ERIA Research Project Report FY2024, No. 29

Study on the Introduction of Heat Pumps and Once-Through Boilers to Support GX in Asia

By

ERIA Asia Zero Emission Center

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Economic Research Institute for ASEAN and East Asia

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Preface

The introduction of high-energy-efficiency equipment, such as heat pumps and once-through boilers, stands as a pivotal advancement in our journey towards sustainable energy use and carbon neutrality in Asia. This project aims to explore and demonstrate the feasibility and benefits of these technologies in Viet Nam, Thailand, and India.

Asia's rapid economic growth has been accompanied by a substantial increase in energy demand and associated carbon emissions. This reality underscores the urgency of implementing decarbonisation strategies in the region while ensuring continued economic growth and energy security for its developing countries.

The core objective of this project is to support the global transition towards a greener future by promoting the adoption of industrial heat pumps, commercial heat pump water heaters, refrigeration and freezing equipment, and small once-through boilers. These technologies offer substantial energy-saving potential by leveraging the principles of heat transfer, which can significantly reduce the carbon footprint of heating and cooling processes.

This phase focuses on establishing partnerships with local entities and identifying user companies for trial projects. By engaging with local companies and conducting user seminars, we aim to raise awareness and facilitate the integration of these high-energy-efficiency systems.

The authors hope that this study will not only advance the adoption of energy-efficient technologies in Asia but also serve as a model for other regions striving for sustainable development. Through concerted efforts and continuous innovation, we believe that achieving carbon neutrality is within our reach, paving the way for a cleaner and more resilient future.

Hiroshige Muraoka

President of Nomura Research Institute Singapore Pte. Ltd.

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This study was undertaken based on close collaboration with industry specialists and government who are focused on carbon reduction and energy efficiency improvement issues in Asia (specifically Viet Nam, Thailand, and India). The authors particularly would like to thank all the participants in the various meetings and seminars, as well as other participants who were involved in the project in one way or another.

The presentations at the workshop – held by the government authorities, industry players, and other stakeholders – and ensuing discussions will play a pivotal role in providing direction and inspiring relevant parties to develop future strategies and policy measures to support carbon reduction and energy efficiency improvement activities.

The authors would like to express sincere appreciation for kind and generous support for this study, without which this report would not be possible. All errors and mistakes are the authors' responsibility.

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List of Abbreviations and Acronyms

AEEE	Alliance for Energy Efficient Economy
AHPNW	Asian Heat Pump Thermal Storage Technologies Network
ASEAN	Association of Southeast Asian Nations
ASME	American Society of Mechanical Engineers
AZEC	Asia Zero Emission Community
BAU	Business-as-usual
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BMS	Building Management Systems
CDM	Clean Development Mechanism
CF	Carbon Fiber Composite
COP	Coefficient of Performance
COPt	Coefficient of Performance for tapping sanitary hot water
CNG	Compressed Natural Gas
DEDE	Department of Alternative Energy Development and Efficiency
DIW	Department of Industrial Works
ECBC	Energy conservation building code
EERS	Energy Efficiency Resource Standards
EGAT	Electricity Generating Authority of Thailand
EN	European Standards
ERIA	Economic Research Institute for ASEAN and East Asia
ESCO	Energy service companies
GGDC	Groningen Growth Developing Centre
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, and Air conditioning
HSPF	Heating Seasonal Performance Factor
IPPU	Industrial Processes and Product Use
JCCI	Japanese Chamber of Commerce and Industry
JCM	Joint Crediting Mechanism
JRAIA	Japan Refrigeration and Air Conditioning Industry Association
JIS	Japanese Industrial Standards
MEPS	Minimum Energy Performance Standard

METI	Japan Ministry of Economy, Trade and Industry
MNC	Multinational Corporation
MSME	Micro, Small, and Medium Enterprises
MOIT	Ministry of Industry and Trade
MOU	Memorandum of understanding
NDC	Nationally Determined Contributions
NRI	Nomura Research Institute
PAT	Perform, Achieve and Trade
PLI	Production Linked Incentive
RAMA	Refrigeration and Air-conditioning Manufacturer Association
REC	Renewable Energy Certificates
SEER	Seasonal Energy Efficiency Ratio
SME	Small- and medium-sized enterprises
TABPV	Thai Association of Boiler and Pressure Vessel
TGO	Thailand Greenhouse Gas Management Organisation
TIS	Thailand Industrial Standards
TISI	Thailand Industrial Standards Institute
TPES	Total primary energy supply
VCS	Verified Carbon Standard
VECEA	Vietnam Energy Conservation and Energy Efficiency Association
VISRAE	Vietnam Society of Refrigeration and Air-Conditioning Engineers
VNEEP	Vietnam National Energy Efficiency Program
VOC	Volatile Organic Compound

Executive Summary

Rapid economic growth in Asia has led to a significant increase in energy demand and associated carbon emissions, particularly in countries such as Viet Nam, Thailand, and India. As these countries continue to experience rapid industrial growth, the need for sustainable energy solutions becomes increasingly critical to reducing greenhouse gas emissions and achieving carbon neutrality. To address this challenge, the introduction of high energy efficiency equipment, such as heat pumps and once-through boilers, presents a pivotal opportunity to achieve several objectives – namely continued economic growth and enhanced efficiencies through the scalability of the new technologies, as well as improved sustainable energy use and reduced carbon footprint across the region.

This report explores the feasibility and benefits of adopting heat pumps and once-through boilers in these three countries. The study highlights the significant potential of these technologies to reduce energy consumption and carbon emissions in both industrial and commercial sectors. Heat pumps, which are three to five times more energy-efficient than traditional boilers, offer a sustainable solution for heating and cooling by extracting heat from the surrounding environment. Similarly, once-through boilers, which are more compact than traditional fire tube boilers, offer scalability and higher efficiency, thereby significantly reducing fuel consumption in industrial processes.

Despite the clear advantages, the adoption of these technologies in Asia remains limited due to several barriers:

- High upfront costs: Both heat pumps and once-through boilers, though efficient, require significant initial investment. This may discourage adoption, especially amongst small and medium-sized enterprises (SMEs).
- Limited awareness of the potential benefits: In Viet Nam, Thailand, and India, there is still a general lack of awareness about the long-term benefits of these energy-efficient technologies, both in terms of cost savings and their positive environmental impact.
- Technical barriers: The complexity of integrating heat pumps into existing industrial systems, coupled with limited technical expertise, may render it difficult for businesses to adopt these technologies.
- Inadequate policy support: A lack of regulations, and guidelines further exacerbates the slow uptake of these energy-efficient equipment, as companies interviewed revealed a high state inertia which needs to be overcome with more policy support.

Faced with these challenges, we recommend the following five strategic directions to develop a roadmap for the improvement of adoption of such energy-efficient technologies and equipment:

- Financial scheme: It is necessary to reduce the initial financial burden on businesses, particularly SMEs, to incentivise the switch from conventional less energy-efficient technologies to their newer and improved counterparts. We propose the introduction of leasing options to alleviate this initial financial barrier. Furthermore, the leasing options can be combined with the use of carbon credits, where leasing companies collect carbon credit allowances generated by using energy-efficient equipment and trade them on the carbon credit trading market. This will hopefully lower the entry barriers for companies interested in decarbonisation by removing the need for them to directly manage and trade carbon credits.
- Awareness campaigns: Governments and related partners can conduct targeted outreach programmes such as workshops and seminars especially for industry stakeholders and equipment user companies to raise the overall awareness about the long-term benefits (both financial and environmental) of these technologies and equipment
- Technical training: It will also be essential to invest in local capacity building initiatives, as it would be insufficient to only implement the new equipment without training local staff, such as engineers and technicians, to operate and maintain it. Skilled technicians not only optimise the energy efficiency of heat pumps and once-through boilers while reducing safety risks and environmental impacts, but also play a key role in promoting these technologies. By informing end-users about their advantages and proper operation, they help drive adoption and support long-term sustainability.
- Policy and regulatory support: Alongside the recent push to adopt greener technologies, governments and related ministries or agencies could establish standards and guidelines for these new energy-efficient equipment if they have not yet been created. For example, to make the benefits of the new energy-efficient equipment clearer, it would be beneficial to establish standards for the indices, evaluation methods, and guidelines to compare equipment performance. At the same time, considering the safety aspect of heat pumps, it will also be necessary to create guidelines for the handling of refrigerants.
- Collaboration between different stakeholders: Although there are research initiatives that are led by the public sector, manufacturers, and academia, these tend to exist separately. The situation can be improved by leveraging the expertise of ESCOs, who are experts in energy efficiency as they provide comprehensive solutions, from energy audits to installation and maintenance. Local ESCOs can be particularly effective in demonstrating the energy-saving potential and cost-effectiveness of the new energy-efficient equipment, because they tend to have strong ties with the local government as well as possess a wide local user base.

As a way forward, work needs to be carried out on different stakeholders, and efforts need to be focused on integrating these energy-efficient equipment into energy strategies at the national, regional, and company level.

The authors are of the opinion that by integrating these advanced systems into their energy strategies, Viet Nam, Thailand, and India can make substantial progress towards their carbon neutrality goals, thereby further contributing to the global effort to combat climate change.

Through concerted efforts and innovative approaches, the region can achieve significant energy savings, reduce its carbon footprint, and set an example for other regions striving for sustainable development.

Chapter 1
Project Introduction

1. Background and Objectives

As the world's leading emitter, Asia plays a central role in the push for decarbonisation to combat climate change. Decarbonising Asia, however, must go hand in hand with sustaining economic growth and ensuring energy security for developing countries in the region. Energy consumption in Asia will continue to increase, therefore increasing energy efficiency and switching to renewable energy are of utmost priority in the region's transition to net zero.

Globally, heat pump technology has been recognised as an energy-efficient solution to sustainable heating and cooling. Rather than producing heat, heat pumps extract heat from surrounding air, ambient water or waste heat from industrial processes, and transfer the heat to where it is needed. In the cooling cycle, cold refrigerant absorbs heat in the evaporator and transfers it to outside air. Devices like electric heaters that convert energy directly into heat theoretically cannot exceed 100% energy efficiency. However, heat pumps can achieve energy efficiency beyond 100%. For example, when used in low to medium temperature ranges, heat pumps can be 3–5 times more energy-efficient than traditional boilers. As of 2021, around 10% of space heating globally were met by heat pumps. Investment in heat pumps across the EU almost doubled from €13 billion to €23 billion from 2020 to 2023.

However, it is important to note that regions where heat pumps are being widely adopted have primarily focused on their use for heating and hot water in facilities and households. For example, European home installations expected to reach 5 million units annually by the 2030s and shown in the Table 1-1, over half of heat pump sales in Europe are for heating purposes, which highlights the difference in market drivers between those early adopting countries with colder climates and Southeast countries.

Despite the growth of heat pumps in advanced economies like Europe and the U.S., they currently supply only about 5% of global industrial heat, indicating that widespread adoption is still limited. Industrial process heat remains predominantly reliant on fossil fuels, with over 85% of heating energy being supplied by natural gas, coal, and oil boilers. However, given the high energy efficiency and potential for significant carbon emissions reduction, the use of industrial heat pumps is expected to increase in the future (Figure 1-1).

While some regions in Viet Nam, Thailand, and India experience winter, much of these countries have year-round warm climates, resulting in low demand for heating. In these countries, it is difficult to grow the heat pump market in the same way as Europe or Japan, where heating and hot water systems are leading the market. Heat pump technology is

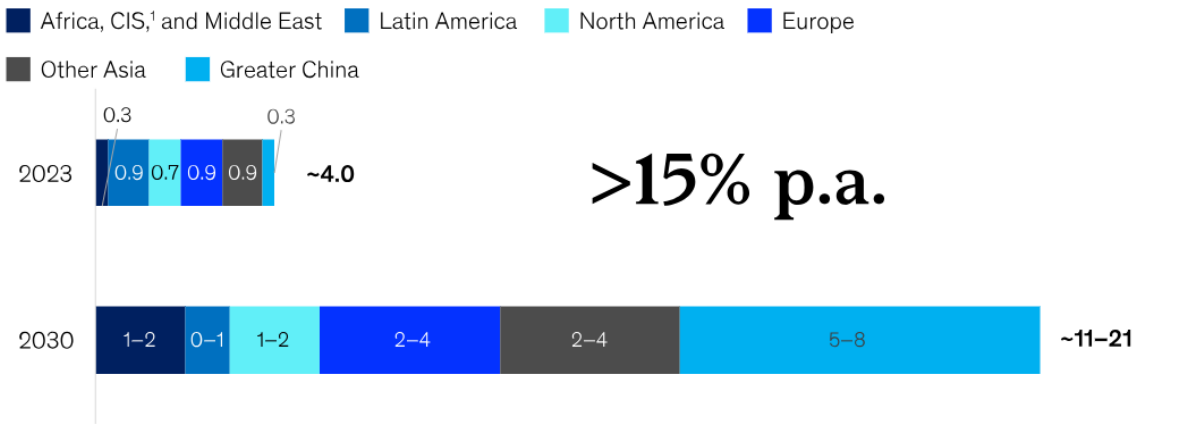
still not widely adopted in Viet Nam, Thailand, and India, in the industrial sector, and even in residential households, or the service sector. According to the Japan Electro-heat Center, heat pump adoption in Viet Nam is in a transitional phase, with research institutions actively developing industrial heat pump technology. While some units have been introduced, mainly by European and Japanese manufacturers, adoption remains limited due to low awareness and high initial investment costs. In Thailand, several recent cases of heat pump introduction have been observed, particularly by local air-conditioning manufacturers. However, the lack of awareness and upfront costs continue to hinder widespread adoption based on the same report. In India, despite a few confirmed examples of heat pump use, the industrial sector's heavy reliance on coal, oil, and natural gas, which account for 83% of its energy consumption. This implicitly suggests that in the industrial sector, the use of boilers powered by fossil fuels remains dominant, while the adoption of heat pumps is very limited.

Table 1.1: Sales of Heat Pumps (2023)

		France	Germany	England	USA	Japan
Sales	Heating equipment	Units: 540,000 Share: 51.4%	Units: 350,000 Share: 26.9%	Units: 53,000 Share: N/A	Units: 3,600,000 Share: N/A	N/A
	Hot water equipment	Units: 177,000 Share: 12.4%	Units: 24,000 Share: 5.6%	Units: N/A Share: N/A	Units: 140,000 (2022) Share: 1.1%	Units for residential use: 586,000 Units for industrial use: 3,200 Share: N/A

Source: Heat Pumps and Thermal Storage Technology Center of Japan (2023).

Figure 1.1: Global Industrial Heat Pumps Market



[1]Commonwealth of Independent States.
Source: *McKinsey Global Energy Perspective 2023* Current Trajectory and Achieved Commitments scenarios; McKinsey Platform for Industrial Electrification

Source: McKinsey & Company (2024).

Once-through boiler is another technology which can significantly increase energy efficiency and reduce fuel consumption in industrial manufacturing. Once-through boilers are composed of water tubes where water is supplied from one end and steam is extracted from another without circulating back again, leading to fast steam generation time, high pressure efficiency with compact system design. The global market share of once-through boilers is not clearly defined, but their high efficiency, compact design, and safety features are widely recognised. A report predicts the global boiler market size to reach US$110.6 billion in 2023 and US$202.44 billion in 2030. In countries like Thailand and Viet Nam, multiple Japanese companies have already installed and sold these boilers, suggesting that the market is expected to grow further in these regions.

Developing Asia is poised for substantial economic growth, which will lead to a sharp increase in energy demand especially in the industrial sectors, exacerbating the challenges of energy security and carbon emissions. As a result, there is an urgent need for these countries to adopt energy-efficient technologies like heat pumps and once-through boilers to mitigate the environmental impact of their growth.

In December 2023, Asia Zero Emission Community (AZEC) was officially established by 11 partner countries, including Australia, Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. The AZEC partners are dedicated to advancing policy development and coordination, encouraging public–private partnerships, and enhancing cooperation in decarbonisation technologies green supply chains, and transition finance. It is expected that AZEC would be a major platform to incentivise and proliferate the use of energy efficient heat pumps and other technologies in the region.

The Asia Zero Emission Community (AZEC) initiative focuses on fostering regional cooperation amongst Asian countries, including Thailand and Viet Nam, to achieve net-zero emissions. While India is not formally part of AZEC, its significant carbon emissions make it a crucial player in global decarbonisation efforts. Amongst the project focuses on Viet Nam, Thailand and India, which economies grows substantially and lead to a sharp increase in energy demand, aligning with AZEC's mission by promoting decarbonisation in Thailand and Viet Nam, where the adoption of energy-efficient technologies like once-through boilers is encouraged. In parallel, similar efforts in India aim to reduce its substantial CO_2 emissions through the integration of cleaner energy sources and advanced technologies. By addressing the unique challenges in these three countries, the project contributes to the broader goal of sustainable development across Asia, supporting AZEC's vision of a low-carbon future and enhancing regional climate resilience. And this project focuses on understanding energy situation and necessity of carbon neutral, issues and needs of heat pumps and once-through boilers, which are high-efficient equipment and proposing measures to overcome those issues.

In this report, 'heat pumps' includes refrigerators, chillers and air conditioners with compressor-based compression and expansion mechanisms. The project emphasis on

industrial usage, 'industrial' in this context encompasses all types of corporate use, not only limited to manufacturing and processing in factories but also including commercial applications in hotels and similar establishments. For the purposes of this project, distinctions based on the heat source or the state of the medium (liquid or gas) during output are not explicitly made.

Additionally, the report focuses on once-through boilers includes small once-through boilers, which, in Japan, can be handled by individuals who have received special training, without the need for a boiler technician qualification.

2. Selection Process of Target Countries

For this project, a total of three countries – India, Thailand, and Viet Nam were selected.

The selection process began with the consideration of eight countries – Norway, Austria, France, Malaysia, Thailand, Viet Nam, Indonesia, and India. To evaluate the feasibility of introducing new heat pumps and once-through boilers in each of these countries, several criteria and indicators were analysed. These factors were included with the consideration of whether it would be feasible for new market entrants to enter into the respective countries and contribute to the adoption of heat pumps and once-through boilers.

- Qualitative factors
    - Environmental protection posture
    - Attitude towards energy conservation
    - Requirements for industry standards
    - Possibility of new market entrants providing value to each of the markets
- Quantitative factors
    - GDP (nominal)
    - Population
    - Total energy consumption
    - Energy intensity
    - Rate of renewable energy

The table below shows evaluation of each country based on several qualitative factors – equipment-based factors for heat pumps and once-through boilers and relevant standards. The target countries are then benchmarked against one another in terms of overall prospects for new market entrants. Attractive areas are highlighted in light blue, while areas which are deemed less attractive are highlighted in pink.

In conclusion, though the three selected European countries (Norway, Austria, and France) share similar qualities in terms of a proactive stance towards energy conservation and compliance with energy conservation, there is stiff competition facing new market entrants from the state of environmentally friendly industrial technologies and equipment as well as the ability of local players to easily address basic needs from end users.

On the other hand, Asian countries show more potential for new market entrants, as there are different levels of progress in terms of equipment usage, awareness of environmentally friendly industrial technologies, and potential contribution to the adoption of heat pumps and once-through boilers. Specifically, Malaysia, Thailand, Viet Nam demonstrate more potential, as the expected future installation base of heat pumps and once-through boilers is expected to increase, while new market entrants can easily enter each country and provide value for areas which face challenges in terms of energy-saving performance and safety quality.

Table 1.2: Selection of Target Countries – Qualitative Factors

Qualitative Factor	Countries*							
Evaluating Criteria	NW	AU	FR	MY	TH	VN	ID	IN
Environmental protection posture, and Attitude towards energy conservation	• Recognises the need for energy conservation and demonstrates compliance with environmental regulations and net zero efforts			• Main concern is to secure energy to meet demand. Also, investment in energy conservation for the purpose of reducing environmental impact is limited • The limited availability of domestically sourced energy makes it easier to promote initiatives to reduce energy consumption			• Energy saving efforts are being implemented, but investment is limited due to abundance of fossil fuels • Although policies have been introduced, regulations and incentives are more limited compared to the other three Asian countries	
Requirements for industry standards	• Industry standard created based on global ISO standards is widely applied across Europe • Mechanisms and systems for developing standards have been established			• Some countries have introduced international standards (ISO) or have their own standards based on international standards, but most standards used for industrial applications are on a voluntary basis • Need for and awareness of maintenance of standards is not as high as they should be				
Possibility of new market entrants providing value to each of the markets	• Stiff competition, as the development of new technologies and the state of equipment is more advanced compared to Asian countries • Basic needs can be easily met by existing local firms, limiting the prospects for new market entrants			• Current installation of heat pumps is limited, but future adoption is expected. • New market entrants can easily enter each country, contributing to the adoption of heat pumps and once-through boilers • Challenges may be faced in terms of energy-saving			• Market expansion is not easy due to low awareness of energy conservation • Challenges may be faced in terms of energy-saving performance and safety quality, especially by	

		performance and safety quality, especially by existing market players, which new market entrants are poised to address	existing market players, which new market entrants are poised to address

NW = Norway, AU = Austria, FR = France, MY = Malaysia, TH = Thailand, VN = Viet Nam, ID = Indonesia, IN = India.
Source: Authors.

In the table above, Malaysia, Thailand, and Viet Nam were identified as having the most potential. However, comparing between Malaysia and India, India demonstrates more potential based on quantitative factors such as nominal GDP, population, energy intensity. In fact, Malaysia has the highest energy intensity out of the five Asian countries, meaning that it uses more energy to produce products and provide services for the same level of output (GDP). In contrast, India is the opposite, meaning that there are still many opportunities for its industries to become more energy intensive.

As such, after evaluation using a combination of different qualitative and quantitative factors, the three countries selected for research for this project are – Viet Nam, Thailand, and India.

Table 1.3: Selection of Target Countries – Quantitative Factors

Category	Quantitative Factor*	Countries				
		MY	TH	VN	ID	IN
Market size	Nominal GDP (bn USD)	407.0	495.4	408.8	1,319.1	3,416.6
	Population (million)	34.3	71.8	98.9	277.5	1,428.6
Energy sector-related	Total energy consumption (TWh)	1,331.3	1,387.9	1,244.1	2,791.4	10,103.2
	Energy intensity** (kWh/$)	1.52	1.23	1.49	0.80	0.96
	Rate of renewable energy	8%	8%	23%	10%	10%

*Note: Base year of nominal GDP, total energy consumption, and energy intensity is 2022. Base year of population is 2023.
**Note: Energy intensity refers to the amount of energy used to produce a given level of output or activity (GDP). Using more energy to produce a product or provide a service results in higher energy intensity.
Source: Euromonitor, U.S. Energy Information Administration (2023), IEA.

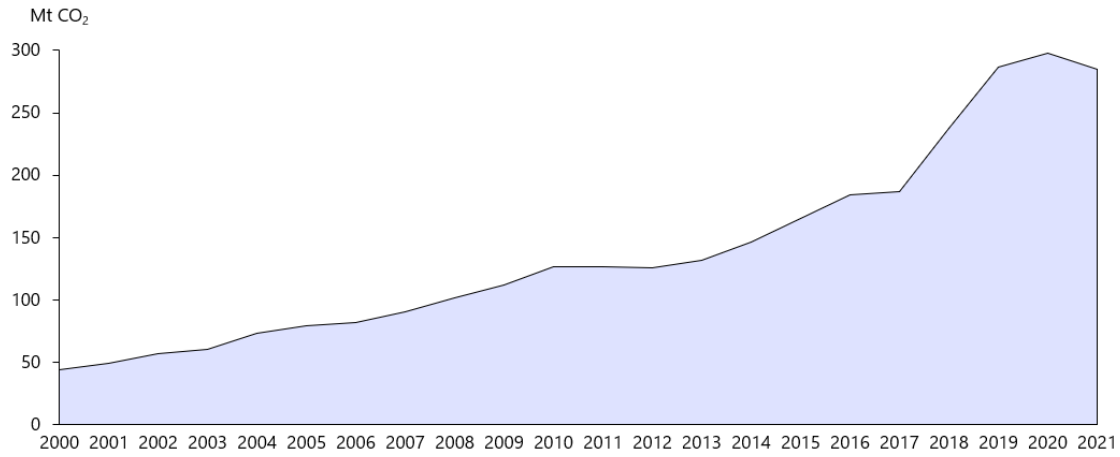
3. Current Status of Carbon Neutrality Efforts

I. Viet Nam

Along with its economic growth, GHG emissions in Viet Nam have risen rapidly, recorded 544% increase from 2000 to 2021. The CO_2 emission was 285Mt CO_2 in 2021, making it the second largest emitter in ASEAN. Although the country's CO_2 emissions per capita is

2.9t CO_2, still below the overall average in Asia. 78% of CO_2 emissions come from coal, which indicates that Viet Nam is still heavily dependent on fossil fuels. With the rapid increase in energy consumption driven by economic growth, a major challenge is to reduce carbon dioxide emissions while ensuring a stable energy supply to sustain that growth. Viet Nam has been actively participating in international platforms and joining global commitments to combat climate change.

Figure 1.2: CO_2 emissions in Viet Nam



Source: IEA (2022).

In COP26, Viet Nam announced a target to achieve net zero emissions by 2050. Besides that, the National Climate Change Strategy (Decision 896/QD-TTg) was issued in 2022 to specify its actions and reiterate its commitments. The Strategy set a goal to reduce national GHG emissions by 43.5% from the Business-As-Usual (BAU) level by 2030, and GHG emissions reduction for industries would be 38.3% from the BAU.

The National Electricity Development Plan For 2021–2030 (more commonly known as the 'Power Development Plan 8') was approved in 2023. Along with the plan to ramp up renewable energy production, Viet Nam is gradually shifting towards the principle of market-based pricing, providing a framework to adjust power prices every 3 months to reflect the cost of production and distribution. The National Green Growth Strategy 2021–2030 (Decision 1658/QD-TTg) specifies national targets to reduce GHG emission per GDP by 15% by 2030 and 30% by 2050 compared to 2014 level.

Separately, policies to promote energy efficiency have been launched since the early 2000s. The Vietnam National Energy Efficiency Program (VNEEP) was launched in 2006 and had achieved an energy consumption reduction of 3% between 2006–2010, and 6% between 2011–2015. Moving forward, VNEEP aims to achieve energy saving of 5%–7% between 2019–2025 and 8%–10% between 2025–2030. The focus of action is on the industry sector which accounts for 54% of total energy consumption. Across the country, approximately 3,000 companies with major energy consumption (defined as consumption

over a certain threshold) are required to produce an annual energy management report and implement activities to achieve energy efficiency.

The Law on Economical and Efficient Use of Energy was established in 2010 and plays a core role in energy conservation in the country.

The national energy efficient label programme for consumer products was introduced as a voluntary scheme in 2008 and made mandatory in 2013. It has generated notable progress, including an estimated 100 mil kWh of energy savings per year due to the switch to energy-saving air conditioners. In 2023, the Ministry of Industry and Trade (MOIT) announced a plan to introduce an energy efficiency label for industrial equipment such as boilers and refrigeration systems, which is targeted to start by 1st April 2025.

Table 1.4: VNEEP Objectives from 2019–2030

2019–2025	2025–2030
Reduce average energy consumption in industries compared to 2015–2018 by: Steel: 3–10% Chemicals: >7% Plastics: 18–22.46% Cement: >7.5% Textile: >5% Beer, alcohol and beverage: 3–6.88% Paper: 8–15.8%	Reduce average energy consumption in industries compared to 2015–2018 by: Steel: 5–16.5% Chemicals: >10% Plastics: 21.55–24.81% Cement: >10.89% Textile garment: >6.8% Beer, alcohol and beverage: 4.6 – 8.44% Paper: 9.9–18.48%

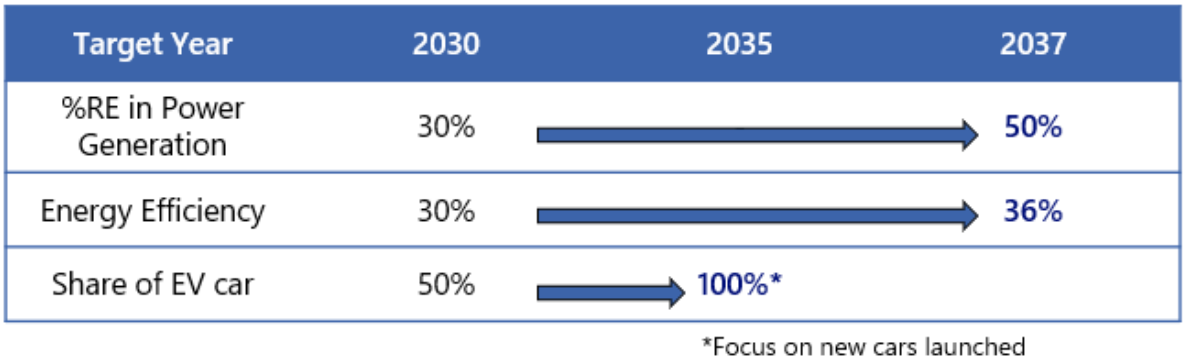
Source: Authors (based on Viet Nam Government' information).

II. Thailand

Currently, there are several efforts to pursue carbon neutrality in Thailand. The Thai government has set a target to achieve carbon neutrality by 2065. The government outlined this goal in the national policy 'Thailand 4.0' initiative, which emphasises sustainable economic growth and environmental responsibility with aiming to reduce carbon emissions and promote greener practices across industries.

Separately, Thailand has formulated a draft National Energy Plan 2024 ('NEP 2024') responsible by Energy Policy and Planning Office (EPPO) as a policy framework to guide related agencies towards transformational change to clean energy systems and plan to achieve the goal of becoming a carbon neutral country by 2050, as the energy sector is the largest contributor of GHG emissions in Thailand. It focuses on balancing economic growth with environmental sustainability. There are expected to be initiatives for alternative energy development, energy efficiency, oil, and natural gas. Drafts of these plans have recently been discussed in public hearings and they are expected to be implemented by the end of 2024.

Figure 1.3: Key Milestones of NEP2024 to achieve Carbon Neutrality



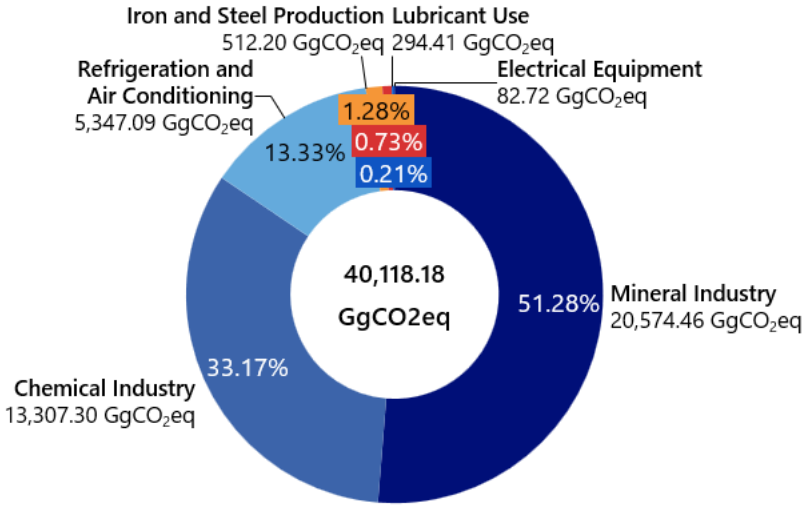
Source: Energy Policy and Planning Office (EPPO) (2024).

The new National Energy Plan will combine 5 major energy strategies: the Power Development Plan (PDP), Alternative Energy Development Plan (AEDP), Energy Efficiency Plan (EEP), Gas Plan, and Oil Plan. These plans will integrate decarbonisation goals for the energy sector. The strategy includes a significant increase in the share of renewable energy in power generation, targeting rapid installation of renewable energy sources, with a goal of at least 50% of new power plants being renewable energy by 2050.

Aligned with this strategy, Thailand will continue to focus on key GHG reduction efforts such as promoting renewable energy development and improving energy efficiency, alongside adopting new technologies to transition its energy system towards decarbonisation.

In 2000 and 2018, the Industrial Processes and Product Use (IPPU) sector contributed 8.65% and 10.77% of Thailand's total GHG emissions, respectively. The cement industry was the leading emitter in this sector, responsible for 51.28% of emissions. The chemical industry and the use of products like substitutes for ozone-depleting substances made up 33.17% and 13.33% of emissions, respectively. Emissions from metal production, non-energy products derived from fuels, and other product manufacturing and uses accounted for 2% of the sector's total GHG emissions.

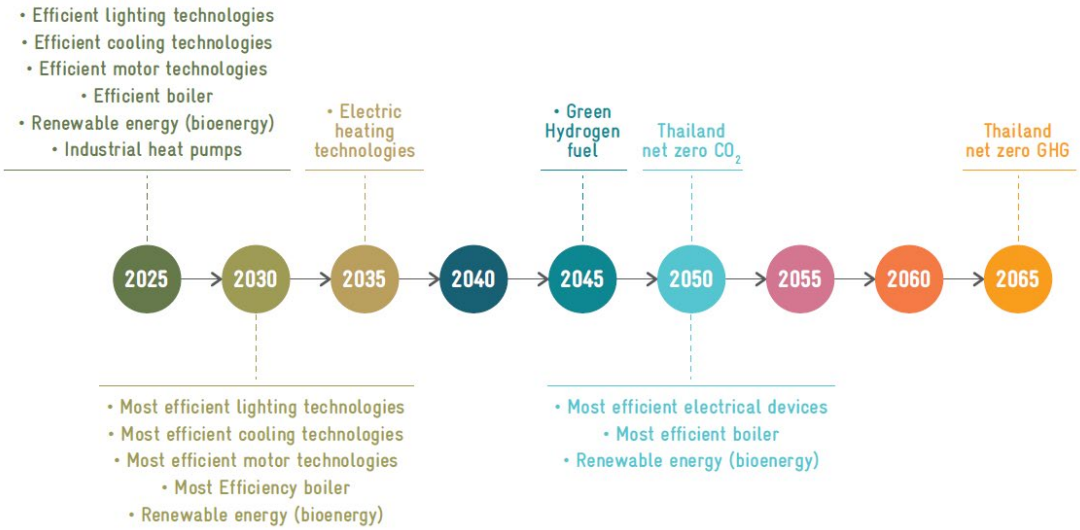
Figure 1.4: GHG Emission from the IPPU Sector, 2018



Source: Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy, Office of Natural Resources and Environmental Policy and Planning Ministry of Natural Resources and Environment (2022).

Decarbonising the industrial sector relies heavily on energy efficiency, fuel switching, and the electrification of end-use technologies. Electrifying industrial processes involves replacing technologies that rely on non-electricity sources with those powered by electricity. Manufacturing industries also have the potential to substitute fossil fuels with renewable energy sources like biomass and solar for heating applications. Green hydrogen, generated through renewable electricity, will be crucial for decarbonising hard-to-electrify sectors such as iron and steel, aluminium, and cement. In these industries, hydrogen burners could be paired with electric heating to produce the high temperatures required, replacing traditional fossil fuel combustion. Figure 1.4 outlines the timeline for implementing key GHG reduction measures in manufacturing to achieve net-zero emissions.

Figure 1.5: Net zero GHG emission timeline for manufacturing industries



Source: Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy, Office of Natural Resources and Environmental Policy and Planning Ministry of Natural Resources and Environment (2022).

Thailand's private sector acknowledges that the shift to a low-carbon economy presents numerous opportunities for value creation, improved efficiency, and cost savings. These include enhancing efficiency as industries move toward value-added S-curve sectors under the BCG model, reducing costs through waste recovery, boosting energy efficiency and green logistics, and accessing new markets for sustainable, climate-friendly products. The Thai government plans to collaborate closely with the private sector to develop clear policies and incentives, helping transform financial and investment challenges into opportunities for low-carbon growth.

III. India

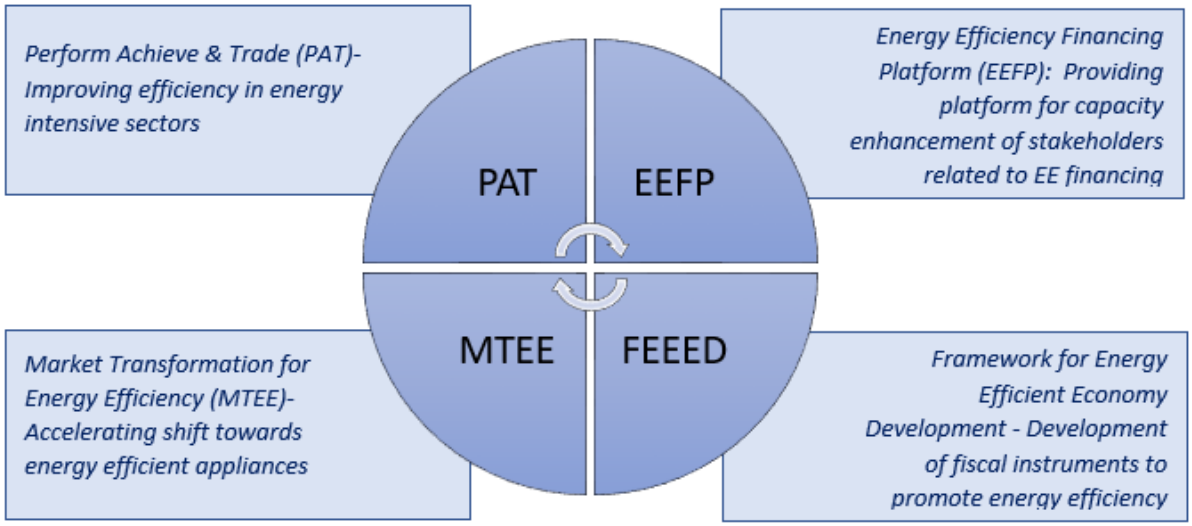
India has ambitious targets aimed at carbon neutrality, decarbonisation, and fostering sustainable initiatives. Being a signatory to the Paris Agreement, India aims to limit global warming to 1.5°C as compared to pre-industrial levels. It has also pledged to achieve net zero carbon emissions by 2070 at COP26. India has set a roadmap of comprehensive strategies that are shaping the nation's journey towards a greener and more sustainable future.

The country launched its National Action Plan on Climate Change (NAPCC) in 2008 with eight different national missions spread across different sectors to focus on sustainable development. The NAPCC outlines a national strategy that aims to enable the country to adapt to climate change and enhance the ecological sustainability of India's development path. The eight missions are: (1) National Solar Mission, (2) National Mission for Enhanced Energy Efficiency (NMEEE), (3) National Mission on Sustainable Habitat, (4) National Water

Mission, (5) National Mission for Sustaining the Himalayan Eco-system, (6) National Mission for a Green India, (7) National Mission for Sustainable Agriculture, (8) National Mission on Strategic Knowledge for Climate Change.[1]

The second mission of the NAPCC – the National Mission for Enhanced Energy Efficiency (NMEEE) is particularly focused on strengthening the market for energy efficiency by creating a conducive regulatory and policy regime, in which innovative and sustainable business models for the energy efficiency sector are envisaged. NMEEE, which was initiated in 2011, consists of four initiatives:

Figure 1.6: Initiatives taken under the NMEEE



Source: Authors (Based on Bureau of Energy Efficiency, NMEEE Program).

In the past decade, India revised its sustainability goals and Prime Minister Narendra Modi declared five strategies called 'Panchamrit' at COP26 in Glasgow in 2021.[2]

1. Raise non-fossil fuel-based energy capacity of the country to 500 GW by 2030.
2. By 2030, 50% of the country's energy requirements would be met using renewable energy.
3. Reduction of the total projected carbon emissions by 1 billion tons from 2021 to 2030.
4. Carbon intensity of the economy would be reduced to less than 45% by 2030.
5. The country would become carbon neutral and achieve net zero emissions by 2070.

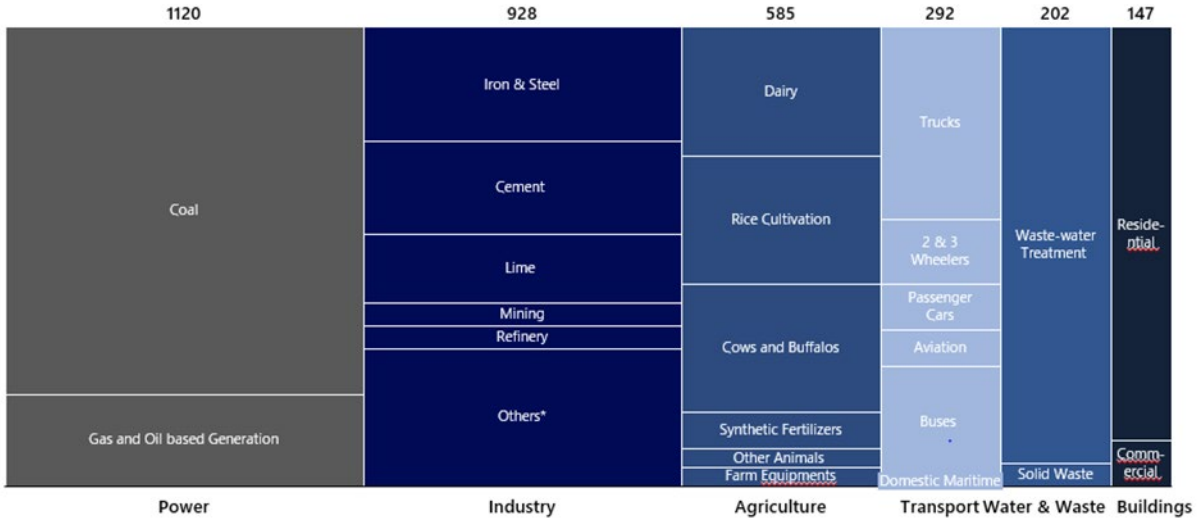
[1] Press Information Bureau (Ministry of Information & Broadcasting Government of India), NAPCC, 01 Dec 2021

[2] PM Modi delivers India 'Panchamrit' gift at COP26 to fight climate change- Hindustan Times

Prime Minister Modi also called upon developed economies to make $1 trillion available for climate financing due to the importance of tracking climate finance to mitigate climate threats.[3]

In 2023, India recorded 3,247 million tons of CO_2 emissions wherein the power sector, led by coal-fired generation (1,120 million tons), and the industry sector (928 million tons) were the largest contributors. In response to this, the government and many Indian companies have pledged to adopt measures and strategies to achieve carbon neutrality.

Figure 1.7: Sectoral GHG Emissions of India (Emissions in Mt CO_2)



Source: McKinsey & Company, Decarbonising India: Charting a pathway for sustainable growth (2022)

Companies are synchronising with the 2050 Pathways Platform, Climate Neutral Now, RE100, EP100 and EV100 to minimise and mitigate the effects of carbon emissions. They are also registering for Science Based Targets Initiative (SBTi) to become net zero. Thus far 122 companies have registered for SBTi in India, out of which 20 companies are targeting to become net zero by 2050. The largest Indian corporate leaders in carbon neutrality are Infosys, JSW Steel, Hindustan Zinc, Mahindra Life space Developers, Wipro & ACC etc. Globally, the SBTi targets are taken by 5,600 companies.[4]

[3] Decarbonising India, McKinsey Sustainability
[4] CDP India, Decarbonizing India: Driving Climate Action Through Disclosure, 2023

Chapter 2
Industry Insights Regarding High Energy Efficiency Equipment

1. Energy-Efficient Solutions and the Role of Heat Pumps and Once-through Boilers

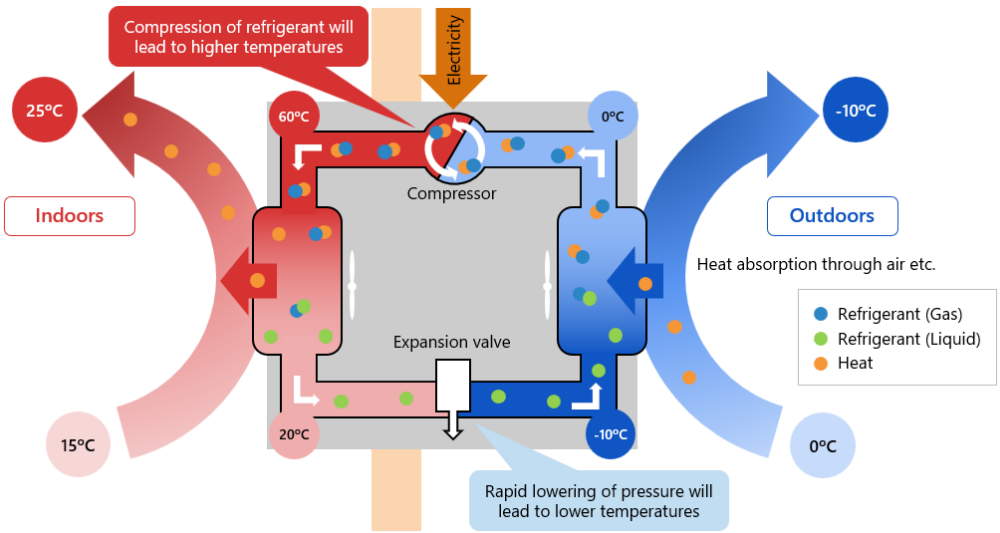
1.1 Energy-Efficient Solutions

Various devices and solutions are available to enhance efficiency and reduce consumption. These include smart thermostats, which optimise heating and cooling by learning user preferences, and LED lighting, which offers significant energy savings compared to traditional incandescent bulbs. Enhanced insulation materials and building envelope insulation improve temperature regulation within buildings, reducing the need for excessive heating or cooling. Additionally, solar panels harness sunlight to provide a renewable energy source, reducing reliance on fossil fuels.

1.2 Role of Heat Pumps

Amongst these energy-efficient solutions, heat pumps are particularly significant. They operate by transferring heat rather than generating it, utilising electricity to move heat from one place to another, which allows them to provide both heating and cooling with high efficiency. Heat pumps can achieve efficiencies of 300–400% by recovering waste heat and utilising both cooling and heating functions.

Figure 2.1: Structure and Mechanism of Heat Pumps



Source: Heat Pump and Thermal Storage Technology Center of Japan (Accessed 12 September 2024).

Heat pumps can allow for efficient cooling as well as heating. With reference to the figure above, in indoor applications where heating is required, electricity is applied at the compressor to compress refrigerants, which allows for temperatures to be increased to up to 60°C. This heat is then used to increase indoor temperatures from 15°C to up to 25°C.

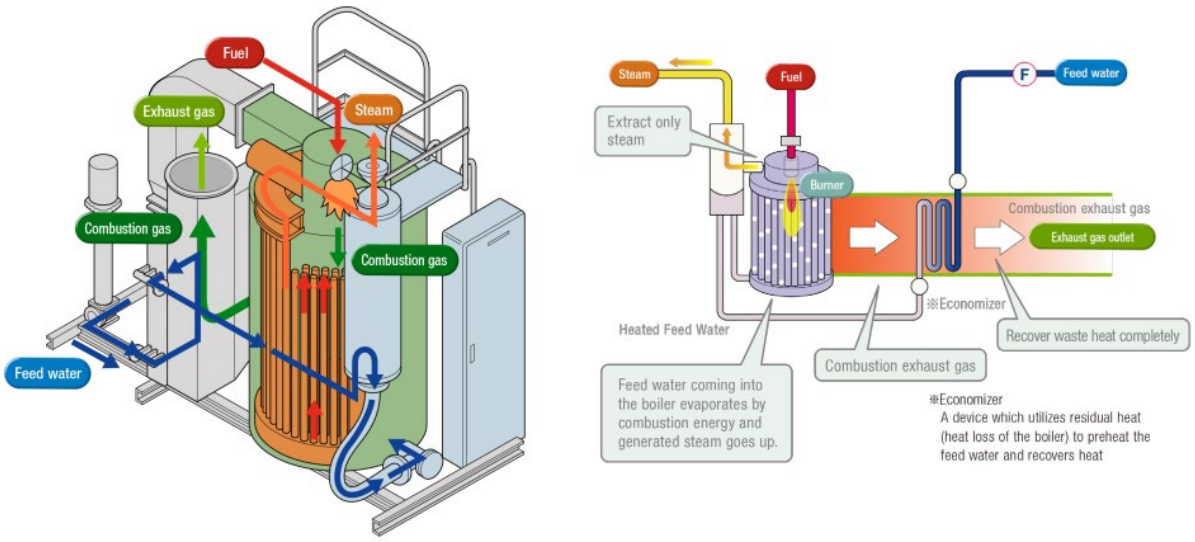
On the other hand, with the use of an expansion valve, the rapid lowering of refrigerant pressure can lower temperatures to –10°C. This can then allow for heat absorption from the air, which will equalise temperatures to 0°C. Subsequently, refrigerants will be cycled back to the compressor to allow the cycle to restart. As a result of this, efficiency is greatly improved compared to less-advanced air conditioners and refrigerators which have been in use for decades.

1.3 Role of Once-through Boilers

Once-through boilers are another high-efficiency equipment and becoming increasingly recognised for their efficiency and potential to contribute to decarbonisation efforts in various industries. These boilers operate by continuously passing water through heated tubes, generating steam in a single pass. Unlike traditional boilers, which store and heat large quantities of water, once-through boilers do not require water storage, allowing for immediate steam generation. This design leads to several key advantages, particularly in terms of energy efficiency and environmental impact. A notable feature of once-through boilers is the ability to recover waste heat by incorporating an economiser, which brings the boiler's thermal efficiency close to 100%. The economiser recovers residual heat from the exhaust gases, which would otherwise be lost, and uses it to preheat the feed water. This process significantly enhances the overall energy efficiency of the boiler, reducing fuel consumption and lowering CO_2 emissions.

In addition to the use of economisers, once-through boilers can be equipped with multiple small boilers, allowing for precise control over the number of units in operation at any given time. This flexibility, combined with advanced control methods that finely adjust the combustion conditions, ensures that the boilers operate at optimal efficiency. By maintaining high operational efficiency, these advanced systems further contribute to reducing fuel usage and minimising carbon emissions.

Figure 2.2: Basic Concept of Once-through Boilers



Source: Kawasaki Thermal Engineering (Accessed 12 September 2024).

Steam boiler is the most important heat source in facilities that use heat, such as factories, hotels, hospitals and high-rise buildings. Steam has advantages such as, it can hold more heat than hot water, it is easy to transport, safe and hygienic, and it can release heat and return water for reuse.

Compared to other type of boilers, once-through boilers are compact, have smaller capacity and therefore are set up in multiple installation (MI) system. Due to this characteristic, when little steam is required, the number of once through boilers running can be reduced, leading to saving of energy, while the capacity of fire-tube boiler remains constant with high radiation heat loss.

Figure 2.3: Comparison of once-through boilers and fire tube boilers

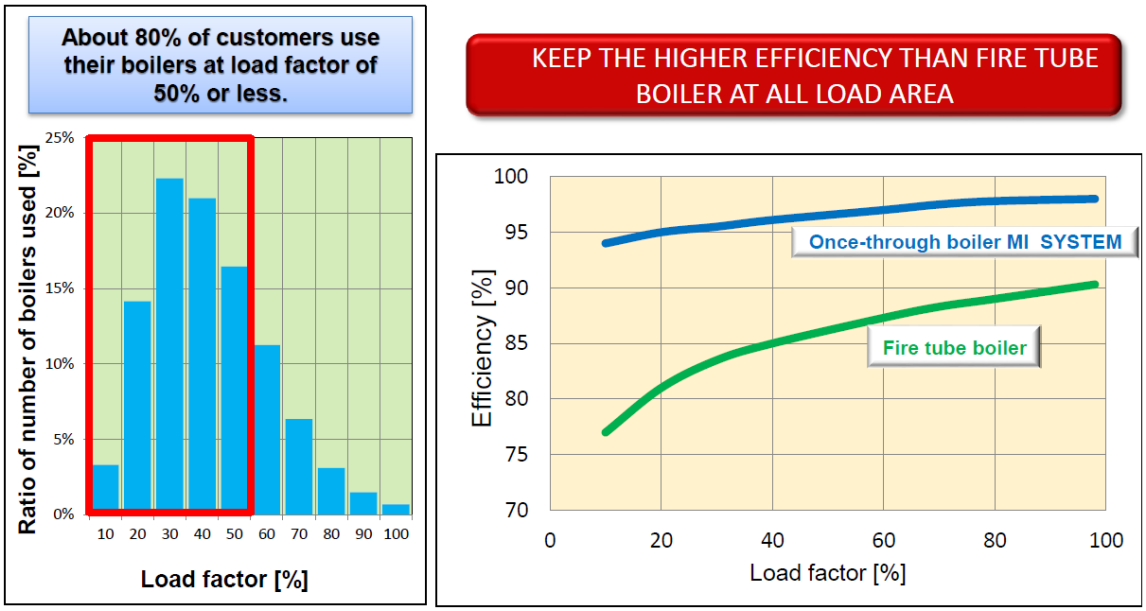
Capacity: 2 ton/hour	Once-through boilers	Fire tube boilers
Rated boiler efficiency	~98%	~90%
Boiler size	Compact	Large
Water capacity	Low (~120L)	High (~2500L)
Start-up time	Short (~5 min)	Long (~50min)
Radiation heat loss	Low	High
Energy saving	High	Low
Safety	High	Low

Source: Miura Co., Ltd (2024).

Once-through boilers are more efficient and scalable than conventional fire tube boilers, due to the compact size of each once-through boiler. For example, in a situation where a plant operator has five 2-ton once-through boilers and a single 10-ton fire tube boiler,

when only 2 tons of steam is required, only one once-through boiler needs to be fired (and the remaining four can be kept on standby), while the 10-ton fire tube boiler needs to be fired at 20% capacity. This translates to a much larger heat loss surface for the fire tube boiler, leading to wasted heat from radiation loss. In fact, it has been found that approximately 80% of users utilise their boilers at a load factor of 50% or less, which means that fire tube boilers are conventionally not used at their full potential capacity.

Figure 2.4: Steam Load Factor and Comparison of Boiler Efficiencies



Source: Miura Co., Ltd (2024).

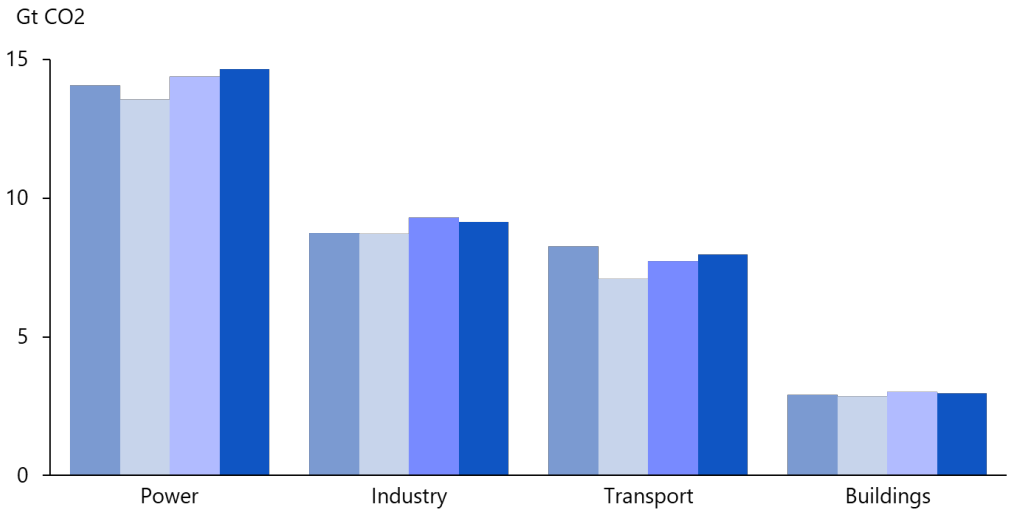
2. Current Status of Introduction of High Energy Efficiency Equipment

The industrial sector accounts for 37% (166 EJ) of global energy use and 25% (9.15Gt) of carbon emissions in 2022. In developing countries, energy requirements for industry can be up to 50% of the total. Therefore, tackling energy efficiency in Industry sector has been one of the key priorities for governments in developing Asia in their pathway towards net zero. Since the industry sector is still dependent heavily on fossil fuels, which contributes to high carbon emissions and energy costs. Transitioning to heat pump technology for electrification and energy reduction in these industrial sectors is crucial for sustainable development. By adopting heat pumps, manufacturers can significantly lower their energy consumption and carbon footprint while potentially reducing operational costs. This shift towards electrification and energy efficiency is essential for these countries to meet their climate goals and enhance their industrial competitiveness in the global market. On the other hand, pursuing energy efficiency technology in the industry sector is a challenging journey. Industrial manufacturing relies on long-term assets which require significant capital investment, and the lack of financial support and access to capital in developing Asia is a major hurdle to the sector's green transition.

The growing energy consumption in the services sector is a critical issue that cannot be overlooked. Over the past few decades, electricity use for space cooling in buildings across ASEAN has surged dramatically, with consumption reaching around 80 TWh in 2020 – an astounding sevenfold increase from the levels seen in 1990. This rise reflects the increasing demand for cooling services in response to rising urbanisation, economic growth, and improved living standards in the region.

The number of air conditioners in ASEAN is expected to continue increasing rapidly. By 2040, the stock of air conditioners is projected to jump from approximately 50 million units in 2020 to an estimated 300 million units. This surge in demand for cooling equipment is likely to drive up electricity consumption significantly, with space cooling potentially accounting for 300 TWh of electricity use by 2040. ASEAN countries will face is how to expand access to space cooling services while simultaneously minimising the adverse effects on energy consumption and greenhouse gas (GHG) emissions. Balancing the growing need for cooling with the urgent necessity to curb GHG emissions will require coordinated efforts, innovative technologies, and strategic policies aimed at enhancing energy efficiency and promoting the use of renewable energy sources.

Figure 2.5: Global CO_2 emissions by sector, 2019–2022



Source: IEA (2022).

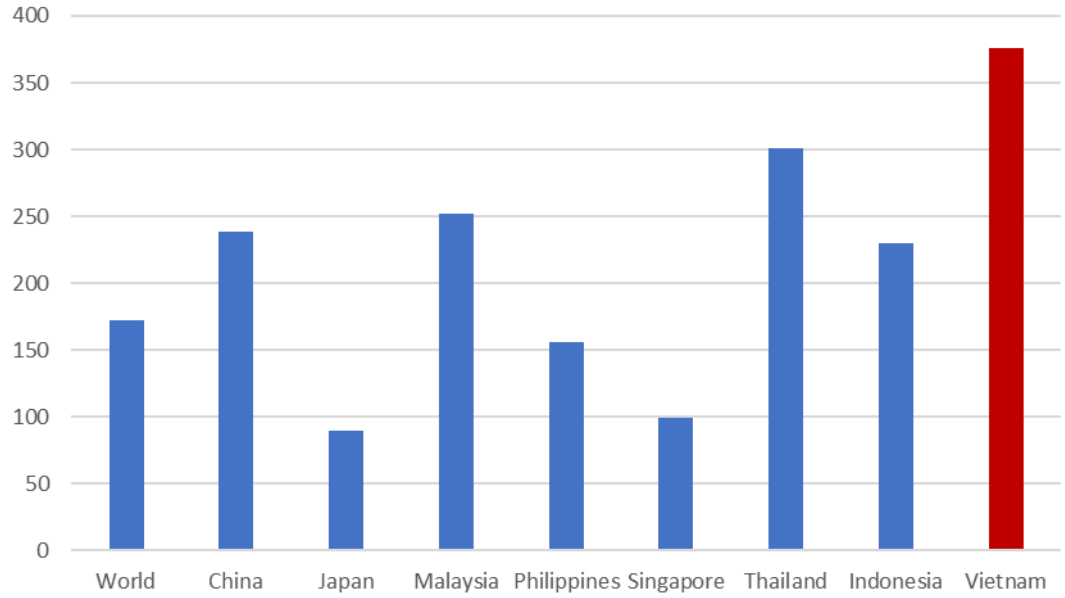
This section presented the situation in each country in terms of major policies for the promotion of energy efficient equipment, current status of adoption, especially for heat pumps, and some of the key challenges encountered by industry stakeholders.

I. Viet Nam

The Vietnam Energy Statistics 2020 report showed that the country's total primary energy supply (TPES) per GDP was more than double the world's average, which means the

country requires much more energy to generate the same amount of GDP compared to other countries.

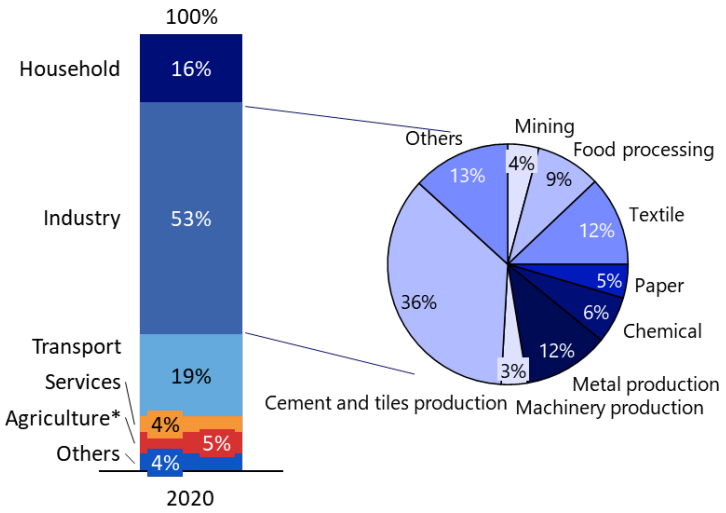
Figure 2.6: Total Primary Energy Supply (TPES) per GDP (kg oil equivalent/1,000 US$)



Source: Vietnam Energy Statistics (2020).

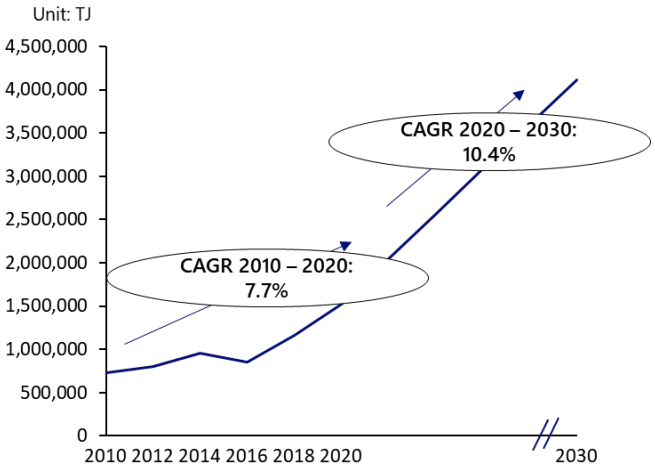
According to the Department of Energy Conservation and Sustainable Development under the Ministry of Industry and Trade, surveys conducted by the National Program on Energy Conservation and Efficiency for the 2019–2030 period (VNEEP3) showed that the industrial sector accounted for more than 50% of total national energy consumption, while it also had the potential for energy savings of up to 30–35%. Although most businesses are aware of the laws and regulations on energy conservation and efficiency, many have not yet implemented them, and even if they have been implemented, they are largely implemented in a perfunctory manner. A key challenge to the adoption of energy efficient systems is the lack of financial capacity, which is especially prevalent amongst local small and medium companies. More specifically speaking, companies require financial support such as incentives, preferential loans, instalment schemes or revenue-sharing models to cover high upfront costs. However, such incentives and schemes are still limited. A few leading players such as GreenYellow, a French company specialising in decentralised solar photovoltaic production and services, have started to provide such revenue-sharing models in Viet Nam.

Figure 2.7: Electricity Consumption by Sector in Viet Nam, 2020



Source: Vietnam Energy Statistics (2020).

Figure 2.8: Industry Energy Consumption Trend in Viet Nam



Source: Vietnam Energy Outlook (2021).

The rapid increase in energy demand associated with economic growth has been acknowledged as a challenge, and moves have been made to require companies to conserve energy through the establishment of national building energy standards (QCVN 09:2017/BXD), roadmap for removing low-efficient vehicles and equipment and minimum energy efficiency level for certain products (Decision No. 14/2023/QD-TTg).

The Vietnam Scaling Up Energy Efficiency Project (VSUEE), financed by the World Bank, aims to increase energy efficiency in industrial sectors in Viet Nam, by providing credit guarantee (risk sharing facilities) and technical assistance for businesses and ESCOs.

Directive 20/CT-TTg on the enhancement of electricity saving from 2023–2025 states that as an overall goal, the country must strive to save at least 2% of annual electricity consumption. Businesses with electricity consumption of 1 million kWh/year or more

must save at least 2% of electricity consumption in a year and ensure compliance with the provisions of the Law on Economical and Efficient Use of Energy as well as related legal documents on the economical and efficient use of energy and electricity saving.

Heat pumps have been used in some buildings, hotels and in food/beverage production (for pasteurisation), to provide a temperature of 50–60°C. Heat pumps have the potential to save up to 70% electricity consumption. however, the investment cost tends to be too high, which forms a key barrier to its adoption.

Although the use of heat pumps within Viet Nam remains limited, environmental initiatives are being rolled out the integration of heat pumps into their strategies especially amongst foreign-affiliated companies and large corporations.

Vinamilk is one of the biggest dairy companies in Viet Nam and a pioneering enterprise in applying advanced energy-saving solutions to minimise environmental impacts. Vinamilk installed solar power systems, a system to collect and reuse waste heat, and boilers using biomass and CNG (Compressed Natural Gas) in its network of factories and farms, thereby helping to save energy in the production process. Thanks to the application of energy-saving solutions, Vinamilk managed to reduce energy consumption by 10% to 20%, saved production costs, reduced greenhouse gas emissions, and enhanced the image and reputation of the business.

The Sheraton Hanoi Hotel is a prime example of a business leading the way in decarbonisation efforts in Viet Nam. This hotel has implemented a series of energy-saving measures, including high-efficiency chiller air conditioning systems with inverters, energy-efficient lighting, and the use of thermal insulation. Moreover, it utilises heat pumps to provide hot water for guest rooms, significantly reducing energy consumption. Through these combined initiatives, the hotel has not only minimised its environmental impact but has also transformed into a modern, eco-friendly facility that maximises the use of natural light and ventilation in its design. These efforts resulted in remarkable energy savings: in 2005, electricity costs accounted for 14.74% of the hotel's revenue, but by 2008, this figure had dropped to just 4.83%. This demonstrates how a thoughtful combination of technology and design can lead to both environmental and economic benefits, setting an example for other businesses in Viet Nam's hospitality industry.

II. Thailand

In 2011, the Ministry of Energy in Thailand issued a 20-Year Energy Efficiency Development Plan with the goal of reducing energy intensity by 25% by 2030 compared to 2005 levels. In addition, there are incentives and regulations which encourage the use of energy efficient equipment. These are summarised in the table below.

Table 2.1: 20-Year Energy Efficiency Development Plan

Incentives and Regulations under the 20-Year Energy Efficiency Development Plan
Subsidies ranging from 50,000 baht to 3,000,000 baht for the purchase of high energy efficiency equipment with a payback period of 7 years or less Exemption of import tax on machinery Exemption of corporate income tax for 3 years when energy consumption is reduced to a specified ratio with an investment of at least 1 million baht (500,000 baht for SMEs)

Source: Energy Policy and Planning Office (EPPO) (2011).

In addition, the Energy Conservation Promotion Law and Energy Efficiency Resource Standards (EERS) promote energy conservation and efficiency in factories and buildings. At the corporate level, awareness of carbon neutrality is still not very high. Therefore, when it comes to investing, it is not uncommon for companies to install equipment that is not energy-efficient or equipment which does not perform as well as it should due to cost considerations.

In Thailand, the focus on energy-saving technologies is becoming increasingly significant across various industries. Currently, the food manufacturing sector, which is the primary user of heat pumps, constituting 80–90% of all heat pump users, relies heavily on these systems to provide both hot and cool water for their 24-hour operations. However, high initial costs cause many companies to be hesitant to invest in heat pumps despite their potential benefits. Nonetheless, the market is witnessing growing interest in high-temperature heat pumps due to their relatively fast payback period, which averages around 2.5 years under continuous operation.

Traditionally, the other main users of heat pumps in Thailand have been hotels and hospitals, utilising them for heating swimming pools and providing hot water. While standard heat pumps operate within a temperature range of 60–90°C, limiting their application to industries requiring higher temperatures, the development of heat pumps capable of exceeding 100°C is opening new possibilities.

However, despite the promising potential of heat pumps, their adoption in Thailand remains limited with boilers still dominating the market. The broader push towards carbon neutrality, driven by the increasing adoption of electric vehicles, solar cells, and other high-efficiency technologies, may eventually provide a boost to the uptake of heat pumps as industries seek to reduce their carbon footprint.

III. India

The Indian government introduced new domestic and international policy actions aimed at reducing greenhouse gas (GHG) emissions by 45% from 2005 levels by 2030, securing 50% of the country's total electric capacity from non-fossil fuels, and achieving virtually zero GHG emissions by 2070. Despite these ambitious targets, the continued high usage

of fossil fuels, which is supported by government subsidies to protect domestic industries, remains a significant challenge. In the industrial sector, which accounts for more than half of India's domestic energy consumption, coal and petroleum still dominate as energy sources, even as electrification efforts are gradually progressing.

To drive energy efficiency, India has implemented programmes such as the Energy Conservation Act and the Energy Conservation Building Code (ECBC). The Energy Conservation Act sets forth minimum requirements for renewable energy usage and energy efficiency standards across industrial, transportation, and commercial buildings. The ECBC complements this by establishing effort-based metrics for energy efficiency in building design and construction. However, these measures alone may not be sufficient to catalyse the widespread adoption of energy-efficient technologies, such as heat pumps, once-through boilers, and advanced refrigerants.

The adoption of high energy-efficient equipment varies significantly across sectors, reflecting both progress and persistent challenges. The private sector is at the forefront of this transition, with many companies increasingly aware of the need for energy efficiency and decarbonisation. As of 2023, more than 122 Indian companies have committed to science-based targets for carbon reduction, with 42% of large companies setting net-zero targets by 2050 or sooner. Energy Service Companies (ESCOs) play a vital role in this sector, helping businesses achieve their energy efficiency goals. However, challenges remain, particularly for smaller companies that lack the resources to implement such changes effectively.

The public sector, on the other hand, faces significant barriers to adopting high energy-efficient equipment. Procurement complexities, often involving sourcing from multiple countries, and limited funding are major hurdles. Public sector energy efficiency programmes in India are often underfunded, with many projects failing to meet their potential due to these financial and bureaucratic constraints.

In the Micro, Small, and Medium Enterprises (MSME) sector, the challenges are even more significant. Even though they contribute nearly 30% of India's GDP, they are highly fragmented and underfunded, thus making it difficult for businesses to invest in energy-efficient equipment. ESCOs are generally reluctant to engage with MSMEs due to low ROI and the sector's limited understanding of the long-term benefits of energy efficiency. The technology gap is significant and many Indian MSMEs lag in adopting modern technologies.

Renewable energy adoption is currently the most visible trend in India's sustainability efforts. By 2024, India's installed renewable energy capacity had surpassed 175 GW, making it one of the largest RE markets globally. However, this focus on Renewable energy often results in what some experts call the 'leaking pot syndrome', where the emphasis on renewable energy overshadows the need for broader energy efficiency solutions. The market for high-efficiency products, such as 5-star rated appliances, remains limited due to higher costs and low consumer awareness. For instance, while 5-

star rated air conditioners are available, they represent a smaller share of the market, with the majority still opting for cheaper, less efficient 3-star models due to a lack of awareness about long-term ROI.

Foreign companies have a significant opportunity to penetrate the Indian market for energy-efficient equipment. However, they face challenges due to non-alignment with government policies such as the Make in India initiative and the Production Linked Incentive (PLI) scheme. High tariffs on imported equipment further complicate their entry.

Therefore, India must introduce more stringent and clear component standards for energy-efficient equipment to overcome these challenges. The current lack of regulatory clarity often results in inconsistent product quality, which in turn discourages industries from investing in these technologies. The government needs to implement comprehensive regulations that mandate specific performance criteria for energy-efficient equipment, which will boost confidence in their reliability and long-term benefits. Additionally, providing targeted incentives or subsidies for initial investments could also help offset the high upfront costs that currently deter many businesses from adopting these solutions.

The expansion of the Bureau of Energy Efficiency (BEE) and Bureau of Indian Standards (BIS) programmes to cover a broader range of equipment, such as heat pumps, under the star labelling scheme would be a significant step forward. Furthermore, enhancing the PLI scheme to focus on the development and manufacturing of energy-efficient technologies tailored to India's specific climatic conditions would make India into a global leader in sustainable technology exports.

3. Carbon Credit Market

I. Viet Nam

In Viet Nam, on January 7, 2022, the Government issued Decree 06/2022/ND-CP regulating the reduction of greenhouse gas emissions and the protection of the ozone layer. This Decree has specific provisions on the development roadmap and timing of the implementation of the domestic carbon market, such as to develop a pilot carbon credit exchange by 2025, and regulations on carbon credit management, GHG emission quota exchange and carbon credit exchange by 2027.

Viet Nam does not have a mandatory market for carbon credits. Various carbon credit projects are active in Viet Nam, particularly in sectors such as forestry, renewable energy, and waste management, on a voluntary basis. The projects are typically registered under international standards like the Clean Development Mechanism (CDM) or the Verified Carbon Standard (VCS), allowing them to generate carbon credits that can be traded on global markets.

In 2024, the Ministry of Industry and Trade has issued a plan to strengthen carbon credit management and develop sectoral GHG emission reduction. The ministry will coordinate with relevant agencies to finalise the legal frameworks to implement international agreements on carbon credit transfers. The draft development plan for the country's carbon credit market has been discussed in 2024, marking a significant step towards establishing a formal trading system. The plan outlines a trial period for the carbon credit market, which will be implemented nationwide from 2025 to 2028. Following this trial phase, the market is set to become fully operational across the country in 2029.

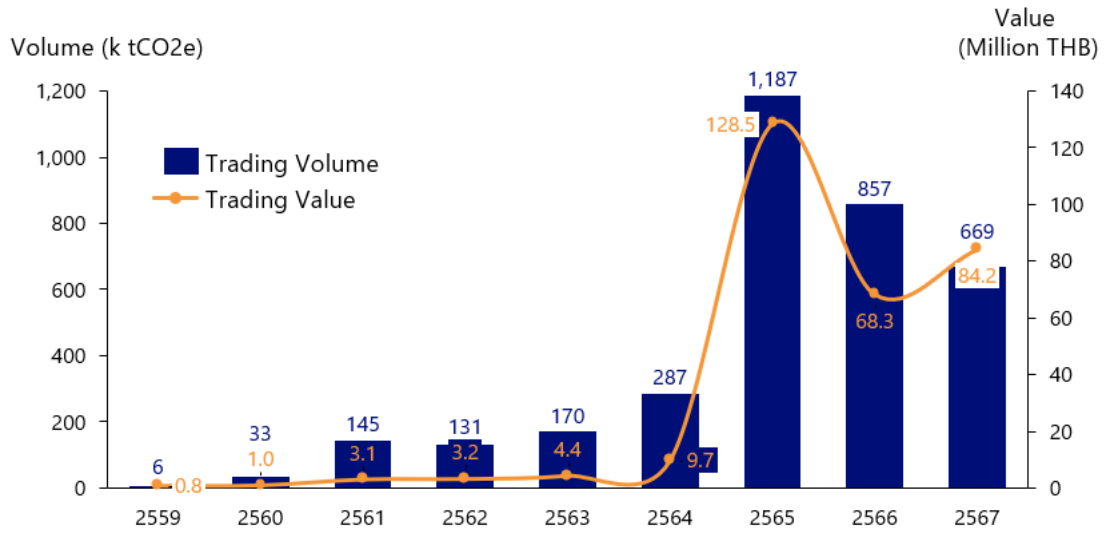
Viet Nam is committed to aligning its carbon credit market with both domestic and international markets. To achieve this, Viet Nam is focusing on developing comprehensive legal frameworks and enhancing infrastructure. This ongoing effort aims to ensure a robust and effective carbon credit market, positioning Viet Nam as a key player in global carbon trading and contributing to its broader environmental goals.

II. Thailand

Thailand's carbon credit market is a rapidly evolving sector, driven by both domestic policies and international trends. The country's commitment to reducing GHG emissions and achieving its climate goals under the Paris Agreement addressing climate change has led to the establishment of various mechanisms aimed at promoting sustainable development. One key initiative is the Thailand Voluntary Emission Reduction Program (T-VER), which allows companies and organisations to earn carbon credits by implementing projects that reduce or remove GHG emissions, such as renewable energy, energy efficiency, reforestation, and waste management initiatives. These carbon credits can then be sold or traded to other entities looking to offset their emissions, providing a financial incentive for organisations to invest in sustainable practices and contribute to Thailand's overall carbon reduction targets. Rules and procedures for project development, GHG emission reduction methodologies, verification and certification of emission reduction credits have been developed by Thailand Greenhouse Gas Management Organisation (TGO), considering of CDM methodologies, considering the national context and circumstances.

The carbon credit market in Thailand is still in its developing stages but shows significant potential for growth as the country intensifies its efforts toward carbon neutrality by 2050. The Thai government has introduced various policies and incentives to encourage private sector participation in carbon offset projects, aiming to create a strong market framework that aligns with international standards. Additionally, Thailand's carbon market is likely to benefit from increased global interest in sustainable investments, as more companies and investors seek to reduce their carbon footprints and comply with international environmental standards. The development of the carbon credit market is expected to attract both domestic and international investments, driving innovation in low-carbon technologies and promoting sustainable economic growth in Thailand.

Figure 2.9: Volume and Trading value of Voluntary Carbon Credit from the T-VER project



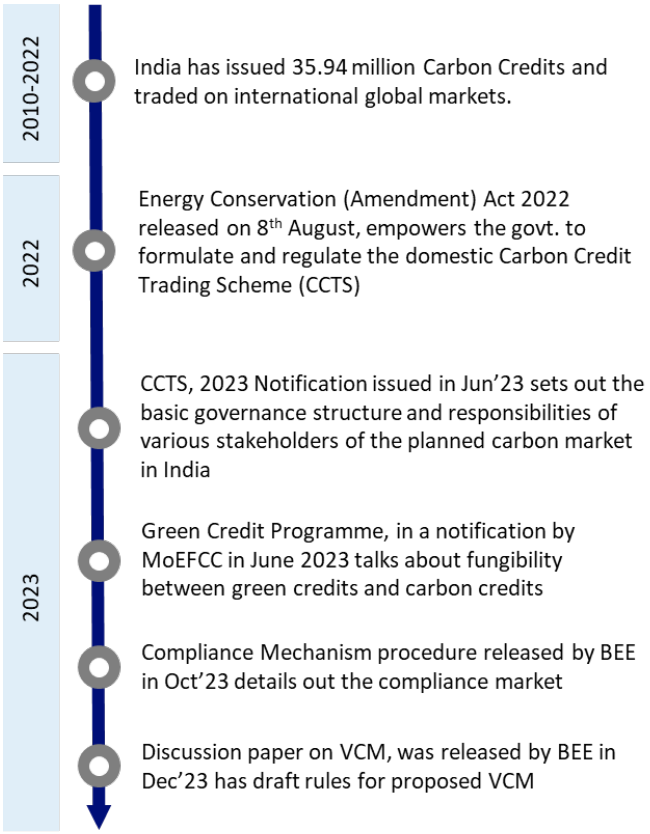
Source: Carbon market, Thailand Greenhouse Gas Management Organization (2024).

In addition to T-VER, Thailand is also exploring the potential of a carbon tax to incentivise low-carbon practices and generate revenue for climate change mitigation efforts. While the implementation of a carbon tax is still under consideration, its introduction could significantly influence the dynamics of the carbon credit market in Thailand. The growing awareness of climate change and the increasing demand for sustainable products and services are expected to further fuel the development of Thailand's carbon credit market. As the country continues to embrace green initiatives, the carbon credit market is poised to play a crucial role in driving economic growth and environmental protection.

III. India

India has been at the forefront of climate action, striving to meet global climate goals through its ambitious Nationally Determined Contributions (NDCs). To facilitate the achievement of these enhanced targets, the Indian government has initiated the development of a domestic carbon market, aimed at mobilising new mitigation opportunities by creating demand for emission credits from both private and public entities. On 28th June 2023, the Carbon Credit Trading Scheme was launched, establishing the basic governance structure and responsibilities of various stakeholders in India's planned carbon market. While the compliance segment is scheduled to commence in 2025-26, the voluntary carbon market currently lacks a defined timeline for its launch.

Figure 2.10: Timeline of India's Domestic Carbon Market Development



Source: Authors (Based on Government Websites).

The domestic Indian carbon market is still in its nascent stage, but Indian companies are actively participating in the global market on a voluntary basis. In 2023, approximately 1,586 Indian projects were registered in the four major registries (VCS, Gold Standard, ACR, CAR), spanning renewable energy, forestry, and household and community projects.

India currently operates two market-based emission reduction schemes: the Perform, Achieve and Trade (PAT) scheme and the Renewable Energy Certificates (REC) scheme. Under the PAT scheme alone, Indian units have saved over 106 million tons of CO_2 emissions from 2015 to June 2024. These market-based mechanisms have effectively incentivised both mandatory and voluntary actions, rewarding entities for their additional efforts through credits or certificates.

India is continuing to develop its domestic carbon market, with a focus on creating a robust framework that will support the country's climate goals while attracting investment and participation from both domestic and international stakeholders.

4. Standards and Regulation regarding to Heat Pumps and Once-Through Boilers

4.1 Industry standards for air conditioners, heat pumps, and boilers

The following section covers the relevant standards related to air conditioners, heat pumps, and boilers in Viet Nam, Thailand, and India. Information was obtained from interviews with local associations, ESCOs, as well as desktop research.

I. Viet Nam

The Vietnamese Energy Efficiency standards are based on international standards, while the Energy Efficiency performance levels are prescribed by the Ministry of Industry and Trade (MOIT). Testing at laboratories designated by the MOIT is mandatory. To bear the Energy Efficiency label, the products must meet the minimum energy performance standard (MEPS) prescribed by the MOIT in corresponding Energy Efficiency standards.

Due to limited adoption, there are not many companies manufacturing heat pumps or once-through boilers, and many of the relevant standards are not widely recognised nor applied widely. Foreign companies selling these products in Viet Nam often find that local user companies do not request compliance with specific standards. As a result, these foreign companies either adhere to the standards of the country where the products are manufactured or apply no standards at all.

Table 2.2: Relevant Industry Standards for heat pumps in Viet Nam

Official number	Content of industry standard
TCVN 6104	Refrigeration and heat pump systems - Safety and environmental requirements
TCVN 10273	Air-cooled air conditioners and air-to-air heat pumps - Test methods and calculations of seasonal efficiency coefficients
TCVN 11276	Refrigeration systems and heat pumps - Details of hoses, anti-vibration dampers, expansion joints and non-metallic pipes - Requirements and classification
TCVN 11277	Refrigeration and heat pump systems – Assessment of tightness of components and connections
TCVN 13139	Ductless, portable, single-exhaust ductless air-cooled air conditioners and air-to-air heat pumps – Testing and performance specification
TCVN 13854	Heat pump for water heating - Testing and determining feature specifications.
TCVN 13855	Water heating heat pump – Testing and determining performance parameters under low load conditions and calculate performance according to heating season
TCVN 13856	Refrigeration system and heat pump - Valve, Requirements, testing and labelling
TCVN 6576	Ductless air conditioners and heat pumps - Test and define feature specifications
TCVN 6577	Air conditioners and ducted air-to-air heat pumps - Test and define feature specifications

TCVN 7327	Determine the sound power level of air conditioners and air source heat pumps.
TCVN 7328	Water source heat pump - Testing and evaluation of the feature
TCVN 9981	Multi-cluster system air conditioners and air-to-air heat pumps – Testing and evaluation of feature specifications
TCVN 12728:2019	Boilers - technical requirements for design, manufacture, installation, use and repair
QCVN: 01 - 2008/BLĐTBXH	National technical regulation on safe work of steam boiler and pressure vessel

Source: Authors (Based on Government Website).

Table 2.3: Relevant Industry Standards for boilers in Viet Nam

Official number	Content of industry standard
Decision 67/2008/QD-BLDTBXH	Issuing the Procedure for technical safety inspection of boilers, pressure vessels, refrigeration systems, gas filling systems, gas cylinders and steam and hot water pipelines
Decision 235-QD/LB	Issuing technical safety regulations for boilers
TCVN 12728:2019	Technical requirements for boiler design and manufacture
TCVN 8630:2019	Boilers – energy efficiency and determination methods

Source: Authors (Based on Government Website).

II. Thailand

In Thailand, industry standards for air conditioners, heat pumps, and boilers are essential for promoting energy efficiency, environmental sustainability, and consumer safety. Especially, the energy efficiency is a key primary focus of Thailand's heating, ventilation, and air conditioning (HVAC) industry.

For the aspect of energy efficiency, Thailand has adopted several energy labelling programmes that categorise air conditioners, heat pumps, and boilers based on their efficiency ratings. For air conditioners, there is 'Energy Label No.5' that certifies its efficiency with a 0 to 5-star rating for efficiency. This Energy Label No. 5 is a voluntary standard for electronic appliances in Thailand overseen by EGAT (Electricity Generating Authority of Thailand) in accordance to the policy from DEDE (Department of Alternative Energy Development and Efficiency). The label also features information on CO_2 emissions reduction, circular economy certification, and a QR code for product details. The main criteria for air conditioners are SEER (Season Energy Efficiency Ratio). For other equipment such as heat pumps, the main criteria are COPt (Coefficient of Performance for tapping sanitary hot water), but Energy label No. 5 for heat pump is overseen only by DEDE and has no star ratings to further depict energy efficiency.

Figure 2.11: Energy Label in Thailand

Source: Electricity Generating Authority of Thailand (2024).

There is also energy labelling programmeme called 'Green Label' which is an eco-certification programme in Thailand by the Thailand Environment Institute in collaboration with the Ministry of Industry. It aims to promote environmentally friendly products and services by certifying those that meet specific sustainability criteria. This label is considered Type 1 Ecolabel based on ISO 14024. Thailand Environment Institute has signed many MOUs with related authorities on Ecolabel of foreign countries for the Green Label to be accepted as a standard, including Japan Ecomark. Other than the product's properties, the Green Label also considers the manufacturing process. This green label programme is applicable for air conditioner and heat pump.

Figure 2.12: Green Label in Thailand

Source: Thailand Environment Institute (2024).

For the aspect of product and consumer safety, TIS (Thailand Industrial Standard) is a set of regulations and guidelines developed by the TISI (Thailand Industrial Standards Institute) under the Ministry of Industry. These standards ensure that products meet safety, quality, and performance benchmarks for both domestic and international markets. There are 2 important types for TIS standard which are the compulsory TIS that required by law for both domestic and international manufacturer for certain products including air conditioner and the voluntary TIS that is not required by law, but manufacturers can choose to apply for to certify the quality and safety of their products such as boiler and heat pump.

Figure 2.13: TIS (Thailand Industrial Standard)

Source: TISI (2024).

Apart from TIS standard for the safety issue, there are also The Ministerial Regulations on safety protocols for boiler (2006) placed a safety regulation that cover manufacturing, installation, usage, maintenance and modification, decommissioning, and factory personnels. On the manufacturing and installation topics, they refer to the TIS, global standards of ASME (American Society of Mechanical Engineers), JIS (Japanese Industrial Standards), or EN (European Standards) and other comparable standards. The boiler must also be inspected by a registered engineer. Factories must also register their boilers through an online portal of DIW (Department of Industrial Works) and send an annual checkup report.

Table 2.4: Relevant Industry Standards in Thailand

Official number	Content of industry standard
TGL-57-11	Green Label Requirements for Heat Pump Products
TGL-07-R4-20	Green Label Requirements for Room Air Conditioners Products
EN 255-3	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors. Heating mode. Testing and requirements for marking for sanitary hot water units (Used as reference for Energy Label by DEDE for heat pumps)
TIS 385-2524	Room air conditioners
TIS 1155-2557	Air-cooled split type room air conditioners
TIS 1529-2561	Air-Conditioner safety requirement (Compulsory)
TIS 2134-2565	Room air conditioners: energy efficiency (Compulsory)
TIS 2564-2555	Room air conditioners: installation
TIS 2710-2558	Non-ducted air conditioners and heat pumps - Testing and rating for performance
TIS 2711-2558	Ducted Air-Conditioners and Air-to-Air Heat pumps - Testing and Rating for Performance
TIS 2712-2558	Multiple Split-System Air-Conditioners and Air-to-Air Heat pumps - Testing and Rating for Performance
TIS 2714-2558	Air-cooled air conditioners and air-to-air heat pumps - Testing and calculating methods for seasonal performance factors
TIS 3201-2564	Non-ducted portable air-cooled air conditioners and air-to-air heat pumps having a single exhaust duct - Testing and rating for performance
TIS 3623-2566	Air to Water Heat Pump: Energy Efficiency Requirement
TIS 855-2532	Boilers: general construction
TIS 2609-2557	Non-destructive testing - Magnetic particle testing for boiler and pressure vessel

Source: Authors (Based on Government, TISI Website).

III. India

In India, mandatory standards and regulations are primarily focused on boilers, governed by the Indian Boiler Regulations, 1950, which provide detailed technical guidelines for the design, materials, construction, testing, and inspection of boilers and related components. For appliances such as refrigerators, air conditioners, and chillers, Indian standards exist but are not as stringent. These appliances are typically regulated through the BEE Star Labelling programmes, which rate room air conditioners, chillers, light commercial air conditioners, and deep freezers based on their energy efficiency, encouraging manufacturers to adopt more energy-efficient technologies.

Table 2.5: Relevant Industry Standards in India

Official number	Content of industry standard
IS 16528	Boiler and Pressure Vessels performance requirements
IS 8633	Technical requirements for location of boilers installations and boiler houses
IS 13980	Acceptance tests on industrial boilers – code of practice
IS 3503	Steel for marine boilers, pressure vessels and welded machinery structures
IS 8596	Recommended parameters of stationary steam boilers
IS 3412	Electric Water Boilers
IS 16590	This standard specifies the requirements and test methods for determining the performance of vapor compression type chillers used for cooling applications
IS 16678	Refrigerating Systems and Heat Pumps Safety and Environmental Requirements
IS 18154	Air-cooled air conditioners and air-to-air heat pumps Testing and calculating methods for seasonal performance factors
IS 1391	Room Air conditioners- Specifications
IS 1474	Specification for commercial refrigerators
IS 17550	Household Refrigerating Appliance- Characteristics and test methods
IS 13261	Sound power rating of air - Conditioning and air - Source heat pump equipment
IS 302	Safety of household and similar electric appliances

Source: Authors (Based on Government, BIS Website).

5. Needs and Concerns of Relevant Entities

This section illuminates the challenges associated with heat pump implementation in the target country through a comprehensive interview process. Our multifaceted approach began with interviews of key industry stakeholders, including manufacturers, industry associations, and ESCOs, to gain third-party perspectives and a macro-level understanding of the heat pump landscape. We then conducted interviews with user companies and surveys to ascertain their specific needs and challenges as primary stakeholders.

I. Viet Nam

a) Manufacturers' perspective

In Viet Nam, due to the warm climate, the demand for cooling is much greater than for heating. The high initial investment required for the installation of heat pumps and once-through boilers is a barrier to adoption. When it comes to installing cooling systems, more affordable conventional or second-hand equipment is often preferred.

- 'Vietnam has significant climate regional variation. For example, Northern Vietnam has colder winters, which should theoretically generate higher demand for heating solutions such as heat pumps. However, the duration of winter is shorter, and the regions which experience four seasons is smaller than that of Japan or Europe. Therefore, the overall demand in Vietnam is focused more on cooling rather than heating, especially in the industrial and residential sectors.' (Heat Pump Manufacturer)
- 'While heat pumps offer lower running costs, their high initial cost remains a significant barrier. In food processing plants, where hot water at 50-60°C is used for daily cleaning, the advantages of heat pumps could be fully utilised, indicating potential demand in this sector. With economic incentives such as subsidies, their adoption would likely increase.' (Heat Pump Manufacturer)
- 'Energy-efficient equipment tends to be relatively more expensive compared to other products with similar functions. However, with the accessibility of subsidies or other forms of financial support, it seems more likely that contractors would be able to widely promote and sell these energy-saving devices to user companies.' (Heat Pump Manufacturer)
- 'Imported second-hand equipment, many of these devices are outdated and not particularly energy-efficient, also make it harder to promote the adoption of higher-efficiency equipment. They present competition for newer, more energy-efficient technologies. In fact, Vietnamese industries often prioritise short-term cost savings over long-term benefits, making the adoption of capital-intensive technologies such as heat pumps less appealing. As such, in many cases, traditional system continues to be preferred in Vietnam.' (Heat Pump Manufacturer)

Furthermore, Viet Nam's financial market is still developing, thereby making it even harder for businesses to secure necessary funds.

- 'In Vietnam, there is few leasing companies operating in the country with 100% foreign ownership. The leasing market is still underdeveloped, resulting in little demand for leasing equipment such as heat pumps at this time.' (Leasing company)

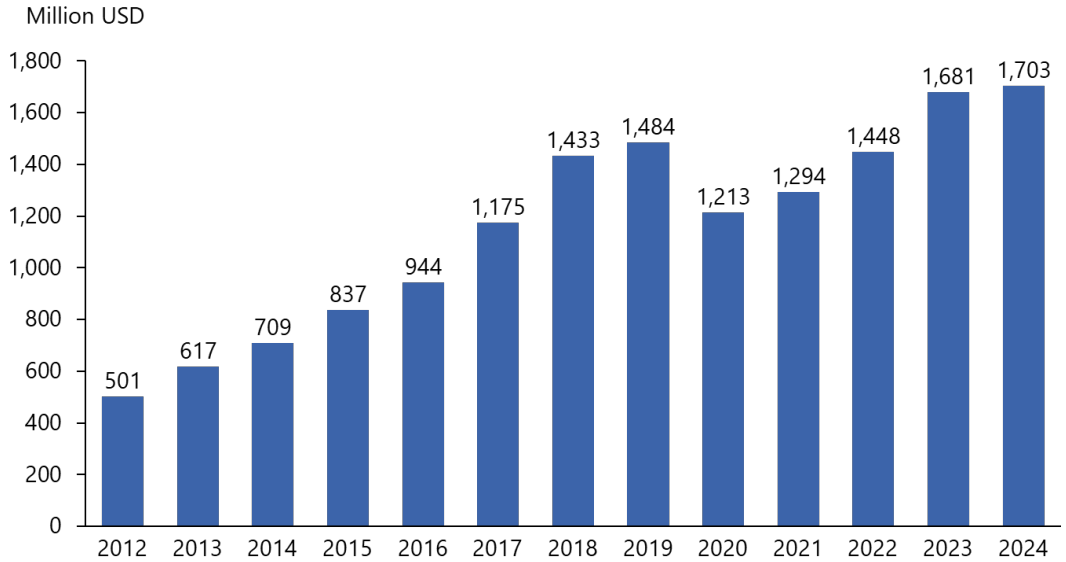
The following information supports this statement:

- The medium- to long-term capital demand of Viet Nam's economy is estimated to be around $29 billion to $42 billion per year. In many developed countries, financial leasing is a common method for providing long-term capital; however, in Viet Nam, it remains relatively small and heavily reliant on bank loans. There are not many companies in Viet Nam that offer equipment leasing. Financial leasing is an optimal form of medium- to long-term credit, helping companies raise funds easily without collateral. With the issuance of Circular 26/2024/TT-NHNN concerning leasing in July 2024, the financial leasing market is expected to expand. Financial leasing could be useful when investing in high-energy-efficiency equipment, which tends to be relatively expensive.

The underdevelopment of financial leasing in Viet Nam is thought to be due to several reasons:

- High credit risk in developing countries
- Inadequate legal framework for debt collection and collateral enforcement
- Low awareness of leasing
- Difficulty in establishing long-term contracts due to inflation

Figure 2.14: Industry revenue of rental and leasing activities in Viet Nam



Source: Statista (2024).

Skilled professionals in the field of energy-efficient technologies are also limited as there are few local companies which manufacture heat pumps. Japanese manufacturers have established sales and service offices, it may be difficult to cover the entire country due to administrative and logistical issues.

- 'We rely on local contractors for the sale of heat pumps in Viet Nam. As our company does not handle this directly, we face challenges in fully understanding the needs and conditions of our end-user companies.' (Manufacturer)

Another issue that emerged from interviews with manufacturers is the lack of awareness regarding safety. Heat pumps require the use of refrigerants, some of which contribute to global warming or pose risks to human health.

- 'We found the cylinders used to transport refrigerants are sometimes leaking or rusting, raising safety concerns. This disregard for the potential environmental and health impacts could hinder the adoption of heat pumps in the future.' (Manufacturer)

b) Local Associations and ESCOs' perspective

Heat pump technologies have been introduced in Viet Nam for several years, however its usage in the industrial sector in Viet Nam is still limited but there is potential demand for improving the energy efficiency of chillers and boilers. It is necessary to first promote and raise the level of awareness amongst businesses about environmentally friendly technologies.

- 'The heat pump market in Vietnam is not non-existent, however, to develop this technology in the coming time, it is necessary to first promote and raise awareness of businesses and people about green–clean, environmentally friendly technology.' (VECEA)
- 'The main requirements for energy-efficient equipment in Vietnam are for chillers and boilers, which consume large amounts of energy. In other words, there is significant potential for energy-saving applications for chillers and boilers. Many MNCs in Vietnam are willing to invest in energy-efficient equipment, especially those from Japan, the EU, and the US. ESCOs such as VETS Energy typically serve companies located in industrial parks with a total energy consumption of over 6 million kWh/year and minimum equipment investment of $500K – $1 million.' (ESCO)
- 'Since there are universities in Vietnam that specialise in energy-related fields, offering lectures at such institutions could play a key role in advancing the technology and fostering wider adoption.' (ESCO)

In Viet Nam, the ESCO (Energy Service Company) industry is still underdeveloped and few companies or experts capable of conducting energy assessments and offering energy-saving solutions. Most of the companies providing heat pumps in Viet Nam are foreign-owned, and it is not easy for them to maintain enough technicians to cover the entire country. Providing such services is key to helping businesses in Viet Nam understand the

benefits of heat pumps and once-through boilers, which can drive investments in these technologies.

- 'The market is also fragmented with the presence of numerous brands from China, Japan, US, as well as local brands such as Seamax and Megasun.' (Local Association)
- 'There are few companies manufacturing heat pumps in Vietnam. To promote their widespread adoption, it is essential to integrate heat pump technology related to installation and production.' (ESCO)
- 'High-efficiency equipment such as heat pumps and once-through boilers can significantly reduce energy consumption by integrating them effectively requires a thorough understanding of the overall energy usage of buildings, whether in offices or factories. For instance, considering the potential for utilising waste heat from heat pumps or determining the appropriate capacity of the equipment is crucial to selecting and installing the right systems.' (ESCO)

A policy framework must be established to support and promote the development of energy-saving technologies and encourage investors to apply these technologies in their projects.

- 'It is necessary to build a system of policies to support and encourage the development of energy-saving technologies such as heat pumps and heat storage, and encourage investors to apply these technologies in their projects. However, it is also necessary to clarify the investment rate of this technology, to calculate which stage to include it in, and how to support it appropriately.' (VECEA)

Viet Nam has been a recipient of support initiatives from international NGOs to conduct feasibility studies on energy-efficiency systems. Under these initiatives, many companies have received funding support to identify and implement the appropriate solutions for their facilities. Highlighted in these feasibility studies are the key challenges for the adoption of energy efficient equipment, which are:

- High initial investment cost for heat pumps, which is higher than that of traditional heating methods.
- Lack of awareness and technical capacity to adopt heat pump systems (at both the management and operational levels). Decision making for capital expenditure is usually top-down, and reluctance at top management usually translates to the lack of willingness for adoption.
- Existing factory settings may pose difficulties for the installation of new technologies and systems. For old factories, their systems are not modular, and replacement of systems may lead to operational disruptions. As such, factories tend to fully depreciate their systems before replacement of existing equipment.

- Heat pumps are larger in size and require bigger, well-ventilated space to install, therefore a larger installation space is required.
- Heating capacity is lower when ambient temperature decreases, leading to efficiency reduction at low temperatures.
- Heat pumps require longer heating time compared to direct heating.
- During operations, heat pumps may produce sounds of between 50 to 60 decibels.

To achieve the desired performance, heat pump system design needs to be configured to different project settings. For example, in high-rise residential projects, multi-system setting is more efficient than centralised system in terms of energy saving.

c) User Company's perspective

- According to a food manufacturer, there is a clear demand for energy-efficient equipment in the industry, but challenges remain. The high initial investment costs are a major barrier, especially for smaller companies. Larger companies prioritise system performance. There is also a need for government incentives and regulatory frameworks to support the adoption of energy-saving technologies. In Viet Nam, decarbonisation initiatives and the potential for a carbon credit system could help drive this transition.
- Key initiatives for green production in food processing include using environmentally friendly packaging material, biomass for boilers, circular economy, waste heat recovery. Biomass such as wood residues has been used for the boiler systems for the past 15 years.
- Barriers to adoption of energy efficient technology is the investment cost and ROI. For big companies, high capex is not a barrier – as the company can access capital, so the most important factor is the actual system efficiency/performance.
- To encourage adoption of energy-efficient technology, there needs to be incentives, legal frameworks and regulations from the government. Globally, many countries have developed such frameworks to support companies. In Viet Nam, following COP26 commitments, the government is developing the roadmap for decarbonisation in industrial production sectors, and carbon credit framework. The presence of a domestic carbon market can also incentivise producers.
- In food processing, major sources of energy consumption are boilers and chillers. Boilers are used for boiling and pasteurisation and have capacity ranging from 1T/hour to 6T/hour. The biggest chiller has capacity of 300kW.
- Heat pump technology has not been adopted as it can only generate temperate up to 50-60 degree Celsius, whereas in food processing, high heat is required for

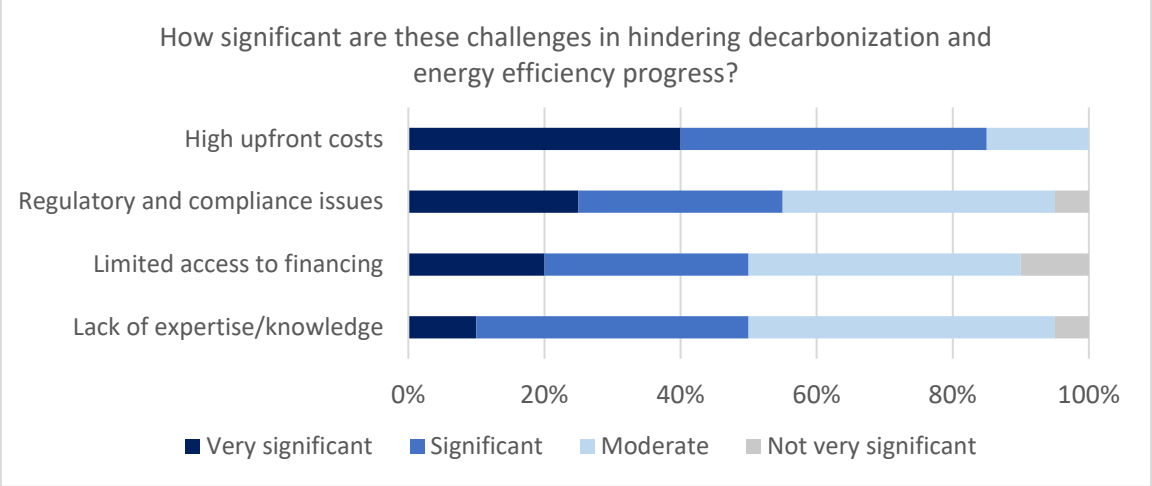
pasteurisation. Most food processing companies use large capacity boilers with economisers for waste heat recovery. The boilers are run 24 hours and 7 days, and have stored heats to minimise operational disruption if there is a power outage.

- Once-through boilers are used in smaller capacity production. One of the limitations for once-through boilers is the higher cost for fuel, as it uses diesel, whereas conventional boilers using cheaper heating oil or biomass.

We conducted a survey with 20 members of the Japanese Chamber of Commerce and Industry (JCCI) in September 2024, and found that major companies, especially Multinational Corporation (MNC), exporters and those with strong emphasis on brand names, have started to set out action plans towards Net Zero. According to the survey, 65% have implemented some kind of initiatives to reduce GHG emissions such as using LED lighting, renewable energy and adopting industrial waste heat recovery system for heat hot water supply.

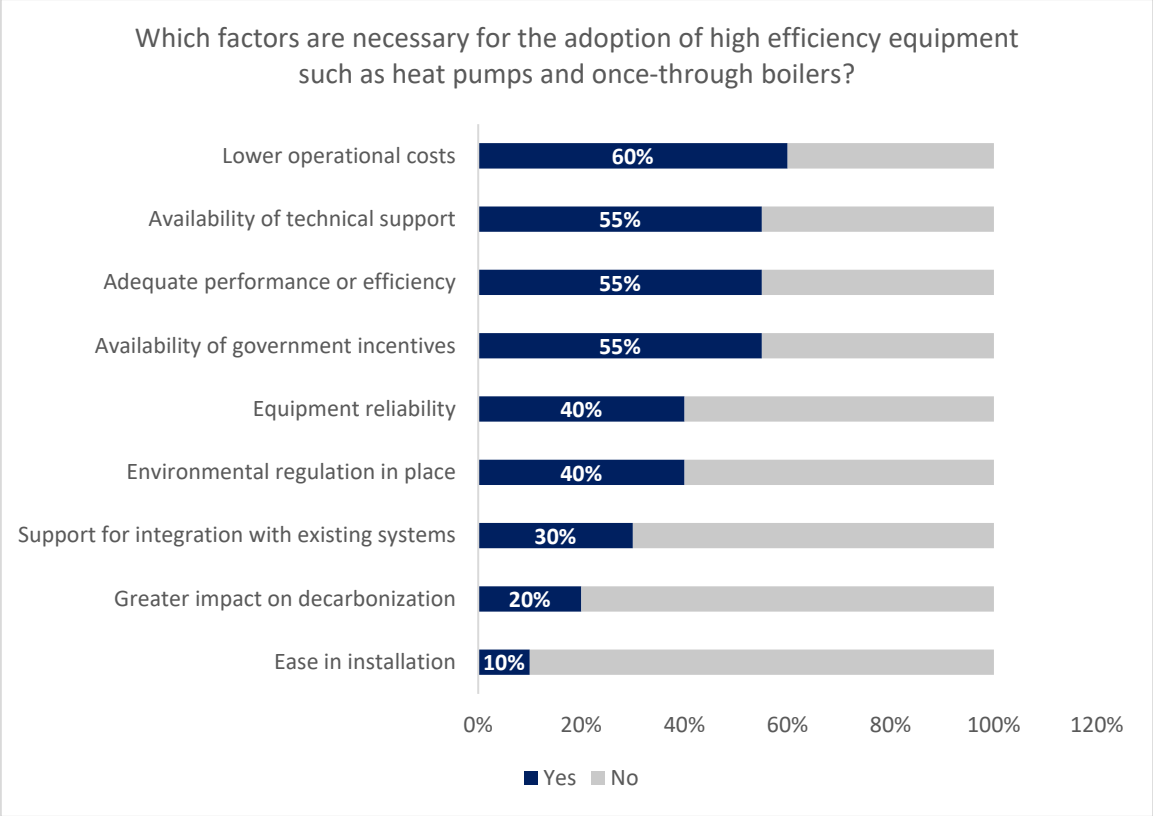
Initiatives that can be implemented must meet key operational requirements and can deliver cost-benefit advantages. While many MNCs and big local companies have started to adopt energy-efficient systems, awareness and adoption amongst smaller companies are still very limited. High upfront cost is cited as the biggest challenge in implementing energy-efficient initiatives. More incentives and support from the government and achieving the goal of reducing operational costs are the top two decision factors when companies consider investing in an energy-efficient system. Availability of technical support and system achieving adequate performance of efficiency are also important factors.

Figure 2.15: Significant Challenges Hindering Decarbonisation and Energy Efficiency Progress



Source: Authors.

Figure 2.16: Factors Necessary for the Adoption of High Efficiency Equipment



Source: Authors.

II. Thailand

a) Manufacturers' perspective

Thailand's climate is similar to that of Viet Nam, characterised by high temperatures and humidity throughout most of the year. This significantly reduces the need for heating in both residential and industrial sectors. In Thailand, the low cost of propane and high electricity prices have reduced incentives for adopting heat pumps, with biomass boilers becoming more popular due to their compatibility with existing systems and shorter ROI. While solar power has received the most attention in energy-saving efforts, interest in technologies like heat pumps and once-through boilers is expected to grow as companies look for additional energy-saving solutions beyond solar.

- In hotels and condominiums, small heating units are often installed in each room, and since bathing habits differ from those in Japan and the overall climate in Thailand is warm throughout the year, there is less demand for heating for both hot water and warm air throughout the entire building. (Heat pump manufacturer)
- The low cost of propane gas and the relatively high electricity prices significantly reduce the incentives to adopt heat pumps, resulting in limited deployment at

present. Moreover, biomass boilers, which utilise abundant agricultural waste such as rice husks, are becoming increasingly popular. (Heat pump manufacturer)

- These boilers are often more compatible with existing systems, making them easier to replace without significant changes to infrastructure. When comparing the return on investment (ROI) of conventional boilers to that of heat pumps, the latter, which often requires five to six years to recover the initial investment, can seem less attractive, particularly in the short term. This short-term cost consideration tends to overshadow the long-term advantages of heat pumps, which offer superior energy efficiency and lower operational costs over time. While the upfront costs of installing heat pumps may be higher, their potential for substantial energy savings and environmental benefits makes them a worthwhile investment in the long run. (Heat pump manufacturer)
- The focus on reducing energy consumption has primarily been on solar power, which has garnered the most attention, especially with the support from the Board of Investment. As a result, energy-saving equipment like heat pumps and once-through boilers have not received as much attention. In recent years, companies that have already implemented solar power are beginning to seek additional energy policies, leading to high expectations of growing interest in energy-saving equipment. (Heat pump manufacturer)

In the case of once-through boilers, some models are relatively affordable, and their replacement of existing boilers is comparatively straightforward. As a result, more companies are opting for once-through boilers over conventional ones. There may be potential demand for heat pumps in environments such as factories, where stable equipment operation is prioritised.

- The decision is not about whether to purchase a boiler, but rather whether to choose a cheaper, moderately reliable option or a slightly more expensive model that offers greater peace of mind. Since a boiler shutdown can have a significant impact on the production line, reliability and low risk of failure are highly valued. Smaller companies, with more limited financial resources, tend to prioritise cost and opt for the cheapest available options. For medium and large-sized companies, about 90% of those we propose to choose once-through boilers, prioritising efficiency and reliability. (Once-through boilers manufacturer)
- In commercial facilities like hotels, even if cooling equipment breaks down, the impact is usually limited to an increase in indoor temperature, which is not very critical. As a result, cheaper equipment tends to be chosen more often. In contrast, factories face significant consequences when equipment failure leads to production line stoppages, making reliability and stability a priority. This creates a higher likelihood that they will choose our products for their proven stability. (Heat pump manufacturer)

Heat pumps, especially those capable of simultaneously producing hot and cold water or utilising waste heat, can achieve high efficiency. And to propose efficient usage may promote heat pumps adoption. However, efficiently utilising waste heat or simultaneous heating and cooling is challenging. The limited awareness of these methods and the shortage of skilled technicians needed to implement them are significant obstacles. The increase in technicians is essential not only for installation but also for after-sales service and disposal.

- Proposing solutions like utilising waste heat from boilers in combination with heat pumps can lead to greater adoption of heat pumps, as it demonstrates a more integrated and efficient use of energy. (Heat pump manufacturer)
- While systems that provide both heating and cooling offer better efficiency, they require equal usage of hot and cold water, making it difficult to find suitable applications. Sometimes, companies hesitate to provide data, which makes it more difficult to propose efficient usage. (Heat pump manufacturer)
- To optimise energy usage by heat pumps, it is necessary to understand the energy consumption of the entire facility and find ways to integrate heat pumps into systems that can efficiently utilise both hot and cold outputs, while also considering optimal placement for waste heat recovery. Additionally, since heat pumps excel in continuous operation, simply replacing boilers and using them in the same way is not always efficient. Proposing efficient configurations, including combined use with boilers, could help encourage adoption by user companies. (Heat pump manufacturer)
- As a company policy, it has been decided that at least one technician must be assigned to each country. However, Thailand is vast, it seems difficult to cover all of Thailand with only in-house technicians. Since they rely heavily on third-party distributors to reach the entire country, they lack control over what happens after selling refrigerators to customers. Monitoring disposal is even harder, making it challenging to manage refrigerants properly. Without clear guidelines for refrigerant handling, there's concern that they might be released into the atmosphere. I've never heard of any established guidelines for handling refrigerants in this context. (Refrigeration manufacturer)

When it comes to cooling equipment, there doesn't seem to be a widely used method in the industry for testing energy efficiency performance. As a result, making clear performance comparisons is currently difficult. The difficulty in comparing performance may be discouraging the selection of higher-efficiency equipment.

- In many cases, the quality of cooling systems is evaluated based on how much they can cool and the amount of power they consume. Many user companies simply judge the equipment by whether it sufficiently cools and whether their electricity bills have decreased. As a result, energy efficiency doesn't seem to play

a significant role in how companies select their equipment. Therefore, it is crucial to raise awareness about these long-term benefits and the positive impact on energy efficiency, which could help drive greater adoption of heat pump technology in the future. (Heat pump manufacturer)

In Thailand, the leasing industry has developed mainly around the automotive finance market, allowing for more flexible funding options compared to Viet Nam.

- The automotive finance market in Thailand grew from approximately 900 billion baht in 2016 to around 1.2 trillion baht in 2021, and it is expected to further grow to around 1.8 trillion baht by 2026, driven by increased consumer purchasing power and the adoption of EVs. While leasing is still rarely used for equipment investments such as heat pumps and boilers, the expansion of the financial leasing market could make it possible for SMEs, which often struggle to secure sufficient initial investments, to invest in high-energy-efficiency equipment.

b) Local Associations and ESCOs' perspective

While there is a clear potential for energy-saving and space-efficient solutions such as once-through boilers and heat pumps, their successful implementation is hindered by factors such as water quality, maintenance requirements, and the technical demands of installation. Overcoming these barriers will be crucial for broader adoption and the realisation of the full benefits these technologies can offer.

- The adoption of once-through boilers has been met with challenges, primarily due to the country's poor water quality. Once-through boilers, especially those with small water tubes, are highly sensitive to water fouling. Contaminants in the water can quickly cause damage, making these boilers prone to breakdowns. This issue is exacerbated in rural areas where water quality is particularly poor, and there is often a lack of trained personnel to perform the necessary frequent maintenance. As a result, many users in these regions revert to using more traditional fire-tube boilers, which are more robust and better suited to handle the lower water quality, despite being larger and less space-efficient. (ESCO)

- The limited adoption of once-through boilers is largely due to the delicate balance between their compact size, which is a significant advantage for customers with space constraints, and their fragility. While these boilers are prized for their space-saving benefits, they tend to start leaking after about a year of use, largely due to water quality issues and the need for continuous maintenance. This makes them less appealing to customers who are unable or unwilling to commit to the rigorous upkeep required to keep them operational. (ESCO)

- Furthermore, the transition to more advanced energy-saving technologies such as heat pumps is also proving challenging for users in Thailand. Installing a heat

pump is not a straightforward process; it requires the integration of several related components and a solid understanding of engineering principles. The complexity of installation, coupled with the need for a significant upfront investment, makes heat pumps less accessible, particularly for those without the necessary technical knowledge or financial resources. (Asian Heat Pump & Thermal Storage Technologies Network – AHPNW)

c) User Company's perspective

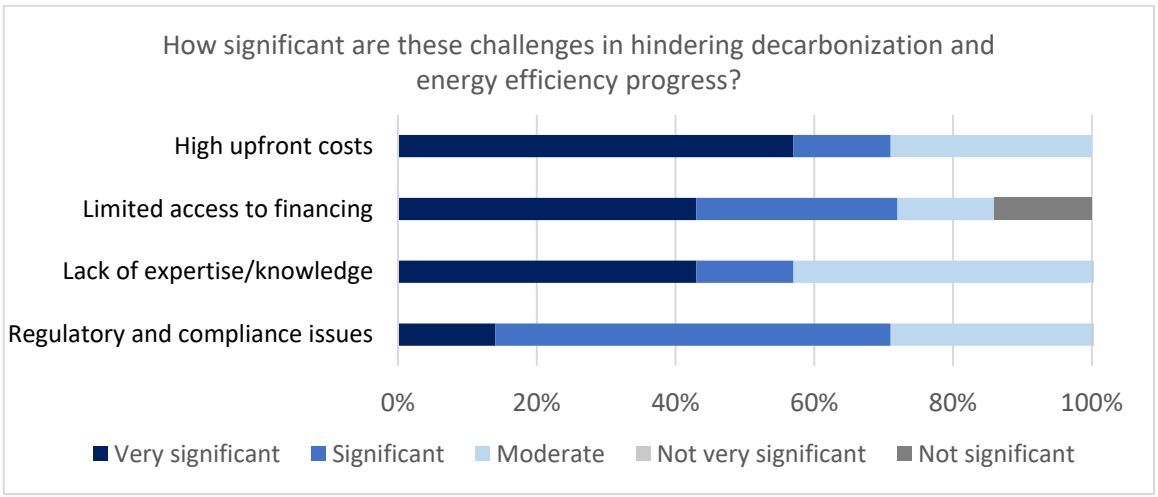
In summary, these challenges above are the key highlighted barriers for the users to adopt energy-efficiency equipment including the concerns about cost, maintenance, and know-how. There is a suggestion that subsidised programme will be one of a key attractive approach for users to start implementing energy-efficiency equipment.

- From the perspective of uses, most of the initiatives' goal is basically to increase the profit and one of the methods is to reduce the product cost and expense especially to reduce the electricity cost which is quite high for all-year-round production sites and service facilities such as manufacturing sites and hotels. Benefits to achieve energy sustainability seem to be considered as side benefits apart from the main goal to increase the profit. Also, the management is not eager to adopt energy-efficient equipment because it does not directly affect to cost reduction. For example, coal-fired boiler is still widely use in the manufacturing site in Thailand as the price of coal is relatively low comparing to another materials. (Local food manufacturer)
- Moreover, if the users need to change the existing equipment from the conventional system to another brand-new system with high energy-efficiency, there will be a big investment for purchasing equipment as energy-efficient equipment is still perceived as high price product comparing to the existing conventional one. Also, highly consideration for short-term pay-back period will be needed. Therefore, the adoption of energy-efficient equipment for the purpose of sustainable energy is not being considered as the top priority for the users. (Local food manufacturer)
- Apart from the challenge of cost and expense reduction, the user needs highly consideration for maintenance issue. Most of users in Thailand especially all-year-round production sites and service facilities have their own in-house technical staff members to standby for unexpected issues when the machinery is not working. Therefore, the key requirement when purchasing new equipment is easy maintenance for in-house technical staff members. As for some production site which its location is far away from the city areas, it is hard to access prompt service from the outsourced service provider and there is also an issue of poor internet connectivity making remote support difficult to be done. Furthermore, an

> advanced energy-saving technology is also difficult to be introduced amongst the old senior staff members as they already get accustomed to the conventional methods. (Local food manufacturer)

Adopting energy-saving technologies in Thailand presents several challenges and opportunities. In a survey done with user companies in targeted industries in September 2024, the survey's result is aligning with the key message from above user interview that cost and technical skills is the issues that make energy-saving technology is difficult to adopt amongst user companies. From the survey's result, high upfront cost is the most significant challenges in implementing energy-efficient initiatives. Following by lack of expertise and knowledge that is also highly a key challenge in adopting new technologies.

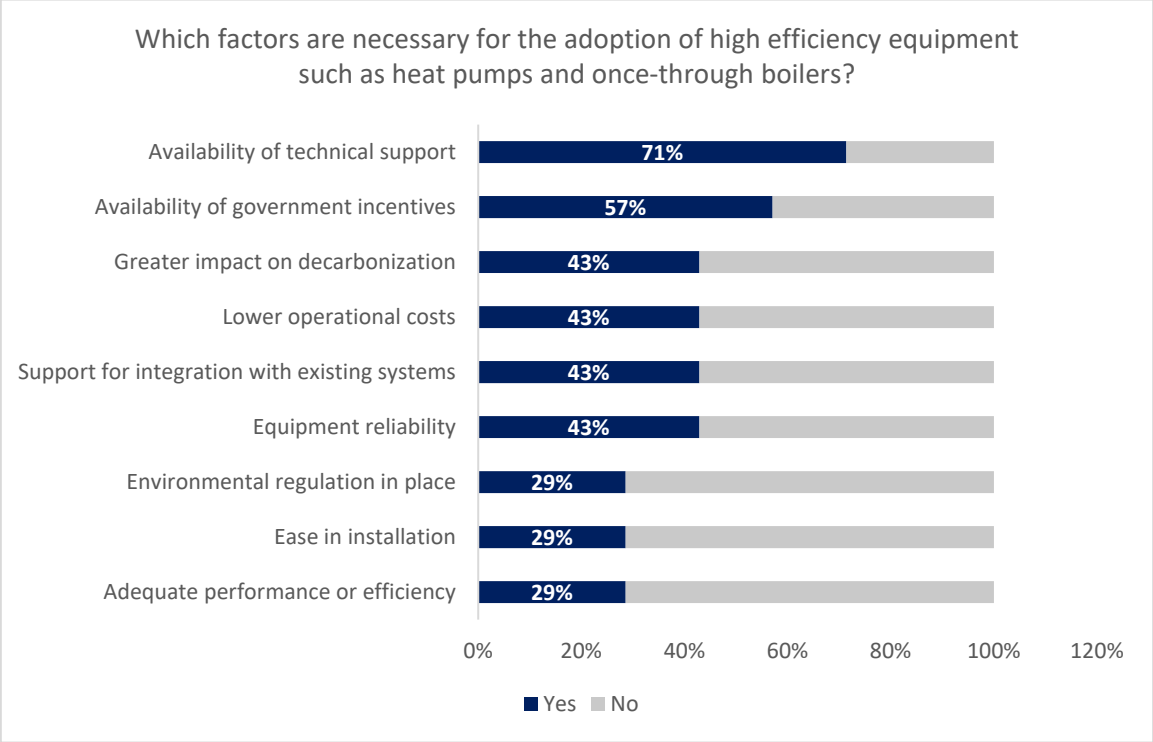
Figure 2.17: Significant Challenges Hindering Decarbonisation and Energy Efficiency Progress in Thailand



Source: Authors.

The transition to energy-saving technologies involves overcoming initial challenges while leveraging the growing trend towards sustainability and available resources. Emphasising the long-term benefits and engaging in education and awareness initiatives can facilitate this transition. The survey result of factor necessary for the adoption of high efficiency equipment in Thailand also shows that government incentive or subsidised programme will be the key factor for user to adopt high efficiency equipment with the highest result at 71.40%. Also, another important factor is availability of technical support with the result at 57.10%. These two factors are expected to solve the issues of high cost and lack of technical knowledge in the user's companies.

Figure 2.18 Factors Necessary for the Adoption of High Efficiency Equipment in Thailand



Source: Authors.

Key concerns and needs regarding the adoption of energy-efficient equipment by target industries in Thailand which are food manufacturing and hotel can be described as below.

Table 2.6: Concerns and Needs from Targeted Industries in Thailand

Industry	Concerns & Needs
Food Manufacturing	The initial investment for high-efficiency equipment can be substantial which is significantly challenging for smaller manufacturer Coal-fired boiler is still widely used in Thailand as coal price is relatively low comparing to another materials therefore alternative technology is not yet be aware of. Any equipment in production line that operates all-year-round including heat pump need prompt technical support to prevent production shutdown, especially for the manufacturing site in the rural area in Thailand.
Hotel	Cost-cutting measure is prioritised over investments in high-efficiency equipment, particularly in case of immediate financial returns cannot foresee. Lack of knowledge in the benefits of energy-efficient equipment and unready in technical-skilled staff members to maintenance high-efficient equipment. Increasing consumer demand for sustainability might be able to enhance hotel brand image and attract eco-conscious travellers.

Source: Authors.

III. India

a) Manufacturers' perspective

India experiences a drop in temperature during the dry season of around 10°C (50°F), therefore there is significant demand for air conditioning. On the other end of the spectrum, record high temperatures from heat waves which have led to heat-related deaths have also hit the country, creating a challenge to provide sufficient cooling facilities. The Indian government issued the India Cooling Action Plan and has made meeting cooling demands a priority. It is expected that the demand for cooling will only continue to increase in the future. Given the significant demand for air conditioning, some Japanese air conditioning manufacturers are actively conducting business in India. However, the situation differs when it comes to heat pumps, excluding air conditioning systems and through-flow boilers. Interviews with Japanese companies revealed that many either lack a direct sales presence or, if one exists, it often operates through joint ventures with insufficient support infrastructure.

- There is a sales office in India, but the organisational structure to fully support customers, including after-sales services, has not yet been adequately established. (Heat pump manufacturer)
- India has proven to be a challenging market to penetrate, and it remains difficult to gain control or establish a strong presence there. (Refrigeration manufacturer)

Desk research has suggested that cost-driven practices and regulatory frameworks may serve as significant barriers to the adoption of heat pumps and once-through boilers. Both the initial capital investment required for these advanced technologies and lower operation cost of traditional heating systems can deter companies from making the switch, particularly in regions where budget constraints are a concern.

- India has a large and growing manufacturing industry, which creates significant demand for heating and cooling processes in factories. However, Indian industries, especially small and SMEs, are highly cost sensitive. The high initial costs can be a deterrent, making manufacturers reluctant to adopt heat pump technology. In the case of other general consumer goods, low prices paired with large economies of scale are expected to expand the market in India. However, in the case of heat pumps, it is difficult to lower the price because they require customisation based on the customer's energy usage and application.
- The Indian government provides subsidies for conventional energy sources such as coal and gas, which makes it less attractive to improve energy efficiency and replace their existing boilers to heat pumps which use electricity. In India, while subsidies for renewable energy are increasing, the country still provides significant financial support to fossil fuels like coal, oil, and gas. Although fossil fuel subsidies decreased by 72% between the 2014 and 2021 fiscal years,

amounting to $8.528 billion in 2021, they remain nine times higher than subsidies for renewable energy.

For foreign manufacturers, India presents significant challenges in terms of regulatory compliance, particularly with regards to boiler standards. While products conforming to JIS standards can be sold in markets like Thailand and Viet Nam, in India, boilers must adhere to the country's specific regulatory framework. This requirement poses a substantial barrier for the sale of once-through boilers by foreign companies. As a result, many hesitate to enter the Indian market for energy-efficient equipment due to these stringent standards. Although no similarly strict regulations currently exist for heat pumps and chillers, the potential for future standardisation similar to that seen with boilers could deter foreign companies from expanding into India. The uncertainty surrounding the possible tightening of regulations adds an additional layer of hesitation for companies considering entry into the market. This regulatory complexity makes India a more challenging environment for energy-efficient equipment compared to its Southeast Asian neighbours.

- In India, due to regulations on boilers, it is difficult for Japanese manufacturers to sell once-through boilers in the country. (Once-through boilers manufacturer)
- In Thailand and Viet Nam, products that conform to JIS standards can be sold, but in India, they must meet the country's unique boiler regulations. This makes compliance with the standards challenging, which has prevented market entry into India. (Once-through boilers manufacturer)

b) Local Associations and ESCOs' perspective

Financial challenges significantly hinder the promotion of energy-efficient equipment, as high capital costs and limited funding deter businesses from investing. Reliability and performance concerns in India's diverse climate also slow adoption, with customers seeking assurance of equipment efficiency. Moreover, complex government policies and high tariffs on imported components further discourage international companies from entering the market.

- Financial challenges are amongst the most significant concerns for associations working to promote energy-efficient equipment. The high capital expenditure required for such equipment, coupled with limited funding options, makes it difficult for many businesses to invest in these technologies. The initial cost barrier is a major deterrent because many companies prioritise short-term savings over long-term ROI. This is particularly true in sectors where cost-cutting is a priority, and the benefits of energy efficiency are not immediately apparent. (Indian Association)

- Reliability and performance concerns also play a significant role in the slow adoption of energy-efficient equipment. The diverse climate conditions across India mean that equipment needs to be reliable and adaptable to different environments. For example, air conditioning systems that perform well in moderate climates may not deliver the same efficiency in more extreme conditions. Customers require assurances that the equipment will meet their performance expectations and deliver the promised energy savings. (ESCO)
- The alignment with government policies is another critical issue. Many companies find it challenging to comply with schemes like Make in India and the PLI scheme due to complex regulations and high tariffs on imported goods. For instance, the import duty on certain energy-efficient components can be as high as 20%, making it less attractive for companies to import these products despite their higher efficiency. This has deterred some international companies from fully committing to the Indian market. (ESCO)

Collaboration amongst stakeholders, such as the government, overseas manufacturers, and industry leaders, can provide solutions to address financial challenges while delivering the stability that users demand.

- Innovative business models, such as the 'Pay as You Save' approach, where Energy Service Companies (ESCOs) manage the capital investment, and end-user companies pay based on actual energy savings can be explored further. This model could reduce financial risks for customers while ensuring equipment performance meets expectations. (ESCO)
- Partnerships between foreign manufacturers and Indian ESCOs could help bridge regulatory gaps and customise solutions to address India's unique operational challenges. (ESCO)

c) User Company

India's focus on energy conservation has shifted toward comprehensive decarbonisation, but high installation costs, complex integration, and limited government incentives hinder adoption. Concerns about ROI and reliance on imported heat pumps further complicate the transition to high-temperature heat pump technology. However, Pharmaceuticals, food manufacturing companies, and cosmetics sectors are likely to adopt heat pumps due to strong cash flow and operational cost reduction. The commercial sector, including hotels and supermarkets, may also consider heat pumps if government support or subsidies improve accessibility. End-user companies in sectors such as pharmaceuticals and food & beverage are increasingly adopting energy-efficient technologies like heat pumps, driven by rising energy costs and stringent carbon reduction targets. Despite this progress, several challenges impede widespread adoption, including high installation costs, complex process integration, and a lack of government incentives. These barriers

have left many companies in an exploratory phase, concerned about ROI and significant initial investments.

- Over the past 5-10 years, the perspective on energy conservation and decarbonisation in India has evolved significantly. Initially, the focus was on improving energy efficiency and adopting renewable energy sources. However, with multinational corporations (MNCs) committing to net-zero goals, there has been a clear shift towards comprehensive decarbonisation and carbon neutrality. (Chemical, Pharmaceutical, F&B Company)

- A primary driver for adopting heat pumps is the need to reduce thermal demand and move away from fossil fuel-based boilers. Air-source and water-source heat pumps are becoming viable for processes requiring lower-grade heat, typically below 60°C. For higher temperature applications (above 60°C), biomass boilers remain the preferred option due to their superior efficiency at these temperatures. (Pharmaceutical Company)

- We are interested in high-temperature heat pump technology but are awaiting more proven solutions and better ROI. Indian companies like Thermax are developing high-temperature heat pumps with capacities of 80–90°C, but these technologies are still in their early stages and are not widely adopted. (Pharmaceutical Company)

- Many industries continue to favour natural gas (NG), biomass, or electric boilers over once-through boilers for their higher steam output and suitability for industrial applications. Although once-through boilers have lower steam capacity and are less common in industrial settings, they are gaining traction in the commercial sector, particularly in hotels, due to simplified regulatory compliance with non-IBR boilers. (Pharmaceutical Company)

- The adoption of heat pumps in India faces significant challenges. High initial investment and integration costs are major barriers, with many companies finding the upfront expenses daunting compared to conventional technologies like biomass boilers. Integrating heat pumps into existing processes often requires substantial modifications, further increasing the cost and complexity. Additionally, there is a general lack of awareness about heat pumps and their potential benefits, which contributes to hesitation in exploring these solutions. The availability of waste heat also influences the efficiency of heat pumps. In industries where waste heat is plentiful, heat pumps can significantly reduce energy consumption and improve efficiency. However, not all industrial processes generate sufficient waste heat, limiting the feasibility of heat pump adoption in sectors where waste heat is either scarce or unavailable. (Food and Beverage Company)

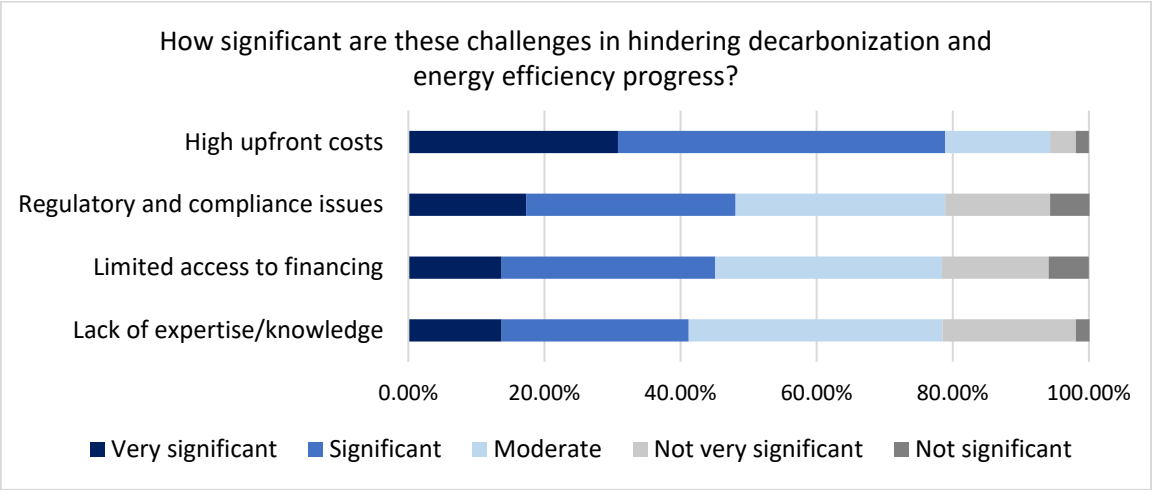
- Another major hurdle is the lack of government policies and incentives to support the adoption of energy-efficient technologies like heat pumps. Unlike regions such

as the US and EU, where substantial subsidies and tariff benefits drive adoption, India has limited governmental support. The absence of robust incentives makes it difficult for companies to justify the switch to heat pumps, slowing the pace of decarbonisation across industries. (Food and Beverage Company)

- Currently, India relies heavily on imported heat pumps, with local system integrators such as Promethean Energy, Rockshell, and UCPL handling installation and integration. Domestic manufacturing of high-grade heat pumps is still in its nascent stage. (Food and Beverage Company)

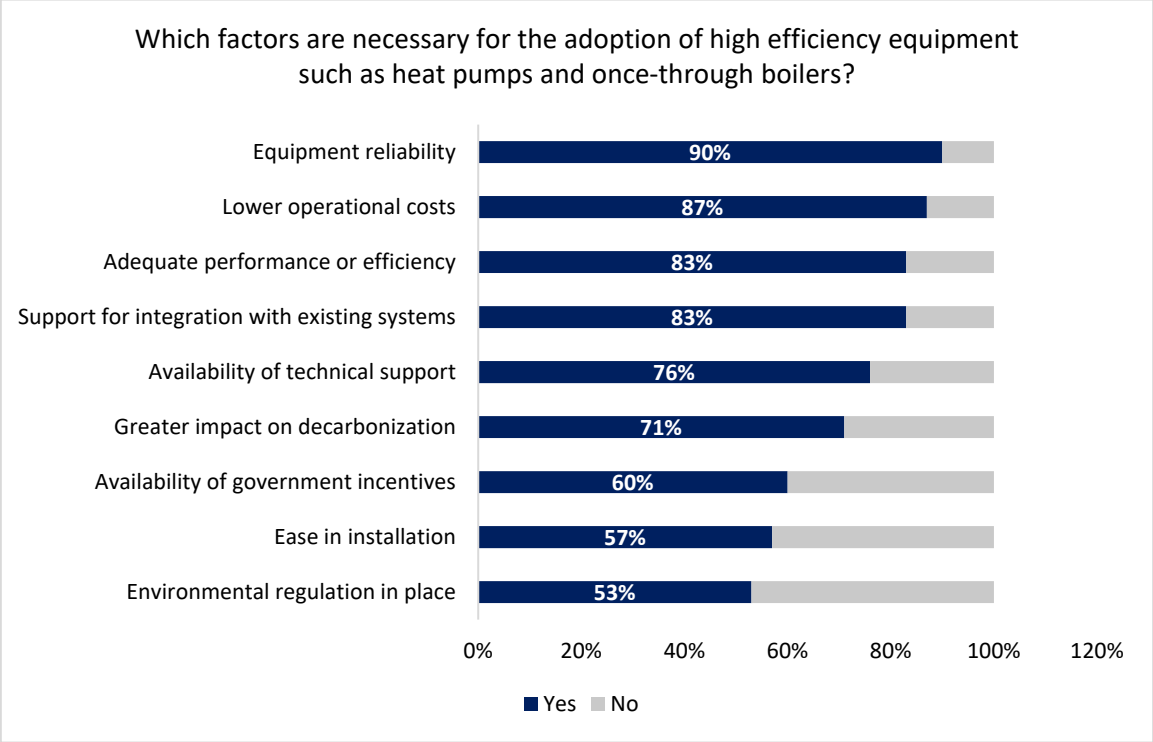
Based on the survey results from 66 user companies, high upfront costs were identified as the most significant barrier to decarbonisation and energy efficiency, with 79% of respondents citing them as either very significant or significant. On the other hand, key factors driving the adoption of high-efficiency systems like heat pumps and once-through boilers were equipment reliability, technical support availability, and lower operational costs.

Figure 2.19 Significant Challenges Facing Decarbonisation and Energy Efficiency in India



Source: Authors.

Figure 2.20 Factors Necessary for the Adoption of High Efficiency Equipment in India



Source: Authors.

A few companies from diverse industries have shared their concerns and needs regarding the adoption of energy-efficient equipment as shown in Table 2.6.

Table 2.7: Concerns and Needs from Diverse Industries

Industry	Needs & Concerns
Pharma	Using heat pumps for processes such as humidification and maintaining relative humidity, which require heating below 55–60°C. For temperatures above 60°C, biomass boilers are used. High-temperature heat pump technology would be attractive if it were proven and offered a high return on investment (ROI).
Chemical	Recent rise in coal prices has spurred interest in alternative technologies such as heat pumps. Currently they are considering adopting heat pumps, but high cost and long payback periods have delayed their implementation
Food & Beverage	Big companies have the required funds to invest in high energy efficient technologies such as heat pumps and can justify the process cost. The aim is to fully utilise heat pumps and then use boilers
Automotive	Extensively adopting Heat pumps in Paint shops as part of its sustainability targets. The company is actively seeking opportunities to integrate renewable energy into its operations.

Source: Authors.

6. Needs and Concerns of Relevant Entities Summary

6.1 Summary of Concerns in each country

The challenges faced by each country, based on the interviews and other relevant information collected thus far, have been compiled in Table 2-7.

Table 2.8: Summary of Concerns

Country	Issues	
Viet Nam	Need for financial support and incentives	Heat pump and once-through oilers adoption is the high initial installation cost due to the advanced technologies. The options for raising funds are also limited.
	Limited awareness of energy efficiency and benefits	There is low awareness of the importance of purchasing environmentally friendly products, even if they come at a higher price. For most consumers, cost remains the most significant factor in their decision-making.
	Risks associated with refrigerants	There are no guidelines or standards for the handling of refrigerants, and awareness of refrigerants amongst handlers is not high, so there is a possibility of atmospheric release or leakage.
	Shortage of technicians	There is a shortage of technicians who are capable of proposing energy optimisation solutions for buildings, as well as those skilled in the manufacturing and installation of necessary systems.
Thailand	Need for financial support and incentives	Heat pump and once-through boilers adoption is the high initial installation cost due to the advanced technologies.
	Limited awareness of energy efficiency and benefits	While larger companies increasingly prioritise stability and efficiency, SMEs still tend to place less emphasis on purchasing environmentally friendly products, even if they offer better long-term value. For these smaller businesses, price remains the dominant factor in decision-making.
	Risks associated with refrigerants	There are no guidelines or standards for the handling of refrigerants, and awareness of refrigerants amongst handlers is not high, so there is a possibility of atmospheric release or leakage.
	Shortage of technicians	There is a shortage of engineers who can integrate related components and have a strong grasp of core engineering principles. Many companies leave these responsibilities to the sales company, which results in them having little control over the installation or disposal of the equipment.
India	Need for financial support and incentives	Heat pump and once-through oilers adoption is the high initial installation cost due to the advanced technologies. The options for raising funds are also limited.
	Limited awareness of energy efficiency and benefits	There is low awareness of the importance of purchasing environmentally friendly products, even if they come at a higher price. For most consumers, cost remains the most significant factor in their decision-making.
	Risks associated with refrigerants	This issue has not been raised by companies that provide heat pumps in India.
	Shortage of technicians	Difficult to set up a system that provides sufficient support, including after-sales service. Due to the diverse climate conditions across India, equipment must be highly reliable and adaptable to various environments. Therefore, a service system capable of ensuring this reliability is essential.

Source: Authors.

7. Seminars about Decarbonisation

To further our research and promote awareness, we organised informational seminars for potential user companies, focusing on explaining the current energy landscape, emphasising the importance of decarbonisation, and introducing heat pump technology and once-through boilers.

7.1 Contents of the seminars

We conducted seminars targeting participants from Thailand and India, with a primary focus on the manufacturing industry, particularly sectors that heavily utilise hot and cold water. However, the event was open to a broader audience, encouraging wider participation across various industries. The seminar aimed to provide attendees with an in-depth understanding of energy business solutions and strategies for achieving carbon neutrality. The focus was on introducing cutting-edge technologies such as heat pumps and once-through boilers, which are vital for improving energy efficiency and reducing carbon emissions in industrial processes. By showcasing these technologies, the seminar sought to empower businesses with the knowledge and tools necessary to contribute to global sustainability efforts while enhancing their operational efficiency and reducing energy costs. The event featured speakers from leading Japanese companies, industry associations, and Energy Service Companies (ESCOs), facilitating valuable networking opportunities between manufacturers and potential future heat pump installers.

IV. Viet Nam

We did not hold any seminars in Viet Nam during this phase.

V. Thailand

On October 10th, we organised and conducted a seminar in Thailand centred on the theme of decarbonisation, which is becoming an increasingly important topic in the region. The event provided an opportunity to explore the various challenges that Thailand is currently facing in its efforts to reduce carbon emissions. Notably, we highlighted the benefits of adopting technologies of heat pumps and once-through boilers. These technologies were showcased not only for their energy efficiency but also for their potential to significantly reduce CO_2 emissions.

Table 2.9: Presentations held for the Seminar in Thailand

Speaker's Name	Designation	Organisation	Presentation Content
Yohei Ohmori	Deputy Director Industrial Machinery Division	Manufacturing Industries Bureau, Ministry of Economy, Trade and Industry (METI)	Gave opening remark on 'Japan's Green Transformation Strategy Towards Net Zero' with the following topics. • AZEC joint statement and activities • Policy targets in Japan's Energy Policy • 2050 Carbon Neutral and 2030 Climate Goal in Japan • Japan CO_2 emissions and solutions to the world • Green Transformation (GX) • High Value-added Supply Chain to Contribute the International GX
Daisuke Kiuchi	Chief Programme Manager	Economic Research Institute for ASEAN and East Asia (ERIA)	As seminar organiser, gave opening remark related to Asia Zero Emission Center which serve as a platform for stakeholders and AZEC partners' engagement.
Piyatida Trinuruk Kaewchinda	Assistance Professor	Asian Heat Pump & Thermal Storage Technologies Network (AHPNW)	Speak on 'Challenges of Decarbonization in Thailand' topic, with the following contents. • Overview of AHPNW • Decarbonisation in Thailand • Thailand's New Energy Plan (PDP2024 and EEP2024) • Heat Pump Technology and Market in Thailand
Ryosuke Fujioka	Chief Representative	AEM-METI Economic and Industrial Cooperation Committee (AMEICC) Secretariat	Speak on 'Decarbonizing Global Supply Chain through Spurring Consumer-Driven Green Investment' topic, with the following contents. • Motivations toward Decarbonization • Approaches to Increases Energy Efficiency • Spurring Consumer-Driven Green Investment in ASEAN • New Funding Program for GX・DX Training • Financing Green Investment • Support for Establishing a New Rules toward Decarbonization
Akihiro Watanabe	Senior Advisor	MAYEKAWA MFG. CO., LTD	Speak on 'Heat pump for hot water supply and examples of use' topic, with the following contents. • Mayekawa Company Introduction • Heat pump for hot water supply • Advantages of using a heat pump • Introduction Product 'Air Source Heat Pump' • Use cases of heat pump
Kouzu Atsushi	Senior Manager	MIURA CO., LTD.	Speak on 'Once-through Boiler' topic, with the following contents.

			• Miura Company Introduction • Provision of high efficiency once-through boiler systems • Boiler market in Japan • Once-Through Boiler overview • Multiple Installation (MI) system • Hydrogen fired Boiler • MIURA's Maintenance Support • Installation Example

Source: Authors.

VI. India

The seminar, titled 'Decarbonisation with Industrial Heat Pumps & Boilers in India,' held on 3rd October 2024, featured a distinguished panel of Indian & Japanese speakers who explored various aspects of decarbonisation and energy efficiency. The seminar showcased innovative approaches and case studies on reducing greenhouse gas emissions in industrial processes through advanced technologies like industrial heat pumps and energy-efficient boilers.

Table 2.10: Presentations held for the Seminar in India

Speaker's Name	Designation	Organisation	Presentation Content
Satoshi Takagi	Principle Deputy Director	Manufacturing Industries Bureau, Ministry of Economy, Trade and Industry (METI)	• Japan's Green Transformation strategy towards Net Zero • India & Japan's relationship & net-zero goals • Joint Hydrogen Project in India by Yamanashi Hydrogen Company (YHC) and Maruti Suzuki (Case Study) • Policy targets in Japan's Energy Policy • Japan's green transformation GX & CO_2 emissions issue
Daisuke Kiuchi	Chief Programme Manager	Economic Research Institute for ASEAN and East Asia (ERIA)	As seminar organiser, gave a formal address to the audience on the urgency on decarbonisation with industrial heat pumps & boilers in India.
Pramod Kumar Singh	Senior Director Research & Programmes	Alliance for an Energy Efficient Economy (AEEE)	• India's current situation in terms of energy mix and the contribution of energy efficiency in energy intensity reduction • Key drivers of industrial decarbonisation in India • India & global net-zero emissions targets & plans • Industrial energy efficiency initiatives by Indian states

			• Lean-mean-green philosophy for energy efficiency • AEEE association's brief profile & achievements
Akshay Dev	Deputy General Manager	Climaveneta Climate Technologies (Mitsubishi Electric Group Company)	• High-efficient cooling & heating solutions with elaborate functioning • Operating principle of chillers (refrigeration cycle) • Energy efficient chillers • Heat recovery units • High reliability heat pumps • Importance of green refrigerant
Vasantha Kumaran S	Application Engineer, Technical Sales	Aspiration Energy	• Company profile & product portfolio • Heat pumps & chillers functioning • High temperature heat pumps • Common industries using heat pumps • 7 successful case studies of heat pumps

Source: Authors.

7.2 Participant attributes

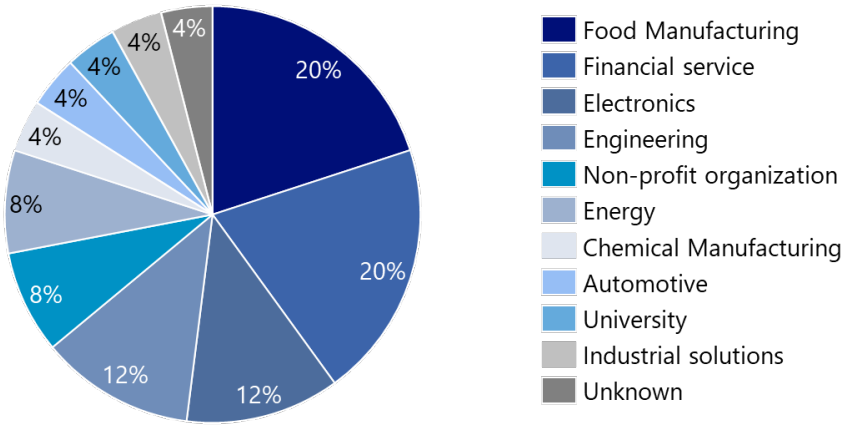
I. Viet Nam

We did not hold any seminars in Viet Nam during this phase.

II. Thailand

The seminar in Thailand had 25 attendees out of the 41 who registered giving out an effective total attendance rate of 61%. The average time joined by the attendees was 1 hour and 22 minutes, showcasing strong interest and engagement from attendees.

Figure 2.21: Industry breakdown of Thailand Seminar Attendees



Source: Authors.

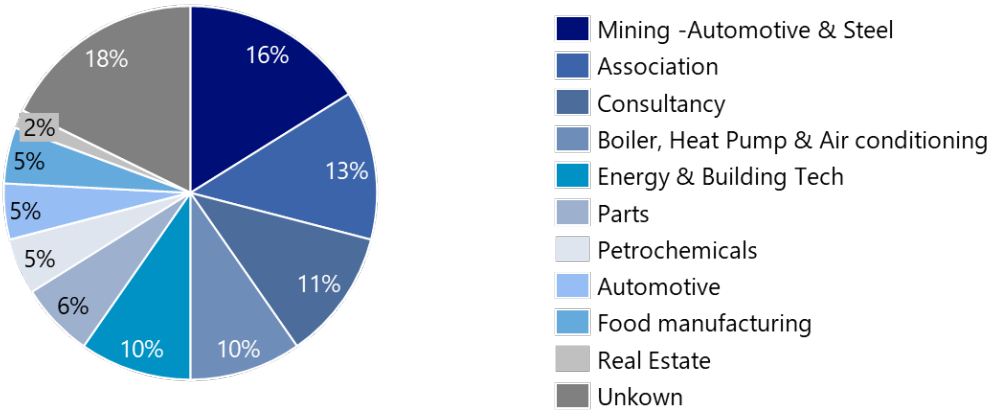
The attendees represented a wide range of industries, with significant participation from Food Manufacturing (5 attendees), Financial Services (5 attendees), Engineering (3 attendees), and Electronics (3 attendees). These industries made up majority of the participants, highlighting their strong interest in adopting sustainable, energy-efficient technologies to lower greenhouse gas emissions. Alongside these key sectors, there were also attendees from various other industries. Most participants are Japanese, with the second majority of Thai, and one Indonesia attendee.

The feedback after the seminar was largely positive, with participants feel satisfied with the overall content and quality of the seminar. Attendees felt that the information presented in the seminar was relevant and applicable to their companies current or future needs. Additionally, some participants are interested in potential collaborations or projects in the future.

III. India

The seminar had 47 attendees out of the 78 who registered giving out an effective total attendance rate of 60%. The average time joined by the attendees was 1 hour and 14 minutes, showcasing strong engagement from attendees.

Figure 2.22: Industry Breakdown of Indian Seminar Attendees



Source: Authors.

The audience came from diverse industries, with a notable presence from Automotive-Mining Companies (8 attendees), Industrial Associations (7 attendees), food manufacturing companies & Dairy (5 attendees). These 3 industries formed the bulk of the participants, reflecting their keen interest in exploring sustainable and energy-efficient technologies for reducing greenhouse gas emissions. In addition to these sectors, attendees from many other industries joined. Geographically, most attendees hailed from India, with few attendees participating from Japan, Thailand, Indonesia, and Singapore.

The post-seminar feedback was positive, with participants appreciating the quality and relevance of the content. Attendees from the mining- automotive, industrial associations, and food manufacturing companies expressed interest in more such seminars on heat pumps and boiler technologies. Participants from the energy and petrochemical sectors were eager for more detailed information. Some attendees also raised technical questions related to the distance between energy generation sources and the equipment using heat-pump output, indicating a desire for more technical insights in future sessions. Attendees also actively engaged in networking throughout the seminar.

Chapter 3

Potential Contribution to Achieving Carbon Neutrality through the Introduction of High Energy Efficiency Equipment

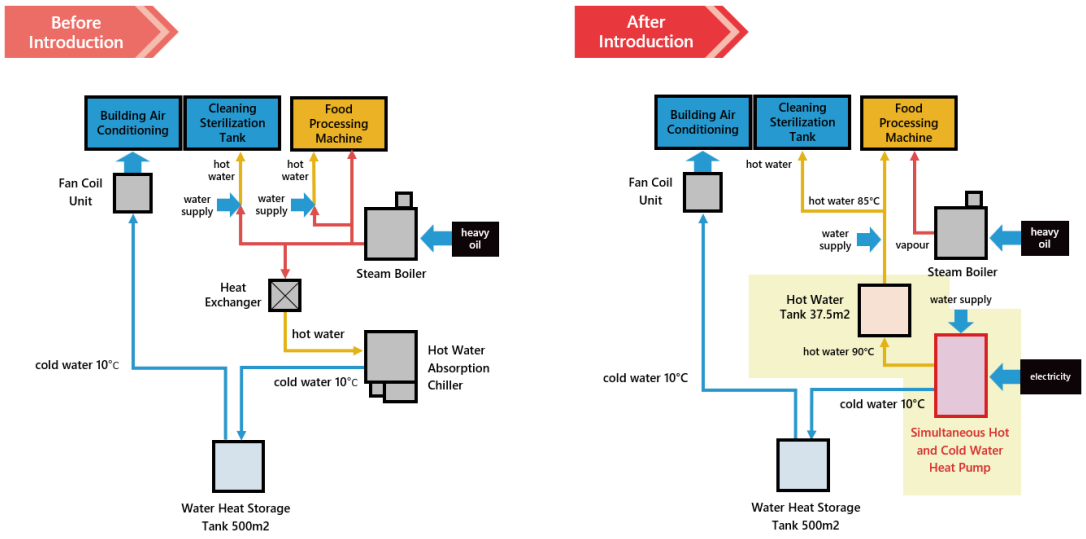
1. Expected Contribution to Carbon Neutrality of Heat Pumps

The impact of heat pumps on decarbonisation varies depending on how they are used. By utilising heat pumps' ability to provide both heating and cooling, as well as recover waste heat, significant improvements in energy efficiency can be achieved.

One case is the use of heat pumps in the production of freeze-dried foods. Heat pumps, which enable the simultaneous extraction of heat and cold, were introduced. In this factory, steam generated by boilers was previously used for food processing equipment and sterilisation/cleaning processes. Additionally, a hot water absorption chiller was employed for air conditioning. These systems were replaced with three heat pumps, which now produce 90°C hot water for the food processing equipment and sterilisation/ cleaning processes. The cooling water from these heat pumps is then utilised for the building's air conditioning.

Furthermore, this case study incorporated a hot water storage tank, allowing for water heating during off-peak night hours. This strategic approach significantly reduced energy costs. The heat pump contributed an 87% reduction in CO_2 emissions and an 80% reduction in energy costs.

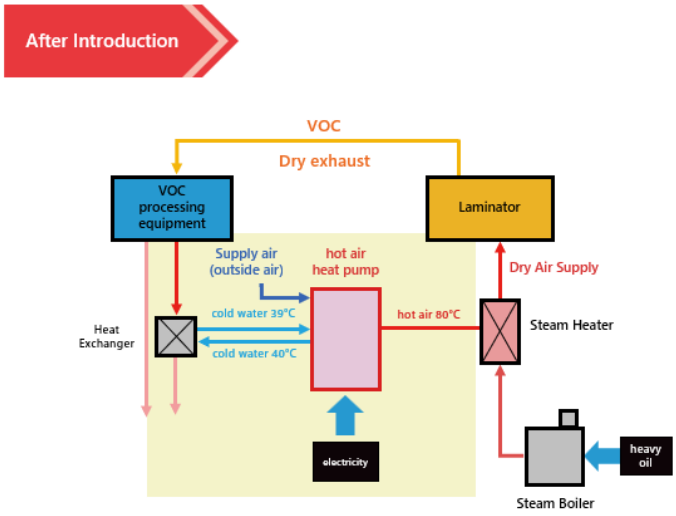
Figure 3.1 Case Study of Simultaneous Usage for Heating and Cooling



Source: New Energy and Industrial Technology Development Organisation (2020).

Another example is the recovery of waste heat in a plastic film manufacturing plant. This factory originally used steam generated by heavy oil boilers. They successfully harnessed waste heat at 55°C from the Volatile Organic Compound (VOC) treatment equipment. Water heated to 39°C through heat exchange with this waste gas was then used as a heat source for a heat pump. The heat pump, in turn, supplied 80°C hot air to the drying process. The introduction of the heat pump resulted in a 60% reduction in primary energy consumption, a 72% reduction in CO_2 emissions, and a 75% reduction in energy costs.[5]

Figure 3.2 Case Study of Waste Heat Recovery



Source: New Energy and Industrial Technology Development Organisation (2020).

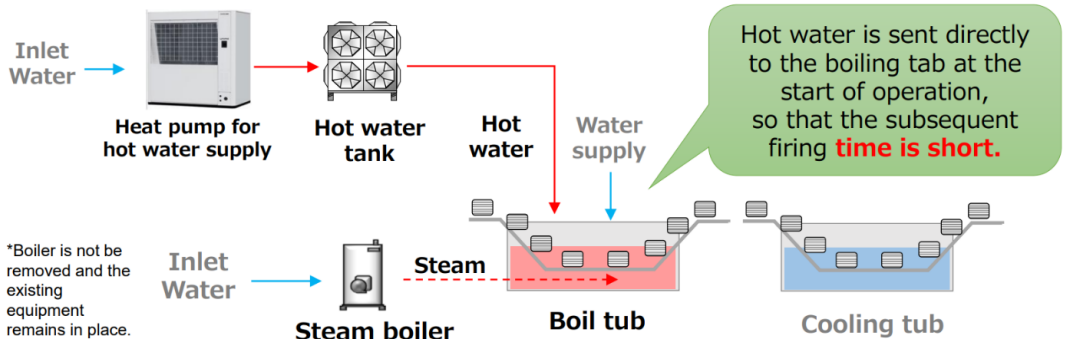
2. Specific Case Studies about Industrial Heat Pumps and Once-Through Boilers

2.1 Case Study 1: Heat pump for hot water supply

In a food production factory making noodles, 3 sets of electric heat pumps are used for hot water production in conjunction with steam boilers. The heat pumps were operated during off-peak period when electricity tariff is lower, producing hot water, which is stored in the hot water tank. Hot water is then supplied directly to the boiling tub, shortening initial heat up time. The set-up leads to 35% reduction in operational cost and 28% reduction in CO_2 emission.

[5] New Energy and Industrial Technology Development Organization "できる、省エネルギー！産業用ヒートポンプ白書", https://www.nedo.go.jp/content/100925495.pdf

Figure 3.3 Case Study of Reducing Initial Heat Up Time



Source: Mayekawa Co. Ltd. (2024).

2.2 Case Study 2: Implementation of once-through boilers

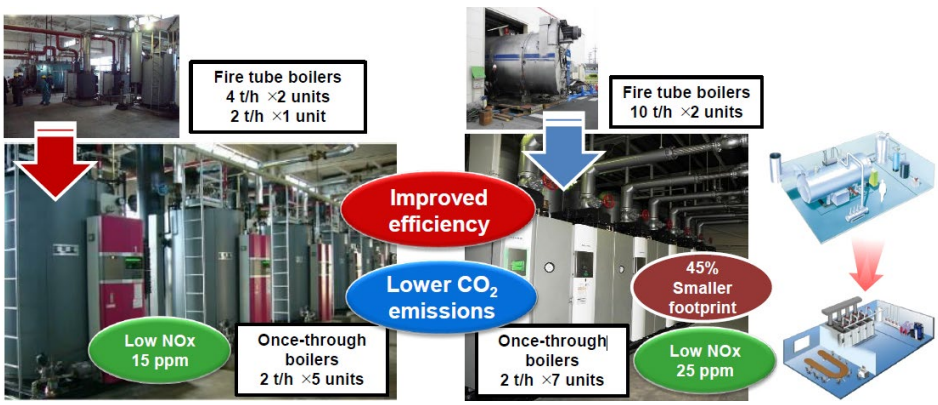
In a case where a factory replaced two 4 t/h fire tube boilers and one 2 t/h fire tube boiler with five 2 t/h once-through boilers, they achieved not only a reduction in NOx emissions but also a 17.6% improvement in energy efficiency and an annual reduction of 1,371 tons of CO_2 emissions.

Figure 3.4 Energy Saving and CO_2 Emissions Reduction by Once-Through Boilers

	Before replacement	After replacement
Boiler type	Fire tube	Once-through
Boiler capacity, quantity	4t/h x 2 2 t/h x 2	2t/h x 5
Boiler efficiency	75.4	93 (17.6% up)
CO_2 emissions (tCO_2/year)	3,813	2,442 (1,371 reduction)

Source: Miura Co. Ltd. (2024).

Figure 3.5 Example of Energy Savings from Once-Through Boilers



Source: Miura Co. Ltd. (2024).

3. Estimation of Carbon Emissions Reduced by Heat Pumps

In a project of the Joint Crediting Mechanism (JCM) in Indonesia carried out by Maekawa Mfg. Co., Ltd. with the partner companies, PT. Adib Global Food Supplies and PT. Mayekawa Indonesia, realised a total of 40 tCO_2 credits were issued over approximately six months. This project involved the introduction of highly efficient cooling equipment using natural refrigerants, specifically ammonia (NH3) and carbon dioxide (CO_2), into the cold chain of refrigerated warehouses. The cooling equipment features a two-stage screw compressor, integrated with an interior permanent magnet synchronous motor, achieving significant improvements in cooling efficiency. This advanced system was installed in the cold storage and quick-freezing facilities of a food processing plant, further contributing to energy savings and CO_2 emissions reduction.[6]

[6] The website of Joint Crediting Mechanism, https://gec.jp/jcm/jp/projects/13pro_ina_03/

Chapter 4

Proposed Measures to Introduce High Energy Efficiency Equipment

1. Target industry for Heat Pumps and Once-through Boilers

When considering industrial applications, they can be broadly categorised into two main sectors: industrial sector and service sector. Table 4.1 presents a qualitative evaluation of the usage methods and temperature ranges for heat pumps and once-through boilers, based on the demand perspectives in Thailand, India, and Viet Nam.

Amongst the industrial sectors, the food and beverage manufacturing industry, machinery and automotive manufacturing industry, and the service sector (including hotels and condominiums) stand out as particularly attractive. These industries are prime candidates for heat pump and once-through boilers adoption due to their energy-intensive processes as well as the growing awareness of sustainability.

The food and beverage industry are one of the most attractive industries because of high heating and cooling demands in factories, particularly in processes such as refrigeration, heating, drying, and pasteurisation. Heat pumps can be used to optimise these processes by providing precise temperature control, providing heating and cooling simultaneously in the process, and recovering waste heat for reuse, which can make factories more energy efficient. In addition, the main customers of food and beverage companies are general consumers. Since the proportion of consumers looking for sustainable products is increasing, this provides an incentive for companies in the food and beverage industry to make their factories more environmentally friendly.

Other industries such as machinery, automotive, paper and chemical are also attractive. These industries are also heavy energy users, particularly in processes such as metalworking, painting, and assembly line operations that require precise heating and cooling. Heat pumps can be effectively utilised in these processes to recover and reuse energy, which can reduce overall energy consumption and improve the environmental footprint of manufacturing operations. These industries are also key drivers of economic growth in Thailand, Viet Nam, and India, as there is a strong focus on modernisation and adopting advanced technologies in these countries.

In India, the textile industry can also be considered a potential market for once-through boilers. India is the second-largest producer of textiles and apparel in the world, with the market projected to reach $190 billion by FY2025. The Indian government is working to enhance the competitiveness of the Indian textile industry and establish India as a global hub for textile manufacturing and exports by developing large-scale textile industrial parks and promoting investment through incentives. The textile industry involves many manufacturing processes that require high-temperature water or steam, making it likely

to have a strong interest in energy-efficient technologies. Once-through boilers, with their high energy efficiency in providing high-temperature water and steam, are highly suitable for such processes.

One reason why these industrial sectors could present a promising market for heat pumps and once-through boilers is that companies not only prioritise energy efficiency but also highly value the stability of their manufacturing processes. In industries where continuous operation is critical, the failure of heating or cooling equipment can cause significant disruptions, leading to production delays, increased downtime, and substantial financial losses. As a result, businesses are increasingly looking for equipment that not only offers high energy efficiency but also ensures consistent and reliable performance. Although the initial cost of such equipment may be higher compared to less efficient alternatives, companies recognise that the long-term benefits far outweigh the upfront investment. Over time, the reduction in energy costs, combined with fewer maintenance issues and minimal downtime due to equipment failure, can lead to significant financial savings. Additionally, the ability to maintain uninterrupted production enhances a company's competitiveness and helps avoid the costly risks associated with operational instability.

The service sector which includes hotels and condominiums is another attractive target for the deployment of heat pumps. This sector not only has a high demand for energy but also faces growing pressure to adopt more sustainable practices. Heat pumps can address these needs effectively, offering significant benefits in terms of energy efficiency, cost savings, and reducing environmental impact. The services sector is a promising market, particularly from the perspective of air conditioning. Since air conditioning accounts for a large portion of electricity consumption and demand is expected to grow, the introduction of high-energy-efficiency equipment is becoming increasingly urgent. By adopting energy-efficient equipment and, in the case of large buildings, implementing central air conditioning systems – where heat generation equipment such as boilers and chillers are centralised and combined with air conditioning units to manage the temperature throughout the entire building – there is significant potential to reduce energy consumption in the services sector.

Hotels and condominiums have a constant and significant demand for hot water, be it for guest rooms, kitchens, swimming pools, or spas. While traditional water heating systems are often energy-intensive, leading to high operational costs and increased carbon emissions, heat pumps provide a more efficient solution by transferring heat from the air or ground to heat water, thus using significantly less energy than conventional systems. Travelers and residents are increasingly concerned about the environmental impact of the places they stay at, and the service sector is responding by seeking out ways to reduce energy use and minimise carbon emissions. However, the demand for hot water in the service sector is not very large, as many areas have warm climates and there is no custom of storing hot water in bathtubs as seen in Japan.

Table 4.1 Market Potential

Equipment	Usage	Temperature	Demand and market potential	Potential
Heat pump	Manufacturing heating and hot water supply in industry	<100℃	There is significant demand for high-temperature steam in factories. However, the use of heat pumps alone to provide high-temperature steam still faces challenges in terms of efficiency and equipment durability. As a result, heat pumps do not yet represent a viable solution for this potential market.	—
		35–100℃	Demand is expected to increase in line with economic growth. Incentives for B2C companies to make their plants more environmentally friendly, especially as an increasing percentage of consumers demand sustainable products	○
	Manufacturing cooling and freezing refrigeration in industry	<15℃	Demand is expected to increase in line with economic growth. In particular, economic growth is increasing demand for frozen and refrigerated foods, so there is a large potential demand for cooling.	○
	Hot water supply in the service sector	35–100℃	Although some hotels and condominiums have swimming pools, the demand for hot water in the service sector is not very high because most areas have warm climates and there is no custom of storing hot water in bathtubs as seen in Japan.	—
	Air conditioning in the service sector	<30℃	Demand is expected to continue to grow, and efficiency improvements are desirable because air conditioning power consumption accounts for the majority of power consumption in the service sector.	○
	Refrigerated / freezer warehouse	<20℃	Major investments are expected to continue in the future.	○
	Data centre	<35℃	Major investments are expected to continue in the future. However, number of facilities are limited comparing to factories.	△
Once-through boilers	Manufacturing heating and hot water supply in industry	>100℃	Demand is expected to increase in line with economic growth. Highly attractive as high-efficiency heating equipment in high-temperature zones that are difficult to generate with heat pumps.	○
		35–100℃	Demand is expected to increase in line with economic growth.	○
	Hot water supply in the service sector	35–100℃	Although some hotels and condominiums have swimming pools, the demand for hot water in the service sector is not very high because most areas have warm climates and there is no custom of storing hot water in bathtubs as seen in Japan.	—
	Steam supply in the service sector	>100℃	Could be used in saunas, but demand is not very large.	—

Source: Authors.

2. Challenges to be Overcome for the Expansion of Adoption of Heat Pumps

2.1 Limited awareness of energy efficiency and benefits

In Viet Nam, Thailand, and India, there is a limited awareness of the broader concept of energy efficiency in these markets. Many businesses and industries prioritise immediate operational cost-savings over long-term energy savings, which lead to a lower emphasis on adopting energy-efficient technologies. In Thailand, efforts toward carbon neutrality are gradually expanding, particularly amongst foreign and large corporations, but these initiatives remain limited in scope.

The general awareness of heat pumps and once-through boilers as an energy-efficient technology is also relatively low. The manufacture and installation of equipment needs to be customised to the individual company's operation and energy consumption. Unlike boilers, heat pumps have the advantage of providing a steady supply of cold or warm water and their efficiency varies greatly depending on how they are used. Therefore, it is important to visualise energy usage for heat pump installations. From this perspective, it is preferable to install heat pumps on a consulting or customised basis. However, the prevalent perspective is that heat pumps often are considered a replacement for boilers. This misconception may cause users to be discouraged from installing heat pumps.

This lack of awareness is a major barrier to the adoption of heat pumps and once-through boilers, as decision-makers are less likely to consider this technology if they are not fully informed about its potential advantages. Unless users can clearly compare the difference in energy efficiency and estimate its effectiveness, it will be difficult for them decide on whether they should install heat pumps.

2.2 Lack of Standardised Metrics and Measurement Methods for Indicating Efficiency

A unified method of measuring efficiency for heat pumps has not been established in Viet Nam, Thailand, and India. COP is frequently used as an indicator of energy efficiency. However, COP fluctuates depending on factors such as outdoor air temperature and the input/output temperature of equipment. For user companies, the inability to compare equipment side by side makes it harder to justify investing in higher energy efficiency devices. This challenge also complicates the introduction of energy efficiency labelling systems, like those used for household appliances. The reason is that the COP can vary significantly depending on testing conditions. A higher COP doesn't necessarily guarantee better energy efficiency, which could undermine trust in a labelling system. Establishing standardised performance metrics and testing methods would help encourage the adoption of more energy-efficient equipment.

2.3 Risks associated with refrigerants

Heat pumps rely on refrigerants, which are central to their operation, to transfer heat. Refrigerants include substances such as fluorocarbons with a high global warming potential, alternative fluorocarbons, ammonia, and carbon dioxide. In Japan and Europe, ammonia refrigerants were the mainstay of refrigerants, they were subsequently replaced with Carbon Fiber Composite (CFC) refrigerants that could achieve higher efficiency. Following that, they were switched to CFC alternatives and natural refrigerants such as ammonia and carbon dioxide as global warming captured attention around the world. On the other hand, ammonia refrigerants and CFC refrigerants are still the mainstream in Viet Nam, Thailand, and India. While heat pumps are equipment that is expected to contribute to decarbonisation, improper handling of CFC refrigerants can conversely lead to global warming and accidents. There is little awareness of the problem of global warming caused by CFC refrigerants, and refrigerants are sometimes released into the atmosphere when equipment is disposed of in Viet Nam, Thailand and India.

Improper installation, maintenance, or disposal can lead to leaks, may not only harm the environment but also pose health risks to workers and the surrounding community. For example, ammonia is a toxic and flammable substance. When mixed with air, it can create the potential for explosions. Because of these risks, the choice of refrigerant needs to be carefully considered. Ensuring the safety of installation, maintenance, and disposal processes is critical to mitigating the risks associated with refrigerants. Most technicians may not be well-versed in best practices for refrigerant charging, recovery, and disposal, which could lead to potential safety hazards and environmental damage.

2.4 Shortage of technicians

Heat pumps are not yet mainstream equipment in these countries, and the number of technicians proficient in their handling is limited. The vast territorial expanse of Thailand, India, and Viet Nam further complicates this issue. It's impractical for manufacturers to ensure safe and environmentally friendly usage of equipment from installation to disposal across such large areas. This geographical challenge underscores the importance of training local technicians who can act as proxies for manufacturers, ensuring proper handling and maintenance of heat pumps throughout their lifecycle.

The benefits of heat pumps are not fully realised by merely installing them. They must be strategically integrated into the overall energy flow of factories and buildings. By carefully analysing how energy is consumed across a facility, heat pumps can be positioned to maximise efficiency and reduce overall energy consumption. For instance, leveraging waste heat and distributing the heating and cooling capacities in a way that complements existing energy needs can significantly enhance the heat pump's performance. This approach ensures that the full potential of heat pumps is tapped, leading to greater energy savings and a more sustainable operation. However, one of the major challenges is the shortage of skilled engineers who can design and propose these optimised energy

solutions. Currently, many heat pump manufacturers address this by sending skilled technicians from their home countries. However, this approach is insufficient for the widespread adoption of heat pumps. For heat pumps to expand on a larger scale, a more comprehensive strategy is needed. The technical expertise required to assess a facility's energy use and suggest the most efficient placement and operation of heat pumps is not yet widespread. Without such professionals, companies may miss opportunities to maximise the energy efficiency gains from these systems. This gap in technical know-how limits the adoption of advanced heat pump technologies and impedes progress toward achieving higher energy efficiency across industrial and commercial sectors. Therefore, increasing the availability of trained experts who can handle energy optimisation will be crucial in expanding the use of heat pumps effectively.

2.5 Need for financial support and incentives

One of the most significant challenges in adopting heat pumps is the high initial cost associated with their installation. Unlike traditional heating and cooling systems, heat pumps often require advanced technologies that enhance efficiency and safety. These technologies include sophisticated control systems, energy optimisation features, and enhanced safety mechanisms. Moreover, the installation of heat pumps often necessitates specialised consulting and customisation to suit specific industrial or commercial needs. The complexity of these systems and the need for tailored solutions mean that the initial investment for heat pumps is considerably higher than for conventional systems. This higher upfront cost can be a major deterrent, especially in cost-sensitive markets. In countries such as Thailand, Viet Nam, and India, where cost considerations play a crucial role in decision-making, it would be desirable to provide financial support to businesses and industries considering the adoption of heat pumps.

Challenges from user companies often highlight the high upfront investment costs. This suggests that the advantages of these technologies are not being fully communicated. It is essential to raise awareness about the value of heat pumps and once-through boilers, not just in terms of cost savings but also in their superior energy efficiency and contribution to environmental sustainability. Fostering an understanding of these broader benefits will be crucial for driving adoption.

3. Proposed Measures to Encourage the Adoption of Heat Pumps

Based on the situation introduced, there is a significant potential demand for heat pumps in Viet Nam, Thailand, and India. Several companies in these countries have the potential to adopt this technology. However, the adoption of heat pumps faces barriers such as high costs and low awareness. Additionally, there are specific considerations to ensure that heat pumps are used safely and in an environmentally responsible manner.

To effectively promote the adoption of heat pumps, it is imperative to address several key areas. First and foremost, increasing awareness of heat pumps is needed. This involves not only informing potential users about the technology but also highlighting its benefits, such as improved energy efficiency and reduced environmental impact. An effective strategy would be to incorporate heat pumps into a labelling system that clearly indicates their high energy efficiency, making it easier for consumers to recognise and appreciate the advantages of these systems. In addition to raising awareness, establishing robust standards and guidelines for heat pumps is desirable. A unified measurement method and standardised indicators will facilitate the cross-comparison of energy efficiency amongst various heat pump models, helping users make informed decisions. These standards will also support the creation of a consistent framework for evaluating and promoting heat pumps in the market.

Furthermore, it is important to address not only the promotion of heat pumps but also their safe and environmentally responsible use. Developing comprehensive guidelines for the installation, maintenance, and disposal of heat pumps will ensure that they are used safely and with minimal environmental impact. These guidelines are considered to cover best practices and safety measures to protect both users and the environment.

Moreover, alongside creating these guidelines, investing in training programmes for local technicians is also helpful. Enhancing the skills and knowledge of technicians through targeted training will ensure they are well-equipped to install, maintain, and troubleshoot heat pumps effectively. This dual approach of raising awareness and building technical expertise will be key to successfully advancing heat pump adoption and contributing to the long-term goal of carbon neutrality.

3.1 Improve awareness of heat pumps and once-through boilers, and their benefits

Given the relatively low awareness of energy conservation, it is crucial to highlight its benefits and promote its adoption. Optimising heat pumps by factoring in energy consumption patterns and utilising waste heat is key to achieving higher efficiency. One approach to foster this understanding is by organising regular seminars and workshops targeting both industry professionals and the general public. This involves educating users on several key aspects: the necessity of energy conservation, the existence of heat pumps, and their potential contributions to energy efficiency.

Firstly, it is important to communicate the role of heat pumps in energy conservation efforts. Users need to understand why energy efficiency is crucial and how heat pumps can play a significant role in achieving these goals. By highlighting the benefits of heat pumps and their potential to enhance energy efficiency, users will be better informed about their value and advantages. Users should be educated on how to operate heat pumps in a manner that maximises their energy efficiency. This includes understanding

best practices for system settings, maintenance, and operational strategies to ensure that heat pumps function at their highest efficiency.

The following topics could be included in the seminar and workshop content:

- A simulation of energy consumption reduction after implementation, providing companies with a clear demonstration of how much cost they can save to help them understand the benefits.
- Emphasising the long-term energy-saving effects, while showing that the payback period for the initial investment is relatively short.
- Highlighting the environmental contribution by reducing carbon footprints through improved energy efficiency.
- Presenting success stories of companies that have implemented heat pumps and improved energy efficiency, helping to alleviate concerns.
- Share firsthand experiences from companies using once-through boilers or heat pumps.
- Visit companies that have actually implemented once-through boilers or heat pumps.

By raising awareness and enhancing knowledge amongst stakeholders, we can drive more informed decision-making, ensuring that heat pumps are utilised to their full potential, thereby maximising energy savings and reducing operational costs.

3.2 Establish standards for indices, evaluation methods, and guidelines to compare equipment performance

At present, there is no widely adopted system for evaluating and comparing the performance of heat pumps in Thailand, Viet Nam, and India. Performance values are greatly influenced by measurement conditions, such as external temperature, pressure, humidity, temperature of the heat source, and temperature of the output water. This lack of standardisation creates confusion amongst consumers and businesses, making it difficult to assess the true energy efficiency and cost-effectiveness of different heat pump models. Additionally, this can lead to inappropriate equipment selection, where consumers might choose a product based on price alone without understanding its long-term energy consumption and operational costs.

To overcome this issue, developing and implementing a set of standardised performance indicators for heat pumps, such as the COP, Seasonal Energy Efficiency Ratio (SEER), and Heating Seasonal Performance Factor (HSPF) can be considered. When setting these indicators, it is also a need to develop standardised testing and evaluation methods that can be used to assess the performance of heat pumps under various operating conditions. These indicators and methods should be adapted to the specific climate conditions and

energy needs of Thailand, Viet Nam, and India to ensure relevance and accuracy. The introduction of these uniform indicators and evaluation methods will support users in their equipment selection and decision-making. In addition, industrial heat pumps could be included in the energy efficiency label programmes that exist in Thailand, Viet Nam, and India. The inclusion of heat pumps in energy efficiency labels would also ultimately increase awareness of heat pumps themselves and their benefits.

To effectively develop and implement standardised performance metrics a dual approach is important. This approach should involve both top-down initiatives driven by local and Japanese governments, as well as international organisations, and bottom-up adoption by manufacturers and user companies.

From the top-down perspective, governments and international institutions must play a pivotal role in establishing clear regulatory frameworks and promoting the widespread adoption of these performance metrics. Governmental bodies should actively encourage the use of standardised indicators by implementing policies, offering incentives, and creating awareness amongst manufacturers and users. For example, Japan could work closely with local governments to set energy efficiency standards that include COP, SEER, and HSPF as key criteria for equipment certification. International organisations such as JAICA could also support this by implementing them as actual projects.

At the same time, a bottom-up approach is crucial to ensure these standards are recognised, applied, and adopted in practice. Manufacturers must be encouraged to integrate these performance metrics into their product development processes. Facilitating technical training for manufacturers on how to incorporate these metrics into their products is one way for widespread. Increasing the number of user companies applying these metrics is another critical aspect of the bottom-up approach. One effective way to achieve this is through the dissemination of success stories from businesses that have implemented heat pumps using standardised performance indicators, demonstrating improvements in energy efficiency and cost savings. By sharing such real-world examples, governments and manufacturers can help alleviate concerns from potential users and promote a wider adoption of heat pumps.

3.3 Creation of guidelines to handle heat pumps and their refrigerants

As the adoption of heat pump technology continues to grow in Thailand, Viet Nam, and India, it is desirable to address the safety aspects of installation, maintenance, and disposal of these systems. One critical aspect that requires particular attention is the handling of refrigerants, which are essential to the operation of heat pumps but can pose environmental and safety risks if not managed properly. There are currently no widely recognised standards in Thailand, Viet Nam, or India. The development of such guidelines in these countries is necessary to ensure the safe and sustainable use of heat pump technology.

In Japan, the Japan Refrigeration and Air Conditioning Industry Association (JRAIA) has established the 'JRA-GL Guidelines,' which set forth proper procedures for the installation, maintenance, and disposal of refrigeration and air conditioning systems, including heat pumps. These guidelines cover critical aspects such as the handling of refrigerants, safety measures, and environmental considerations. Adopting these standards and developing localised guidelines that are adapted to specific regional conditions would enable companies to safely and efficiently use heat pumps while minimising their environmental impact.

To achieve this, it's essential to implement targeted training and certification programmes. These programmes can be designed to equip local technicians and engineers with the skills and knowledge needed for the installation, maintenance, and disposal of heat pumps, following guidelines like the JRA-GL. A systematic training curriculum can be developed in collaboration with local vocational schools and technical universities, incorporating insights from Japanese experts familiar with the JRA-GL guidelines. The programmes will focus on crucial topics such as safe handling of refrigerants, system diagnostics, and environmentally responsible disposal methods. Certification will play a key role, ensuring that only qualified individuals handle heat pump systems. To encourage broad participation, governments and industry associations can provide incentives and grants to individuals and companies that complete these training and certification courses. Additionally, a long-term support framework can be established to ensure technicians remain up to date with the latest standards and practices through ongoing learning and information updates.

Another important step in this process is establishing partnerships between local product suppliers and installation companies. Local installers understand the business practices of their region and can provide valuable advice to tailor the guidelines and training programmes to local cultural aspects. Their local networks may also help in disseminating the guidelines effectively. Foreign manufacturers supplying heat pumps can be valuable partners as they introduce and apply guidelines that reference best practices from other countries. Such partnerships can help translate the guidelines into actual implementation projects, creating successful case studies.

3.4 Improve knowledge of maintenance of heat pumps and once-through boilers

In Thailand, Viet Nam, and India, the limited number of technicians proficient in handling heat pumps and once-through boilers poses significant challenges. To promote the widespread adoption of heat pumps in the industrial and commercial sectors, it is essential to equip technicians with specialised training that addresses the unique demands of each environment. This report outlines the key areas of technical education required for successful heat pump implementation in both segments.

In the industrial sector, such as manufacturing and the food and beverage industries, technicians must possess a strong understanding of the fundamental operation of

industrial-scale heat pumps. This includes knowledge of heat transfer, compression, and expansion principles. Additionally, training in system design and selection is crucial, as technicians need to choose the right heat pump system based on facility size, energy consumption, and temperature control requirements. Installation skills are another priority, particularly in complex environments where heat pumps must be integrated with existing piping, electrical, and HVAC systems. This training must emphasise safe installation procedures and compliance with industry regulations. Regular maintenance and troubleshooting capabilities are also critical, as industrial heat pumps require consistent upkeep to prevent operational issues. Technicians should be trained to inspect components such as compressors, refrigerants, and heat exchangers. Finally, energy efficiency optimisation training is essential, allowing technicians to operate the heat pumps in a way that minimises energy use while maintaining effective performance.

In the commercial sector, which includes hotels, shopping malls, and office buildings, the focus of training shifts slightly. Technicians must understand the basic operation of commercial heat pumps, especially in the context of heating, cooling, and hot water supply. The capacity selection process is critical in these settings, as systems must be chosen based on factors like facility size and heating or cooling load. In addition to selecting the right equipment, technicians should also be proficient in integrating heat pumps with building management systems (BMS) or other automated control systems, ensuring the smooth operation of large-scale facilities. Energy management and monitoring skills are another essential area of training, as commercial buildings often have high energy consumption. Technicians must be equipped to track heat pump performance in real time and make adjustments that enhance energy efficiency. Given the customer-facing nature of commercial environments, especially in hospitality, it is important for technicians to develop strong troubleshooting skills to address equipment failures quickly, minimising the impact on customers.

There are several areas of training that are equally important in both the industrial and commercial sectors. One of these is refrigerant technology. Since heat pumps rely on refrigerants, technicians must understand how to handle them in an environmentally responsible manner. This includes selecting eco-friendly refrigerants and adhering to local regulations regarding refrigerant use and disposal. To address this issue, developing comprehensive training programmes and certification requirements is ideal. These initiatives should cover all aspects of heat pump management, from installation and maintenance to efficient operation and safe disposal, ensuring that technicians are fully aware of the risks and possess the necessary skills to handle refrigerants safely and effectively.

This investment in workforce development goes beyond addressing immediate technical needs. It paves the way for wider adoption of energy-efficient technologies, improved safety standards, and better environmental practices. Well-trained technicians can not only maximise the energy efficiency of heat pumps and once-through boilers while minimising safety risks and environmental harm, but also play a crucial role in promoting

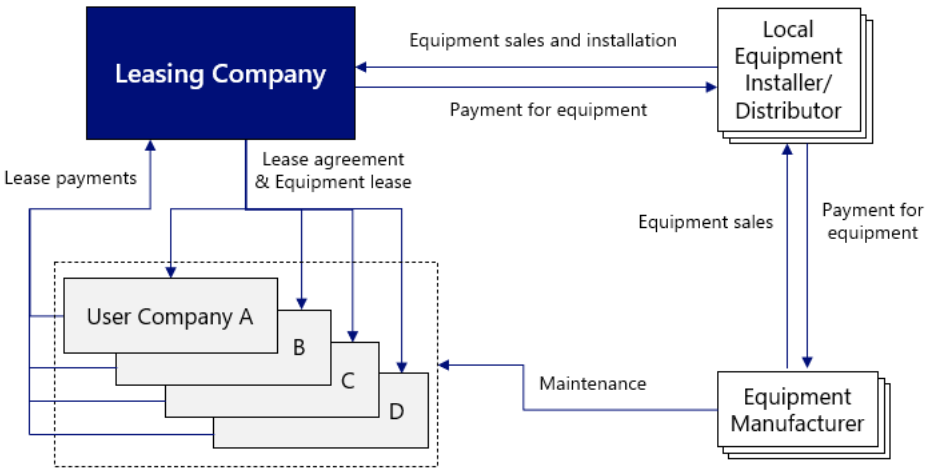
these technologies. By educating end-users about the benefits and proper usage of these systems, they can increase adoption rates and ensure long-term sustainability.

Ultimately, this approach will significantly contribute to these countries' efforts to enhance energy efficiency and reduce their carbon footprint. It represents a strategic investment in the future, fostering a skilled workforce capable of supporting the transition to more sustainable energy solutions while ensuring their safe and effective implementation.

3.5 Introduce a business model with incentives to install high energy efficiency equipment

Many companies are reluctant to adopt heat pumps due to the high upfront installation costs. However, introducing leasing options could help reduce this financial barrier. By offering leasing contracts, companies can significantly lower the initial investment required for heat pump installation, making it easier for them to adopt energy-efficient technologies. This approach would make the technology more accessible and financially viable, especially for SMEs that often struggle to secure the capital needed to cover large upfront costs. This shift is crucial for accelerating the transition to more sustainable energy solutions across various industries. In countries like Viet Nam, Thailand, and India, where equipment leasing is not yet widespread, efforts are needed to promote leasing as a viable option. This includes highlighting benefits such as improved cash flow and the ability to invest in long-term advantages even without immediate available capital. Additionally, leasing provides companies with the stability of predictable long-term equipment operating costs. Successful case studies of leasing implementations can serve as models for other companies, encouraging broader adoption.

Figure 4.1 Sample Leasing Structure



Source: Authors.

Another option is introducing a leasing model that leverages carbon credits. In this system, the leasing company collects the carbon credits generated using energy-efficient equipment and trades them on the carbon credit market. This allows companies to gain carbon credits without any additional effort. This model presents several clear benefits, including financial gains and simplified participation in decarbonisation efforts. Companies using energy-efficient equipment can sell accumulated carbon credits, generating additional revenue or offsetting costs. Furthermore, leasing companies take on the complex administrative tasks associated with carbon credit registration, such as ensuring compliance with certification standards, accurate credit registration, and managing third-party verification. This reduces the burden on individual businesses, lowering the entry barriers for companies interested in decarbonisation. This model is particularly beneficial for SMEs, which often face challenges in financing and implementing sustainability strategies. By offering both financial incentives and easier access to carbon credit markets, this approach accelerates the shift towards a low-carbon economy while enabling a wider range of businesses to participate.

4. Proposed Business Structure to Implement These Measures

To effectively implement these proposed solutions in the target country, it is highly advantageous to proceed with local cooperation such as industry associations and ESCOs. This approach allows for broader outreach to potential users while simultaneously fostering collaboration with the local government.

Industry associations provide platforms for professionals and industry stakeholders to exchange knowledge, promote best practices, and foster innovation. They often have the expertise and resources regarding the industry and business environment, which play a critical role in developing and promoting industry standards, advocating for energy efficiency, and ensuring safety in the design and operation of related equipment. Their network can act as a bridge between government regulators and industry players, and other stakeholders, these associations drive the implementation of sustainable practices, thereby contributing to the overall growth and development of the industry while addressing environmental and energy consumption challenges in the region. Collaborating with these organisations can also help overcome cultural and language barriers, as they are familiar with local customs and communication styles. This can be particularly important in countries like Thailand, Viet Nam, and India, where business practices and regulatory environments may differ significantly from Western countries.

ESCOs are experts in energy efficiency and can provide valuable insights into the implementation of heat pumps and once-through boilers in various industrial and commercial settings. They provide comprehensive solutions, from energy audits to installation and maintenance, ensuring that these technologies are utilised to their full potential, leading to significant energy savings and reduced operational risks. ESCOs can

assist in demonstrating the energy-saving potential and cost-effectiveness of these technologies, which can be crucial in encouraging adoption of heat pumps and once-through boilers.

This strategy of these local engagement serves a dual purpose: it enhances our ability to reach a wider user base and facilitates stronger ties with governmental bodies. By leveraging local expertise and networks, we can ensure that our initiatives are well-aligned with regional needs and regulatory frameworks.

Chapter 5
Conclusion

This project has reaffirmed the critical need for energy-saving equipment in the evolving energy contexts of Viet Nam, Thailand, and India. These countries are facing mounting pressures to optimise their energy consumption, and the demand for technologies that can reduce energy usage has never been more urgent. However, through in-depth interviews with key stakeholders – including manufacturers, ESCOs, and end-user companies – numerous challenges and obstacles have come to light regarding the effective implementation and adoption of these energy-saving technologies.

As Viet Nam, Thailand, and India are expected to face even stricter energy efficiency requirements in the future, the significance of promoting and deploying energy-saving equipment will intensify. Addressing the barriers to adoption, such as high initial costs, lack of technical knowledge, and operational hurdles, will become even more essential in ensuring these technologies can deliver on their potential to reduce energy consumption and lower carbon footprints.

Within the framework of this project, we propose concrete steps to overcome these challenges such as establishing comprehensive standards for user education, developing indicators and evaluation methodologies to effectively compare equipment performance, and creating clear guidelines for the safe and efficient handling of heat pumps and refrigerants. We also propose formulated guidelines to support engineers in the field and developed innovative business models designed to lower the initial investment barrier that often hinders adoption.

Through these multifaceted measures, we hope to significantly enhance the adoption rate of energy-saving equipment – such as heat pumps and once-through boilers – in Viet Nam, Thailand, and India. By doing so, we aim to contribute meaningfully to the reduction of energy consumption in these regions, thereby playing our part in the global fight against climate change. We firmly believe that the widespread deployment of energy-efficient technologies will help accelerate progress toward a more sustainable and environmentally responsible future.

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