these stakeholders will be key to achieving the objectives of sustainable cooling, enhancing EE, and contributing to Viet Nam's broader climate action goals.

9.2 Mainstreaming gender equality issues and alleviation of impacts on vulnerable groups

The following steps should be taken to reduce the vulnerability of poor groups that cannot afford modern cooling solutions, and women:

- Conduct gender-disaggregated surveys within Viet Nam to understand the impact of the absence of cooling on different groups, such as the disabled and poor people, with regard to their productivity, general health, mortality, etc. This would help policymakers make informed decisions to provide equitable access to cooling.
- Disseminate relevant information and warnings on impending heatwaves; impose restrictions on outdoor work during peak heat conditions.
- Introduce financial support programs for workers in informal sectors to combat heat stress. For example, Arsht Rock has created an extreme heat income insurance for women working in the informal sector in the Indian state of Gujarat. In the first phase, starting from April 2023, they are targeting 21,000 women to provide 3 USD per day during heat waves in the summer season (Rockefeller, 2023).
- Offer incentives for energy-efficient cooling systems, focusing on low-income and female-led households.
- Address disparities in cooling access between urban/high-income and rural/low-income groups through targeted financial and microfinance solutions promoting sustainable cooling.

9.3 Framework for monitoring, reporting, and adaptation of governance

To ensure the NCAP remains effective and responsive to evolving conditions, a clear framework for monitoring and reporting on its implementation, underpinned by the governance structure, will be established. This will involve regular reviews of progress against targets, assessment of the effectiveness of coordination mechanisms, and adaptation of strategies and institutional arrangements as needed. The stakeholder mapping and assigned responsibilities will be continuously updated and refined to ensure the NCAP aligns with evolving national priorities, regulatory changes (including further developments in governmental restructuring), and international best practices. Effective ongoing engagement and robust collaboration among all listed stakeholders will be fundamental to achieving Viet Nam's sustainable cooling objectives, enhancing national EE, and contributing significantly to its broader climate action goals.

10 Resources and financing mechanisms for the NCAP

The successful integration of the sustainable cooling sector to contribute to the NDC, NZT targets, and international commitments requires substantial financial resources. Funding is essential for investments in infrastructure, equipment, and technology to support EE improvements and GHG emission reductions. A well-structured financing framework is critical to ensuring the effective implementation of urban cooling strategies.

A successful financing mechanism will need the active participation of four main groups as follows:

(1) Policymakers (ministries) to push market demand.

(2) Main players in the cooling value chain (importer, manufacturer, service provider, end-user, E-waste collector and treatment) to behave according to the sustainable cooling roadmap.

(3) Financial Institutions (international and national) to leverage investment.

(4) Technical professional (evaluator, auditor) to provide technical support and confidence to Financial Institutions.

The list of stakeholders is summarised in Figure 16.

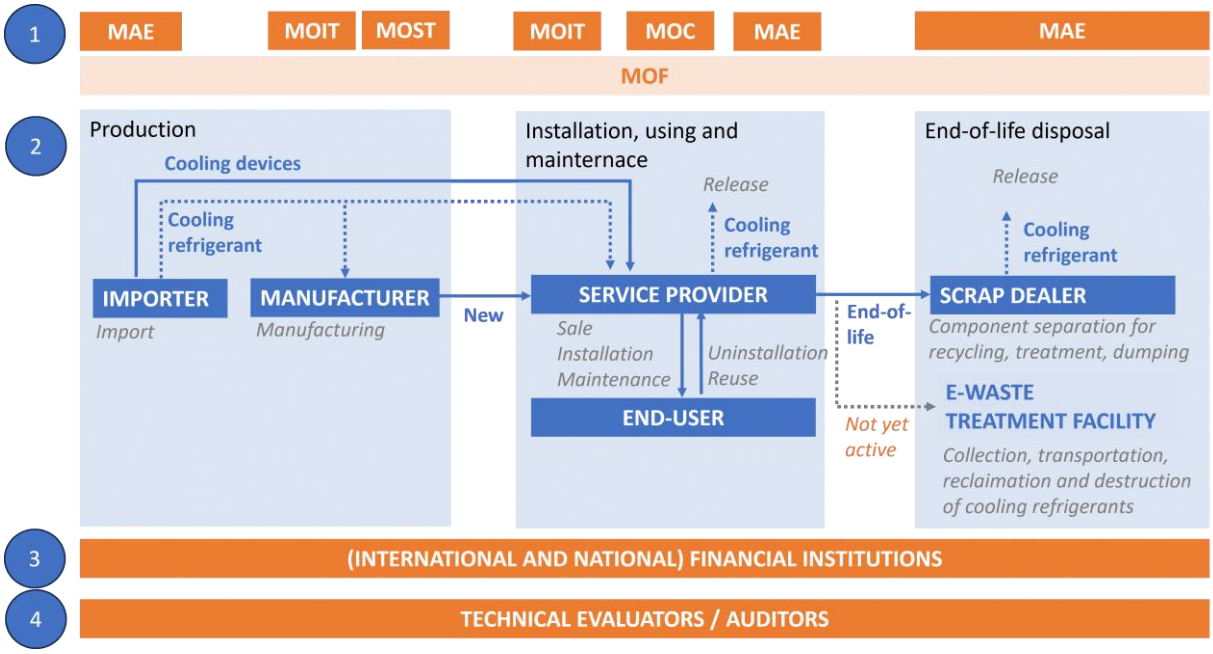


Figure 16: List of potential stakeholders for financing a cooling project

Source: Compiled under ETP/UNOPS Technical Assistance

To enhance financing for urban cooling and sustainable cooling initiatives, Public-Private Partnerships (PPPs) can be leveraged to distribute costs and risks while benefiting from the private sector's expertise and efficiency. Incentives such as tax benefits, loan guarantees, and subsidies can encourage private sector investments. Additionally, innovative financing mechanisms, including green bonds, crowdfunding, and community-owned RE projects, can provide alternative funding avenues.

While international climate finance plays a key role in supporting climate change mitigation and adaptation efforts, there is currently no comprehensive study on the distribution of financial resources specifically allocated to urban cooling in Viet Nam. Developing a transparent and

efficient financial strategy will be crucial in ensuring the long-term sustainability and effectiveness of NDC implementation in the urban cooling sector.

Financing and business models for scale-up

There are various business models for financing the cooling sector tested in international practice. Not all are applicable in Viet Nam due to the need to ensure payback to FIs as well as stakeholder structure in the value chain, in which Viet Nam has a very strong network of scrap dealers.

Three models seem to be most suitable for Viet Nam, under the different phases of the cooling value chain that are recommended to be considered further for pilot activities from now until 2030, namely (i) Model - Cooling as a service; (ii) Model – Trade in; (iii) Model - Generate and sell Internationally Transferred Mitigation Outcomes (ITMOs) under Article 6.2 of the Paris Agreement. The details of each model are presented in the Annex.

11 Conclusions and the way forward

Cooling demand in Viet Nam is rising quickly. The Government has signed the Montreal Protocol and its Kigali Amendment, the Paris Agreement, a net zero pledge at COP26, and the PCG at COP28. These commitments point in one direction, which is to achieve sustainable cooling by adopting passive cooling strategies in building and urban design, raising the EE of cooling equipment and switching quickly to ultra-low- and non-GHG refrigerants. The NCAP turns those commitments into a clear, step-by-step path from today's pressing heat stress to a climate-smart cooling economy by mid-century, timed actions while working alongside other national measures to complete the job.

The centrepiece of the NCAP is the Kigali-aligned HFC trajectory that freezes consumption at 14 $MtCO_2e$ by 2028, drives the first 10 % cut in 2029, and reaches an 80 % reduction in 2045 – a trajectory that is fully aligned with the Kigali Amendment. Parallel product and equipment restrictions, together with a four-stage life-cycle programme that evolves from foundational recovery pilots (2024-28) to full refrigerant circularity (2040-44), give the industry a clear market signal while protecting households and businesses from sudden cost shocks.

2024-2028 – Strengthening the regulations on EE

- Expand MEPS and energy-label rules for room-AC, chillers and refrigerators.
- Launch initial refrigerant recovery and reclaim centres and public awareness campaigns on efficient thermostat settings.
- Hold HFC use remains steady under the freeze cap.

2029-2034 – Financing & Scaling High-Impact Solutions

- HFC phasedown milestone: first 10% reduction achieved in 2029.
- Import-quota bans extend to high-GWP refrigerants in transport refrigeration, chillers and portable ACs, with mandatory recovery of refrigerants from large systems taken out of service.
- Workforce capacity: at least 8,000 technicians certified in the safe handling of A2L/A3 refrigerants by 2034, cutting leakage rates and accident risks.

2035-2044 – Deep cuts and full market shift

- Achieve the 30% and 50% HFC reduction milestones; progressively tighten GWP ceilings from 750 to 150.

- Embed cool-roof programmes and passive-design rules into mainstream construction approvals.

2045 and beyond – Locking in the gains

- Deliver the 80% HFC cut and "full refrigerant circularity", with end-to-end tracking of every cylinder.
- Ensure that virtually all new cooling equipment uses natural or ultra-low-GWP refrigerants and that post-2040 buildings routinely halve cooling loads through good design.

The payoff is large. High-efficiency equipment and better design trim electricity use by about 10 TWh in 2030 and 69 TWh in 2050, roughly the annual output of four large power plants. Direct refrigerant-related emissions fall by 7.8 $MtCO_2e$ in 2030 and 20 $MtCO_2e$ in 2050, led by the Residential and Commercial AC segment. Together with a greener power grid, total cooling-sector emissions drop to only a fraction of today's level, helping safeguard Viet Nam's NDC and net zero goals.

Delivering these outcomes will require significant, well-targeted investment. The NCAP estimates that upgrading equipment, building recovery infrastructure, training technicians and scaling passive-cooling measures will call for several billion USD by 2030. The Plan therefore pairs its technical milestones with a blended-finance strategy that draws on domestic public funds, green credit lines, public-private partnerships and innovative models such as Cooling-as-a-Service, trade-in schemes and the generation and sale of Article 6 mitigation outcomes. International climate finance can cover high upfront costs, while revenues from energy savings and carbon markets repay investors. Mobilising this capital and tracking its impact through the Plan's MRV (Measurement, Reporting, and Verification) system is as important as the technical targets themselves.

Furthermore, to complement the strategy of enhancing equipment EE and transitioning to low-GWP refrigerants, the NCAP will build upon and expand successful urban-scale interventions. The ongoing "Sustainable Urban Cooling in Viet Nam's Cities" initiative, jointly led by UNEP's Cool Coalition, GGGI, and the DCC under MAE, provides a crucial foundation. The two pilot Urban Cooling Action Plans (UCAPs) currently under preparation for Can Tho and Tam Ky offer tested, city-scale roadmaps for significantly lowering cooling-related energy consumption, mitigating urban heat-island effects, and ensuring affordable thermal comfort for residents. Building on this groundwork, the NCAP recommends a strategic approach to scale up these successes nationwide by:

- **i) Replicating the development of UCAPs** for other high growth cities and urban centres across Viet Nam, adapting successful models to local contexts.
- **ii) Systematically incorporating urban cooling targets and passive cooling measures** into forthcoming provincial and city-level climate action plans, master plans, and socio-economic development strategies.
- **iii) Actively mobilising concessional finance, public investment, and private capital** to support the implementation of district-level sustainable cooling solutions, including the promotion of green roofs, widespread adoption of passive building design principles, nature-based solutions, and the deployment of high-efficiency, low-GWP cooling technologies at the community and building scale.

This integrated approach, combining technological advancements with urban planning and design strategies, will be essential for holistically addressing cooling demand.

Success now hinges on disciplined execution: publish each scheduled regulation on time, keep data flowing through the monitoring system, and make full use of the financing tools already described in the Plan. Staying the course will not only cut carbon and save electricity; it will keep people healthy, businesses productive, and Viet Nam competitive in a warming world.

Achieving these milestones will deliver more than emissions cuts: it will free gigawatts of electricity for new economic activity, shield vulnerable communities from extreme heat, and open regional export opportunities for high-efficiency, climate-friendly cooling technologies. By staying the course on this agreed roadmap, Viet Nam can turn cooling from a fast-growing source of emissions into a flagship of green growth, proof that development, resilience and net zero ambition can move forward together.

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Annex

Annex 1: Categorisation of cooling sector/sub-sectors

Table 10: Targeted cooling sector/sub-sectors under the NCAP

No	Cooling sector /sub-sector	Definition
1	**AC**	**Systems primarily designed for providing thermal comfort to occupants in enclosed spaces by altering air temperature and humidity.**
1.1	Residential and Commercial AC	• Encompasses room or small-space AC, including non-ducted single-split systems (typically 2–15 kW with separate outdoor condensing and indoor fan-coil units) and self-contained window/portable units (typically 1–10 kW).
1.2	Central AC and Chiller	• Central AC: Multi-split systems with one outdoor unit serving multiple indoor units; includes VRV/VRF systems. • Chillers: Provide indirect cooling by cooling a secondary fluid (e.g., water) for air or process cooling.
1.3	MAC	AC units in road transport vehicles, including passenger cars, buses, and trucks.
2	**Refrigeration**	**Systems and appliances primarily used for preserving perishable goods (e.g., food, pharmaceuticals) by maintaining temperatures below ambient levels, including freezing.**
2.1	Domestic Refrigeration	Household refrigerators and freezers; typically self-contained, factory-assembled plug-in units.
2.2	Commercial Refrigeration	• Stand-alone units: e.g., ice cream freezers, vending machines, and display cases. • Condensing units: Pre-assembled compressor-condenser systems for connection to various refrigeration circuits.
2.3	Industrial Refrigeration	• Systems with capacities from 100 kW to 30 MW, often centralised or distributed in facilities such as food processing plants and large supermarkets. Smaller condensing units (1–20 kW) are also included.
2.4	Transport Refrigeration	Refrigerated units installed in vehicles, trailers, and containers for cold-chain logistics.

Annex 2: Three financial models for piloting sustainable cooling investments in an immediate period

(i) Model - Cooling as a service

This model pilots the willingness, participation and contribution of stakeholders in the second phase of cooling devices, i.e., installation, use and maintenance. This pilot confirms the reduction potential in total energy consumption of the cooling sector.

Under this pilot, at least two ESCOs receive financing to cover the investment cost of equipment and cooling services. A cooling service contract will be signed between the ESCO and the cooling users, monitored by the auditor for identification of payback to ESCO and, thus, to Financial Institutes (Fis). The performance of different stakeholders is as follows:

- ESCO pays for equipment under the positive list and performs installation and maintenance of a cooling device/system. This helps ESCO to be more active without a financial burden.
- The manufacturer provides equipment, guarantees its performance and receives immediate payment from ESCO.
- End-user pays for the cooling volume he uses. The cooling service will be charged in USD/cooling unit, which is higher than the electricity price. This helps reduce energy consumption and the upfront payment for cooling users. This also helps the cooling users not to worry about the performance of the system.
- FIs provide financing to ESCO and receive payback per the financing contract.
- Technical evaluator helps FIs in the assessment, evaluation and post evaluation of cooling service.
- The pilot project will provide technical support to FIs in the evaluation of the ESCO contract, development of a positive list, providing a cooling reader and cooling reading database and arranging financing for FIs.

The concept of the pilot model is presented in the figure below.

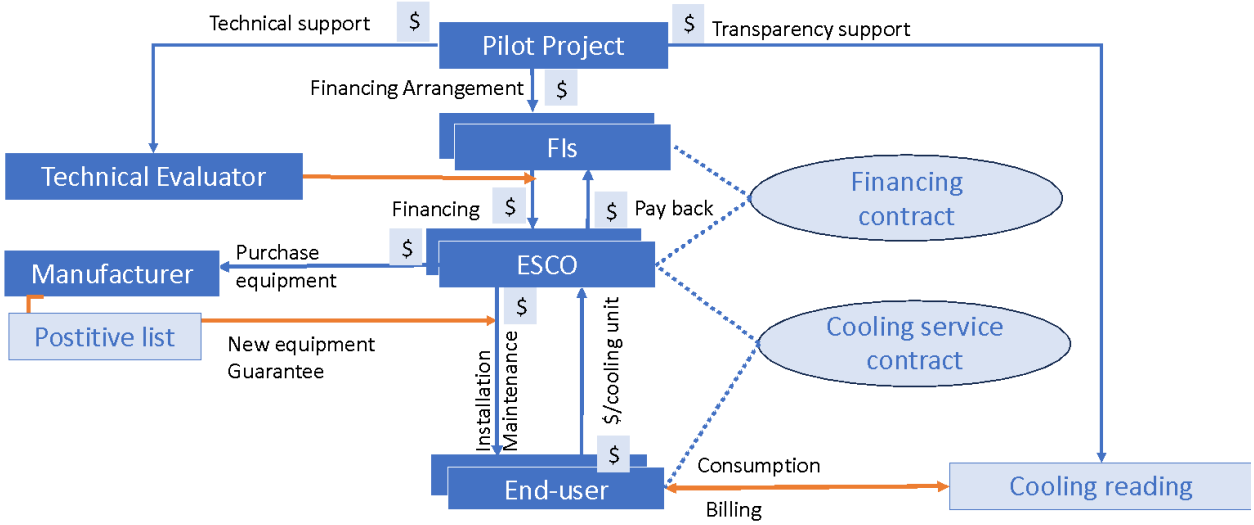

Figure 17: Pilot concept of Cooling as a Service model in Viet Nam

Source: Compiled under ETP/UNOPS Technical Assistance

Based on the initiatives of Daikin, the model should be piloted in the commercial sector, i.e., ACs in the commercial sector.

(ii) Model - Trade in

This model pilots the willingness, participation and contribution of stakeholders in the third phase of cooling devices, i.e. end of life disposal. This pilot confirms the possibility of avoiding leakage of cooling refrigerant from end-of-life disposal.

Under this pilot, at least two E-waste treatment facilities receive financing to introduce and perform trade-in services and equipment under the positive list. The fee for treatment of collected cooling devices, including recovery, reclamation, and destruction of cooling refrigerants, will be negotiated between the facility and the manufacturer on the E-waste contract.

The performance of different stakeholders is as follows:

- E-waste treatment facility purchases equipment from the manufacturer per positive list, pays technician for dismantling and installation of cooling equipment, performs E-waste treatment and pays back FIs per financing contract.
- The manufacturer provides equipment, guarantees its performance and receives immediate payment for E-waste for recapitalising and production. The manufacturer pays an E-waste treatment facility for the collection, transportation and treatment of its end-of-life E-waste per the E-waste contract and obligation under the Extended Production Responsibility.
- End-user registers trade-in equipment and pays for the difference.
- The pilot project will provide technical support to FIs in the evaluation of E-waste financing contracts, development of a positive list, trade-in database and arrangement of finance.

The concept of the pilot model is presented in the figure below.

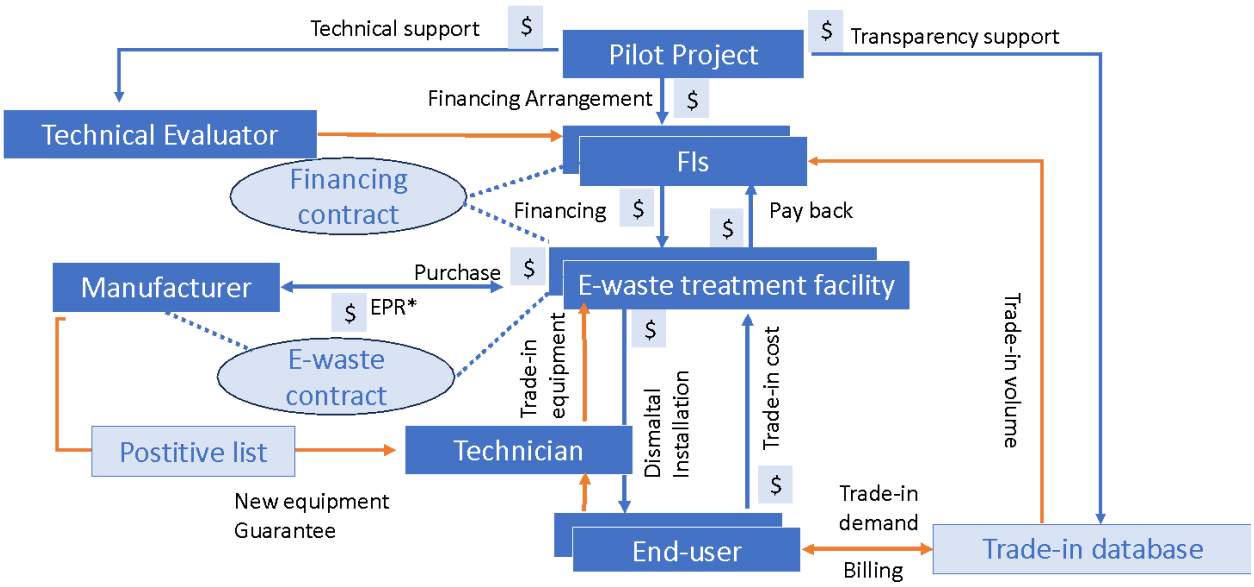

Figure 18: The pilot concept of trade-in a model in Viet Nam

Source: Compiled under ETP/UNOPS Technical Assistance

Based on international practice, this model should be piloted with residential AC.

(iii) Model - Generate and sell ITMOs under Article 6.2 of the Paris Agreement

This model is based on revenues from international carbon markets for EE improvement of cooling devices or recovery and reuse of high-GWP refrigerants. The approach would function as follows, using a concrete, but fictitious example:

The government of Viet Nam agrees with the government of South Korea on Article 6.2 cooperation covering the cooling sector. Under that collaboration, private or public developers of EE improvement activities of cooling devices or recovery and reuse of high-GWP refrigerants can develop and submit project ideas for approval and authorisation of ITMOs for the mitigation achieved by the projects. These projects need to apply a baseline and monitoring methodology agreed upon by South Korea and Viet Nam. The emission reductions must be verified by independent third-party auditors accredited by the governments; these could be auditors accredited under ISO 14065 or the Clean Development Mechanism - CDM.

South Korea is willing to buy ITMOs at a price of 40 USD/tCO_2e. The government of Viet Nam issues ITMOs only for 50% of the reductions actually achieved in order to cover the need for a corresponding adjustment of its emissions balance.

A project developer works with retailers to offer 100,000 ACs with an efficiency level of 30% higher than the baseline level, which is 75% of the efficiency of ACs sold in Viet Nam in 2022, at a discounted price. As a baseline, ACs use 1,000 kWh/year (Le & Pitts, 2019). The average savings per AC reach 300 kWh/year, so a total of 30 GWh is saved annually.

Given a baseline GEF of 0.9 CO_2/MWh (DCC, 2020), the annual mitigation reaches 27,000 tCO_2. The crediting period of the project is 10 years, so a total of 0.27 $MtCO_2$ mitigation is achieved, and 0.135 million ITMOs would be issued. The accumulated revenue would reach 5.4 million USD. Therefore, a retail discount per AC of several hundred USD could be offered, and the project developer would still make a profit. Given that the ITMO sales revenues would only accrue ex post, a loan from a domestic private bank would have to be used to pre-finance the retail discount, secured through the ITMO revenue.

Another project developer would recover refrigerant at the end of the life of ACs operating on R-22. Given each AC contains 1 kg of R-22 with a GWP of 1,760 as per the IPCC 5th Assessment Report, preventing the release of the R-22 generates an emissions reduction of 1.76 tCO_2e, i.e., an ITMO volume of 0.83. The carbon credit revenue would reach 33 USD for each AC treated in the recycling plant.

The figure details the process for the generation of ITMOs through Article 6.2 below.

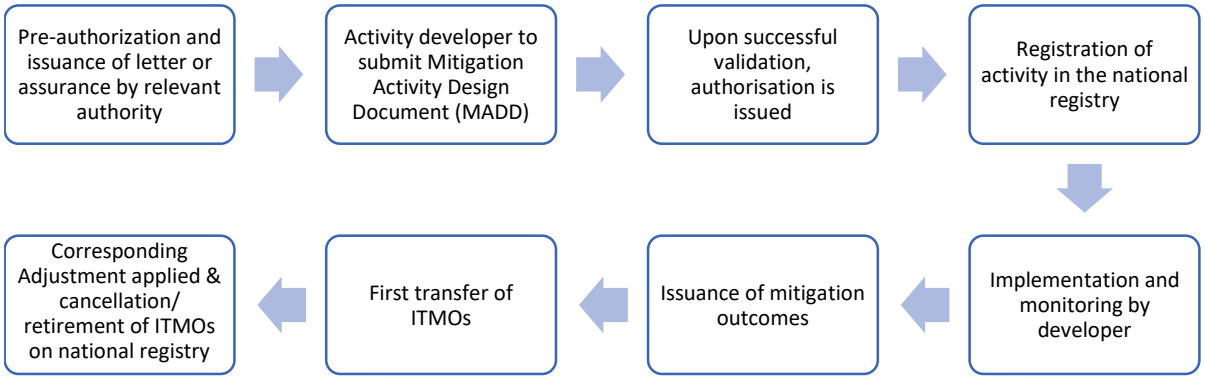

Figure 19: Process for generation of ITMOs through Article 6.2

Source: Compiled under ETP/UNOPS Technical Assistance