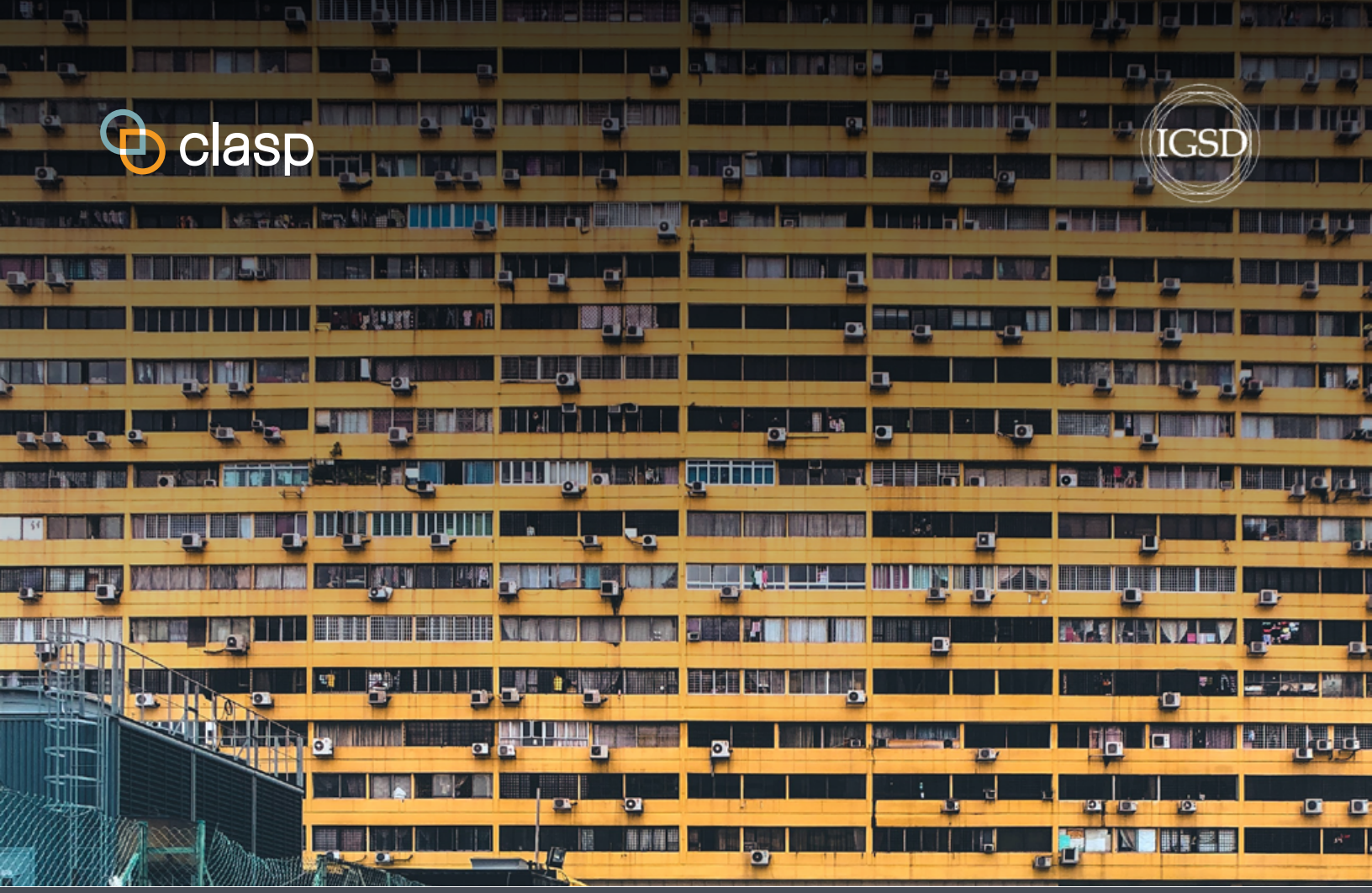

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IGSD

Pathways to Prevent Dumping of Climate Harming Room Air Conditioners in Southeast Asia

20 SEPTEMBER 2023

Partners

Institute for Governance & Sustainable Development (IGSD)

Authors

Lina Kelpsaite, CLASP

Jillian Webber, CLASP

Katriana Dubytz, CLASP

Shirin Mavandad, CLASP

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COLLABORATION

IMPACT

TRANSPARENCY

SERVICE

Acronyms & Abbreviations

AAMRA	ASEAN AEO Mutual Recognition Arrangement
ACFTA	ASEAN-China Free Trade Agreement
ACTS	ASEAN Customs Transit System
AEC	ASEAN Economic Community
AEO	Authorized Economic Operators
AFTA	ASEAN Free Trade Area
AHTN	ASEAN Harmonize Tariff Nomenclature
AJCEP	ASEAN-Japan Comprehensive Economic Partnership
AKFTA	ASEAN-Republic of Korea Free Trade Area
AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
ATIGA	ASEAN Trade in Goods Agreement
BAU	Business As Usual
BRI	Belt and Road Initiative
BSRIA	Building Services Research and Information Association
BTU	British Thermal Unit
CBDR	Common But Differentiated Responsibilities
CAP	Compliance Assistance Programme (UNEP)
CEPT	Common Effective Preferential Tariff
CFC	Chlorofluorocarbon
CCAC	Climate & Clean Air Coalition
CITIRA	Corporate Income Tax and Incentives Rationalization Act
CSPF	Cooling Seasonal Performance Factor
DTA	Double Taxation Agreement
ED	Enhanced Deductions
EPZ	Export Processing Zones
FTA	Free Trade Agreement
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	German Agency for International Cooperation
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HPMP	HCFC Phase-out Management Plan
IGSD	Institute of Governance & Sustainable Development
IES	Industrial Estates
ISO	Organization for Standardization
ITH	Income Tax Holiday
JRAIA	Japan Refrigeration and Air Conditioning Industry Association
JV	Joint Venture
kW	Kilowatt
LBNL	Lawrence Berkeley National Laboratory
MEPS	Minimum Energy Performance Standard
MFN	Most Favorable Nation
MNI	Mitsubishi Heavy Industries
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MRA	Mutual Recognition Agreement
$MtCO_2e$	Metric tonnes carbon dioxide equivalent
NOU	National Ozone Unit
ODS	Ozone-Depleting Substance
R&D	Research and Development
RAC	Room Air Conditioner(s)
RCEP	Regional Comprehensive Economic Partnership
SCIT	Special Corporate Income Taxes
SEA	Southeast Asia
SEA Network	Southeast Asia Network of Ozone Officers
SEZ	Special Economic Zones
SHINE	Standards Harmonization Initiative for Energy Efficiency
SIDA	Swedish International Development Co-operation Agency
THACOM	Thai Compressor Producing Company
U4E	United for Efficiency
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VAT	Value-Added Tax
WCO	World Customs Organization
Wh	Watt-hour

Preface

By Viraj Vithoontien, who worked for 24 years on the Montreal Protocol Operations. The Montreal Protocol phases out the consumption and production of Ozone Depleting Substances (ODS).

Three decades ago, while working for the government of Thailand I was on the team that determined that the majority of ODS used in Southeast Asia were for production of electronics equipment made by multinational companies for sale in developed countries.

A positive outcome was when our team announced our findings, multinational companies accepted shared responsibility and signed a leadership pledge to phase-out ODS from factories in developed countries within one year of phaseout in their home country.

This report evaluates the dumping in Southeast Asia of new cooling equipment containing obsolete refrigerants scheduled for phase out and phase down under the Montreal Protocol. Let us ensure these latest findings build agreement for shared responsibility to make the most affordable and sustainable cooling technology available in every country worldwide.

Contents

1. Executive Summary

Southeast Asia (SEA) is one of the hottest regions in the world. Like other parts of the world hit with rising temperatures and heatwaves, people in SEA are looking to cooling technology like Room Air Conditioners (RACs) to cope with the heat and lead productive lives.

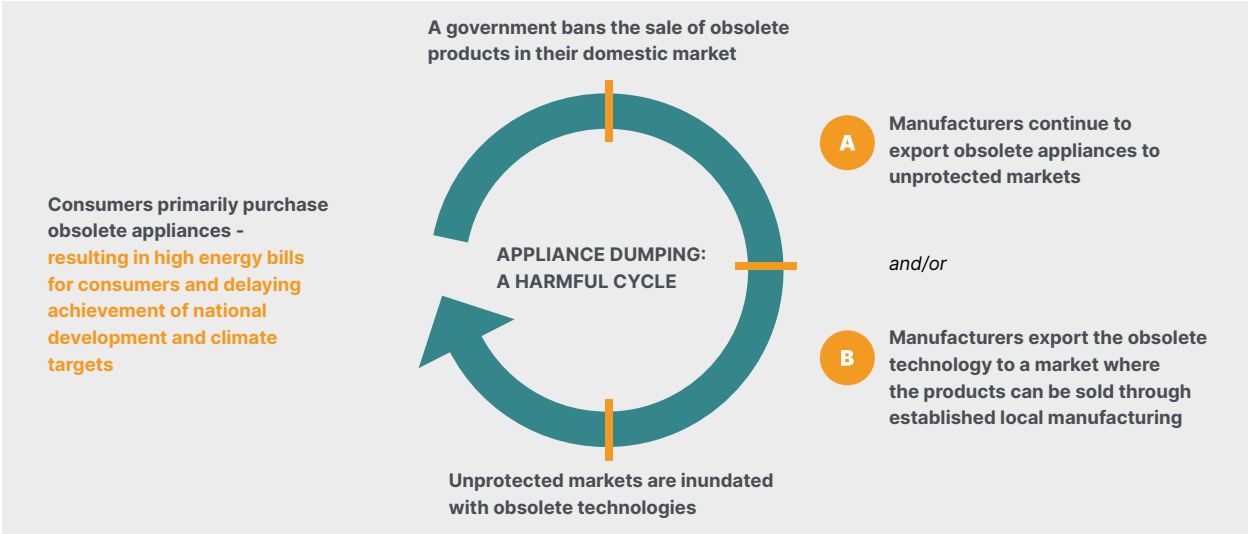
In 2019, only 15% of SEA households owned an air conditioner, but RAC sales are set to rise sixfold in the next two decades.[1]

The widespread availability and affordability of energy efficient RACs will be pivotal to reduce the impact of these air conditioners on national electricity grids and the climate. Efficient models will also save money for governments and consumers, due to the reduced running costs of the efficient models.[1]

Currently energy efficiency policies in SEA lag behind the innovation in RAC technology and the policies of surrounding countries. As low-efficiency and high-global warming potential (GWP) refrigerants are banned in markets around the world, SEA is at risk of becoming a dumping ground for obsolete appliances manufactured by multinational companies that are banned in their own domestic markets (Figure 1). Rolling out and enforcing national energy efficiency policies coupled with accompanying measures would halt this trend.

In an effort to provide insight on six Southeast Asian markets at risk of environmental dumping, CLASP assessed the RAC markets for Indonesia, Malaysia, the Philippines, Singapore,[2] Thailand, and Vietnam. The six countries represent 90% of the regional SEA market. CLASP and IGSD welcome suggestions for future research on topics and countries not included in this report.

FIGURE 1: A HARMFUL CYCLE OF APPLIANCE ENVIRONMENTAL DUMPING



1 IEA. 2022. Roadmap Towards Sustainable and Energy-Efficient Space Cooling in ASEAN. https://iea.blob.core.windows.net/assets/734a5f85-db0a-4d27-a457-3b04adc3af00/Roadmap-TowardsSustainableandEnergy-EfficientSpaceCoolinginASEAN.pdf

2 Singapore was included as a benchmarking for regional RAC efficiency.

1.1. REGIONAL CONTEXT OF THE SIX COUNTRIES

Among the six countries analyzed, Malaysia and Singapore have the highest ownership of RACs (over 80% of households own one). Indonesia and the Philippines have the lowest ownership rates (at or below 25%), followed by Thailand and Vietnam (at or below 55%).

Large multinational companies dominate RAC sales in the SEA market, at 89% of total 2021 sales. Most of the RACs available are produced in SEA, with Malasia and Thailand producing most of the RACs for domestic use and export. All six countries also import RACs to meet the growing demand. About half (52%) of imported RACs are traded within the region, while the remaining proportion (47%) is imported from outside the region, primarily from China.[3]

Around the world, major economies like Brazil, China, India and Japan, have adopted increasingly stringent Minimum Energy Performance Standard (MEPS) to help drive the market shift to more efficient RAC technologies. However, the policies in SEA countries have not kept up so the RACs produced locally, along with those imported, are widely inefficient.

MEPS are among the key tools that should be used together to fight inefficient appliance dumping, but they cannot address this problem in isolation.[4] Solutions require a suite of policies, including collaborative efforts between exporting and importing countries.

1.2. TECHNICAL NOTE

For the purpose of this report, the low efficiency threshold is aligned with China (inverter) MEPS level (CSPF 6.1 Wh/Wh for CC ≤ 4.5 kW, CSPF 5.1 Wh/Wh for 4.5 kW < CC ≤ 7.1 kW, and CSPF 4.5 Wh/Wh for 7.1 kW < CC ≤ 14.0 kW), the ASEAN 2025 MEPS target level, and U4E model regulations for air conditioners. Similarly, high-GWP for RACs is above the 750 GWP threshold recommended in the U4E model regulations.[5]

1.3. KEY FINDINGS

1. Dumping of Low Efficiency RACs in Southeast Asia

- **Inefficient RACs dominate Southeast Asian markets.** There were **6.2 million low efficiency RACs sold in 2021** among the six Southeast Asian markets, **74% of total sales**. These high sales pose increased cost and energy consumption burdens for consumers and the energy grid.[6] The largest proportion of inefficient RAC sales occurred in Indonesia and the Philippines,[7] at 97% and 78% respectively. Malaysia, Thailand, and Vietnam, each had 60% or more of low efficiency sales. Singapore has the most efficient RAC market, with just 21% of low efficiency RAC sales.
- **Most low efficiency RACs produced in Southeast Asia region are by multinational companies.** Among the six markets, 59% of low efficiency sales were produced in the region by multinational companies by multinational companies headquartered in Japan, South Korea, China, and the U.S. All brands produce low efficiency RACs.[8] The remaining 12% of low efficiency sales were produced locally by Southeast Asian companies.
- **About one-fourth (29%) of low efficiency RACs were imported from outside the SEA region, with 82% of imported RACs coming from China.** These were imported mainly by multinational companies, subsidiaries to multinational companies, or joint ventures (JV) with multinational companies based in Japan, South Korea, China and the U.S.
- **Most RACs imported to SEA do not meet export country MEPS. 93% of RACs imported to SEA from China do not meet China MEPS.** Of RAC imports from China, 93% of Japanese brand models, 94% of South Korean brand models, 96% of Chinese brand models, and 85% of JV company brand models do not meet China MEPS. 59% of RAC exports from South Korea to SEA are below South Korea's MEPS levels and 21% of RAC exports from Japan to SEA are below Japan Top Runner requirements.

3 COMTRADE 2023
4 See Andersen, Stephen O., Ferris, R., Picolotti, R., Zaelke, D., Carvalho, S., Gonzalez, M. (2018). Defining the legal and policy framework to stop the dumping of environmentally harmful products. Duke Environmental Law & Policy Forum: Vol. XXIX:1., Part V, Tool 5. http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf.
5 U4E Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Air Conditioners: https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/. For the purpose of regulations, this report aligns with GWP values used by the Montreal Protocol Kigali Amendment Annex F Controlled Substances.
6 Total sales in 2021 (8.3 million) include 12% of sales for which CLASP does not have efficiency data and therefore cannot categorize as low efficiency. It is likely the percentage of total sales that were low efficiency in 2021 is higher than 74%.
7 Including both window and single split systems.
8 CLASP identified 27 unique brands across six markets with known market shares which were provided by BSRIA.

- **China, Japan, and South Korea[9] do not have policies that prevent dumping.** This means MEPS do not apply to appliances for export and export products cannot be sold domestically.
- **Nine of the most popular multinational brands operating in the SEA region have set climate commitments and sustainability goals.** These companies have made commitments to achieve carbon neutrality by 2030 (Carrier, LG), 2050 (Daikin, Hitachi, Mitsubishi Electric, Panasonic, Samsung and Sharp), or 2060 (Midea). All companies except for Samsung and Sharp aim to achieve net zero from the entire value chain, including improved product efficiencies and use of lower-GWP refrigerants. Continuing to manufacture and sell inefficient products undermines these commitments and goals.

2. Impact of Dumping of Low Efficiency RACs Using High-Global Warming Potential Refrigerants into Southeast Asian Markets

- **Inefficient RACs cause indirect greenhouse gas (GHG)** emissions from the fossil fuel-based electricity used to power the appliances over their lifetime. The use of high-GWP refrigerants also contributes to direct GHG emissions from leakage over the RAC life cycle and end of life discharge of the refrigerants.
- **Transitioning to high efficiency RACs that use lower-GWP refrigerants can reduce the cost burden** on consumers and help governments achieve national development and climate targets.

3. Impact of Three Policy Scenarios

To assist policymakers and other stakeholders understand the environmental effects of dumping RACs in Southeast Asia, CLASP modeled the potential impact of three policy scenarios benchmarked against no policy intervention (Business As Usual). The policy scenarios are:

- **Business As Usual (BAU) –** Current market and future projections in accordance with current growth trends without policy intervention. A gradual market transition to a low-GWP refrigerant[10] beginning in 2035 is assumed in accordance with the Montreal Protocol HFC phase-down schedule and technological development trends.
- **Policy Scenario 1 –** Adoption of China MEPS[11] for RACs in 2025.
- **Policy Scenario 2 –** Adoption of China MEPS for RACs in 2025 and regulation of refrigerant usage in RACs in accordance with United for Efficiency (U4E) guidelines[12] (GWP ≤ 750 and ODP = 0) in 2025.
- **Policy Scenario 3 –** Adoption of China MEPS for RACs in 2025, regulation of refrigerant usage in RACs in accordance with U4E guidelines (GWP ≤ 750 and ODP = 0) in 2025, and an accelerated market transition to a low-GWP refrigerant, which will be introduced to the market in 2025.

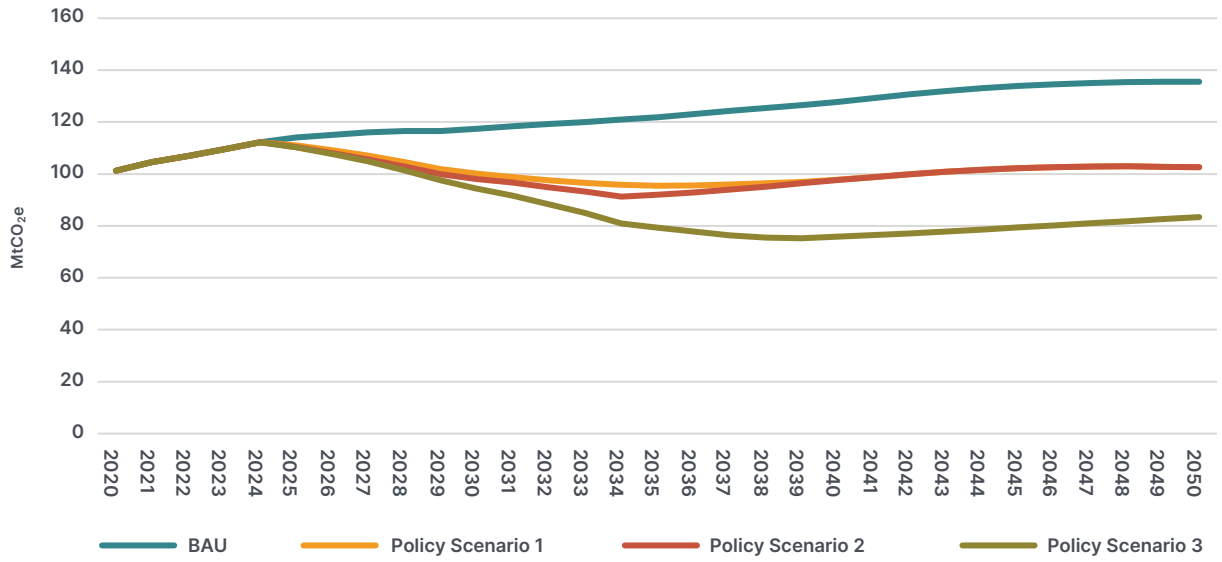
Nonetheless, for purposes of assessing the policy scenarios, if all six countries adopted China MEPS by 2025 (Policy Scenario 1), the region would achieve emissions reductions of **639 $MtCO_2e$ cumulatively 2025-2050** (Figure 6) or a 20% reduction as compared with BAU (Figure 2). These reductions are equivalent to avoiding emissions from 12 coal-fired power plants from the region over that same period.[13]

If all six countries adopted China MEPS and U4E refrigerant guidelines (Policy Scenario 2), the region would achieve emissions reductions of **675 $MtCO_2e$ cumulatively 2025-2050.**

If all six countries adopted China MEPS, U4E refrigerant guidelines, and an accelerated low-GWP transition starting in 2025 (Policy Scenario 3), the region would achieve emissions reductions of **1,039 $MtCO_2e$ cumulatively 2025-2050**, nearly one third of emissions reduction as compared with BAU (Figure 3). This scale
of emissions reductions would have a tangible influence on national climate goals.

9 Per MOTIE Notification No. 2020-225 RACs, producers are prohibited to produce, import and sell RACs that do not meet MEPS.
10 R-290 is used as the low-GWP refrigerant (including factors like GWP, charge, etc.).
11 China's current MEPS for inverter, cooling-only RACs: CSPF 6.1 Wh/Wh for CC ≤ 4.5 kW, CSPF 5.1 Wh/Wh for 4.5 kW < CC ≤ 7.1 kW, and CSPF 4.5 Wh/Wh for 7.1 kW < CC ≤ 14.0 kW (converted from China SEER in GB 21455—2019 to ISO CSPF using "Lost in translation" (2020) by Park et al.). These MEPS are harmonized with U4E guidelines and ASEAN 2025 target MEPS and countries globally seek to harmonize to this level.
12 In September 2019, United for Efficiency (U4E) published model energy performance standards and labeling guidance to assist governments in developing and emerging economies in establishing or strengthening their regulations. These guidelines present an opportunity for African countries to harmonize around ambitious and achievable MEPS and refrigerant requirements. GWP of 750 was chosen to allow for R-32. https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/
13 Assuming 500 MW capacity at 50% load factor with 34% efficiency and a carbon emission factor of 95.52 kg CO2/mmBtu, where annual emissions stay constant year-on-year.

FIGURE 2: ANNUAL COMBINED DIRECT AND INDIRECT EMISSIONS ($MtCO_2e$) FOR THE AGGREGATED SIX COUNTRIES, BY POLICY SCENARIO, 2020-2050

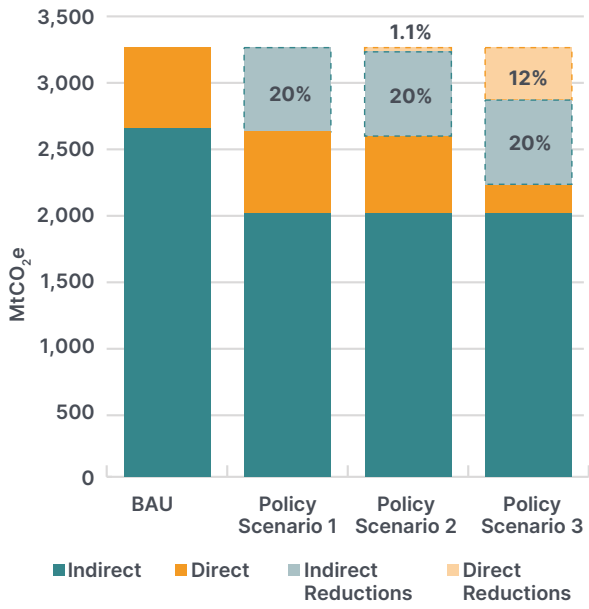


The cost savings of reduced electricity usage resulting from the implementation of MEPS in the policy scenarios would be **USD 148 billion cumulatively 2025-2050**, aggregated across all six countries. These cost savings exceed the combined energy investment of the six analyzed countries over the last quarter century (USD 134 billion).[14] This magnitude of savings could meaningfully impact Southeast Asian consumers.

1.4. KEY TAKEAWAYS FOR POLICYMAKERS AND OTHERS TO PREVENT ENVIRONMENTAL DUMPING OF RACS

- **Environmental dumping occurs not only through imports, but also through low efficiency RAC production by multinational brands operating in the region.** Measures like energy efficiency policies and energy efficiency-minded trade policies can work together to support Southeast Asian countries meet consumer demand and achieve climate goals, while simultaneously limiting emissions from the cooling sector.
- **Effective solutions to environmental dumping are a shared responsibility.** The actions to stop environmental, financial, and compliance burdens from dumping require collaboration with and mitigating actions from importing- and exporting-country stakeholders. In this regard, it is important to keep in mind the capacity limitations of low-

FIGURE 3: CUMULATIVE EMISSIONS AND EMISSIONS REDUCTIONS ($MtCO_2e$) FOR THE AGGREGATED SIX COUNTRIES, 2025-2050, BY EMISSION TYPE AND SCENARIO, WITH PROPORTION OF REDUCTIONS FROM TOTAL BAU EMISSIONS INDICATED



14 "Investment in energy with private participation (current USD", World Bank (1998-2022), https://data.worldbank.org/indicator/IE.PPI.ENGY.CD

resource import countries. Un- and under-regulated markets are the most vulnerable to the impact of inefficient RACs using high-GWP refrigerants.

Based on the findings of this report and drawing from IGSD's anti-environmental dumping "toolkit",[15] Southeast Asian policymakers and other stakeholders can take the steps outlined in Figure 7 and work together to halt environmental RAC dumping. Through collaboration with export countries and the private sector, and with support from the Montreal Protocol, SEA countries can ensure the transition to highly-efficient, low-GWP RACs in the South Asian markets.

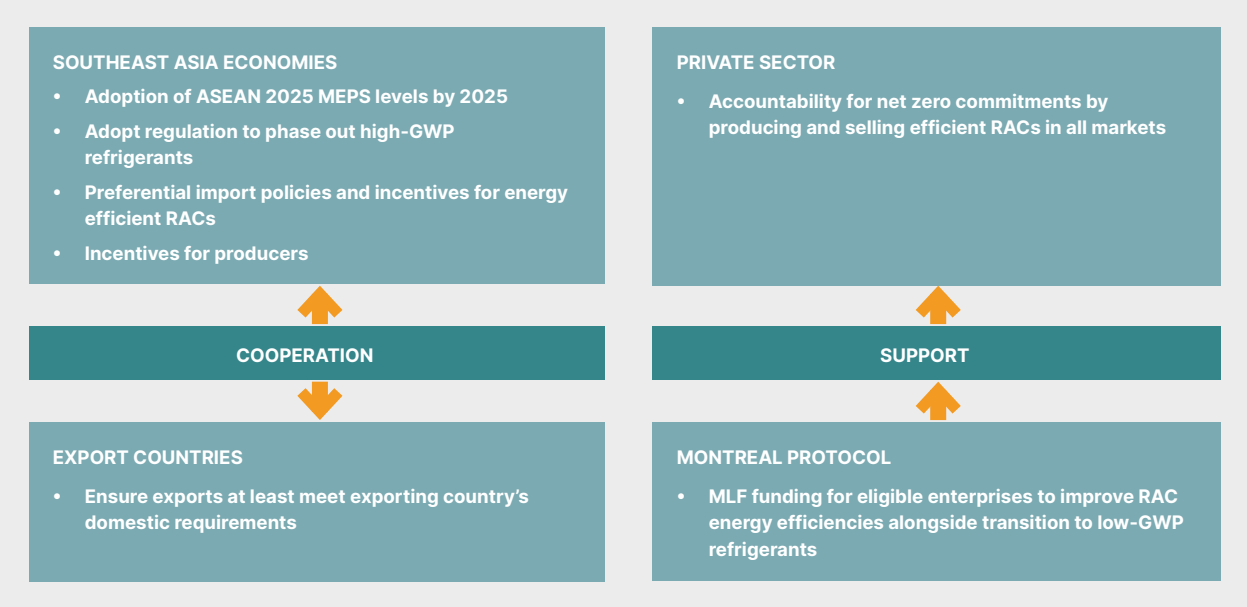
a. Recommendations for Policymakers in Countries Exporting to SEA

- **Ensure exports at least meet the exporting country's domestic requirements.** Environmental dumping is a shared responsibility and exporting countries are part of the solution. Lack of policies that prevent dumping facilitate the export of products banned domestically and undermines import countries' economies. Exporting inefficient, environmentally harmful RACs creates a market for poor quality appliances that worsen air pollution and climate resilience – global issues that do not recognize national borders. Export economies can show leadership and commitment to climate, development and international environmental justice by aligning exports with domestic market requirements.
- **Export countries can also remove loopholes or exemptions that allow such exports** and promote other policy mechanisms, agreements and cooperation with key stakeholders that will disincentivize export of low-efficiency RACs using high-GWP refrigerants. Such policies will not only benefit SEA economies, but all import markets.

b. Recommendations for Policymakers in SEA Economies

- **Adopt ASEAN 2025 Target MEPS levels by 2025 consistent with major trade partners.** Currently, the MEPS for RACs in the Southeast Asian countries, except for Singapore, are much lower than those of the major Southeast Asia region trade partners including China, South Korea, and Japan. China adopted world-leading MEPS in 2020 prompting a major market transformation to more efficient units with low-GWP refrigerant. Southeast Asian countries agreed to adopt ASEAN

FIGURE 4. RECOMMENDATIONS FOR POLICY MAKERS AND OTHER STAKEHOLDERS TO PREVENT ENVIRONMENTAL DUMPING OF ROOM AIR CONDITIONERS (RACs)



15 For more information refer to "Defining the legal and policy framework to stop the dumping of environmentally harmful products." http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf.

2025 MEPS target for RACs, but to-date, only Singapore is on track to meet this commitment. Implementing MEPS at levels comparable to MEPS in RAC source countries can prevent the environmental dumping of inefficient products and provide substantial GHG emissions savings over time.

- **Adopt regulations in line with the Kigali Amendment to accelerate phase out high-GWP refrigerants.** The Kigali Amendment to the Montreal Protocol calls for gradual reduction in the consumption and production of HFCs. The share of RACs with R-32 is rapidly increasing in the six countries. Phasing out the remaining market share of R-410A RACs, an obsolete high-GWR refrigerant, would help SEA economies meet climate targets and commitments under the Kigali amendment. SEA countries can follow Singapore's lead and adopt policies banning high-GWP refrigerants to reduce climate impact.
- **Introduce preferential import policies and incentives to promote high efficiency RACs.** Preferential import policies for efficient equipment[16] can help promote adoption of the equipment and make it more competitive. The measures can include reduced import duties, lower value-added taxes, subsidies, and others. The preferential treatment of efficient RACs can be built in Free Trade Agreements, e.g., ASEAN-China FTA can include a provision of incentives for companies importing RACs that meet China's MEPS or introduce reciprocal efficiency requirements for appliances. Policy makers can also consider adding import criteria of only high efficiency RACs to Authorized Economic Operators (AEOs) certification; this could provide benefits to companies including priority treatment (e.g., for inspections), simplified and expedited procedures, lower inspection rates, and financial incentives.
- **Design incentive programs for producers to produce and consumers to buy more efficient RACs.** Incentive and financing programs for consumers such as on-bill-financing can help spur demand for highly efficient RACs. Green government procurement is also an effective means to promote energy efficient appliances. Through green procurement, governments can demonstrate the benefits of transitioning to efficient RACs and signal to producers to produce more efficient RACs. Bulk purchases help to aggregate demand and purchase high efficiency and low GWP RACs at affordable prices. This type of program can be designed to target replacement of older and inefficient RAC equipment that contains high-GWP refrigerants.

c. Recommendations for Stakeholders in the Private Sector Doing Business with SEA

- **Commit to net zero by producing and selling efficient RACs in all markets.** Nine out of the ten most popular multinational brands have committed to net zero targets, with seven companies aiming to reduce emissions throughout their value chain, including use of their products by consumers.
- **Provide transparent, publicly available strategies and actionable plans to meet net zero goals,** as well as instruments to track progress and measure impacts. Strategies to bring efficient appliances to all consumers should be part of any corporate strategy to meet net zero targets.
- **Extend commitments to produce and promote efficient appliances equally to all markets globally.**

d. Recommendations for Stakeholders of the Montreal Protocol

- **Provide MLF funding for local enterprises to improve RAC energy efficiencies alongside the transition to low-GWP.** Governments are concerned about protecting local production and MLF support for energy efficiency improvements to locally owned RAC producers in the five SEA countries could help strengthen and maintain their competitiveness. Maintaining the energy efficiency enhancement as part of HFC phase down strategy could benefit the Southeast Asia producers and local markets.

16 For example, policies that require meeting exporting-country or benchmark MEPS such as China's.

2. Introduction

IMAGE: JOSHUA TSU / UNSPLASH

The demand for cooling is rapidly growing both globally and in Southeast Asia (SEA) as more people seek thermal comfort in increasing temperatures and heatwaves. SEA is one of the hottest regions in the world; to survive and maintain productivity, more households are purchasing air conditioning units.[17] In 2021, 8 million of the 188.6 million global room air conditioner (RAC) sales were in Southeast Asia, yet as of 2019 only 15% of households own an air conditioner.[18] Affordability to purchase air conditioner remain a challenge for many.[19]

In July 2023, the UN signaled that the 'era of global boiling has arrived.' Record heatwaves have sweltered much of Asia and are expected to worsen.[20] To cope with rising temperatures and to meet the needs of urbanizing populations, RAC sales in SEA are expected to rapidly rise in coming years. To run these systems, national energy grids may be stretched beyond capacity. The availability of energy efficient RACs will be pivotal to reduce the impact of growing RAC use on electricity grids, the climate, and consumers.

RAC technologies have significantly evolved since early 1980s when inverter technology was introduced for air conditioning.[21] Highly efficient units are widely available globally, yet Southeast Asian markets are dominated by RACs that strain the grid, burden consumers with high energy bills, and release refrigerants that harm the ozone layer. Energy efficiency policies in SEA lag behind developments in RAC technology. Without these policies in place and enforced, SEA countries face "environmental dumping" of inefficient RACs that use high-global warming potential (GWP) refrigerants.

2.1. PROJECT BACKGROUND

In a 2018 publication in the Duke University School of Law's Environmental Law & Policy Forum, "the dumping of environmentally harmful products" (henceforth, "environmental dumping") is defined as the practice of exporting products to another country or territory that:

1. Contain hazardous substances,
2. Have environmental performance lower than is in the interest of the local and global consumers or that is contrary to the interests of the local or global commons, or
3. Can undermine the ability of the importing country to fulfill international environmental treaty.[22]

In the case of RAC equipment, this includes:

- Export of technology that cannot legally be sold in the country of export as a consequence of failure to meet environmental, safety, energy efficiency, or other product standards.
- Export of technology that is unusable in the country of export because refrigerants are no longer available because of national regulation or phase-out and phase-down control schedules under the Montreal Protocol.[23]

In 2020, CLASP conducted a study on *Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa* in collaboration with IGSD.[24] The goal of the study was to assess the extent and impacts of environmental dumping of inefficient room air conditioners and identify the underlying factors that enable dumping (i.e., lack of minimum energy performance standards (MEPS), unfavorable trade agreements, etc.). The study analyzed market profiles for 10 of the largest cooling equipment markets in Africa. The findings confirmed market evidence of environmental dumping of inefficient, high-GWP cooling appliances into African markets. The majority of low efficiency RACs are imported into Africa from outside the region, but a significant number of low efficiency RACs are also assembled by joint ventures (JVs) between local African companies and large non-African producing

17 BSRIA, 2023.
18 "The Future of Cooling in Southeast Asia," International Energy Agency, October 2019, https://iea.blob.core.windows.net/assets/dcadf8ee-c43d-400e-9112-533516662e3e/The_Future_of_Cooling_in_Southeast_Asia.pdf.
19 Ibid..
20 Raul Dancel, "Record heatwave of up to 45 deg C scorches much of Asia, and it's going to get worse," *The Straits Times*, 20 April 2023, https://www.straitstimes.com/asia/record-heatwave-of-up-to-45-deg-c-scorches-much-of-asia-and-it-s-going-to-get-worse. See also: Ajit Niranjan, "'Era of global boiling has arrived,' says UN chief as July set to be hottest month on record," *The Guardian*, 27 July 2023, https://www.theguardian.com/science/2023/jul/27/scientists-july-world-hottest-month-record-climate-temperatures.
21 Toshiba. What is the inverter technology all about? http://www.toshibacca.com/en/learn-more/what-is-inverter#:~:text=In%201980%2C%20Toshiba%20invented%20the,leading%20brands%20of%20air%20conditioners.
22 Andersen, Stephen O., Ferris, R., Picolotti, R., Zaelke, D., Carvalho, S., Gonzalez, M. (2018). Defining the legal and policy framework to stop the dumping of environmentally harmful products. Duke Environmental Law & Policy Forum: Vol. XXIX:1. http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf.
23 Ibid.
24 CLASP. 2020. Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa. https://www.clasp.ngo/research/all/environmentally-harmful-dumping-of-inefficient-and-obsolete-air-conditioners-in-africa/.

companies. Dumping into African markets is facilitated by weak or non-existent energy performance standards and the lack of proactive anti-environmental dumping policies.

Southeast Asian countries are also at risk of dumping of inefficient RACs and RAC components. Building on the experiences and lessons learned from the 2020 Africa study, CLASP conducted a holistic review of RAC trading and producing practices in Southeast Asia. The review aimed to understand and determine the extent of inefficient equipment dumping and identify what factors contribute to dumping.

This report aims to:

- identify market and trade trends at national and regional levels to document where and how environmental dumping occurs,
- quantify the impact of environmental dumping by modelling the environmental benefits of different policy scenarios, and
- provide recommendations on how policymakers and other stakeholders can prevent environmentally and economically damaging low efficiency, high-GWP RAC products from entering Southeast Asian markets.

CLASP used market data collected by Building Services Research and Information Association (BSRIA), imports and exports data from the UN International Trade Statistics Database (Comtrade), published country specific reports, and the findings of on-the-ground surveys and interviews with key stakeholders among the Southeast Asian countries to inform the study and findings. To model the climate impacts of low efficiency RACs and policy scenarios, CLASP used stock accounting direct and indirect models. See Annex I: Approach and Methodology for more information on the methodology of the study.

2.2. GEOGRAPHICAL SCOPE

CLASP assessed the RAC markets in the six largest Southeast Asian economies: Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. Singapore is used as a benchmark of an energy-efficient market in the region. Combined, the six focus countries account for over 90% of the RAC market in Southeast Asia.

2.3. PRODUCT COVERAGE

This report assesses single split RACs, which are the most popular air conditioning systems used in residential and commercial buildings in six focus countries. In the Philippines, the study also assessed window units because, unlike the other five countries, window systems have a large market share in the market, along with single splits. Based on previous CLASP studies and interviews, the second-hand RAC market in six Southeast Asian countries is documented to be small, and therefore was not included in this study.

2.4. DEFINING "LOW EFFICIENCY"

For the purposes of this report, we define a "low efficiency" RAC as one which does not meet a minimum efficiency threshold of China's current MEPS for inverter, cooling-only RACs: CSPF 6.1 W/W for cooling capacity (CC) ≤ 4.5 kW, CSPF 5.1 W/W for 4.5 kW < CC ≤ 7.1 kW, and CSPF 4.5 W/W for 7.1 kW < CC ≤ 14.0 kW.[25] CLASP selected this threshold for three reasons:

1. China produces a significant portion of RACs for the six selected SEA markets and the rest of the world;
2. China has demonstrated success in implementing this once ambitious MEPS level—which China is considering to revise in next few years—rendering these efficiencies technologically achievable for Southeast Asian markets; and
3. this MEPS level is also listed in the U4E model regulations[26] to which countries globally are seeking to harmonize to. The ASEAN region has also committed to adopt this MEPS level in 2025.

25 Converted from China SEER in GB 21455—2019 to ISO CSPF using "Lost in translation" (2020) by Park et al. https://doi.org/10.1016/j.esd.2020.01.003.
26 In September 2019, United for Efficiency (U4E) published model energy performance standards and labeling guidance to assist governments in developing and emerging economies in establishing or strengthening their regulations. These guidelines present an opportunity for African countries to harmonize around ambitious and achievable MEPS and refrigerant requirements. GWP of 750 was chosen to allow for R-32. https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/.

3. Global RAC Market & Policy Trends

IMAGE: CARLEEN BENITEZ-HECHANOVA / UNSPLASH

Global RAC demand has been steadily growing in recent years, reaching 167 million in 2021. Nearly three quarters of all RACs were sold in Asia region – 51% in China and 23% in the rest of Asia.[27,28] RAC demand is expected to grow in the future with more people owning RACs to help to remain healthy and safe among rapidly increasing global temperatures. From 2016 to 2050, the number of RACs in operation globally is expected to increase by 3.7-times, from 1.2 billion to 4.5 billion.[29]

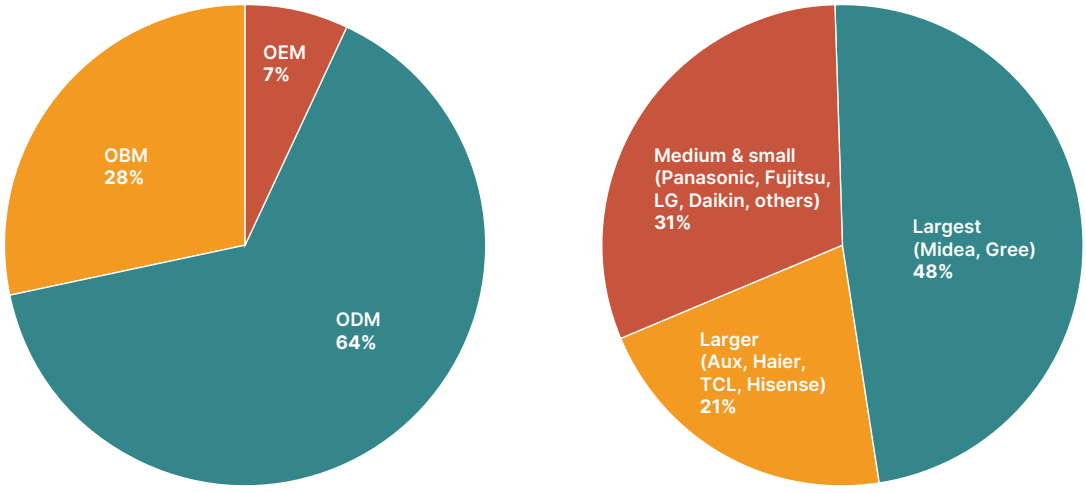
Two of the major RAC producers are China (82% of total global production) and Thailand (5%), which accounted for nearly 90% of global production of 188.6 million units in 2021.[30] Both countries are also the world's leading RAC exporters. China exports to more than 190 countries. Its major export markets[31] include the U.S., Japan, Thailand, Saudi Arabia and Brazil, while Thailand exports the majority of produced RACs to Southeast Asia, Australia, the U.S., India, Japan, South Korea, and the E.U. To meet the demand, most countries either import all of the fully built RACs or import some to meet the demand that is not met by locally produced and sold RACs.

OVERVIEW OF RAC EXPORT FROM CHINA.

In 2021, 63 million RACs units or 41% of total production were exported from China. Nearly two-thirds of RAC exports were split type.

- Figure 5 shows that most of China's RAC exports were done by original design manufacturers (ODM)[32] at nearly 65%, who design and produce appliances purchased by different buyers who may make slight changes to sell it under their own brand name. Some Chinese and other multinational companies with producing capacities in China produce RACs under their own brand and for other brands. Japanese and South Korean producers with producing operations in China are considered ODMs.[33]
- The original brand manufacturer (OBM) export share was at 28.2%, which includes Chinese brands such as Midea and Gree, who are responsible for total production: design, engineering, research and development, supply chain, marketing, and sale of their products.
- The remaining proportion of China's RAC exports, 7.2%, came from original equipment manufacturers (OEM), who produce RACs for buyers based on their designs and specifications.[34]

FIGURE 5: CHINA RAC EXPORTS BY PRODUCTION STRATEGIES AND BRAND EXPORT MARKET SHARES



27 ChinaIOL. 2022. Energy Efficiency Study of China's Exported Room Air Conditioner. https://www.efchina.org/Reports-en/report-cip-20220805-en.
28 Other large markets in Asia include Japan, India, Indonesia, and Vietnam.
29 Sachar, S. et al. 2018. Solving the Global Cooling Challenge: How to Counter the Climate Threat from Room Air Conditioners. Rocky Mountain Institute. www.rmi.org/insight/solving_the_global_cooling_challenge.
30 Energy Foundation China. 2022. Energy Efficiency Study of China's Exported Room Air Conditioner. https://www.efchina.org/Reports-en/report-cip-20220805-en.
31 Based on COMTRADE database.
32 Producer designs most or all products and produce them for buyer.
33 Energy Foundation China. 2022. Energy Efficiency Study of China's Exported Room Air Conditioner. https://www.efchina.org/Reports-en/report-cip-20220805-en.
34 Ibid.

In 2021, about 70% of exports were done by large Chinese brands (Figure 5) with exports between 2-10 million and remaining exports by medium and small producers including Japanese and South Korean brands that had exports below 2 million. Large Chinese brands can pursue production in Southeast Asia as OBMs, ODMs and OEMs. Well-known brands headquartered in Japan and South Korea largely pursue production in Southeast Asia as OBMs and OEMs.[35]

ODM and OEM manufacturers supply the RACs for the buyers, who are the ones to make decisions on various RAC features including efficiency and refrigerant, while OBM manufacturers are responsible for determining what type of RACs are sold in different markets.

Despite growing global demand for more efficient RACs, the efficiency distribution of China's exports typically aligns with local demand and MEPS of the importing country.[36] A study conducted by Energy Foundation China found that after China revised RAC MEPS, the overall level of energy efficiency of RAC exports slightly increased, but was still much lower than efficiencies of RACs sold in the domestic market.37 In 2021, 36.6% of exported RACs were below China's MEPS.38 The export share of inverter RACs grew by 18 percentage points from 2017 to 2021, but fixed speed units39, which are less efficient than inverter ones, still dominate the exports, at 69% in 2021.[40],[41]

China's exports of RACs with lower-GWP refrigerant R-32 has been steadily increasing in recent years (Figure 6). In 2021, over half of RAC split type exports had R-32 refrigerant, a sharp increase from 30% in 2019. The export share of split RACs with R-22 refrigerant saw a sharp decrease from 2019 to 2021, from 34% to about 10%, respectively.[42] Similarly, for window units, R-22 decreased from 35% to 10% over the three years and the share of R-32 more than doubled, from 18% to 49%. The remaining exported RACs had R-410A refrigerant.[43]

FIGURE 6: REFRIGERANT MARKET SHARES IN RAC EXPORTS FROM CHINA 2019-2021

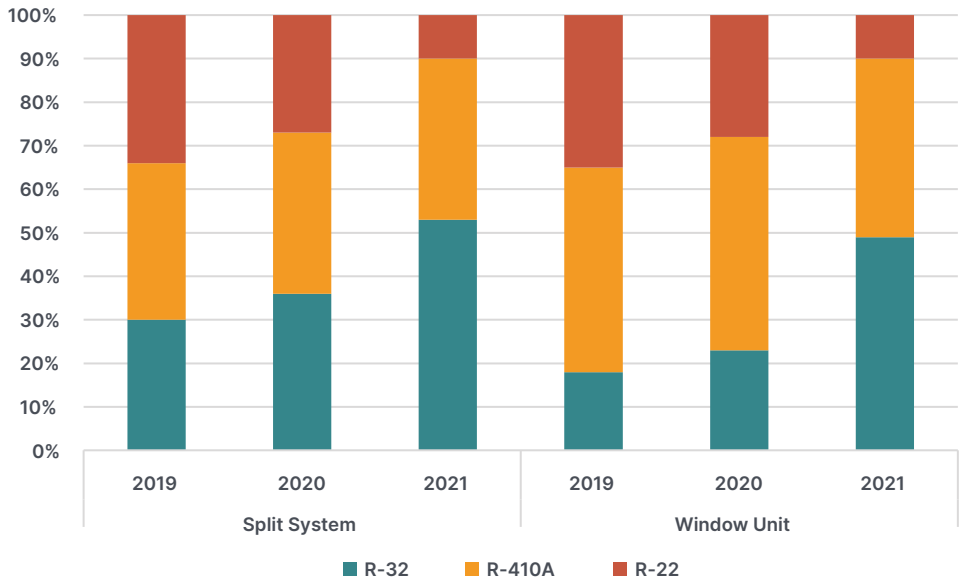


Image source: Zeng, L. et al. 2023. China's MEPS Lead to Major AC Market Transformation

35 Industry export in China.
36 Exports are guided by China's Standardization Law promulgated by the Standing Committee of the National People's Congress, Nov. 4, 2017, effective Jan. 1, 2018), art. 26, http://www.npc.gov.cn/zgrdw/npc/xinwen/2017- 11/04/content_2031446.htm which stipulates that "technical requirements for exported products and services shall be implemented in accordance with the contract".
37 Energy Foundation China. 2022. Energy Efficiency of China's Exported Room Air Conditioners, https://www.efchina.org/Reports-en/report-cip-20220805-en.
38 Based on 12 country study—Japan, India, Thailand, Saudi Arabia, UAE, Australia, Spain, Italy, the U.S., Brazil, and South Africa.
39 A fixed-speed RAC has a fixed speed compressor, which is less efficient than an inverter RAC with a variable speed compressor.
40 Energy Foundation China. 2022. "Energy Efficiency Study of China's Exported Room Air Conditioner." https://www.efchina.org/Reports-en/report-cip-20220805-en.
41 Note in *Andersen, Stephen O., Ferris, R., Picolotti, R., Zaelke, D., Carvalho, S., Gonzalez, M. (2018). Defining the legal and policy framework to stop the dumping of environmentally harmful products. Duke Environmental Law & Policy Forum: Vol. XXIX:1.* "Article 26 of China's Standardization Law, (as amended Jan. 1, 2018), http://www.npc.gov.cn/npc/xinwen/201711/04/content_2031446.htm. Article 26 provides that the "technical requirements for exported products and services shall be implemented in accordance with the contract articles [therefor]." Id. According to the Interpretation of Article 26 of the Standardization Law, both import and export parties can agree to adopt, for instance, international standards, importing country standards, exporting country standards, or third country standards, to define the technical requirements for their contracts. <...> That said, this Interpretation further specifies that the goods or services exported must be in line with the local laws and regulations of the importing country (such as the importing country's mandatory standards)."
42 Zeng, L. et al. 2023. China's MEPS Lead to Major AC Market Transformation. Accessed on June 26. https://www.clasp.ngo/research/all/chinas-meps-lead-to-major-ac-market-transformation/.
43 Zeng, L. et al. 2023. China's MEPS Lead to Major AC Market Transformation. Accessed on June 26. https://www.clasp.ngo/research/all/chinas-meps-lead-to-major-ac-market-transformation/.

ENERGY EFFICIENCY POLICY TRENDS

Energy efficiency policies are key in ensuring that only efficient appliances are sold, curbing energy demand for space cooling. Increasing RAC ownership is already putting strain on national electricity grids. Given current technology levels, IEA estimates the global energy demand for space cooling can increase by 40% by 2030 as compared to 2000.[44] To date, over 80 economies have adopted energy efficiency policy tools for RACs, including MEPS.

Large RAC markets including China, Brazil, and India have used policy tools, including MEPS, to help drive the market shift to more efficient RAC technologies; Table 1 summarizes their current MEPS levels.

TABLE 1: RAC MEPS AND HIGHEST LABELING TIER IN SELECTED ECONOMIES[45]

ECONOMY	EFFICIENCY METRIC	NATIONAL MEPS LEVELS	LAST REVISION (YEAR)	ISO CSPF MEPS (ESTIMATE)
China	China SEER	5.0	2020	6.09
Brazil	CSPF	3.14 (4.5)	2022 (2025)[46]	3.14 (4.5)
India	ISEER	3.5	2022	3.79

In Brazil, the average efficiency of registered RACs since 2020 is CSPF 5.5 Wh/Wh and most of the registered units are in the highest (A) class. In 2025, the MEPS will increase to CSPF 4.5 Wh/Wh, with the highest (A) class set at CSPF 7.0 Wh/Wh.

China's RAC market transformation. In 2020, China adopted the world-leading RAC energy efficiency policy (GB 21455-2019) with the new seasonal performance metric (SEER) for fixed speed and variable speed RACs. The new MEPS level is SEER 5.0 Wh/Wh (CSPF 6.1 Wh/Wh) for RACs under 4.5 kW, which constitute the majority of the RAC cooling market.

The market share of inverter RACs has increased rapidly within two years after MEPS adoption.[47] Most fixed speed RACs have been phased out from the domestic market. In addition, the new policy spurred a rapid increase of RACs in the highest energy efficiency level (Grade 1) and helped accelerate the transition to the low-GWP refrigerant R-32. In 2021, 96.6% of cooling-only RACs sold in China had R-32 as their primary refrigerant.[48]

China aims to revise the current policy in the coming years and has started the initial market study. The efficiency of the current best available technology (BAT) in China, CSPF 7.64 Wh/Wh, which is just above China's Grade 1 level (CSPF 7.32 Wh/Wh), could be adopted as the new RAC MEPS in 2025.[49] Due to China's high export numbers, their market transformation has the potential to impact the entire international RAC market.

Advancing inverter RACs in India. In 2006 and 2015, India's Bureau of Energy Efficiency (BEE) launched voluntary labeling programs for fixed speed and inverter (variable speed) RACs, respectively. In 2018, the program became mandatory for both types of RACs and shifted to common rating plan and seasonal performance metric - the Indian Seasonal Energy Efficiency Ratio (ISEER). BEE also set up a schedule for revising the MEPS and energy label tiers to continuously improve the energy performance of RACs. The last policy revision was done in 2021.

The labeling program helped drive a dramatic transformation of the Indian split RAC market from 2009 to 2021. During this period, the energy performance of 1-star split RACs and 5-star split ACs has improved by 43% and 61%, respectively. Moving to ISEER has also had a tremendous effect on the Indian market, shifting from 4% inverter RACs in 2015 to 62% in 2020, which are currently the most popular type of RAC.[50] The rapid growth in inverter market share was also supported by government and bulk procurements that specified requirements for ISEER values that only inverter units could meet.[51]

44 IEA. 2022. Space Cooling – Tracking Report. https://www.iea.org/reports/space-cooling
45 LBNL. 2020. "Lost in translation" (2020) by Park et al. https://doi.org/10.1016/j.esd.2020.01.003.
46 Next revision scheduled in 2025.
47 This is based on MEPSY analysis of RACs in China, conducted by CLASP China team in 2022.
48 Energy Foundation China, 2022. Research Report on Energy Efficiency of Domestic Household RACs in China.
49 Phadke, A., et al. 2020. Chinese policy leadership would cool global air conditioning impacts: Looking East.
50 India Bureau of Energy Efficiency (BEE). Presentation at workshop 2020 Best Practices in AC Efficiency Policy: Experiences from Brazil, China, and India.
51 Mr. P.K. Mukherjee, interviewed December 2018.

4. Southeast Asia RAC Market, Trade Flows, & Trade Policies

IMAGE: HANDY WICAKSONO/UNSPLASH

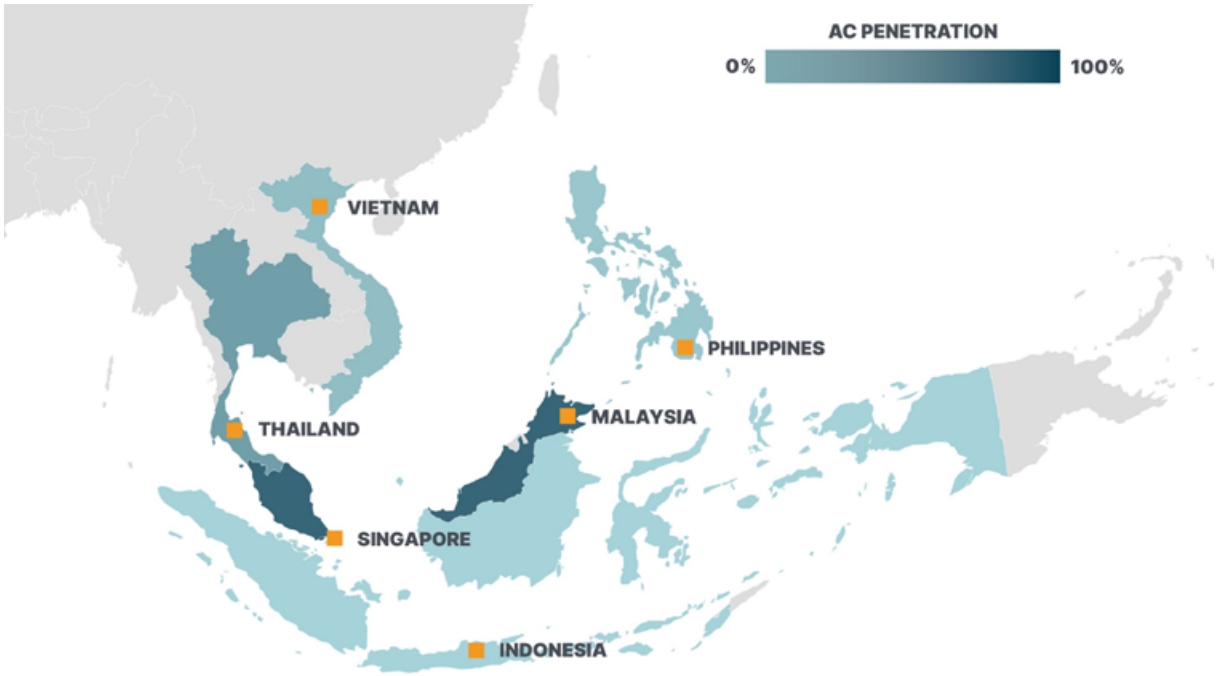
4.1. MAIN FINDINGS

- In 2021, the RAC market across the six countries was 8.3 million units. The highest RAC penetration was in Singapore and Malaysia, at 85% and 81%, respectively, while RAC penetration is still relatively low in Indonesia (15%), the Philippines (25%), Vietnam (32%), and Thailand (55%).
- Single split systems dominate the RAC markets in all six economies. The Philippines is the only market where window units are more popular: 65% of RAC sales in 2021 were window units.
- All six countries import RACs from other countries in the region and China to meet the growing demand. In 2021, the six economies imported 52% of RACs from countries within the region and 47% from China. Imports from China more than doubled in the past decade due to changes in trade policies and tariffs, as well as to meet growing RAC demand.
- RAC import tariff on RACs traded within ASEAN region is 0%. Under the ASEAN-China Free Trade Area (ACFTA), tariffs on RACs imported from China vary: Singapore, Malaysia, and Indonesia have a 0% tariff, Thailand and the Philippines have 5% tariff, and Vietnam has 15%. Under recently signed Regional Comprehensive Economic Partnership (RCEP), tariffs on RAC imports from China are much higher in all analyzed economies except for Singapore, which has zero tariff. Both agreements are implemented alongside.
- The RAC production and trade in Southeast Asia is dominated by the multinational companies as discussed in Chapter 5 which seek to expand their dominance through expansion of local production and increased imports while adopting different production arrangements to offer cost-effective but not necessarily efficient RACs. The trade of RACs is guided by national policies and trade agreements which can also favor the dumping of RACs with obsolete technologies.

4.2. SEA RAC MARKET

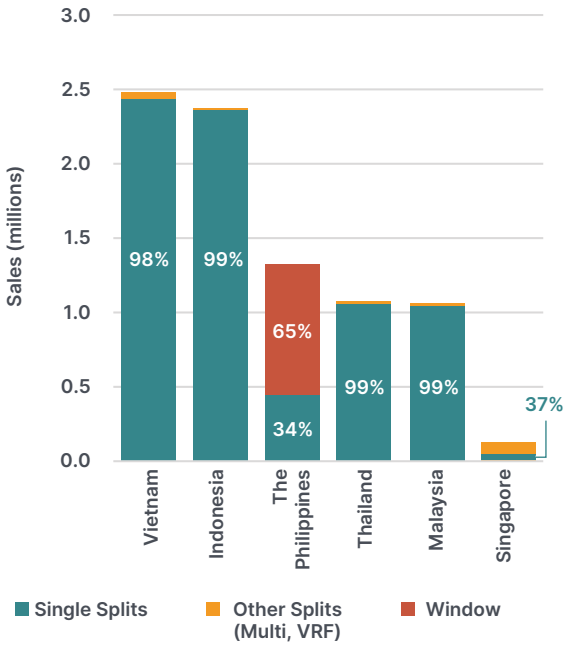
Many households in Southeast Asia still do not have access to air conditioners. [52] In Indonesia and the Philippines, RAC penetration is below 25%. In Vietnam and Thailand, it is below 55%. In Singapore and Malaysia, penetration is above 80% (Figure 7). RAC sales in Southeast Asia are expected to rapidly grow in the next decade.: 3-5% for Vietnam, Thailand, Singapore, and Indonesia, and 7-9% for Malaysia and the Philippines.[53]

FIGURE 7: RAC PENETRATION IN SIX ECONOMIES, 2021



52 BSRIA data, 2021.
53 BSRIA data, 2021.

FIGURE 8: RAC MARKETS IN SIX SOUTHEAST ASIAN ECONOMIES, 2021



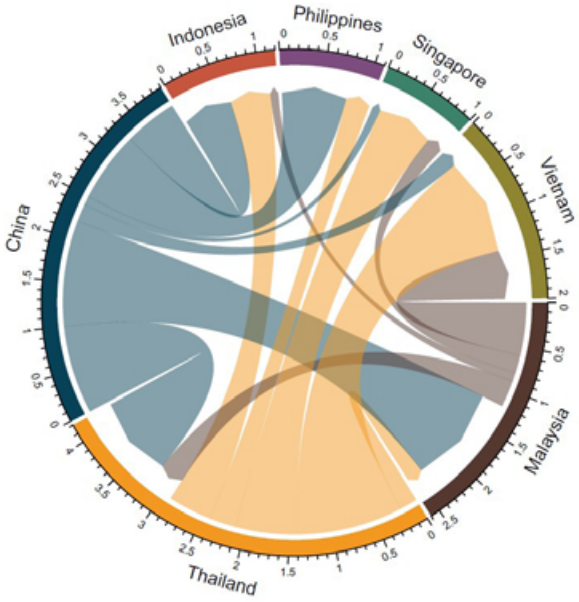
The six analyzed countries have the largest RAC markets in the region, with a combined total of 8.2 million units sold in 2021. Indonesia and Vietnam have largest RAC markets, over 2 million units sold annually, while RAC markets in Philippines, Thailand and Malaysia are over 1 million units, as shown in Figure 8. Single split systems dominate RAC markets in five economies. Singapore has large, 37%, share of other split type systems including multi splits and variable refrigerant flow (VRF) systems. The Philippines is the only country in the region where nearly 65% of sold RACs in 2021 were window units.

4.3. TRADE FLOWS

All six economies import RACs from countries within the region and China to meet the growing demand. Based on Comtrade data (Figure 9), in 2021 the analyzed countries imported 4.2 million RACs from Thailand and Malaysia - 2.9 million and 1.3 million units, respectively. Nearly 3.8 million units were imported from China, which is the main source of RAC imports outside Southeast Asia region.[54]

RAC imports from China dominate imports in Thailand, Malaysia, the Philippines, and Indonesia. Thailand and Malaysia imported 22% and 30% of RACs in 2021, respectively, primarily from China while the remaining demand was met thought domestic production. The Philippines imported over half of RACs, mainly from China. Vietnam and Indonesia imported over 60% of RACs while all RACs in Singapore were imported. Indonesia imported RACs primarily from China and Thailand, and Vietnam and Singapore from Thailand and Malaysia.[55]

FIGURE 9: RAC TRADE FLOWS IN SOUTHEAST ASIA, WITH SALES VOLUME (MILLIONS) INDICATED, 2021[56]



The intraregional RAC trade has been steadily decreasing while imports from China have significantly increased. Figure 10 shows that in the past decade, the majority of RACs have been traded within the region, but between 2016-2021 the intraregional trade declined by 30%. During the same period, imports from China nearly doubled, reaching 47% of all imports in 2021. This can primarily be attributed to trade policies, which are discussed in more detail in the next chapter, and increased RAC demand.

In the last decade, RAC imports from China grew in all countries except for Singapore (Figure 11). Thailand experienced the most significant growth of RAC imports from China, on average, over 100% annually between 2017-2021. This was likely due to

54 Total imported number of RACs under HS 841510 to the six countries is 8 million which is nearly the same number of RACs sold in six countries in 2021. Such large RAC import number is likely because split systems consist of outdoor and indoor units. The countries may import only indoor or outdoor unit that can be recorded under this code as one unit. Thus, the imports under HS841510 can represent not only split systems but also partial system imports.
55 BSRIA data, 2021.
56 The COMTRADE data presented here for HS 841510 includes all types of RACs including window, split and portable. In case of split systems, the imported unit can be a complete set, only indoor and only outdoor unit.

FIGURE 10: RAC IMPORTS IN SOUTHEAST ASIAN COUNTRIES 2012-2021

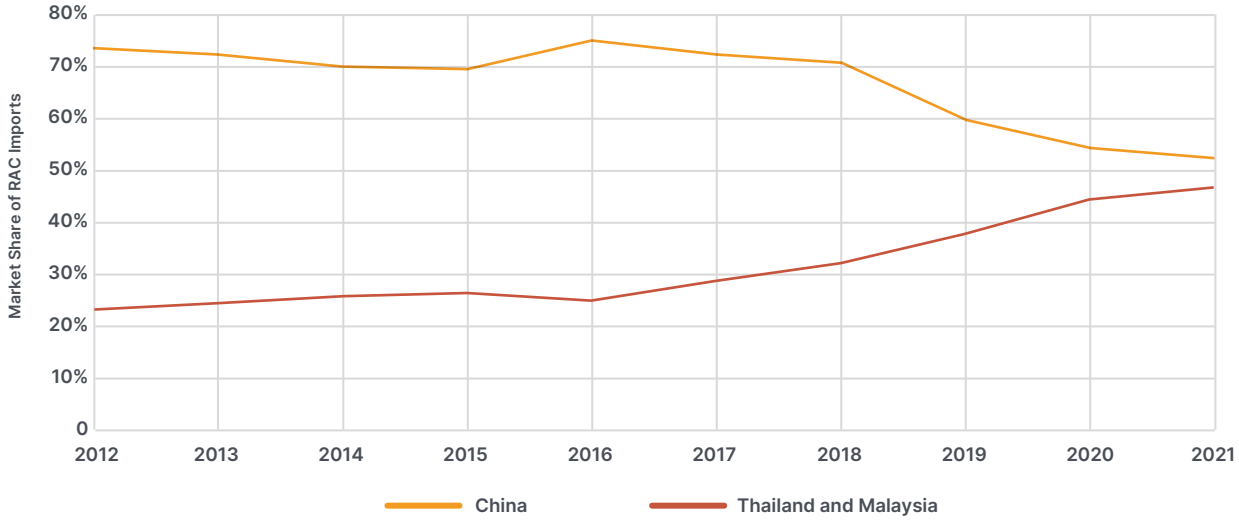
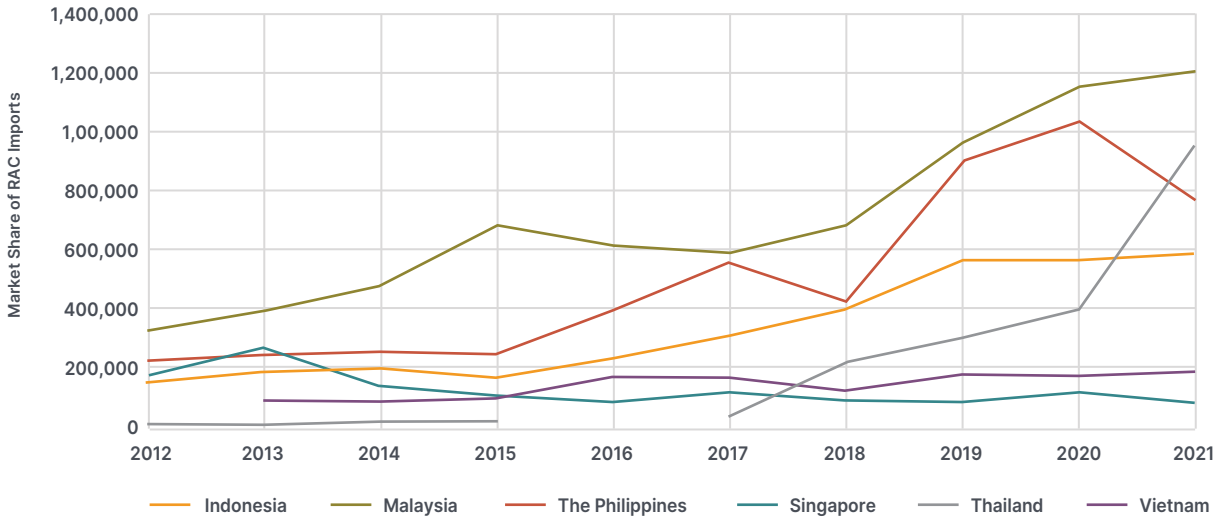


FIGURE 11: RAC IMPORTS IN SOUTHEAST ASIAN COUNTRIES FROM CHINA, 2012-2021[57]



2018 tariff reduction and clearing RAC stock after China adopted new MEPS policy in 2020. China's RAC exports to other countries grew at slower rate – 19% annually to Malaysia and 17% to Indonesia; exports to the Philippines and Vietnam grew by 8% and 3%, respectively. In Malaysia, exports from China increased due to growing demand for wide selection of RACs at an affordable price.

4.4. TRADE POLICY LANDSCAPE

Trade policies can play an important role in shaping RAC trade flows. For economies that import RACs, trade policies can determine availability of the appliance and can also influence the adoption of energy-efficient appliances. Both tariffs and non-tariff barriers can affect trade. ASEAN participates in several FTAs aimed at eliminating tariffs among member countries. This section provides a summary of selected trade policies that can potentially influence intra-ASEAN trade and RAC trade with China. It also addresses some non-tariff barriers that can potentially influence the trade landscape. Refer to Annex II: Trade Agreements for more details on trade policies.

57 Gaps in the graph reflects missing COMTRADE data: no data for 2016 for Thailand and 2012 data for Vietnam.

ASEAN FREE TRADE AREA

Under Association of Southeast Asian Nations (ASEAN[58]) Free Trade Area (AFTA), all member states eliminated the tariff on RAC (HS 841510) and compressors (HS 841430) that are produced and traded within the region. AFTA was established in 1992 with an aim to eliminate tariffs and non-tariff barriers among the Southeast Asian economies. It has an overarching goal of facilitating their integration into one single market. Currently, there is no common tariff structure under AFTA, and each ASEAN Member State applies a tariff rate of 0-5% for products originating within the region, which is 0% for room air conditioning equipment. [59]

SOUTHEAST ASIA REGIONAL AND COUNTRY AGREEMENTS WITH CHINA

Table 2 shows the tariff rates on RACs under the ASEAN-China Free Trade Agreement[60] (ACFTA) and Regional Comprehensive Economic Partnership (RCEP), which vary among the six economies. Under ACFTA, Indonesia, Malaysia, and Singapore have maintained 0% on RAC imports, while The Philippines and Thailand reduced tariffs to 5% from 10% and 20%, respectively in 2018. Vietnam has the highest tariff at 15% on RAC imports from China, which potentially resulted in fewer imports, estimated at 9% in 2021.

Table 2 also shows the Most-Favored Nation (MFN) Tariffs[61] for comparison. Under RCEP, during the first year of agreement implementation, tariff rates align with the MFN rates. However, exceptions include Indonesia (10% vs. 15%) and Vietnam (30% vs. 25%), with the possibility of gradual reductions over a 20-year period.

RCEP came into effect in January 2022 and operates concurrently with the ACFTA. The regulatory framework for overseeing the trade of RACs will be contingent on the countries engaged and provisions of the agreements.[62] RAC trade with China is expected to be governed by ACFTA. In Thailand, the importers can select which agreement would be more beneficial for them to import RACs into Thailand.[63]

TABLE 2: TARIFFS ON RAC IMPORTS FROM CHINA COMPARED TO MFN TARIFFS

Country	Rates of Duty (%)				
				RCEP[66]	
	MFN[64]	ACFTA[55] (before 2018)	ACFTA[65] (2018-now)	Base rate/ Year 1	Year 20
Indonesia	15%	0%	0%	10%	0%
Malaysia	30%	0%	0%	30%	30%
The Philippines	10%	10%	5%	10%	5%
Singapore	0%	0%	0%	0%	0%
Thailand	30%	20%	5%	30%	27%
Vietnam	25%	15%	15%	30%	15%

SOUTHEAST ASIA AND THE CHINA BELT AND ROAD INITIATIVE (BRI)

BRI aims include facilitating and supporting the expansion of Chinese businesses into overseas markets. In 2020, five analyzed economies—Singapore, Indonesia, Malaysia, Vietnam, and Thailand—were among major recipient countries of BRI investments.[67] For Indonesia, the ACFTA, along with BRI have helped strengthen bilateral relations between the two countries, positioning China as Indonesia's fourth-largest trading partner.[68]

In Thailand, AUX Group opened a factory in 2019 under BRI framework to expand into Southeast Asia and particularly Thailand. The factory is located in the Thai-Chinese Rayong Industrial Zone, jointly developed by investors from China and Thailand. This zone holds the status of being China's designated national overseas Economic & Trade Cooperation Zone.[69]

In April 2019, China's National Development and Reform Commission (NDRC) announced a "BRI

58 ASEAN Member States: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.
59 ASEAN. Trade in Goods. https://asean.org/our-communities/economic-community/trade-in-goods/.
60 A free trade agreement is a pact between two or more nations to reduce barriers to imports and exports among them.
61 MFN tariffs are non-discriminatory tariffs that countries agree to impose on imports from all other members of the World Trade Organization (WTO) in absence of preferential trade agreement such as FTA.
62 Interview with representative from Malaysia's Customs Department, May 2023.
63 Interview with representative from Thailand's Department of Trade Negotiations, April 2023.
64 World Bank. World Integrated Trade Solution (WITS), https://wits.worldbank.org/Default.aspx?lang=en.
65 Association of Southeast Asian Nations (ASEAN). Free Trade Agreements with Dialogue Partners.
66 RCEP text. https://www.dfat.gov.au/trade/agreements/in-force/rcep/rcep-text.
67 ISEAS. 2022. 2022/57 "Assessing the Belt and Road Initiative in Southeast Asia amid the COVID-19 Pandemic (2021-2022)" by Wang Zheng https://www.iseas.edu.sg/articles-commentaries/iseas-perspective/2022-57-assessing-the-belt-and-road-initiative-in-southeast-asia-amid-the-covid-19-pandemic-2021-2022-by-wang-zheng/.
68 Adamczyk, W. 2022. Reasons for Sino-Indonesian cooperation. https://warsawinstitute.org/reasons-sino-indonesian-cooperation/.
69 NINGBO. 2019. AUX inaugurates plant in Thailand. http://ningbo.chinadaily.com.cn/2019-08/28/c_404025.htm.

Green and Efficient Cooling Initiative"[70]. This initiative focuses on fostering international policy dialogue, facilitating information exchange, collaborating on the development of energy efficiency standards, and collectively advancing market transformation towards higher efficiency, among goals. However, the progress of these objectives were constrained by limited follow-up activities due to the COVID-19 pandemic and other contributing factors.

In March 2022, China issued a governmental policy document promoting green development of BRI.[71] The document outlines recommendations for Chinese enterprises to comply with prevailing international environmental standards or, if more stringent, China's own environmental standards, particularly in cases of higher requirements than BRI partner countries.

SOUTHEAST ASIA AGREEMENTS WITH OTHER ECONOMIES

Table 3 displays the tariffs on RACs under the ASEAN-Japan Comprehensive Economic Partnership (AJCEP) and ASEAN-Republic of Korea Free Trade Area (AKFTA). Prominent RAC brands in the SEA region originate from either of these two countries, and a portion of RACs produced are exported to the SEA region.

TABLE 3: TARIFFS ON RAC IMPORTS FROM CHINA COMPARED TO MFN TARIFFS

Country	Rates of Duty (%)		
	MFN[72]	AJCEP[55]	AKFTA[73]
Indonesia	15%	0%	0%
Malaysia	30%	5%	0%
The Philippines	10%	0%	5%
Singapore	0%	0%	0%
Thailand	30%	0%	5%
Vietnam	25%	40%[74]	40%

NON-TARIFF TRADE MEASURES AFFECTING RAC TRADE IN SOUTHEAST ASIA

Non-tariff trade measures potentially affecting RAC trade include energy efficiency policies, quotas, local content requirements and bans. Moreover, standards pertaining to other product qualities, including safety, can significantly impact the availability of certain higher efficiency products, particularly if they restrict the market entry of specific technologies.

Energy efficiency policies, such as Minimum Energy Performance Standards (MEPS), when developed and applied in a WTO-consistent manner,[75] including applying equally to domestically produced and imported RACs, can help increase the efficiency of imported RACs. All six economies have MEPS which are applicable to domestically produced and imported RACs. Currently, none of the six countries have trade preferences for energy-efficient products.

Harmonization of testing and energy performance standards among ASEAN member states can help further integrate the ASEAN market and trade as well as facilitate trade with other countries. Under ASEAN Standards Harmonization Initiative for Energy Efficiency (SHINE), all ASEAN member states agreed to adopt ISO 5151: 2010 as the testing standard by 2020. The countries also agreed to adopt Cooling Seasonal Performance Factor (CSPF) metric (ISO 16358-1: 2013) to evaluate performance. This metric enhances efficiency within the RAC market and also harmonizes the MEPS requirements, as discussed in Section 6.2.1.

Protection of national industry through local content requirements and quotas. In 2020 Indonesia tightened import rules (Regulation 68/2020) on RAC equipment requiring import permits to control the import growth.[76]

Bans on imports of certain products and/or components. Indonesia, Malaysia, and Thailand have banned production and import of equipment including RACs with R-22 refrigerant. In 2022, Singapore banned the supply and import of new household RAC equipment that use refrigerants with Global Warming Potential (GWP) over 750.

70 https://www.ndrc.gov.cn/fzggw/jgsj/hzs/sjdt/201904/W020190910582061655527.pdf.
71 Opinions on Promoting the Green Development of the "Belt and Road Initiative" [关于推进共建"一带一路"绿色发展的意见] (Promulgated by China National Development and Reform Commission, Ministry of Foreign Affairs, Ministry of Ecology and Environment, and Ministry of Commerce, March 16, 2022) (hyperlink to original Chinese).
72 World Bank. World Integrated Trade Solution (WITS), https://wits.worldbank.org/Default.aspx?lang=en.
73 Association of Southeast Asian Nations (ASEAN), Free Trade Agreements with Dialogue Partners.
74 Tariff is expected to be eliminated in 2024.
75 See Andersen, Stephen O., Ferris, R., Picolotti, R., Zaelke, D., Carvalho, S., Gonzalez, M. (2018). Defining the legal and policy framework to stop the dumping of environmentally harmful products. Duke Environmental Law & Policy Forum: Vol. XXIX:1, Part VI, Key Considerations for Policymakers and Other Stakeholders Aimed at Protecting Environmental Anti-Dumping Tools from International Trade Challenges . http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf.
76 Reuters. 2020. Indonesia tightens rules on sneakers, bicycles as imports surge. https://www.reuters.com/article/indonesia-trade/indonesia-tightens-rules-on-sneakers-bicycles-as-imports-surge-idINL4N2FX1IK.

CUSTOMS

Some Southeast Asian economies have customs programs that offer companies *Authorized Economic Operators (AEOs)* certification. This grants a range of benefits, including priority treatment (e.g., for inspections), simplified and expedited procedures, lower inspection rates, and financial incentives. Refer to Annex II: Trade Agreements for more information on the companies with AEO certification.

The ASEAN-level MRA is under development—ASEAN AEO Mutual Recognition Arrangement[77] (AAMRA)— is expected to be implemented by 2025.[78] The AAMRA will allow companies with AEO certification in one ASEAN economy to have reduced documentary and cargo inspections across all ASEAN member countries.

MRAs with China. Singapore has had an AEO MRA with China since June 2012[79], while The Philippines recently formalized an MRA in January 2023.[80] Thailand signed an action plan in April 2022 to advance negotiations on an MRA, and Malaysia completed initial consultations in 2021.[81]

Currently, there seems to be no active negotiations with Vietnam and Indonesia for MRAs with China. It is notable that Singapore, an all-import country, has the most MRAs with China.

77 Mutual Recognition Agreements (MRAs) between two economies, which can be countries or regions, allow AEOs within each economy to enjoy the benefits of the other economy's AEO program.
78 Singapore customs. 2022. ASEAN Customs chiefs launch Joint Action Plan to mutually recognise programmes to facilitate cargo clearance. Media reléase. https://www.customs.gov.sg/files/Singapore_Customs_Press_Release_07_June_Final.pdf.
79 Singapore customs. 2012. inSYNC. Singapore customs newsletter. Issue 20. https://www.customs.gov.sg/news-and-media/publications/inSYNC_Issue20_ecopy.pdf.
80 Reuters. 2023. China, Philippines customs sign AEO agreement to facilitate trade. https://www.zawya.com/en/world/china-and-asia-pacific/china-philippines-customs-sign-aeo-agreement-to-facilitate-trade-svnv6qkh.
81 China Daily. 2021. China in AEO talks with Malaysia and Thailand. https://www.ciie.org/zbh/en/news/exhibition/news/20210926/29525.html.

5. Low Efficiency RACs in SEA

IMAGE: AMIRUL AQID / UNSPLASH

5.1. MAIN FINDINGS

- 6.2 million "low efficiency" units (i.e., below China MEPS) were sold in 2021 among the six Southeast Asian markets, constituting 74% of total sales.
- In 2021, Indonesia and Vietnam, the two largest RAC markets, dominated the low efficiency sales, with 2.3 million (37% of total low efficiency sales) and 1.5 million (25%) units sold respectively.
- 71% of low efficiency units were produced in the Southeast Asia region, primarily by subsidiaries of multinational companies (47%) and joint ventures between SEA-based companies and multinational brands (12%), and SEA-based companies (12%). The multinational brands are based in Japan, South Korea, China, and the U.S.
- Imports constituted 29% of low efficiency, primarily from China (82% of total low efficiency imports). The rest originated from South Korea (17%) and India (0.4%), accounting for the other major non-SEA sources of low efficiency RACs. These proportions are likely higher as country-of-origin data was unavailable for 12% of the overall RAC dataset.
- All 27 identified brands sell low efficiency units.

IMAGE: HOANG THANH / UNSPLASH

5.2. MARKET BASED EVIDENCE

Based on RAC market data collected by CLASP and BSRIA, CLASP analyzed data on low efficiency units—those with efficiencies below China MEPS[82]—in the selected six Southeast Asian countries. This threshold was chosen due to China's significant production of air conditioners for both the six selected Southeast Asian markets and globally, as well as the successful implementation of this once ambitious MEPS level. This success underscores the feasibility of achieving similar efficiencies within the Southeast Asian markets.

Inefficient RACs dominate Southeast Asian markets, except for Singapore. In 2021, there were a total of **6.2 million low efficiency RACs sold across** the six Southeast Asian markets, representing **74% of total sales**.[83] Indonesia and Vietnam, the two largest RAC markets, had the most low efficiency sales in 2021, with 2.3 million and 1.5 million, respectively (Figure 12). These units constituted 97% of Indonesia's total market, and 60% of Vietnam's market.

The Philippines, considering both window units and single splits, recorded 1 million low efficiency sales in 2021, which comprised 78% of the total market. Malaysia and Thailand each had about 0.7 million low efficiency sales, constituting 68% and 62% of the total markets, respectively. Singapore, which is included as a benchmarking country for comparison due to its advanced efficiency policies, accounted about 10,000 low efficiency sales, constituting only 21% of their total market.

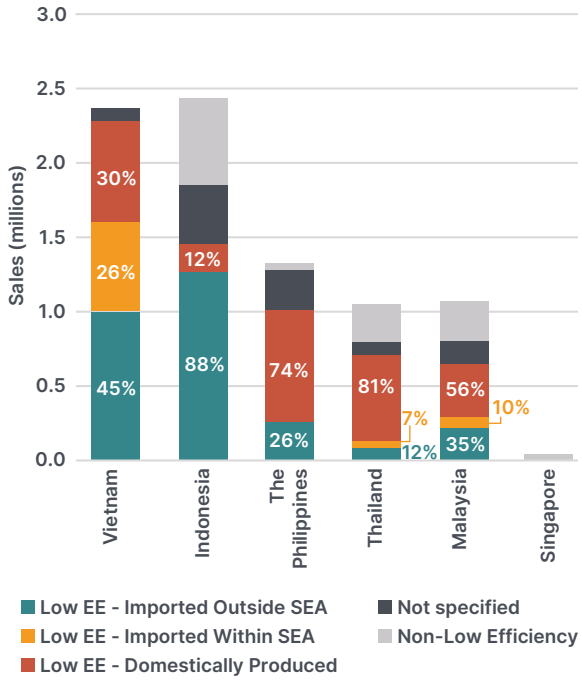
Among the six markets, **71% of low efficiency sales originated from domestic production in the Southeast Asia region. The remaining 29% were imported from outside the region, mainly from China**. Low efficiency sales from domestic production had the largest market shares in Malaysia and the Philippines, exceeding 70%. Conversely, in the case of Indonesia and Vietnam, domestic production accounted for only 30% and 12% of low efficiency RACs, respectively.

Low efficiency sales imported from within the region had the largest market shares in Vietnam and Singapore, at over 90%, whereas Indonesia had only 56% from within the region. A significant majority, 82% of RACs imported from outside the region came from China.

82 For cooling-only RACs: CSPF 6.1 Wh/Wh for CC ≤ 4.5 kW, CSPF 5.1 Wh/Wh for 4.5 kW < CC ≤ 7.1 kW, and CSPF 4.5 Wh/Wh for 7.1 kW < CC ≤ 14.0 kW. Converted from China SEER in GB 21455—2019 to ISO CSPF using "Lost in translation" (2020) by Park et al. https://doi.org/10.1016/j.esd.2020.01.003.

83 Total sales in 2021 (8.3 million) include 12% of sales for which CLASP does not have efficiency data and therefore cannot categorize as low efficiency; it is likely the percentage of total sales that were low efficiency in 2021 is higher than 74%.

FIGURE 12: LOW EFFICIENCY RAC SALES BY MARKET, WITH IMPORTED AND DOMESTIC SHARES INDICATED (2021) (LOW EFFICIENCY RACS: N=362, V= 6,159,571)[84]

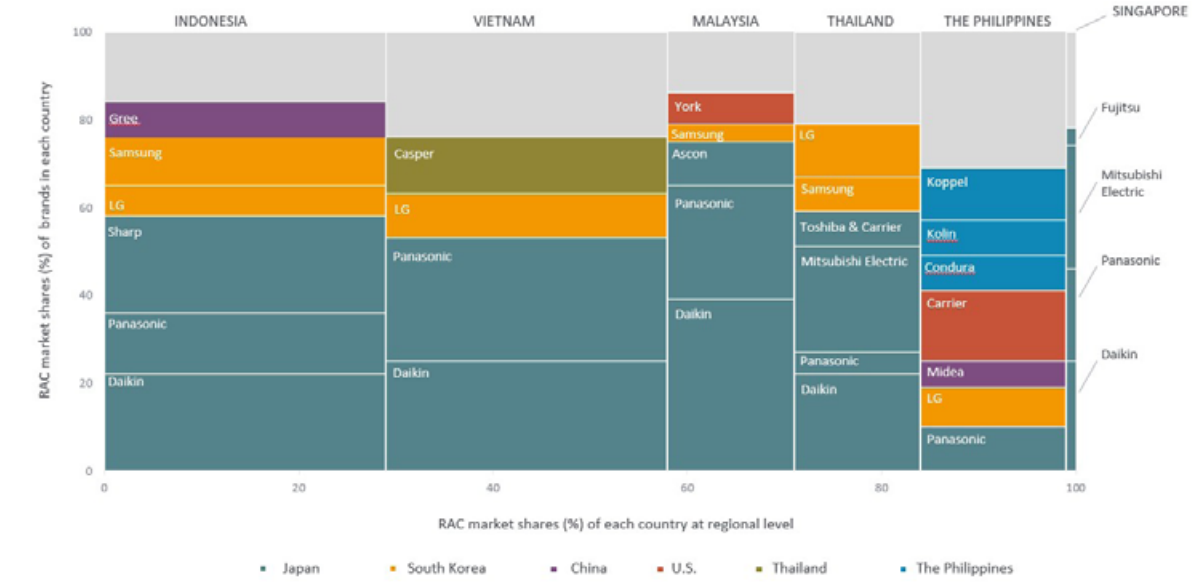


BRANDS & SOURCES

RAC markets in the six Southeast Asian countries are dominated by multinational brands headquartered in Japan, South Korea, China, and the U.S., all of which sell low efficiency RACs.[85] Figure 13 shows that Japan- headquartered companies hold the largest market shares in five of the six markets.[86] South Korea- headquartered companies have the second largest RAC market share across analyzed economies, while China and the U.S. hold larger shares of markets in Indonesia and Malaysia. Only in the Philippines most RACs are produced by locally-owned businesses or joint venture (JV) companies between local businesses and major brands headquartered in the U.S. and China.

The three most popular brands across the six markets are Dakin, Panasonic, and LG, with overall market shares of 22%, 18%, and 7% respectively. Daikin and Panasonic are Japanese brands, while LG is a South Korean brand. Based on the BSRIA dataset, it is apparent that Panasonic produced nearly all RAC sales within the SEA region in 2021 while Daikin produced an estimated 78% and LG only produced 57% in the region. All imports of Daikin and most LG units came from China, with LG importing some RACs from South Korea.

FIGURE 13: BRAND MARKET SHARE VERSUS MARKET SIZE PROPORTION, BY COUNTRY[87,88]



84 The category "Not Specified" represents units lacking efficiency data and thus are not counted as low efficiency but are represented on the graph to visualize their potential addition to the count of low efficiency units. Singapore's market shares are 92% for "Low Efficiency – Imported Within SEA," 8% for "Low Efficiency – Imported Outside SEA," and 0% for "Low Efficiency – Domestically Produced." Most units across the six markets, and subsequently those represented in the dataset, are 5 kW or less.
85 CLASP identified 27 unique brands across six markets with known market shares which were provided by BSRIA.
86 The country where the brand is headquartered is determined by the headquarters location of the headquarters of that brand.
87 The remaining market share (gray area) represents other brands with smaller market shares (under 4%) as provided by BSRIA.
88 Brands and/or producers were not identified by BSRIA for 12% of estimated combined market for 6 analyzed countries.

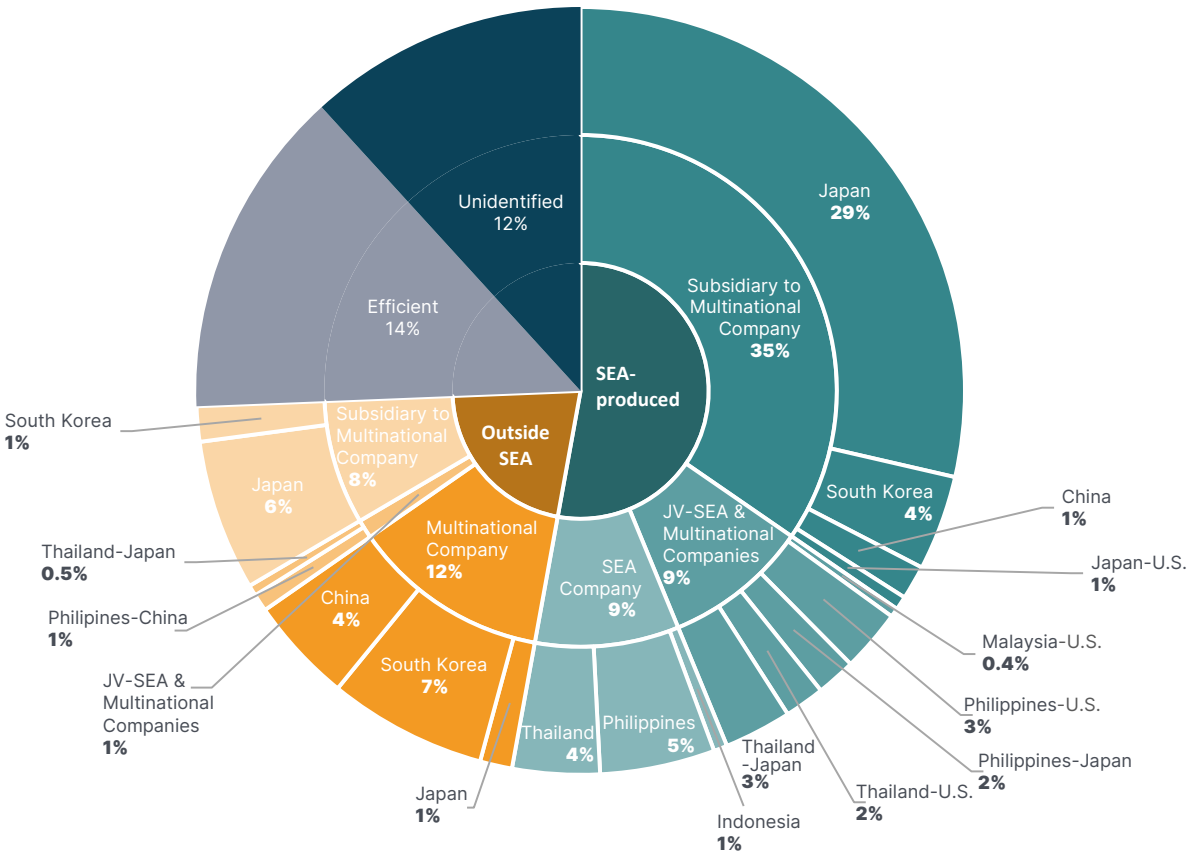
About 47% of low efficiency RACs were produced in SEA by multinational companies operating through local subsidiaries. An additional 27% were imported to the region by multinational companies (Figure 14). These multinational companies are primarily headquartered in Japan with a few across South Korea, China, and the U.S. The companies have producing facilities in one or more analyzed countries, except for Singapore. The RACs are imported by the same multinational companies. Most of these companies, identified in this study, have production facilities in China and import RACs from there.

About 41% of low efficiency RACs sold in the region were produced by local subsidiaries of Japanese brands.[89] These include Daikin, Panasonic, Mitsubishi Electric, Ascon,[90] Sharp, and Toshiba/Carrier,[91] which have established producing facilities in one or more countries across Southeast Asia. Thailand and Malaysia are key production facilities for Japanese brands in the region, serving as hubs for producing RACs for in-country sales, exports to other Southeast Asian markets, and even beyond the region. Some Japanese brands entered the Southeast Asian RAC market prior to the 2000s, and have successfully built brand recognition, continuing to expand their production bases.[92]

South Korea-headquartered companies imported a greater quantity of low efficiency RACs than they produced within the region. LG, with RAC plants in Indonesia, Vietnam, and Thailand, produced and sold about 5% of total low efficiency RACs in 2021. Both Samsung and LG imported roughly 11% of the total estimated low efficiency RACs among the six countries (Figure 14).

China-headquartered producers have a much smaller presence in the region, resulting in the sale of fewer

FIGURE 14: SOURCES OF LOW EFFICIENCY RACS SOLD IN THE SIX SOUTHEAST ASEAN COUNTRIES (N=6,159,571)



89 This includes Toshiba/Carrier JV that produced about 1% of low efficiency RACs.
90 Local brand in Malaysia, a subsidy to Daikin.
91 Japanese-U.S. joint venture with headquarters in Japan.
92 eJARN. 2022. SEA Asia. https://www.ejarn.com/detail.php?id=71097&l_id=2.

low efficiency RACs. Aux, Midea, Gree and Haier, with plants in Indonesia, Vietnam, and Thailand, produced about 2% of low efficiency RACs. China-headquartered brands—Gree, Midea, Hisense, Haier, and TCL—imported about 7% of the low efficiency RACs sold in 2021 from China. China-headquartered producers have been expanding their production bases due to increased labor costs in China and tariff reductions.[93,94]

Joint venture companies between locally-owned businesses in the Philippines, Malaysia, and Thailand, alongside multinational RAC brands headquartered in Japan or the U.S. produced 12% of low efficiency RACs. These brands include Carrier in the Philippines and Malaysia, Panasonic in the Philippines, and Mitsubishi Electric, Mitsubishi Heavy Industries (MHI), and Toshiba/Carrier in Thailand.

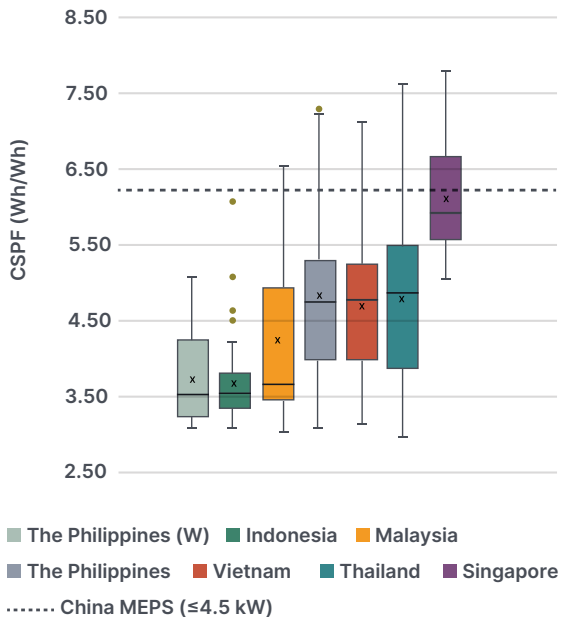
Over half of the compressors used across refrigeration equipment[95] in five SEA countries are imported, with a significant 57% sourced from China. Additional imports come from Singapore[96] (5%), Japan (5%), South Korea (4%), Brazil (3%) and Thailand (3%). Daikin, Panasonic, LG, Mitsubishi Electric and Samsung have compressor production facilities in China.

In Thailand, prominent compressor producers include Daikin, Siam (Mitsubishi subsidiary), TCFG (a Toshiba and Fujitsu joint venture), Kulthorn Kirby, Thai Compressor Producing Co. (THACOM, a subsidiary of MHI), and LG. As of 2018, Thailand's estimated compressor production capacity touched 12 million units, most of which are supplied to local RAC producers. Panasonic produces compressors in Malaysia (with an estimated capacity of 3.5 million units in 2018), primarily for in-house use, though some are also distributed to other producers or exported.[97]

EFFICIENCY ANALYSIS

All six RAC markets have a sales-weighted median efficiency below China MEPS. Efficiency levels for 2021 RAC sales across the six markets ranged from CSPF 2.97–7.80 Wh/Wh with a sales-weighted median efficiency of CSPF 4.18 Wh/Wh (Figure 15). The most inefficient markets are the Philippines (window units), Indonesia, and Malaysia, which have similar median efficiencies at around CSPF 3.60 Wh/Wh. The Philippines (single splits), Vietnam, and Thailand markets have higher median efficiencies at around CSPF 4.80 Wh/Wh. Singapore's market had the highest median efficiency, CSPF 5.93 Wh/Wh, and a minimum efficiency (CSPF 5.06 Wh/Wh), which is greater than all other countries' median efficiencies.

FIGURE 15: RANGE OF RAC EFFICIENCY LEVELS IN SIX SOUTHEAST ASIAN COUNTRIES (2021), ORDERED BY MEDIAN EFFICIENCY (N=452)[98,99]



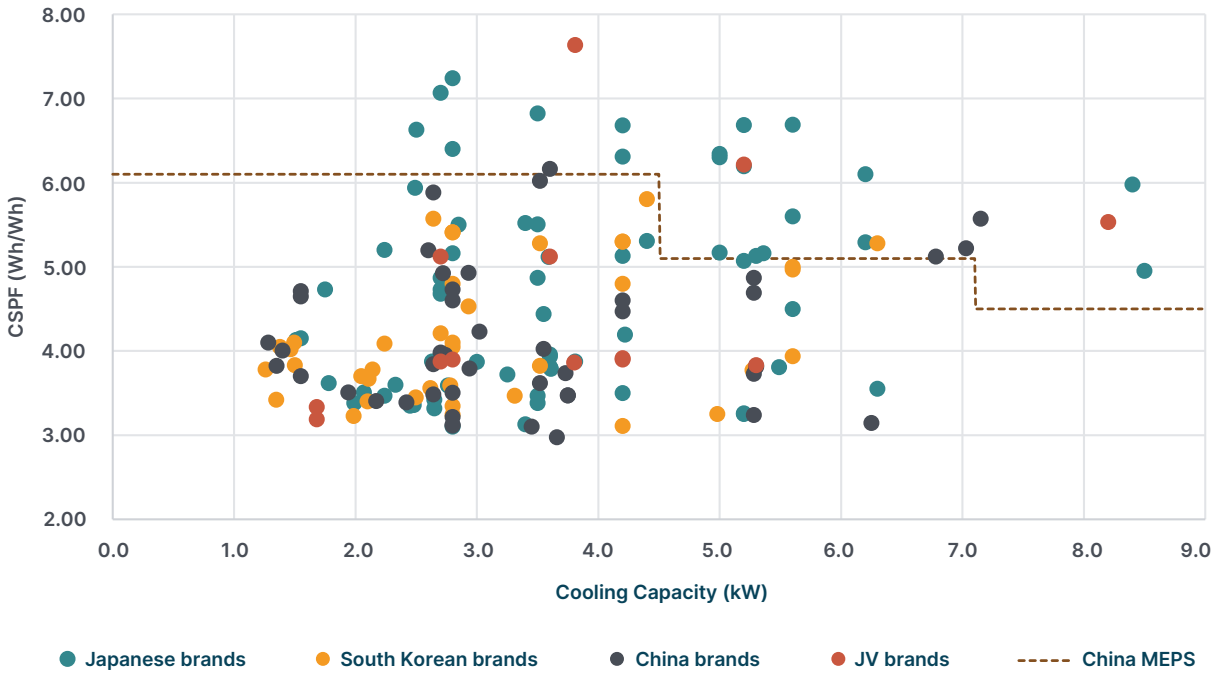
For all six markets, low efficiency units are common across compressor and refrigerant types. Across the six markets, 38% of low efficiency sales in 2021 were inverter units. The high proportion of inverter technology among low efficiency units underscores the importance of technology-neutral efficiency policies. Inverter technology penetration varies by market. The median efficiency (CSPF) for inverter units was 4.81 Wh/Wh and for non-inverter units was 3.49 Wh/Wh. Refrigerants present among the aggregated six markets were R-410A, R-32 and R-22. For each refrigerant, the proportion of its total 2021 sales that were low efficiency was 78% for R-32, 84% for R-410A, and 100% for R-22.[100] See Section 6 for more detailed discussion on refrigerants in the six analyzed markets.

93 eJARN. 2022. SEA Asia. https://www.ejarn.com/detail.php?id=71097&l_id=2.
94 eJARN. 2022. SEA Asia. https://www.ejarn.com/detail.php?id=71097&l_id=2.
95 Comtrade data under HS 841430, which includes compressors for refrigerating equipment.
96 Per COMTRADE data, in 2021 Singapore imported over 8 million refrigerating compressors under HS 841430 and exported similar amount. The exports are likely imported compressors.
97 Nicholson, S. & Booten, C. 2019. Mapping the Supply Chain for Room Air Conditioning Compressors. Accessed on May 15, 2023. https://www.nrel.gov/docs/fy19osti/73206.pdf.
98 Each referenced country represents their single split RAC market except for "The Philippines (W)," which represents window units in the Philippines.
99 The shaded boxes represent the interquartile range (25th through 75th percentiles), with the horizontal line and "X" representing the median and average, respectively.
100 Units with R-22 have a very small presence among the six Southeast Asian markets and the sample size for R-22 units is only three (n=3).

The majority of RAC exports do not meet the export country MEPS. In general, major exporting countries have policies that do not prevent dumping. This means domestic RAC MEPS do not apply to exports, enabling the export of products that cannot be sold domestically. The exports are guided by the policy requirements of importing countries. **93% of RACs exported from China do not meet China MEPS.** Among RAC exports from China to SEA markets, 93% Japanese brand models, 94% South Korean brand models, 96% Chinese brand models and 85% JV company brand model exports do not meet China MEPS as shown in Figure 16. **A large number of RACs exported from South Korea and Japan also do not meet South Korea MEPS and Japan Top Runner requirements,[101] at 59% and 21%, respectively.** [102]

The three leading brands with the largest Southeast Asia market shares—Daikin, Panasonic, and LG—have the capacity to produce efficient RACs, but still offer many low efficiency RACs in the SEA region. CLASP compared the efficiencies of RACs offered by these brands.[104] Figure 17 shows, for each brand, the availability of unit efficiency varies by market. For instance, Panasonic models are only sparsely available below CSPF 5.00 W/W in Indonesia, yet Panasonic models of all evaluated efficiencies are available in Singapore, with CSPF 4.00 W/W and 5.00 W/W being widely available. Additionally, for all three brands, Indonesia and Malaysia consistently have the lowest efficiency units available whereas Singapore has the highest. This demonstrates the brands' capacity to produce highly efficient units and thus their dumping of lower efficiency units in markets with less stringent standards. Similar efficiency spreads are highly likely for other brands as well.

FIGURE 16: DISTRIBUTION OF RAC MODEL EXPORTS FROM CHINA, BY EFFICIENCY AND CAPACITY, 2021 (N=297)[104]



101 Japan does not have MEPS but rather producers are required to meet the specified weighted average efficiency value across their RAC sales (Top Runner program).
102 Per MOTIE Notification No. 2020-225 RACs, producers are prohibited to produce, import and sell RACs that do not meet MEPS.
103 Models having brands owned by joint ventures, where the official country where the brand is headquartered could not be definitively assigned to one country, were removed from this graph.
104 The product-level data analyzed in this section are a representative sample of each of the six markets and CLASP made a conscious effort to select models representing the range of efficiencies available among a diversity of brands, yet these data do not represent the entirety of models available within these markets and/or brands.

FIGURE 17: AVAILABILITY OF RAC MODEL EFFICIENCIES FROM DAIKIN, LG, AND PANASONIC, BY MARKET[105]

	CSPF (W/W)	4.00	5.00	6.00	7.00
Daikin	Indonesia				
	Malaysia				
	The Philippines				
	The Philippines (W)				
	Singapore				
	Thailand				
	Vietnam				
LG	Indonesia				
	Malaysia				
	The Philippines				
	The Philippines (W)				
	Singapore				
	Thailand				
	Vietnam				
Panasonic	Indonesia				
	Malaysia				
	The Philippines				
	The Philippines (W)				
	Singapore				
	Thailand				
	Vietnam				

	= widely available (≥ 60% of sample)
	= available, but not widely (< 60% of sample)
	= not available
	= no information

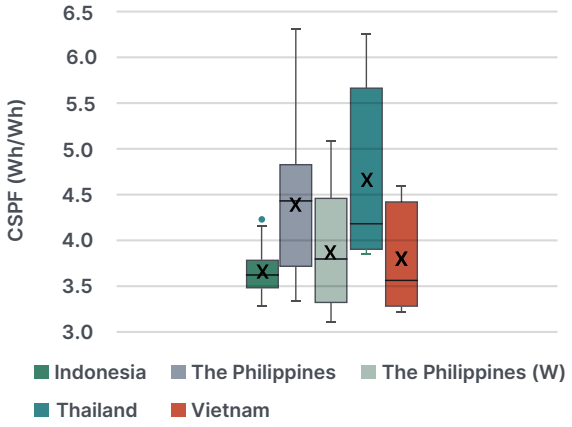
Most RACs produced by locally owned brands do not meet China MEPS which have been used as a gauge for energy efficiency in this report. CLASP looked at the range of efficiencies of the following selected popular local RAC brands:[106]

- Thai companies[107] with brands including Central Air, Tasaki[108]
- Vietnamese brands including Funiki, Reetech[109]
- Indonesian brands including Polytron, AICOOL
- Filipino brands including Condura, Kolin, Koppel

Figure 18 shows that locally-owned companies in Indonesia, Vietnam, and the Philippines (window units) have the lowest median efficiencies and sell exclusively low efficiency units, whereas the Philippines (single splits) and Thailand produce some units in compliance with China MEPS. Locally owned brands in the Philippines (Koppel, Kolin and Condura), Thailand (Casper) and Indonesia (Polytron) constituted about 11% of low efficiency RAC sales in 2021. Governments, including those in the six analyzed countries, are concerned that locally owned businesses may not have the capability to meet ambitious efficiency policies. When implementing MEPS and other efficiency requirements, governments can offer support to companies to make technological improvements.

105 Daikin, LG, and Panasonic were selected for analysis because these brands are present in the most markets and have the largest market shares. Credit to IEA for the design concept of the graphic.
106 Local brands that are among most popular local brands and listed above.
107 Foley, M. 2017. Introduction of Alternative Refrigerant in the Thailand AC Sector and the Role of Intellectual Property, Case Study. https://www.ccacoalition.org/sites/default/files/2017_technology-airconditioning-workshop_SessionIV_Foley.pdf.
108 Produced by local Thai ODM/OEM producer Bitwise. https://yamada-cg-th.com/wp-content/uploads/2018/06/Air-Conditioner-Industry-in-Thailand-201806.pdf.
109 These two locally owned brands currently import their branded RACs from other SEA countries.

FIGURE 18: EFFICIENCY RANGES OF RACS PRODUCED BY LOCALLY OWNED COMPANIES (N=108)



BRAND CLIMATE COMMITMENTS

CLASP reviewed the climate commitments of the Southeast Asia region's ten most popular Japanese, South Korean, Chinese, and the U.S. brands. Annex III: Brand Climate Commitments summarizes the overall commitments with target years and scope, such as emissions reduction in only business operations or throughout the value chain. All companies except for Gree have made commitments to achieve carbon neutrality by 2030 (LG, Carrier), by 2050 (Daikin, Panasonic, Sharp, Samsung, Mitsubishi Electric and Hitachi) or by 2060 (Midea). Among the committed companies, Sharp and Samsung aim to achieve net zero only in their business activities, while the rest include reduced emissions from entire value chain, including improved product efficiencies and use of lower-GWP refrigerants. Daikin, Panasonic and Hitachi have also joined the *World Business Council for Sustainable Development*, a group of over 200 of the world's leading sustainable businesses that collaborate on "accelerating the system transformations needed for a net zero, nature positive, and more equitable future."[110]

4.3. SOUTHEAST ASIA ENERGY EFFICIENCY POLICY LANDSCAPE

REGIONAL HARMONIZATION EFFORTS

Under ASEAN Standards Harmonization Initiative for Energy Efficiency (SHINE), ASEAN member states agreed to harmonize energy performance standards of ACs by 2020 of 2.9 W/W EER or 3.08 Wh/Wh CSPF as mandatory MEPS for all fixed-speed and inverter RACs below 3.52 kW capacities. The member states were also encouraged to adopt a common evaluation method, CSPF, using ISO 16358-1 by 2020 and adopt the international standard ISO 5151:2010 as test standard.

The new phase-step approach for updating ASEAN Regional MEPS includes:

- Step 1: By 2023, adopting 20% more stringent MEPS at ISO CSPF of 3.7 Wh/Wh, and
- Step 2: By 2025, adopt MEPS of ISO CSPF of 6.09 Wh/Wh, which is identical to the current inverter MEPS level in China.

Currently, only Singapore has committed to adopting the 2025 ASEAN MEPS levels in 2025.

NATIONAL ENERGY EFFICIENCY POLICIES

All six Southeast Asian countries studied in this report have adopted the energy efficiency policies for RACs which are summarized in Annex V: National Energy Efficiency Policies. RAC policies, however, have stagnated in five of the analyzed countries. Vietnam aligned with ASEAN 2020 MEPS in 2015 and Malaysia in 2018 but neither have been revised since. Indonesia and the Philippines aligned with ASEAN 2020 MEPS levels and introduced CSPF performance metric only in 2021. In the Philippines, the latest policy revision was the first in two decades. RAC MEPS levels in Thailand have not been changed since 2010 and are the lowest the region.[111] Singapore has the most advanced RAC policy among six countries and is aiming to adopt ASEAN 2025 MEPS levels in 2025.

110 WBCSD. About Us. https://www.wbcsd.org/Overview/About-us.
111 In Thailand, RAC purchases are guided by voluntary EGAT Label No. 5.

IMAGE: ETHAN P. / UNSPLASH

6. Refrigerant Transition in SEA Markets

IMAGE SS-LW / PIXABAY

6.1. MAIN FINDINGS

- Over the last two decades, there has been a transition in SEA RAC refrigerant usage from the high-GWP and ODS refrigerant R-22 to the non-ODS refrigerant R-410A and the lower-GWP refrigerant R-32.
- The share of RACs with R-32 is rapidly increasing in the six countries. No R-290 was found in any of the analyzed markets.
- RAC units with R-22 have been mostly phased out of the Southeast Asian market, with only few offered for sale that are likely old stock.
- RACs containing the high-GWP refrigerant R-410A still accounted for 35% of RAC sales in 2021 across the six Southeast Asian countries. Over 50% of identified brands produced RACs with R-410A. Adoption of more stringent MEPS can accelerate the phase out of R-410A.
- Two-thirds of R-410A units were produced in SEA, mainly by multinational subsidiaries and JV type companies between locally based companies from the Philippines and Thailand and multinational companies headquartered in the U.S., Japan, and China. Imported RACs with R-410A come from China and South Korea. They are imported by multinational companies headquartered in Japan, South Korea and China.
- Three countries—Indonesia, Thailand, and Vietnam— implemented projects under Montreal Protocol HCFC Phase-Out Management Plans to transition from R-22 to R-32.
- All six countries are projected to be on track with the Montreal Protocol's HCFC phase out schedule, including refrigerant use for RAC servicing.

6.2. R-22 PHASE OUT

GLOBAL REFRIGERANT TRANSITION TRENDS

Over the last two decades, there has been a global transition in RAC refrigerant usage from the ozone depleting substance (ODS) and high-GWP refrigerant, R-22, to the non-ODS refrigerant, R-410A, and the non-ODS and lower-GWP refrigerant, R-32 (Table 4). Before the 2000s, most RAC producers used R-22 refrigerant,[112] but the universally adopted Montreal Protocol (see Section 7.3) has implemented phase-out requirements for hydrochlorofluorocarbon (HCFC) consumption and production, impacting refrigerants such as R-22. These phase-out requirements have accelerated the transition to R-410A and R-32. Requirements for non-Article 5[113] countries drove the adoption of the alternative refrigerant R-410A, which became the most widely used refrigerant replacement for RACs.[114] However, R-410A has a high-$GWP_{100\text{-}yr}$ of 2,087.5,[115] meaning it is over 2,000 times the potency of carbon dioxide and has substantial climate impacts.

TABLE 4: REFERENCE LIST OF REFRIGERANTS AND ASSOCIATED CHARACTERISTICS

REFRIGERANT	GLOBAL WARMING POTENTIAL (GWP)[116]	REFRIGERANT TYPE	OZONE DEPLETING POTENTIAL (ODP)	FLAMMABILITY	TOXICITY
R-22	High (1,810)	HCFC	0.05	None	Lower
R-410A	High (2,087.5)	HFC (blend)	0	None	Lower
R-32	Lower (675)	HFC	0	Lower	Lower
R-290	Low (0.02)	HC	0	Higher	Lower

In 2016, the Parties to the Montreal Protocol agreed to the Kigali Amendment which extends the Protocol's focus past ODP substances, requiring phase downs of non-ODP substances with high GWPs that impact climate change. The Kigali Amendment, in combination with national regulations, is driving the industry towards the use of lower-GWP refrigerants through HFC phase down requirements. In late 2012, Daikin introduced R-32, a HFC with a $GWP_{100\text{-}yr}$ of 675, as viable alternative refrigerant[117] and in 2015 offered free access of its patents to developing economies to facilitate the transition to the

112 UN Environment. 2018. RTOC Assessment Report. https://ozone.unep.org/sites/default/files/2019-04/RTOC-assessment-report-2018_0.pdf
113 Article 5 (or A5) countries are Parties to the Montreal Protocol that have less ambitious phase out/down requirements than non-Article 5 countries. Article 5 countries are typically low income, Global South countries.
114 R-22 phase out in non-Article 5 countries is complete for new appliances. https://ozone.unep.org/system/files/documents/TEAP-Assessment-Report-2022-April23.pdf.
115 CLASP used 100-year GWP values from Annex F of the Kigali Amendment to the Montreal Protocol. These values can be accessed through UNEP's OzonAction GWP-ODP Calculator: https://www.unep.org/ozonaction/resources/gwp-odp-calculator-mobile-app/gwp-odp-calculator.
116 CLASP used 100-year GWP values from Annex F of the Kigali Amendment to the Montreal Protocol. These values can be accessed through UNEP's OzonAction GWP-ODP Calculator: https://www.unep.org/ozonaction/resources/gwp-odp-calculator-mobile-app/gwp-odp-calculator.
117 "Corporate Social Responsibility Report," Daikin, 2013, https://www.daikinindia.com/sites/default/files/Daikin-CSR-Report-2012-13.pdf.

lower-GWP.[118] R-32 has been gaining prominence both globally and in the Southeast Asian region. In 2021, R-32 accounted for nearly half of the total production of split RACs.[119]

This decade, HFCs will face substantial phase-down requirements. R-32 is considered a transition refrigerant and the RAC sector will need to adopt even lower GWP refrigerants like R-290 (propane), which is a natural refrigerant with a $GWP_{100\text{-}yr}$ of 0.02[120] and classified as a volatile organic compound (VOC), or to adopt a new refrigerant yet to be commercialized for the RAC sector. The challenge with lower-GWP refrigerants, including R-32 and R-290, is flammability.[121] A transition to R-290 for single split units has been slow due to its safety and liability risks, but it is being adopted by several producers in some countries including China and India. Several countries have been required to update relevant safety standards to allow for flammable refrigerant use at charge amounts necessary for RAC functioning.[122]

Refrigerant Transition Example: China.
In China, the refrigerant transition away from R-22 occurred in roughly the same timeframe as the global transition. In 2010, China produced about 80 million air conditioners which mostly used R-22.[123] Today, R-32 accounts for over 70% of the domestic split market.[124] Commercial and industry players in China determined R-32 and natural refrigerants to be more viable alternatives than R-410A, sparking a deliberate transition to R-32. Recently, Chinese policymakers are promoting a further transition from R-32 to R-290 in RAC sector. In 2022, several R-290 production lines were introduced.[125] China's exports also continue to shift away from R-22, which constituted 34% in 2019 and only 10% in 2021.[126] The exported RACs to Southeast Asia mainly contain R-32 or R-410A refrigerants.

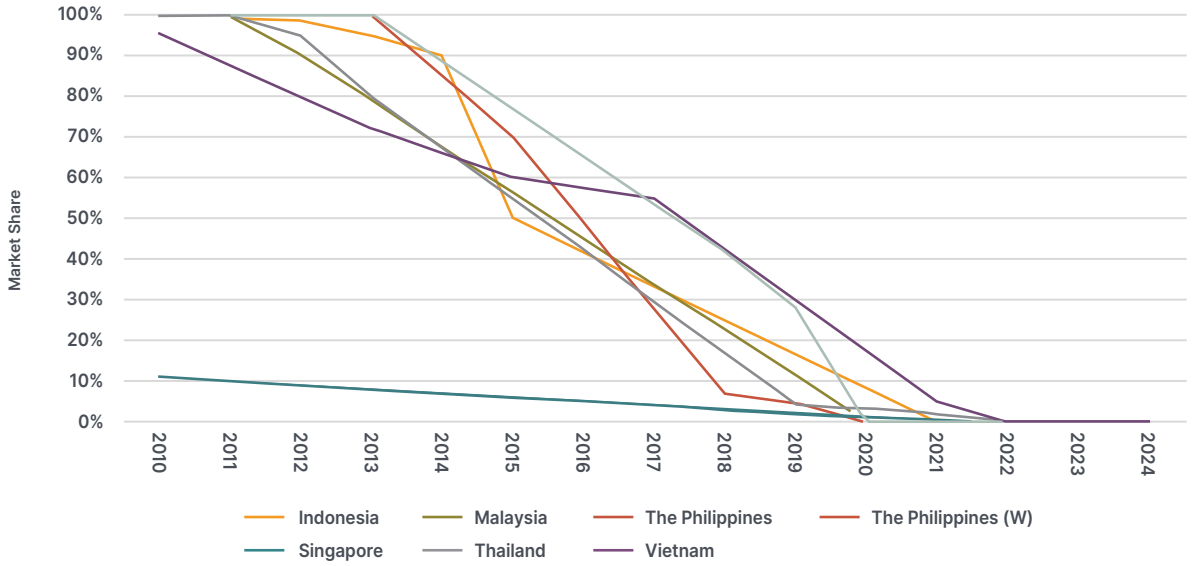
R-22 PHASE OUT IN SEA REGION

In Southeast Asia, R-22 has been nearly phased out in the RAC sector, largely a result of HCFC phase-out financing from the Montreal Protocol's Multilateral Fund (MLF). The transition from R-22 to alternative refrigerants, mainly R-32 and R-410A, in the RAC sector started in the 2010s (Figure 19). With support from MLF, local production facilities in Indonesia, Thailand, and Vietnam began to change RAC production lines to R-32 in 2015 (see Section 7.3 for details). Indonesia, Thailand, and Malaysia enacted bans on the production and import of RACs with R-22 in 2015, 2018, and 2020, respectively (see Section 7.3). Currently, there are few to no sales of RACs with R-22 in Southeast Asian markets (Figure 22). BSRIA confirmed that their data on the few R-22 units offered for sale are residual, previously produced stock. All six countries are projected to comply with the Protocol's complete phase out requirement of R-22 consumption (barring servicing) by 2030.

IMAGE: MARTIN STASTNY / UNSPLASH

118 "Daikin releases more R32 patents," *Cooling Post*, 1 July 2021, https://www.coolingpost.com/world-news/daikin-releases-more-r32-patents/.
119 "2022 Assessment Report," Technology and Economic Assessment Panel, Montreal Protocol on Substances that Deplete the Ozone Layer, March 2023, https://ozone.unep.org/system/files/documents/TEAP-Assessment-Report-2022-April23.pdf.
120 CLASP used 100-year GWP values from Annex F of the Kigali Amendment to the Montreal Protocol. These values can be accessed through UNEP's OzonAction GWP-ODP Calculator: https://www.unep.org/ozonaction/resources/gwp-odp-calculator-mobile-app/gwp-odp-calculator.
121 R-32 flammability class is A2L or mildly flammable refrigerant. https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/34_2019_f_20191213.pdf.
122 "2022 Assessment Report," Technology and Economic Assessment Panel, Montreal Protocol on Substances that Deplete the Ozone Layer, March 2023, https://ozone.unep.org/system/files/documents/TEAP-Assessment-Report-2022-April23.pdf.
123 eJARN. 2011. Refrigerant Prices Soar in China. https://www.ejarn.com/detail.php?id=14595&l_id=.
124 Ibid.
125 Zeng, L. et al. 2023. China's MEPS Lead to Major AC Market Transformation. https://www.clasp.ngo/research/all/chinas-meps-lead-to-major-ac-market-transformation/.
126 CLASP China Market Data.

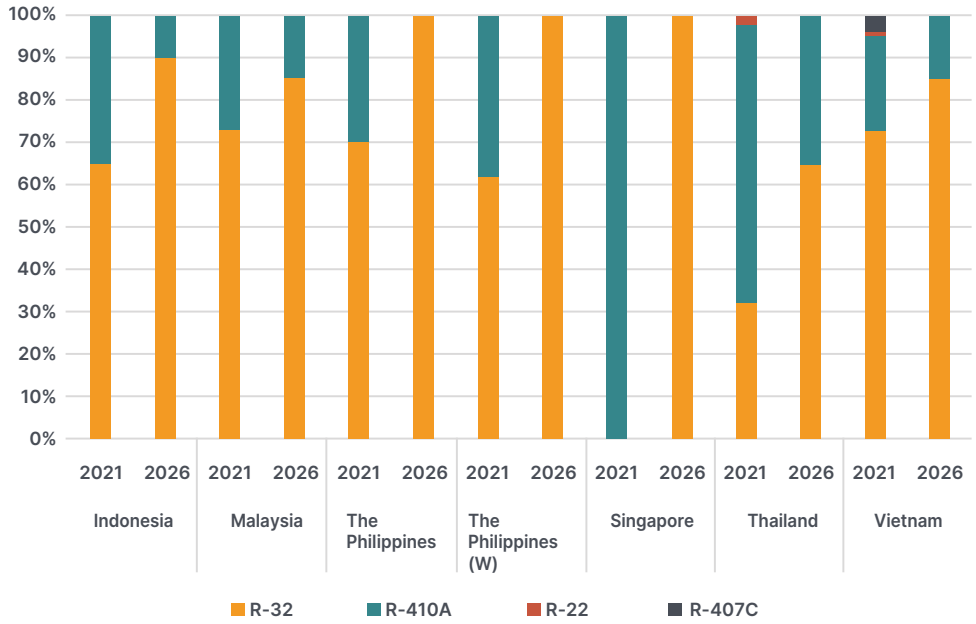
FIGURE 19: ESTIMATED MARKET SHARE OF R-22 AMONG THE SIX SOUTHEAST ASIAN MARKETS, 2010-2026[127]



HFC REFRIGREANTS

The share of RACs with R-32 (HFC) is increasing in the six countries. In Indonesia, Malaysia, the Philippines, and Vietnam, the majority of RACs sold in 2021 (over 60%) had R-32 refrigerant. This is likely due to the transition of domestic production lines from R-22 to R-32, and RAC imports from China with R-32 refrigerant. Singapore and the Philippines are officially expected to achieve a full transition to R-32 by 2026.

FIGURE 20: MARKET SHARE OF RAC REFRIGERANTS BY COUNTRY, 2021 VERSUS FORECASTED 2026[128]



127 It is possible the transition away from R-22 was less gradual and more stepwise, however this graph is a composite projection based on data collected from a number of sources.

128 BSRIA market data is used for all markets except the Philippines and Singapore. Model-level data collected by CLASP and BSRIA is used for the Philippines 2021 data (both window units and splits), as local industry experts have confirmed it is the most accurate market representation, and an average growth rate from 2013-2021 is used to project 2026 data. National Environment Agency (NEA) data is used for Singapore 2021 estimates as this is believed to be the most accurate market data; BSRIA data is used for Singapore 2026 data projections. R-407C is a HFC blend used as a replacement for R-22; it is not represented within the product-level dataset due to lack of online availability.

In 2021, 35% of sold RACs across six countries had R-410A. The refrigerant is still popular in some countries, including in Singapore (90%) and Thailand (66%). Market forecasts for 2026, based on BSRIA research and collected model-level data, estimate all markets except the Philippines and Singapore will still have some R-410A sales, ranging from 10-35% market share (Figure 20). In 2022, Singapore enacted a ban on RAC imports with refrigerants greater than GWP 750, which is expected to swiftly transition the market to R-32 refrigerant.

Except for Singapore, all RACs with R-410A were low efficiency. The median efficiency for low efficiency units with R-410A is CSPF 3.66 Wh/Wh as compared to RACs with R-32 at 4.60 Wh/Wh. Adoption of more stringent MEPS can accelerate the phase out of R-410A.

BRANDS AND SOURCES OF R-22 & R-410A RACS

As of 2021, of the 27 brands represented within the dataset, 56% (15 brands) produced RACs with ODS or high-GWP refrigerants (R-22, R-410A) for sale in the six Southeast Asian markets. Table 5 shows brands that produce and sell RACs with R-410A refrigerant in Southeast Asia. Regarding R-22, only one company, Carrier, was still selling RACs with R-22 refrigerant on the Thai market. Carrier's R-22 RACs are likely old stock that is still being sold. Two-thirds of R-410A units were produced in SEA region mainly by multinational subsidiaries and JV between Filipino and Thai companies with multinational companies headquartered in the U.S., Japan, and China. RACs with R-410A are imported from China and South Korea by Japanese, South Korean and Chinese-headquartered multinational companies.

6.3. AGREEMENTS AND POLICIES ON OZONE DEPLETING SUBSTANCES (ODS)

NATIONAL ODS AND HFC PROGRAMS AND POLICIES

All six countries in this report have ratified the Montreal Protocol (or the legal equivalent) and are classified as Article 5 (mostly developing) countries, which are typically lower-gross domestic product (GDP) countries. Under the Protocol, Article 5 countries' control measures are delayed compared to those of non-Article 5 countries. This delay recognizes the different capacities of developing countries and is consistent with the principle of Common But Differentiated Responsibilities (CBDR), a fundamental principle of international environmental

TABLE 5: BRANDS SELLING RACS WITH HIGH-GWP REFRIGERANT

BRAND	BRAND COUNTRY	COUNTRY OF SALE	PRODUCTION SOURCE
Acson	Malaysia	Malaysia	Malaysia
Aux	China	Indonesia	Indonesia
Carrier	U.S.	The Philippines, Thailand	Malaysia, the Philippines, Thailand
Condura	The Philippines	The Philippines	The Philippines
Daikin	Japan	The Philippines	China, Japan
Fujidenzo	The Philippines	The Philippines	The Philippines
Fujitsu	Japan	Thailand	China, Thailand
Gree	China	The Philippines	China
Kolin	The Philippines	The Philippines	The Philippines
Koppel	The Philippines	The Philippines	The Philippines
Midea	China	The Philippines	China
Mitsubishi Electric	Japan	Indonesia, Singapore	Japan, Thailand
Panasonic	Japan	Singapore	Japan, Malaysia
Samsung	South Korea	Indonesia, Singapore	China, India, South Korea
Toshiba	Japan	Singapore	China, Thailand

law upon which the Vienna Convention and its Montreal Protocol are based. However, these efforts to protect environmental degradation are undermined when non-Article 5 countries use this delay to dump the RACs that can no longer be sold on their domestic markets.

The Southeast Asian countries in this report have national regulations that control the production, import, and sale of ozone depleting substances.[129] Three countries—Indonesia, Malaysia, and Thailand—have banned the import and production of RACs with HCFCs (Table 6). Singapore recently banned import of RACs with high-GWP refrigerants of 750 and greater. See Annex VI: Agreements and Policies on Ozone Depleting Substances (ODS) and High GWP Refrigerants for more detailed information on the Montreal Protocol, Kigali Amendment, and national ODS and HFC regulations.

TABLE 6: SUMMARY OF NATIONAL ODS AND HFC REGULATIONS - BANS

COUNTRY	YEAR ENACTED	REGULATION DETAILS
Indonesia	2015	Bans R-22 in the production of air conditioners and the import of R-22-based equipment.
Malaysia	2020	Bans the produce and assembly of air conditioners (≤ 7.3 kW) using CFCs and HCFCs.
The Philippines	2020	Bans the import of R-22 for producing of RACs by January 1, 2020.
Singapore	2022	Ban to supply and import of new RACs[130] that use refrigerants with GWP over 750 starting in October, 2022.
Thailand	2018	Ban on produce of RACs with HCFC-22 starting in January 2017 and on imports of HCFC-22-based RAC equipment effective as of March 2018. R-22 ACs sale is not allowed from December, 2017.
Vietnam		None

All six countries have National Ozone Units (NOUs) and are members of the Southeast Asia Network of Ozone Officers (SEA Network).[131],[132] Per the SEA Network's official reports, the overall HCFC consumption in member countries has achieved a 64% reduction from the HCFC baseline level (average consumption in 2009-2010), which is ahead of their legal obligations under the Montreal Protocol.[133]

MULTILATERAL FUND SUPPORT FOR REFRIGERANT TRANSITION

The MLF for the Implementation of the Montreal Protocol pays the agreed incremental costs of transition for Article 5 countries. Eligible activities include technical assistance, closing ODS production plants and converting industrial lines, disseminating information, and training and capacity building to support phasing out ODS.[134]

Since its inception, the MLF has supported over 8,600 projects in 148 Article 5 Parties and has phased out 98.6% of global ODS, which are largely comprised of harmful refrigerants. As of 31 December 2021, Vietnam, Indonesia, and Malaysia had the most approved funding for ongoing projects. Indonesia, Thailand, and Malaysia had the most MLF funding disbursed and approved (Table 7). See Annex VII: Multilateral Fund Support for Refrigerant Transition for more information on MLF funding.

IMAGE: ANTEVASIN NGUYEN / UNSPLASH

129 Information on ODS regulations was collected through interviews with local stakeholders in five countries—Indonesia, Malaysia, the Philippines, Thailand, and Vietnam—as well as through desk research.
130 Single-phase, non-ducted, single-split, or multi-split room air-conditioners, with cooling capacity of 17.6kW or lower. Single-phase variable refrigerant flow (VRF), casement, and window type air-conditioners are excluded from the scope.
131 The SEA Network was established in 1993 with support from Swedish International Development Co-operation Agency (Sida) and since 2010 has been supported by the Multilateral Fund under UNEP Compliance Assistance Programme (CAP). U.N. Environment Programme, "South East Asia Network of Ozone Officers."
132 U.N. Environment. Who We Are. https://www.unep.org/ozonaction/who-we-are.
133 U.N. Environment. Southeast Asia Network of Ozone Officers. https://www.unep.org/ozonaction/south-asia.
134 SE for All. 2022. Chilling Prospect 2022. https://www.seforall.org/data-stories/financing-the-replacement-of-harmful-refrigerants.

TABLE 7: COUNTRY GDP & MLF DISBURSED/APPROVED AS OF 31 DECEMBER 2021 (USD)

COUNTRY	2021 PER CAPITA GDP[135]	MLF DISBURSED	MLF APPROVED
Indonesia	$4,333	$76,027,992	$80,636,343
Thailand	$7,066	$74,420,327	$76,988,390
Malaysia	$11,109	$67,086,602	$70,962,731
The Philippines	$3,461	$36,113,069	$37,728,793
Vietnam	$3,757	$18,999,822	$25,574,135
Singapore	$72,794	$0	$0

MLF SUPPORT FOR REFRIGERANT TRANSITION IN RAC PRODUCTION

A significant portion of MLF funding is directed towards Hydrofluorocarbons Phase Out Management Plan (HPMP) implementation, part of which is specifically focused on supporting the RAC production sector to transition away from R-22 to next-generation refrigerants. Stakeholders, including governments and industry in recipient countries, select the transition refrigerant. In the countries analyzed in this study, MFL supported the transition to R-32, which has a lower GWP and only slightly flammable when compared to R-410A (Table 8).[136,137]

In most analyzed countries, HPMP Phase I supported the industry refrigerant transition. It was overseen by one of the implementing agencies, including the World Bank, United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), and United Nations Development Programme (UNDP).

TABLE 8: MLF SUPPORT FOR PRODUCTION LINES CONVERSION IN RAC SECTOR IN FIVE SOUTHEAST ASIAN COUNTRIES

COUNTRY	HPMP[138] PHASE	COMPANIES	NOTES
Indonesia	Phase I (2011-2018)	1 RAC, Panasonic, and 4 commercial AC producers	Conversion to R32 was completed in 2015
Malaysia	Phase II (2017-2022)	None	Planned but funding was reallocated to support HCFC transition in the foam sector
The Philippines	Phase II (2017-2021)	4 RAC producers (Carrier, Koppel, Hitachi and Panasonic)	Due to challenges the project was not completed
Thailand	Phase I (2013-2018)	11 AC producers	
Vietnam	Phase II (2016-2020)	4 AC producers (Hoa Phat, Midea, Nagakawa, and Reetech)	

135 World Bank Data. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=ID-TH-MY-PH-VN-SG.
136 Konghuayrob, S. & Khositkullaporn. K. 2016. Performance Comparison of R32, R410A and R290 Refrigerant in Inverter Heat Pumps Application. Conference Paper. International refrigeration and air conditioning conference. https://docs.lib.purdue.edu/iracc/1577/#:~:text=R32%20is%20an%20alternative%20refrigerant,flammable%20when%20compare%20with%20R410A.
137 The flammability of R32 is 80% less than R-290.
138 HCFC Phase-Out Management Plan.

To meet the deadlines outlined in the HFC phase-down schedules, Article 5 countries recently began to implement national Kigali HFC Implementation Plans (KIPs).[139] The Multilateral Fund will support Article 5 countries' Stage I of the KIP to meet the target HFC reductions.[140] Of the six countries analyzed in this study, Malaysia[141], Vietnam[142], and the Philippines[143] have begun the KIP processes.

6.4. TRANSITION BENCHMARKING AND RAC SERVICING

OVERVIEW OF RAC STOCK AND REFRIGERANT SHARES

To estimate the refrigerant needs to service in-use RACs, CLASP estimated RAC stock and refrigerant proportions using the in-house model and refrigerant proportion tables detailed in Annex I: Approach and Methodology. CLASP defines RAC stock for a given country as the number of units in use at the time of reference, including sales of the year of reference and all unretired units from previous years' sales. Figure 23 shows CLASP's estimate of 2021 RAC stocks by refrigerant in the six countries.[144] The estimated RAC stock with R-22 varies between 4-45% of total stock (Table 9). Only Singapore has an estimated 4% of R-22 RACs installed because of their early introduction and preference of R-410A. Among the six countries, CLASP estimates the year of final market sales for RACs with R-22 will vary from 2019 to 2021, and the last units will remain in operation in varying years from 2027 to 2030. The estimated RAC stock with R-410A varies between 23% to 91% of total stock, as shown in Table 10. Singapore has the largest market share. Among the six countries, CLASP estimates the year of final market sales for RACs with R-410A will vary from 2024 to 2032 and the last of them will remain in operation in varying years from 2033 to 2040.

FIGURE 21: ESTIMATED STOCK OF INSTALLED RACS, BY REFRIGERANT PROPORTION AND COUNTRY, 2021

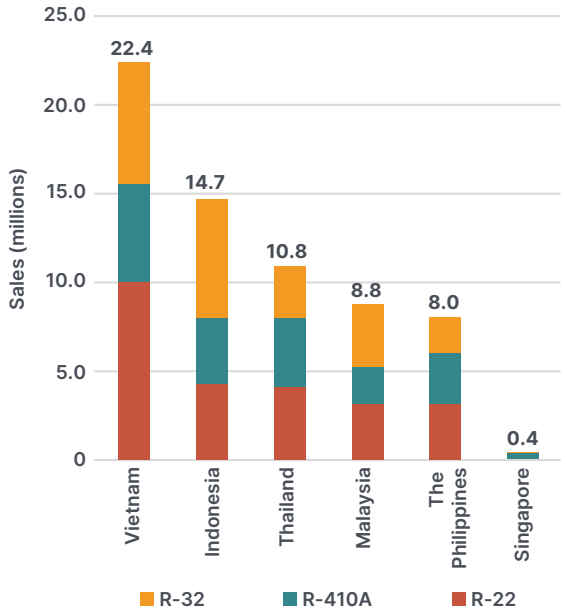


IMAGE: IMAAD WHD / UNSPLASH

139 "National Expert for the Preparation of Kigali HFC Implementation Plan (KIP)," United Nations Convention to Combat Desertification, https://www.unccd.int/cbm/national-expert-preparation-kigali-hfc-implementation-plan-kip.
140 UNE. 2023. Desk study for the evaluation of enabling activities for HFC phase-down. http://www.multilateralfund.org/92/Agenda%20item%206b%20Update%20on%20the%20status%20of%20the%20second/1/9207.pdf.
141 WB. 2020. Strategy options for initial implementation of the Kigali amendment in Malaysia https://documents1.worldbank.org/curated/en/946561593181023216/pdf/Strategy-Options-for-Initial-Implementation-of-the-Kigali-Amendment-in-Malaysia.pdf.
142 "Vietnam – Develop An MRV Framework To Track Kigali Amendment Commitments [VN-23-002]," Climate and Clean Air Coalition, https://www.ccacoalition.org/en/content/vietnam-%E2%80%93-develop-mrv-framework-track-kigali-amendment-commitments-vn-23-002.
143 UNE. 2022. UNDP's work programme amendments for 2022. http://www.multilateralfund.org/91/Agenda%20item%209c%20Projects%20recommended%20for%20blanket%20ap/1/9132.pdf.
144 This report used data from official government, manufacturer and trade sources—which already confirm the significant presence of dumped inefficient RACs using high-GWP refrigerants—however, the scope does not cover the presence of secondhand nor potentially illegal and unreported transboundary shipments of inefficient RACs or RAC components using high-GWP refrigerants.

TABLE 9: ESTIMATED 2021 STOCK OF R-22 AND RELATED STOCK-PROJECTING VARIABLES, BY COUNTRY

COUNTRY	RAC LIFETIME	ESTIMATED R-22 STOCK (2021)	ESTIMATED R-22 PROPORTION OF TOTAL STOCK (2021)	ESTIMATED YEAR OF FINAL R-22 UNIT SALES	ESTIMATED YEAR OF FINAL R-22 UNITS IN OPERATION
Indonesia	8	4.3 million	29%	2020[145]	2027
Malaysia	10	3.2 million	36%	2019	2028
The Philippines	10	3.2 million	40%	2019	2028
Singapore	10	0.02 million	4%	2020	2029
Thailand	10	4.1 million	38%	2021	2030
Vietnam	9	10.0 million	45%	2021	2029

TABLE 10: ESTIMATED 2021 STOCK OF R-410A AND RELATED STOCK-PROJECTING VARIABLES, BY COUNTRY

COUNTRY	RAC LIFETIME	ESTIMATED R-410A STOCK (2021)	ESTIMATED R-410A PROPORTION OF TOTAL STOCK (2021)	ESTIMATED YEAR OF FINAL R-410A UNIT SALES	ESTIMATED YEAR OF FINAL R-410A UNITS IN OPERATION
Indonesia	8	3.7 million	25%	2027	2034
Malaysia	10	2.0 million	23%	2029	2038
The Philippines	10	2.9 million	36%	2024/2025[146]	2033/2034
Singapore	10	0.4 million	91%	2025	2034
Thailand	10	4.6 million	43%	2031	2040
Vietnam	9	5.6 million	25%	2032	2040

R-22 USAGE AND PHASE OUT REQUIREMENTS

As discussed in Section 6.2, very few RACs with R-22 refrigerant are currently sold across the six markets. However, all six countries still have RACs with R-22 in use which require regular servicing and disposal at end of life (EOL). Servicing and disposal at EOL risk releasing substantial quantities of the HCFC-containing refrigerant into the atmosphere. To service RACs and manage refrigerants, a technician must check the refrigerant charge level of a unit and refill the charge, if needed, to yield optimal functioning. Various factors impact the quantities of refrigerants needed for servicing, including refrigerant charge, annual refrigerant leakage, proportion of products leaking, frequency of servicing, proportion of products serviced, and amount of refrigerant vented during servicing. Because none of the countries produce R-22 or R-410A, the refrigerants are imported primarily from China to meet servicing needs.[147]

For servicing of equipment existing on or before 1 January 2030, the Montreal Protocol allows Article 5 countries to use HCFCs up to 2.5% of their calculated base level, when averaged over ten years (2030-2039) until 1 January 2040. CLASP estimated the amount of R-22 needed by each country to service its R-22 RAC stock through 2039 and compared the results to HCFC requirements of the Montreal Protocol compliance (Table 11). See Annex I: Approach and Methodology for details on the assumptions and methodology for projecting R-22 consumption for RAC servicing through end of life.

145 Although Indonesia imposed an ODS ban in 2015, the following UNDP HCFC Inventory report (2014) projects their producing consumption only decreased by half rather than was eliminated: https://www.ccacoalition.org/sites/default/files/resources/Indonesia%20HFC%20Inventory%20%282010-2012%29.pdf.
146 The format of [year]/[year] for the Philippines represents data for single splits, then window units (i.e., [splits]/[window]).
147 COMTRADE, 2021.

TABLE 11: ESTIMATED R-22 SERVICING CONSUMPTION 2030-2039 COMPARED TO MONTREAL PROTOCOL HCFC ALLOTMENT, BY COUNTRY[148]

COUNTRY	2030-2039 CONSUMPTION (KG)	2030-2039 CONSUMPTION (ODP TONNES)	AVERAGE ODP TONNES PER 10 YEARS	MP HCFC ALLOTMENT (ODP TONNES)	PROPORTION OF MP HCFC ALLOTMENT
Indonesia	0	0	0	10.10	0%
Malaysia	0	0	0	12.90	0%
The Philippines	0	0	0	4.05	0%
Singapore	0	0	0	5.40	0%
Thailand	4,656	0.26	0.03	23.19	0.1%
Vietnam	0	0	0	5.53	0%

All countries are projected to be well below the maximum consumption allowed by the MP for HCFC servicing from 2030 through 2039. Even as the servicing allotment covers refrigerants beyond R-22 and equipment beyond RACs, all six countries have a servicing consumption near zero for a major usage source of HCFCs.[149] For all countries except Thailand, the number of R-22 units remaining in stock by 2030 are either none or negligible. Final R-22 sales will occur early enough for all units to retire before the period relevant to the HCFC servicing allotment. Since Thailand has the latest projected R-22 sales (2021) and a lifetime of ten years, R-22 units will persist into the 2030s.

At the end of equipment operation, the ODS should be removed and recycled or destroyed per guidelines under the Montreal Protocol and/or national regulations. Some countries classify spent HCFCs as hazardous waste which are subject to hazardous waste disposal requirements. If spent refrigerants are transported to another country, they can be subject to requirements of transboundary movements of hazardous waste under the Basel Convention. See Annex VIII: Servicing Sector Policies and Support Programs for information on policies relevant for refrigerant management.

R-410A USAGE AND PHASE DOWN REQUIREMENTS

As discussed in Section 6.2, R-410A constitutes a substantial portion of the market for each of the six countries—over 20% of each market in 2021. The Kigali Amendment to the Montreal Protocol requires the six focus countries, A5 Group 1[150] countries, to freeze then phase down HFC consumption from 2024 to 2045 (see Section 6.3 for details). CLASP estimated the R-410A consumption for each country for the various years of the Protocol phase down requirements and compared them to the HFC maximum consumption level for the respective year (Table 12).

In all six countries, R-410A consumption is well below the maximum HFC consumption levels for the respective years due to all six markets having experienced significant shifts to the lower-GWP HFC R-32 in the past decade, as detailed in Section 6.2. Vietnam's projected R-410A consumption is the largest proportion of its base level, as high as 36% in 2024. Notably, Malaysia's base level is more than double that of Vietnam, even though Vietnam's market was about 2.5 times larger in 2021; this is because the HCFC baseline—which is an average of a country's 2009-10 HCFC usage and is used to calculate the HFC baseline—for Malaysia is more than double that of Vietnam.

148 These projections of Montreal Protocol compliance are based on data available to CLASP and stock modelling assumptions, and are therefore not definitive assessments nor should be regarded as such.
149 "Current Use of HCFCs and HFCs," OzonAction Kigali Fact Sheet 2, Economy Division, United Nation Environment Programme, https://wedocs.unep.org/bitstream/handle/20.500.11822/26867/7877FS02_C_Uses_EN.pdf?sequence=1&isAllowed=y.
150 Under the Kigali Amendment, Article 5 countries are split into two groups with slightly different phase down schedules, as per request of the involved Parties.

TABLE 12: ESTIMATED R-410A ANNUAL CONSUMPTION COMPARED TO MONTREAL PROTOCOL ANNUAL HFC MAXIMUM CONSUMPTION REQUIREMENTS, BY COUNTRY ($MtCO_2e$)[151]

	INDONESIA	MALAYSIA	THE PHILIPPINES	SINGAPORE	THAILAND	VIETNAM
Protocol HFC Base Level	N/A	**26.5**	**11.9**	**9.8**	N/A	**10.2**
2024						
Protocol HFC Freeze Level	N/A	**26.5**	**11.9**	**9.8**	N/A	**10.2**
Estimated R-410A Consumption	1.6	1.1	1.1	0.2	2.7	2.3
2029						
Protocol HFC 10% Reduction	N/A	**23.9**	**10.7**	**8.8**	N/A	**9.2**
Estimated R-410A Consumption	1.5	1.2	1.1	0.1	3.1	1.8
2035						
Protocol HFC 30% Reduction	N/A	**18.6**	**8.3**	**6.9**	N/A	**7.2**
Estimated R-410A Consumption	0.0	0.6	0.0	0.0	1.3	0.9
2040						
Protocol HFC 50% Reduction	N/A	**13.3**	**6.0**	**4.9**	N/A	**5.1**
Estimated R-410A Consumption	0.0	0.0	0.0	0.0	0.1	0.0
2045						
Protocol HFC 80% Reduction	N/A	**5.3**	**2.4**	**2.0**	N/A	**2.0**
Estimated R-410A Consumption	0.0	0.0	0.0	0.0	0.0	0.0

151 The data are drawn from the UNEP Ozone Secretariat Data Centre (https://ozone.unep.org/countries/data-table?q=countries/data) and the following Montreal Protocol resource: https://ozone.unep.org/system/files/documents/OEWG-45-4E.pdf. Base level data is not currently available for Indonesia nor Thailand. Base level data for Vietnam is drawn from the data set received from the secretariat of the Multilateral Fund.

7. Impact of Low Efficiency, High GWP RACs in SEA

IMAGE : ALAIARIF / PIXABAY

This section highlights the estimated GHG emissions from low efficiency, high-GWP RACs to compare with the projected emissions reductions and cost savings that can be achieved by eliminating these products from the market. CLASP modelled the combination of indirect emissions associated with RAC energy use, as well as the direct emissions associated with refrigerant release from RAC servicing and unit disposal. CLASP used Mepsy: Climate Impact Calculator and an in-house direct emissions model to generate the impact estimates. Data inputs for both models were derived from interviews with local market stakeholders, industry reports, journal publications, and BSRIA market data. See Annex I: Approach and Methodology for more details on the methodology and assumptions used for the climate impacts modelling.

This section summarizes the regional impact among all six countries.

7.1. MODELLING SCENARIOS

CLASP modeled impacts under the following four scenarios:

- **Business As Usual (BAU) –** Current market and future projections in accordance with current growth trends. BAU does not include any policy intervention. BAU assumes a gradual market transition to a low-GWP refrigerant[152] beginning in 2035 in accordance with the Montreal Protocol HFC phase-down schedule and technological development trends.
- **Policy Scenario 1 –** Adoption of China MEPS[153] for RACs in 2025.
- **Policy Scenario 2 –** Adoption of China MEPS for RACs in 2025 and regulation of refrigerant usage in RACs in accordance with U4E guidelines[154] (GWP ≤ 750 and ODP = 0) in 2025.
- **Policy Scenario 3 –** Adoption of China MEPS for RACs in 2025, regulation of refrigerant usage in RACs in accordance with U4E guidelines (GWP ≤ 750 and ODP = 0) in 2025, and an accelerated market transition to a low-GWP refrigerant, which will be introduced to the market in 2025.

7.2.IMPACTANALYSIS

Low efficiency RACs are readily available across all six Southeast Asian markets. These low-efficiency units are projected to release considerable annual emissions in the absence of policy intervention (Figure 22).

If all six countries adopted China MEPS by 2025 (Policy Scenario 1), the region would achieve emissions reductions of **639 $MtCO_2e$ cumulatively 2025-2050** (Figure 23). These reductions are equivalent to avoiding emissions from 12 coal-fired power plants from the region over that same period.[155]

If all six countries adopted China MEPS and United for Efficiency (U4E) refrigerant guidelines (Policy Scenario 2), the region would achieve emissions reductions of **675 $MtCO_2e$ cumulatively 2025-2050**.

Finally, if all six countries adopted China MEPS, U4E refrigerant guidelines, and an accelerated low-GWP transition by 2025 (Policy Scenario 3), the region would achieve emissions reductions of **1,039 $MtCO_2e$ cumulatively 2025-2050**, equivalent to nearly a third of projected emissions under BAU. The emissions reductions would have a tangible positive impact on national climate goals.

The cost savings of reduced electricity usage from the implementation of MEPS in the policy scenarios would be **USD 148 billion cumulatively 2025-2050**, aggregated across all six countries. These cost savings exceed the combined energy investment of the six analyzed countries over the last quarter century (USD 134 billion).[156] They would have meaningful impact on consumers across the Southeast Asian region.

152 R-290 is used as the low-GWP refrigerant (including factors like GWP, charge, etc.).
153 China's current minimum energy performance standard (MEPS) for inverter, cooling-only RACs: CSPF 6.1 Wh/Wh for CC ≤ 4.5 kW, CSPF 5.1 Wh/Wh for 4.5 kW < CC ≤ 7.1 kW, and CSPF 4.5 Wh/Wh for 7.1 kW < CC ≤ 14.0 kW (converted from China SEER in GB 21455—2019 to ISO CSPF using "Lost in translation" (2020) by Park et al.). These MEPS are harmonized with U4E guidelines and ASEAN 2025 target MEPS.
154 In September 2019, United for Efficiency (U4E) published model energy performance standards and labeling guidance to assist governments in developing and emerging economies in establishing or strengthening their regulations. These guidelines present an opportunity for African countries to harmonize around ambitious and achievable MEPS and refrigerant requirements. GWP of 750 was chosen to allow for R-32. https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/.
155 Assuming 500 MW capacity at 50% load factor with 34% efficiency and a carbon emission factor of 95.52 kg CO2/mmBtu, where annual emissions stay constant year-on-year.
156 "Investment in energy with private participation (current USD", World Bank (1998-2022), https://data.worldbank.org/indicator/IE.PPI.ENGY.CD

FIGURE 22: ANNUAL COMBINED DIRECT AND INDIRECT EMISSIONS ($MtCO_2e$) FOR THE AGGREGATED SIX COUNTRIES, BY POLICY SCENARIO, 2020-2050

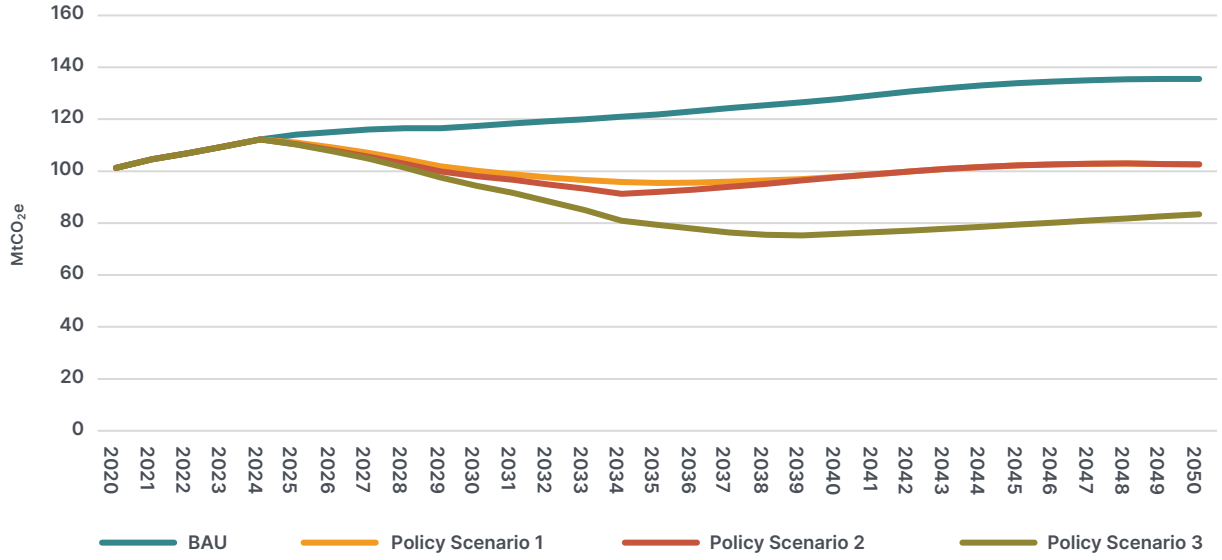
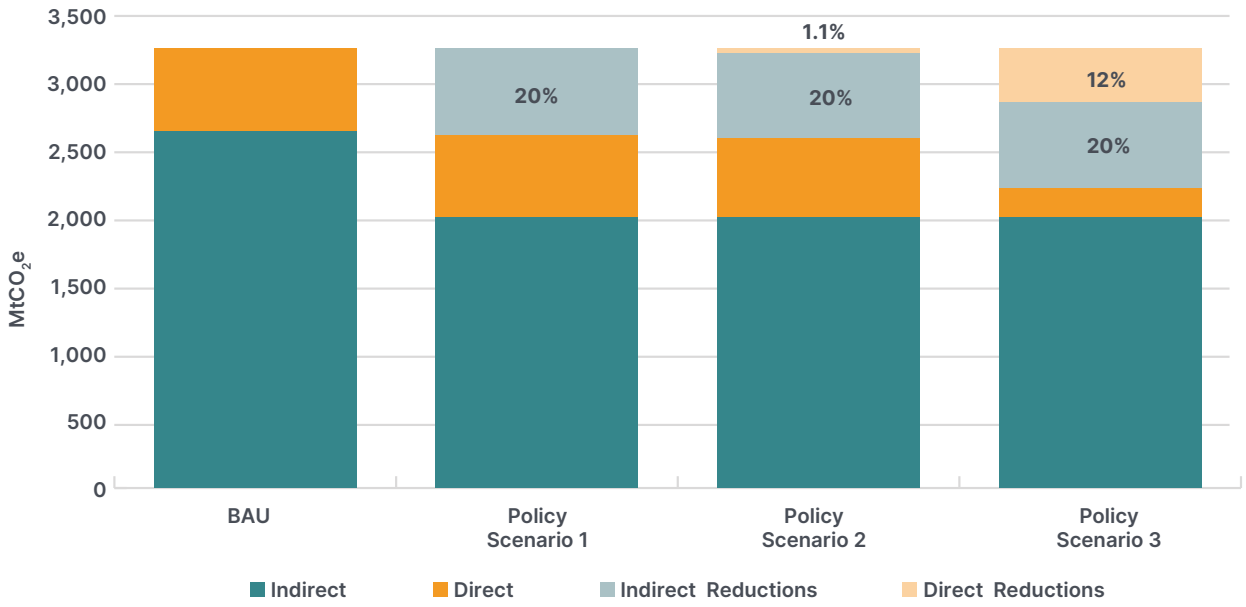


FIGURE 23: CUMULATIVE EMISSIONS AND EMISSIONS REDUCTIONS ($MtCO_2e$) FOR THE AGGREGATED SIX COUNTRIES, 2025-2050, BY EMISSION TYPE AND SCENARIO, WITH PROPORTION OF REDUCTIONS FROM TOTAL BAU EMISSIONS INDICATED



8. Conclusion

IMAGE: PEXELS / PIXABAY

8.1. ASSESSMENT RESULTS

Low efficiency units are readily available across all six Southeast Asian markets. Except Singapore, the RAC markets of the analyzed countries exhibit substantial inefficiency, with low-efficiency units constituting 60-97% of the markets. If all six countries were to adopt China MEPS by 2025 (Policy Scenario 1), the region could achieve an emissions reduction of **639 $MtCO_2e$ cumulatively between 2025-2050** (Table 13). However, by implementing not only China MEPS, but also U4E refrigerant guidelines and expediting the transition to low-GWP alternatives by 2025 (Policy Scenario 3), the region could achieve a CO_2 emissions reduction of **1,039 $MtCO_2e$ cumulatively between 2025-2050**. Table 13 details the cumulative 2025-2050 emissions and emissions reductions by policy scenario.

TABLE 13: SUMMARY OF CUMULATIVE EMISSIONS AND EMISSIONS REDUCTIONS 2025-2050 ($MtCO_2e$), BY POLICY SCENARIO

	BUSINESS AS USUAL	POLICY SCENARIO 1	POLICY SCENARIO 2	POLICY SCENARIO 3
Indirect Emissions	2,641	2,001	2,001	2,001
Direct Emissions	628	628	592	227
Total Emissions	3,268	2,629	2,593	2,229
Indirect Reductions	-	639	639	639
Direct Reductions	-	-	36	400
Total Reductions	-	639	675	1,039

The resulting cost savings of reduced electricity usage from implementing MEPS in the policy scenarios would be **USD 148 billion cumulatively 2025-2050**, aggregated across all six countries.

8.2. RECOMMENDATIONS TO POLICYMAKER AND OTHER STAKEHOLDERS

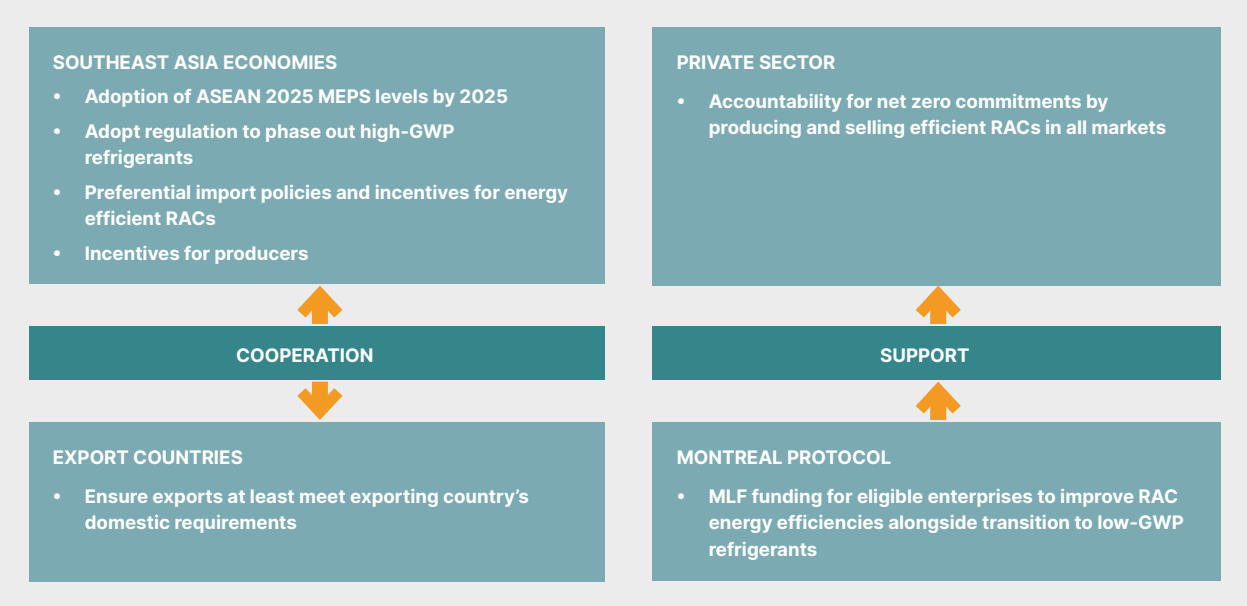
Environmental dumping occurs not only through imports, but also through low efficiency RAC production by multinational brands operating in the region. Measures like energy efficiency policies and energy efficiency-minded trade policies can work together to support Southeast Asian countries meet consumer demand, and achieve development and climate goals, while simultaneously limiting emissions from the cooling sector.

Effective solutions to environmental dumping are a shared responsibility. The actions to stop environmental, financial, and compliance burdens from dumping require collaboration with and mitigating actions from importing- and exporting-country stakeholders. In this regard, we must keep in mind the capacity limitations of low-resource import countries. Un- and under-regulated markets are the most vulnerable to the impacts of inefficient RACs using high-GWP refrigerants.

Based on the findings of this report and drawing from IGSD's anti-environmental dumping "toolkit"[157] Southeast Asian policymakers and other stakeholders can take the steps outlined in Figure 7 and work together to halt environmental RAC dumping. Through collaboration with export countries and the private sector, and with support from the Montreal Protocol, SEA countries can ensure transition to highly-efficient, low-GWP RACs in the South Asian markets.

IMAGE: MARKUS WINKLER / UNSPLASH

157 For more information refer to "Defining the legal and policy framework to stop the dumping of environmentally harmful products." http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf.



POLICYMAKERS IN COUNTRIES EXPORTING TO SOUTHEAST ASIA

- Ensure exports at least meet the exporting country's domestic requirements. Environmental dumping is a shared responsibility and exporting countries are part of the solution. Lack of policies that prevent dumping allowing for export of products banned domestically undermines import countries' economies. Exporting inefficient, environmentally harmful RACs creates a market for poor quality appliances that worsen air pollution and climate resilience – global issues that do not recognize national borders. Export economies can show leadership and commitment to climate, development and international environmental justice by aligning exports with domestic market requirements. Export countries can also remove loopholes or exemptions that allow such exports and promote other policy mechanisms, agreements and cooperation with key stakeholders that will disincentivize export of low-efficiency RACs using high-GWP refrigerants. Such policies will not only benefit SEA economies, but all import markets.

POLICYMAKERS IN SOUTHEAST ASIA ECONOMIES

- Adopt ASEAN 2025 Target MEPS levels by 2025 consistent with major trade partners. Currently, the MEPS for RACs in the Southeast Asian countries, except for Singapore, are much lower than those of the major Southeast Asia region trade partners including China, South Korea, and Japan. China adopted world-leading MEPS in 2020 prompting a major market transformation to more efficient units with low-GWP refrigerant. Southeast Asian countries agreed to adopt ASEAN 2025 MEPS target for RACs, but to-date, only Singapore is on track to meet this commitment. Implementing MEPS at levels comparable to MEPS in RAC source countries can prevent the environmental dumping of inefficient products and provide substantial GHG emissions savings over time.
- Adopt regulations in line with the Kigali Amendment to accelerate phase out high-GWP refrigerants. Kigali Amendment to the Montreal Protocol calls for gradual reduction in the consumption and production of HFCs. The share of RACs with R-32 is rapidly increasing in the six countries. Phasing out the remaining market share of R-410A RACs, an obsolete high-GWR refrigerant, would help SEA economies meet climate targets and commitments under Kigali amendment. SEA countries can follow Singapore's lead and adopt policies banning high-GWP refrigerants to reduce climate impacts.
- Introduce preferential import policies and incentives to promote high efficiency RACs. Preferential import policies for efficient equipment[158] can help promote adoption of the equipment and make it more competitive. The

158 For example, policies that require meeting exporting-country or benchmark MEPS such as China's.

measures can include reduced import duties, lower value-added taxes, subsidies, and others. The preferential treatment of efficient RACs can be built in Free Trade Agreements, e.g., ASEAN-China FTA can include a provision of incentives for companies importing RACs that meet China's MEPS or introduce reciprocal efficiency requirements for appliances. Policy makers can also consider adding import of only high efficiency RACs criteria to Authorized Economic Operators (AEOs) certification that provide benefits to companies including priority treatment (e.g., for inspections), simplified and expedited procedures, lower inspection rates, and financial incentives.

- Design incentive programs for producers to produce and consumers to buy more efficient RACs. Green government procurement is an effective means to promote energy efficient appliances. Through green procurement, governments can demonstrate the benefits of transitioning to efficient RACs and signal to producers to produce more efficient RACs. Bulk purchases help to aggregate demand and purchase high efficiency and low GWP RACs at affordable prices. This type of program can be designed to target replacement of older and inefficient RAC equipment that contains high-GWP refrigerants. Incentive and financing programs for consumers such as on-bill-financing can help spur demand for highly efficient RACs.

STAKEHOLDERS IN THE PRIVATE SECTOR DOING BUSINESS WITH SOUTHEAST ASIA

- Commit to net zero by producing and selling efficient RACs in all markets. Nine out of the ten most popular multinational brands have committed to net zero targets, with seven companies aiming to reduce emissions throughout their value chain, including use of their products by consumers.

- RAC companies should have transparent and publicly available strategies and actionable plans to meet net zero goals, as well as instruments to track progress and measure impacts. Strategies to bring efficient appliances to all consumers should be part of any corporate strategy to meet net zero targets. Commitments to produce and promote efficient appliances must extend equally to all markets globally.

STAKEHOLDERS OF THE MONTREAL PROTOCOL

- MLF funding for enterprises to improve RAC energy efficiencies alongside the transition to low-GWP. The guidelines for the preparation of Kigali HFC implementation plans (KIPs) were approved in 2021.[159] Currently, energy efficiency enhancements alongside conversion of production lines from HFCs to low-GWP alternatives is proposed for pilot projects.[160] Maintaining the energy efficiency enhancement as part of HFC phase down strategy could benefit the Southeast Asia producers and local markets. Governments are concerned about protecting local production and MLF support for energy efficiency improvements to locally owned RAC producers in the five SEA countries could help strengthen and maintain their competitiveness.

159 Decision 87/50: http://www.multilateralfund.org/87/Document%20Library3/1/8758.pdf.
160 UNEP. 2022. Criteria for pilot projects to maintain and/or enhance energy efficiency of replacement technologies and equipment in the context of HFC phase-down (decision 90/50(b)(i)). http://www.multilateralfund.org/91/Agenda%20item%2011b%20i%20Criteria%20for%20pilot%20projects%20to%20m/1/9163.pdf.

Annexes

ANNEX I: APPROACH & METHODOLOGY

To assess split RACs among the six focus countries, as well as the window units within the Philippines, CLASP used market data collected by the Building Services Research and Information Association (BSRIA), imports and exports data from the UN International Trade Statistics Database (Comtrade), and thereafter, published country-specific reports and the findings of on-the-ground surveys and interviews with key stakeholders in the Southeast Asian countries. To model the climate impacts of low-efficiency RACs and policy scenarios, CLASP used direct and indirect stock-accounting models, with key inputs (e.g., sales, lifetime, operating hours, servicing frequency, etc.) provided and validated by the aforementioned sources.

DATA SOURCES

MARKET SIZE & PRODUCT CHARACTERISTICS

To assess the size and product characteristics of the RAC markets in the region, CLASP relied on several sources of data:[1]

- **BSRIA market research on national RAC markets:** This research is on primary data from importers, producers, distributors, and contractors on single split units,[2] as well as window units for the Philippines, for 2021. This was the primary information source on RAC sales projected through 2026 as well as market-level characteristics.
- **Brand model data collected by CLASP and BSRIA:** Data on 452 available models were collected as a representative sample of RACs spanning the six markets. CLASP utilized producer product catalogs in each market — along with product registration databases in Indonesia, the Philippines, and Singapore — to gather model data (including energy efficiency, refrigerant used, capacity, etc.) for RACs in the six focus countries. Efficiency ratings for the models were represented by various metrics across the six markets and were converted to cooling seasonal performance factor (CSPF) for comparison.[3] CLASP made a conscious effort to ensure that the selected models are representative of a range of efficiencies offered by dominant brands. However, this data does not represent the entirety of the models available within these markets. The model data, in combination with the market data, informs the product-level data on the energy efficiency and refrigerants contained in RACs in the six focus countries.
- **Surveys and interviews with local stakeholders**: CLASP engaged with local partners in Indonesia, Malaysia, the Philippines, Thailand, and Vietnam to validate market data and modeling assumptions with producers, industry experts, and government stakeholders, as well as collect additional data on markets and policies.

Data validation and supplemental data sources:

- **Japan Refrigeration and Air Conditioning Industry Association:** Estimates of *World Air Conditioner Demand* report (July 2022) were used as a source of secondary data for RAC sales (2019–2021). Data is available for each of the six focus countries.[i]
- **Euromonitor:** Data on market size, market value, and brand shares were used as a source of secondary data for all focus countries.
- **CLASP's *Room Air Conditioner Market Assessment* & *Policy Options Analysis* reports** for the Philippines, Thailand, and Vietnam:[4] Market sizes, characteristics, and stock data were used to validate and compare data collected by BSRIA and other sources. Some data from reports was also included in the analysis.

INTERNATIONAL & REGIONAL TRADE FLOWS

To assess international trade flows for fully assembled RACs as well as the key product components, CLASP analyzed data from the UN Comtrade Database for RAC units, compressors, and three refrigerants imported to Southeast Asia (R-22, R-410A, and R-32). Import, export, reimport, and

1 The scope of this report does not include the secondhand market nor unreported and potentially illegal imports of inefficient RACs using high-GWP refrigerants, the latter of which is a suitable topic for separate research by an investigative organization, as such unreported and potentially illegal trade would only serve to exacerbate the dumping situation.
2 Ducted splits are included within single splits as they are often covered within split system cooling policies, although they average less than 3% of single splits among the six markets.
3 The following two sources were used to convert various metrics to ISO CSPF: Park et al., "Lost in translation: Overcoming divergent seasonal performance metrics to strengthen air conditioner energy-efficiency policies," *Energy for Sustainable Development* 55, no. 1 (2020): 56-68 and Park et al., "Harmonizing Energy-Efficiency Standards for Room Air Conditioners in Southeast Asia," May 2021.
4 Reports are available at www.clasp.ngo.

reexport data for the years 2012–2021 was analyzed for the following harmonized system (HS) codes:[5]

- **RACs (HS 841510):** Air conditioning machines, comprising a motor-driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be regulated separately. Units designed to be fixed either to a window, wall, ceiling, or floor, and those that are either self-contained or "split-systems", were analyzed.[ii]
- **Compressors:** There is no exclusive HS code for the compressors used in RACs. This report includes import and export data for HS 841430, which are compressors used in refrigerating equipment. Thus, the compressor trade data from Comtrade encompasses all reported import or export of compressors or use in refrigeration equipment (RACs, refrigerators, chillers, etc.), and does not exclusively document the import/export of compressors used in RAC assembly or production.
- **R-22:** As one of the five most popular hydrochlorofluorocarbons (HCFCs), R-22, which is also known as HCFC-22, has been assigned the code HS 290371 (Chlorodifluoromethane (HCFC-22)).[iii] Thus, R-22 data from Comtrade encompasses all reported imports or exports of each refrigerant for any purpose and does not reflect the import or export of each refrigerant exclusively for use in RACs. R-22 has a 100-year global warming potential ($GWP_{100\text{-}yr}$) of 1,760.[6]
- **R-32:** As of 2022, R-32, which is also known as HFC-32, is designated with HS 290342 (Difluoromethane (HFC-32)).[iv] This refrigerant is not ozone-depleting and has a $GWP_{100\text{-}yr}$ of 677. Before the World Customs Organization (WCO) made an amendment, this organic compound was covered along with other HFCs under a single HS code (HS 290339: Fluorinated, brominated, or iodinated derivatives of acyclic hydrocarbons; other than ethylene dibromide (ISO) (1,2-dibromoethane)).[v] Since this change was recent and the import/export data for the new HS code is unavailable, this report includes data on the import and export of HFCs under HS 290339 as well as all reported import or export of HFCs for any purpose and does not reflect import or export of each refrigerant exclusively for use in RACs.
- **Mixtures containing HFCs (including R-410A and R-407C):** Similarly, since 2022, R-410A, a refrigerant mixture of difluoromethane (HFC-32) and pentafluoroethane (HFC-125), has been covered under HS 382763 (other; not included in the subheadings above; containing 40% or more by mass of HFC-125).[vi] Refrigerant R-407C, a mixture of difluoromethane (R-32), pentafluoroethane (R-125), and 1,1,1,2-tetrafluoroethane (R-134a) has been covered under HS 382764 (other; not included in the subheadings above; containing 30% or more by mass of 1,1,1,2-tetrafluoroethane (HFC-134a) but not containing unsaturated, fluorinated derivatives of acyclic hydrocarbons (HFOs)).[vii],[viii],[ix] Though R-410A and R-407C are not ozone-depleting, they have high GWPs of 1,923.5 and 1,624, respectively. Until the 2022 revision, all mixtures containing HFCs were covered by a single code (HS 382478: Mixtures containing halogenated derivatives of methane, ethane, or propane; containing perfluorocarbons (PFCs) or hydrofluorocarbons (HFCs), but not containing chlorofluorocarbons (CFCs) or HCFCs).[x] This report includes data on the import and export of HFC mixtures under old HS codes, including R-410A and R-407C, because Comtrade has yet to provide data for the newly added codes. The import/export data from Comtrade for the HFC mixture encompasses all reported imports or exports of the chemical mixtures for any purpose and does not reflect the import or export of each refrigerant exclusively for use in RACs.

IMPACT EVALUATION

CLASP conducted an impact evaluation for all six countries covered in this study. The impact evaluations focus on two sources of greenhouse gas (GHG) emissions and two evaluations of cost impacts. One source of GHG emissions modeled is direct emissions from refrigerant escape over the life of the equipment and the end-of-life disposal of the refrigerants used in RACs. The other source is indirect emissions from the generation of the electricity consumed by RACs. The modeled cost impacts will be national energy savings from minimum energy performance standard (MEPS) as well as consumer lifecycle cost, considering purchase price and lifetime electricity costs.

5 The harmonized system is an international nomenclature for the classification of products. It allows participating countries to classify traded goods on a common basis for customs purposes. At the international level, the HS for classifying goods is a six-digit code system.

6 CLASP used 100-year GWP values from Annex F of the Kigali Amendment to the Montreal Protocol. These values can be accessed through UNEP's OzonAction GWP-ODP Calculator.

For all six countries, CLASP modeled GHG emissions under four policy scenarios designed to demonstrate the GHG emissions reductions that can be achieved by eliminating environmental dumping of low-efficiency, high-GWP RACs. The four scenarios are:

- **Business-as-usual (BAU):** Current market and future projections per current growth trends; does not involve policy intervention. A gradual market transition to a low-GWP refrigerant[7] beginning in 2035 is assumed following the Montreal Protocol (MP) HFC phasedown schedule and technological development trends.
- **Policy Scenario 1:** Adoption of China's MEPS[8] for RACs in 2025.
- **Policy Scenario 2:** Adoption of China's MEPS for RACs in 2025 and regulation of refrigerant usage in RACs in accordance with U4E guidelines[9] (GWP ≤ 750 and ODP = 0) in 2025.
- **Policy Scenario 3:** Adoption of China's MEPS for RACs in 2025, regulation of refrigerant usage in RACs in accordance with U4E guidelines (GWP ≤ 750 and ODP = 0) in 2025, and an accelerated market transition to a low-GWP refrigerant, which will be introduced to the market in 2025.

For modeling both direct and indirect emissions, CLASP used two representative RAC units per country — one less than or equal to 3.5 kW and one greater than 3.5 kW — to provide an accurate representation of the projected impacts from a combination of common-sized and differently sized units (Table A-1). The representative units are RAC models within the collected dataset of 452 models across the six countries. These units were selected by segmenting each market into two size groups (≤ 3.5 kW and > 3.5 kW) and then calculating the median capacity and efficiency of each group to determine two ideal models. Thereafter, an available model that most closely aligns with the ideal model was selected for each group. Sales were then allocated to each representative unit based on the market share of each size group in a given country.

TABLE A-1: MODELING REPRESENTATIVE UNITS, BY COUNTRY

	GROUP	CAPACITY (KW)	EFFICIENCY (CSPF)	BRAND	REFRIGERANT	MARKET SHARE
Indonesia	≤ 3.5 kW	2.1	3.55	Samsung	R-410A	81%
	> 3.5 kW	5.0	3.50	Aux	N/A	20%
Malaysia	≤ 3.5 kW	2.7	3.98	Midea	R-32	34%
	> 3.5 kW	5.3	3.52	Mitsubishi Electric	R-32	66%
The Philippines	≤ 3.5 kW	2.8	4.84	Carrier	R-32	23%
	> 3.5 kW	4.2	4.67	Koppel	R-32	77%
The Philippines (W)	≤ 3.5 kW	2.1	3.40	LG	R-32	60%
	> 3.5 kW	4.2	4.04	Carrier	R-410A	40%
Singapore	≤ 3.5 kW	2.6	5.98	LG	R-32	29%
	> 3.5 kW	5.2	5.87	LG	R-32	71%
Thailand	≤ 3.5 kW	2.6	4.64	Panasonic	R-32	25%
	> 3.5 kW	5.3	4.99	LG	R-32	75%
Vietnam	≤ 3.5 kW	2.7	4.73	Hitachi	R-32	58%
	> 3.5 kW	5.6	4.77	Daikin	R-32	42%

7 R-290 is used as the low-GWP refrigerant (including factors such as GWP, charge, etc.).
8 China's current MEPS standard for inverter, cooling-only RACs: CSPF 6.1 Wh/Wh for CC ≤ 4.5 kW, CSPF 5.1 Wh/Wh for 4.5 kW < CC ≤ 7.1 kW, and CSPF 4.5 Wh/Wh for 7.1 kW < CC ≤ 14.0 kW (converted from China SEER in GB 21455—2019 to ISO CSPF using Park et al. (2020)). These MEPS are harmonized with U4E guidelines and ASEAN 2025 target MEPS.
9 Under this scenario, it is assumed refrigerant market shares of R-32 equal 100% in 2025.

INDIRECT EMISSIONS

To calculate indirect emissions from RAC usage, CLASP used its free, online tool Mepsy: The Appliance & Equipment Climate Impact Calculator to model the benefits of MEPS implementation. Mepsy is a bottom-up stock-accounting model that multiplies annual sales by average unit energy consumptions (UEC) under different policy scenarios and accumulates sales and retirements to estimate the number of appliances in use in each country (stock) to derive the national energy consumption of the represented appliances. The national energy consumption is multiplied by a grid emissions factor or an electricity tariff to derive the national carbon emissions.[10]

In this analysis, CLASP used data from BSRIA market research and local stakeholder interviews to customize the tool with relevant data for each country and evaluated the GHG emissions impacts at the national and regional levels for the selected policy scenarios. Table A-2 details country-specific inputs for Mepsy and UEC calculations that were used in both the BAU and policy scenarios. Lifetime and annual operating hours data were collected through interviews with local stakeholders. Data on efficiency improvement rates, grid emission factors, and transmission and distribution (T&D) loss factors were collected by CLASP from various journal publications, industry reports, and market research.

UEC is another key assumption for modeling indirect emissions in Mepsy. Cooling capacity and CSPF data were gathered from the selected representative units and assumptions for annual operating hours were derived from interviews with local stakeholders. The following equation was used to calculate the UEC for each representative unit and policy scenario:

$$UEC\ (kWh/year) = \frac{Cooling\ Capacity\ (kW)}{CSPF\ (W/W)}\ x\ Annual\ Operating\ Hours$$

CLASP validated Mepsy's stock projections for the six markets using external estimates, including data from the International Energy Agency (IEA), Green Cooling Initiative (CGI), United for Efficiency (U4E), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and various MP resources.

DIRECT EMISSIONS

CLASP used its in-house direct emissions model to project GHG emissions from refrigerants used in RACs and analyze the climate benefits of introducing requirements for the use of refrigerants with lower GWPs. The stock-accounting model — which uses the same sales and determines the same stock as Mepsy — sums three sources of refrigerant emissions over a unit's lifetime: annual leakage, venting at servicing, and EOL discharge.

All six markets were modeled with four refrigerants: R-32, R-410A, R-22, and R-290. Table A-3 lists the GWP and charge assumptions for the refrigerants. The representative units used in indirect emissions modeling were also used to determine the refrigerant charge and market share–weighted sales were employed. The refrigerant charges are listed in a range (minimum to maximum) because the charges vary with the capacity of the representative unit for a given country.

TABLE A-2: INPUTS FOR MEPSY & UEC CALCULATIONS FOR MODELING INDIRECT EMISSIONS FROM 2020–2025, BY COUNTRY

	LIFETIME (YEARS)	EFFICIENCY IMPROVEMENT RATE	GRID EMISSION FACTOR[10]	T&D LOSS FACTOR	ANNUAL OPERATING HOURS
Indonesia	8	2%	0.64–0.45	9%	2,920
Malaysia	10	2%	0.47–0.33	7%	2,920
The Philippines	10	2%	0.49–0.34	9%	2,190
The Philippines (W)	10	2%	0.49–0.34	9%	2,190
Singapore	10	2%	0.25–0.18	1%	2,920
Thailand	10	2%	0.39–0.27	6%	2,412
Vietnam	9	2%	0.36–0.25	8%	2,190

10 Grid emission factors decrease linearly between 2020 and 2050, with the 2020 and 2050 values shown in Table 14.

TABLE A-3: REFRIGERANT GWP & CHARGE ASSUMPTIONS

	100-YEAR GWP	REFRIGERANT CHARGE (KG)
R-32	675	0.49-1.29
R-410A	2,087.5	0.69-1.85
R-22	1,810	0.69-1.85
R-290	0.02	0.35-0.92

Table A-4 details the key assumptions used for modeling GHG emissions from RAC refrigerants. These assumptions were derived from interviews with local stakeholders, producers, and industry experts.[11]

Table A-5 details estimates of these factors from government sources and industry experts, averaged across stock, for each country.[12]

Another key assumption to the modeling of direct emissions is the annual market share of refrigerants spanning the analysis timeframe. CLASP used a variety of sources to gather historic refrigerant market share data, including national HCFC and HFC inventories, journal publications, and reports from the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), GIZ, Climate & Clean Air Coalition (CCAC), and Lawrence Berkeley National Laboratory (LBNL). Refrigerant market share assumptions, by country and policy scenario, are presented in Tables A6-A12.

TABLE A-4: INPUTS FOR MODELING GHG EMISSIONS FROM REFRIGERANTS, BY COUNTRY

	ANNUAL LEAKAGE RATE	% OF PRODUCTS LEAKING	SERVICES DURING LIFETIME	% OF PRODUCTS SERVICED	% OF REFRIGERANT VENTED AT SERVICING	% OF REFRIGERANT CAPTURED AT END-OF-LIFE
Indonesia	10%	100%	1	30%	50%	0%
Malaysia	4.5%	100%	1	30%	50%	0%
The Philippines	4.5%	100%	1	30%	50%	0%
The Philippines (W)	4.5%	100%	1	30%	50%	0%
Singapore	4.5%	100%	1	30%	50%	0%
Thailand	4.5%	100%	1	30%	50%	0%
Vietnam	2%	100%	1	30%	50%	0%

TABLE A-5: RAC DIRECT EMISSION MODELING ASSUMPTIONS, BY COUNTRY

	REFRIGERANT CHARGE (R-22) (KG)[12]	ANNUAL LEAKAGE RATE	PROPORTION OF PRODUCTS LEAKING	SERVICES PER YEAR	PROPORTION OF PRODUCTS SERVICED	PROPORTION VENTED AT SERVICING
Indonesia	1.17	10%	100%	1	30%	50%
Malaysia	1.32	4.5%	100%	1	30%	50%
The Philippines	1.10	4.5%	100%	1	30%	50%
Singapore	1.29	4.5%	100%	1	30%	50%
Thailand	1.30	4.5%	100%	1	30%	50%
Vietnam	1.37	2%	100%	1	30%	50%

11 An annual leakage rate of 4.5% was used for countries where interviews did not provide specific data corroborated by industry experts, and it is sourced from the 2002 Montreal Protocol report.
12 The refrigerant charge for R-22 for each country is an average of charges for a smaller (≤ 3.5 kW) and larger (> 3.5 kW) representative unit.

TABLE A-6: INDONESIA REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	17%	33%	50%	0%	17%	33%	50%	0%	17%	33%	50%	0%
2016	20%	38%	42%	0%	20%	38%	42%	0%	20%	38%	42%	0%
2017	23%	44%	33%	0%	23%	44%	33%	0%	23%	44%	33%	0%
2018	26%	49%	25%	0%	26%	49%	25%	0%	26%	49%	25%	0%
2019	29%	54%	17%	0%	29%	54%	17%	0%	29%	54%	17%	0%
2020	32%	60%	8%	0%	32%	60%	8%	0%	32%	60%	8%	0%
2021	35%	65%	0%	0%	35%	65%	0%	0%	35%	65%	0%	0%
2022	30%	70%	0%	0%	30%	70%	0%	0%	30%	70%	0%	0%
2023	25%	75%	0%	0%	25%	75%	0%	0%	25%	75%	0%	0%
2024	20%	80%	0%	0%	20%	80%	0%	0%	20%	80%	0%	0%
2025	15%	85%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	10%	90%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	5%	95%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	0%	100%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	0%	100%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	0%	100%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	0%	100%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	0%	100%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

TABLE A-7: MALAYSIA REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	23%	21%	56%	0%	23%	21%	56%	0%	23%	21%	56%	0%
2016	23%	32%	45%	0%	23%	32%	45%	0%	23%	32%	45%	0%
2017	24%	42%	34%	0%	24%	42%	34%	0%	24%	42%	34%	0%
2018	25%	53%	23%	0%	25%	53%	23%	0%	25%	53%	23%	0%
2019	26%	63%	11%	0%	26%	63%	11%	0%	26%	63%	11%	0%
2020	26%	74%	0%	0%	26%	74%	0%	0%	26%	74%	0%	0%
2021	27%	73%	0%	0%	27%	73%	0%	0%	27%	73%	0%	0%
2022	25%	75%	0%	0%	25%	75%	0%	0%	25%	75%	0%	0%
2023	22%	78%	0%	0%	22%	78%	0%	0%	22%	78%	0%	0%
2024	20%	80%	0%	0%	20%	80%	0%	0%	20%	80%	0%	0%
2025	17%	83%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	15%	85%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	12%	88%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	9%	91%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	6%	94%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	0%	100%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	0%	100%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	0%	100%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

TABLE A-8: THE PHILIPPINES (SINGLE SPLITS) REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	25%	5%	70%	0%	25%	5%	70%	0%	25%	5%	70%	0%
2016	45%	6%	49%	0%	45%	6%	49%	0%	45%	6%	49%	0%
2017	66%	6%	28%	0%	66%	6%	28%	0%	66%	6%	28%	0%
2018	86%	7%	7%	0%	86%	7%	7%	0%	86%	7%	7%	0%
2019	67%	28%	5%	0%	67%	28%	5%	0%	67%	28%	5%	0%
2020	48%	52%	0%	0%	48%	52%	0%	0%	48%	52%	0%	0%
2021	30%	70%	0%	0%	30%	70%	0%	0%	30%	70%	0%	0%
2022	21%	79%	0%	0%	21%	79%	0%	0%	21%	79%	0%	0%
2023	12%	88%	0%	0%	12%	88%	0%	0%	12%	88%	0%	0%
2024	3%	97%	0%	0%	3%	97%	0%	0%	3%	97%	0%	0%
2025	0%	100%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	0%	100%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	0%	100%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	0%	100%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	0%	100%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	0%	100%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	0%	100%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	0%	100%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

TABLE A-9: THE PHILIPPINES (WINDOW UNITS) REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	20%	3%	77%	0%	20%	3%	77%	0%	20%	3%	77%	0%
2016	30%	5%	65%	0%	30%	5%	65%	0%	30%	5%	65%	0%
2017	40%	6%	54%	0%	40%	6%	54%	0%	40%	6%	54%	0%
2018	50%	8%	42%	0%	50%	8%	42%	0%	50%	8%	42%	0%
2019	46%	26%	28%	0%	46%	26%	28%	0%	46%	26%	28%	0%
2020	42%	58%	0%	0%	42%	58%	0%	0%	42%	58%	0%	0%
2021	38%	62%	0%	0%	38%	62%	0%	0%	38%	62%	0%	0%
2022	30%	70%	0%	0%	30%	70%	0%	0%	30%	70%	0%	0%
2023	22%	78%	0%	0%	22%	78%	0%	0%	22%	78%	0%	0%
2024	15%	85%	0%	0%	15%	85%	0%	0%	15%	85%	0%	0%
2025	7%	93%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	0%	100%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	0%	100%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	0%	100%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	0%	100%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	0%	100%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	0%	100%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	0%	100%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

TABLE A-10: SINGAPORE REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	92%	2%	6%	0%	92%	2%	6%	0%	92%	2%	6%	0%
2016	91%	4%	5%	0%	91%	4%	5%	0%	91%	4%	5%	0%
2017	91%	5%	4%	0%	91%	5%	4%	0%	91%	5%	4%	0%
2018	91%	6%	3%	0%	91%	6%	3%	0%	91%	6%	3%	0%
2019	91%	7%	2%	0%	91%	7%	2%	0%	91%	7%	2%	0%
2020	90%	9%	1%	0%	90%	9%	1%	0%	90%	9%	1%	0%
2021	90%	10%	0%	0%	90%	10%	0%	0%	90%	10%	0%	0%
2022	72%	28%	0%	0%	72%	28%	0%	0%	72%	28%	0%	0%
2023	54%	46%	0%	0%	54%	46%	0%	0%	54%	46%	0%	0%
2024	36%	64%	0%	0%	36%	64%	0%	0%	36%	64%	0%	0%
2025	18%	82%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	0%	100%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	0%	100%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	0%	100%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	0%	100%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	0%	100%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	0%	100%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	0%	100%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

TABLE A-11: THAILAND REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	34%	11%	55%	0%	34%	11%	55%	0%	34%	11%	55%	0%
2016	41%	17%	42%	0%	41%	17%	42%	0%	41%	17%	42%	0%
2017	48%	23%	30%	0%	48%	23%	30%	0%	48%	23%	30%	0%
2018	55%	28%	17%	0%	55%	28%	17%	0%	55%	28%	17%	0%
2019	62%	34%	4%	0%	62%	34%	4%	0%	62%	34%	4%	0%
2020	64%	33%	3%	0%	64%	33%	3%	0%	64%	33%	3%	0%
2021	66%	32%	2%	0%	66%	32%	2%	0%	66%	32%	2%	0%
2022	60%	40%	0%	0%	60%	40%	0%	0%	60%	40%	0%	0%
2023	54%	46%	0%	0%	54%	46%	0%	0%	54%	46%	0%	0%
2024	47%	53%	0%	0%	47%	53%	0%	0%	47%	53%	0%	0%
2025	41%	59%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	35%	65%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	28%	72%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	22%	78%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	15%	85%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	9%	91%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	2%	98%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	0%	100%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

TABLE A-12: VIETNAM REFRIGERANT MARKET SHARES, BY POLICY SCENARIO, 2015–2050[13]

	BAU				POLICY SCENARIO 2				POLICY SCENARIO 3			
	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290	R-410A	R-32	R-22	R-290
2015	27%	13%	60%	0%	27%	13%	60%	0%	27%	13%	60%	0%
2016	26%	17%	58%	0%	26%	17%	58%	0%	26%	17%	58%	0%
2017	25%	20%	55%	0%	25%	20%	55%	0%	25%	20%	55%	0%
2018	24%	33%	43%	0%	24%	33%	43%	0%	24%	33%	43%	0%
2019	23%	46%	30%	0%	23%	46%	30%	0%	23%	46%	30%	0%
2020	23%	60%	18%	0%	23%	60%	18%	0%	23%	60%	18%	0%
2021	22%	73%	5%	0%	22%	73%	5%	0%	22%	73%	5%	0%
2022	21%	79%	0%	0%	21%	79%	0%	0%	21%	79%	0%	0%
2023	19%	81%	0%	0%	19%	81%	0%	0%	19%	81%	0%	0%
2024	18%	82%	0%	0%	18%	82%	0%	0%	18%	82%	0%	0%
2025	16%	84%	0%	0%	0%	100%	0%	0%	0%	90%	0%	10%
2026	15%	85%	0%	0%	0%	100%	0%	0%	0%	80%	0%	20%
2027	13%	87%	0%	0%	0%	100%	0%	0%	0%	65%	0%	35%
2028	10%	90%	0%	0%	0%	100%	0%	0%	0%	45%	0%	55%
2029	8%	92%	0%	0%	0%	100%	0%	0%	0%	25%	0%	75%
2030	5%	95%	0%	0%	0%	100%	0%	0%	0%	5%	0%	95%
2031	3%	97%	0%	0%	0%	100%	0%	0%	0%	4%	0%	96%
2032	1%	99%	0%	0%	0%	100%	0%	0%	0%	3%	0%	97%
2033	0%	100%	0%	0%	0%	100%	0%	0%	0%	2%	0%	98%
2034	0%	100%	0%	0%	0%	100%	0%	0%	0%	1%	0%	99%
2035	0%	98%	0%	2%	0%	98%	0%	2%	0%	0%	0%	100%
2036	0%	95%	0%	5%	0%	95%	0%	5%	0%	0%	0%	100%
2037	0%	92%	0%	8%	0%	92%	0%	8%	0%	0%	0%	100%
2038	0%	89%	0%	11%	0%	89%	0%	11%	0%	0%	0%	100%
2039	0%	86%	0%	14%	0%	86%	0%	14%	0%	0%	0%	100%
2040	0%	80%	0%	20%	0%	80%	0%	20%	0%	0%	0%	100%
2041	0%	75%	0%	25%	0%	75%	0%	25%	0%	0%	0%	100%
2042	0%	70%	0%	30%	0%	70%	0%	30%	0%	0%	0%	100%
2043	0%	65%	0%	35%	0%	65%	0%	35%	0%	0%	0%	100%
2044	0%	60%	0%	40%	0%	60%	0%	40%	0%	0%	0%	100%
2045	0%	50%	0%	50%	0%	50%	0%	50%	0%	0%	0%	100%
2046	0%	45%	0%	55%	0%	45%	0%	55%	0%	0%	0%	100%
2047	0%	40%	0%	60%	0%	40%	0%	60%	0%	0%	0%	100%
2048	0%	35%	0%	65%	0%	35%	0%	65%	0%	0%	0%	100%
2049	0%	30%	0%	70%	0%	30%	0%	70%	0%	0%	0%	100%
2050	0%	25%	0%	75%	0%	25%	0%	75%	0%	0%	0%	100%

13 Although BSRIA data estimates that Vietnam had a market share of 4% in R-407C in 2021, CLASP combined this with the market share for R-22 for ease of modeling, as their GWPs are very similar, at 1,624.21 and 1,760, respectively.

For estimating the servicing tail requirements for R-22 usage of the installed RACs, CLASP utilized its in-house direct emissions model as well as data provided by the UNEP Ozone Secretariat.[14]

CONSUMER IMPACT

National energy consumption projections from the Mepsy model were multiplied by countries' electricity tariffs to derive national electricity costs and savings.

For the lifecycle cost analyses, CLASP collected pricing data for each of the 452 models in the dataset. For each country, the smaller (≤ 3.5 kW) representative unit was chosen for the BAU scenario. CLASP then collected additional model data for units of the same capacity as the selected BAU model, but with an efficiency that meets China's MEPS. For each model, annual energy consumption (UEC) over the unit's lifetime was multiplied by the given country's electricity tariff and summed with the purchase price to derive the total lifecycle cost.

14 "Data in tables," Data Centre, Ozone Secretariat, United Nations Environment Programme.

ANNEX II: TRADE AGREEMENTS

ASEAN-REGION AGREEMENTS

The Association of Southeast Asian Nations, or ASEAN, was established in 1967 and currently has ten Member States, including the focus countries.[xi] Among other things, the ASEAN seeks to accelerate economic growth, social progress, and cultural development in the region and promote active collaboration and mutual assistance,[xii] which includes the promotion of trade in appliances and equipment across the region.

ASEAN Free Trade Area (AFTA) was established in January 1992 to eliminate tariffs and non-tariff barriers among the Southeast Asian economies and support their integration into one single market. Under AFTA, the Member States have implemented the Common Effective Preferential Tariff (CEPT) Scheme to create a free trade area within the ASEAN region. There is no common tariff, and each Member State applies a tariff rate of 0–5% for products originating within the region. CEPT products are issued a CEPT certificate of origin and qualify for the green lane system, implemented by each Member State, which expedites customs clearance.

Currently, the guiding agreement is the **ASEAN Trade in Goods Agreement** (ATIGA), which was signed in 2010 and provides a legal framework for ASEAN to work towards the free flow of goods in the region.[xiii] The document consolidates all trade commitments among Member States into a single document, including tariff liberalization, rules of origin, non-tariff measures, trade facilitation, customs and standards, technical regulations, and conformity assessment procedures. In 2015, ASEAN members formed the ASEAN Economic Community (AEC) to formally establish an integrated economic region.

Tariffs are standardized across the ASEAN Member States using the 8-digit harmonized system (HS) codes, building off of the 6-digit codes established by the World Customs Organization. HS codes and their respective most favorable nation (MFN) and ATIGA rates of duty are published in the *ASEAN Harmonized Tariff Nomenclature* (AHTN), last revised in 2022. Each Member State publishes a tariff book at the national level. RACs are covered under *AHTN 2022 Section XVI Chapter 84 Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof*.[15]

The tariff on RAC (HS 841510) and compressors (HS 841430) that are produced and traded within the ASEAN region is 0%.

AGREEMENTS WITH CHINA

ASEAN Member States select their own tariff rate for products originating outside ASEAN and under free trade agreements (FTAs) with other countries. The ASEAN–China Free Trade Agreement and Regional Comprehensive Economic Partnership are two agreements to affect RAC trade with China.

ASEAN–CHINA FREE TRADE AREA (ACFTA)

The basis for the creation of the ACFTA was the Framework Agreement on Comprehensive Economic Cooperation signed in 2002 by China and the ASEAN Member States. The **ASEAN-China Trade in Goods Agreement** guides tariff reduction and elimination.

By 2010, the ACFTA reduced tariffs on more than 7,000 product categories, which constitute 90% of imports in the region.[xiv] This covered FTAs between China and six ASEAN Member Countries (ASEAN-6) including Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The Philippines and Thailand chose to reduce the tariffs on RACs (HS 841510) using the sensitive track, meaning to reduce tariffs over time. Other countries, including Vietnam, agreed to eliminate the tariffs for 90% of imports under a delayed timeline, by 2015.[xv] However, to date, Vietnam has not eliminated the tariff on RAC imports from China.

REGIONAL COMPREHENSIVE ECONOMIC PARTNERSHIP (RCEP)

RCEP, signed in November 2020, is a free trade agreement between ten ASEAN Member States and its five FTA partners: Australia, China, Japan, New Zealand, and the Republic of Korea.[xvi] It is the world's largest FTA, covering 2.3 billion people

15 Used Philippines AHTN as that for ASEAN was not available.

with a combined GDP of $25.8 trillion USD.[xvii] The agreement entered into force in January 2022 after it was ratified by six ASEAN and three non-ASEAN economies.[16]

SOUTHEAST ASIA AND THE CHINA BELT AND ROAD INITIATIVE (BRI)

China's BRI was launched in 2013 and aimed to implement a wide range of development and investment initiatives to link East Asia and Europe through physical infrastructure.[xviii] As of February 2023, 147 economies, including the focus countries in this study, have signed on to the projects or indicated an interest in doing so.[xix]

In 2020, the Southeast Asia region was the recipient of significant BRI investment despite China's reduced overall BRI investments worldwide, which continued after China's recovery from the pandemic.[xx] Among ten major recipient countries, five are economies analyzed here: Singapore, Indonesia, Malaysia, Vietnam, and Thailand.[xxi] For Indonesia, the ACFTA, along with BRI, has helped to strengthen bilateral relationships between the countries, making China Indonesia's fourth-biggest trade partner.[xxii]

BRI can facilitate and support Chinese businesses' expansion to overseas markets. For example, infrastructure projects can help ensure a reliable supply of electricity, which in turn allows people to buy appliances. In 2019, the AUX Group opened a factory in Thailand under the BRI framework to expand into Southeast Asia and, particularly, Thailand. It is located in the Thai-Chinese Rayong Industrial Zone, jointly developed by investors from China and Thailand. It is designated as China's national overseas economic and trade cooperation zone.[xxiii]

AGREEMENTS WITH OTHER ECONOMIES

The other agreements relevant to this study are the ASEAN–Japan Comprehensive Economic Partnership (AJCEP) and ASEAN–Republic of Korea Free Trade Area (AKFTA), as the major RAC market players in the region are headquartered in one of the two countries.

ASEAN–JAPAN COMPREHENSIVE ECONOMIC PARTNERSHIP (AJCEP)

AJCEP came into effect in December 2008 and covered trade in services, goods, investments, and economic cooperation. This FTA provides for the elimination of duties on 87% of all tariff lines. Tariff elimination by ASEAN-6 and Vietnam was completed within 10 years of the agreement coming into effect.

ASEAN–REPUBLIC OF KOREA FREE TRADE AREA (AKFTA)

AKFTA, which came into force in 2007, sets out preferential trade arrangements between ASEAN Member States and South Korea. The agreement has eliminated tariffs for 90% of the products traded between South Korea and ASEAN member states, with elimination schedules varying among the member states.

CUSTOMS

The ASEAN Customs is an integral part of the ASEAN economic community, with a vision of a single market and production base fully integrated into the global economy.[xxiv] The coordinating committee on Customs coordinates the customs integration within the region and facilitates consultations with other partners including China, Japan, and South Korea.[xxv]

Seven countries in Southeast Asia, including Thailand, Malaysia, Singapore, and Vietnam, have joined the ASEAN Customs Transit System (ACTS) — a computerized management system that simplifies customs processes, accelerates transit movement, and reduces time and costs.[xxvi] The system may be expanded to the remaining countries in the region and transported by air and water.

Some countries have programs that offer companies with a strong track record of reliability to become certified **authorized economic operators (AEOs)** (Table A-13). This certification signals that a company engages in safe, secure, and compliant international trade practices. Recognition as a low-risk partner grants AEOs benefits such as priority treatment (e.g., for inspections), simplified and expedited procedures, lower inspection rates, and financial incentives.

16 "RCEP Agreement enters into force for the Philippines," Association of Southeast Asian Nations, 2 June 2023. To date, it has yet to be ratified by Myanmar.

TABLE A-13: AEO PROGRAMS & COMPANIES IN FOCUS COUNTRIES

COUNTRY	OVERSIGHT	LAUNCHED[xxvii]	CERTIFIED COMPANIES
Indonesia	Directorate General of Customs and Excise	March 2015	Official Indonesian Traders,[xxviii] including Daikin, Samsung_
Malaysia	Royal Malaysian Customs Department	January 2010	Economic Operators,[xxix] including Panasonic, Mitsubishi Electric, Samsung
The Philippines	Bureau of Customs	December 2019	Toyota Motors Philippines Corp., Panasonic Producing Philippines Corp., Coca-Cola Beverages Philippines[xxx]
Singapore	Singapore Customs	May 2007	Secure Trade Partnership (STP) and STP-Plus companies
Thailand	Customs Department	February 2011	Importers/exporters,[xxxi] including Mitsubishi Electric, Midea
Vietnam	Ministry of Industry and Trade	June 2013	Authorized Traders,[xxxii] including Samsung

Mutual recognition agreements (MRAs) between two economies, which can be countries or regions, allow AEOs within each economy to enjoy the benefits of the other economy's AEO program. There is an ASEAN-level MRA under development — ASEAN AEO Mutual Recognition Arrangement (AAMRA) — which is expected to be implemented by 2025.[xxxiii]

SOUTHEAST ASIA & MRAS WITH CHINA

Singapore has had an AEO MRA with China since June 2012[xxxiv] and the Philippines signed an MRA in January 2023.[xxxv] Thailand signed an action plan to advance negotiations on an MRA in April 2022[xxxvi] and Malaysia completed initial consultations in 2021.[xxxvii] There do not appear to be active negotiations with Vietnam and Indonesia. It is noteworthy that Singapore, an all-import country, has the most MRAs with China.

ANNEX III: BRAND CLIMATE COMMITMENTS

COMPANY	LATEST SUSTAINABILITY REPORT	EMISSIONS REDUCTION TARGET	PRODUCT ENERGY EFFICIENCY INCLUDED IN REDUCTION TARGET?	PRODUCT ENERGY EFFICIENCY STRATEGIES/ ESTIMATED IMPACT
Daikin	2022 Sustainability Report	30% or more by 2025 50% or more by 2030 Net-zero by 2050 Environmental Vision 2050	Yes	- Accelerate product EE/inverter use - Develop and adopt low-GWP refrigerants - Recover and reclaim refrigerants
Panasonic	2022 Sustainability Data Book	110 MT by 2030 More than 300MT/Net-zero by 2050 GREEN IMPACT	Yes	- Use of energy-saving consumer electronics - Included in 2050 reduction target (100 MT from overall customers' energy reduction)
LG	2021-2022 ESG Story Book & ESG Fact Book	Carbon neutrality[xxxviii] by 2030	Yes	- Better eco-products: Reduce emissions by 20% by 2030 during the use of seven major products, including RACs
Sharp	2022 Sustainability Report	40% by 2030 60% by 2035 Net-zero by 2050 in business activities SHARP Eco Vision 2050	No	- Make products that are increasingly more EE - By 2031, reduce Scope 3 (Category 11[xxxix]) emissions by 33%. Over 80% of estimated emissions come from eight major products, including RACs
Samsung	2022 Sustainability Report	Net-zero by 2050 in business activities	No	- Reduce power consumption by 30% on the average of major models of seven consumer products, including RACs
Mitsubishi Electric	2022 Sustainability Report	Net-zero by 2050 in the entire value chain Environmental Sustainability Vision 2050		- Reduce Scope 3 (Category 11) emissions by 15% by 2030 - Promote and disseminate outstanding EE products
Carrier	2022 ESG Report	Carbon neutral operations by 2030 Reduce customers' emissions by more than 1 GT by 2030 2030 ESG Goals	Yes	- Strategies to reduce customers' emissions include leveraging EE products and use low-GWP refrigerants
Gree	2022 CSR Report	None	N/A	N/A
Midea	2022 ESG Report	Carbon neutrality by 2060 Green Strategy	Yes	Make products more eco-friendly
Hitachi	2022 Sustainability Report	50% by 2030 Carbon neutrality by 2050 throughout the value chain Environmental Innovation 2050	Yes	- Reduce CO_2 emissions of products and services - Contribution to emissions reduction of 100MT per year (FY 2024)

ANNEX IV: LOCAL PRODUCER INCENTIVES

INCENTIVES, TAX REDUCTIONS, & OTHER PROGRAMS TO SUPPORT LOCAL INDUSTRIES

The transition to higher-efficiency products can be supported through government incentives. To drive producers and consumers to move toward energy-efficient RAC systems, governments can provide financial incentives such as rebates, tax reductions, or grants. Countries such as Thailand, the Philippines, Malaysia, and Indonesia have introduced tax breaks and initiatives to improve the ease of doing business. Vietnam and Singapore have accelerated business reforms such as executing free trade agreements (FTAs) and double taxation agreements (DTAs). The following section outlines country-specific incentives used to support local production of more efficient products.

Thailand: In 2009, the Excise Department launched an excise tax exemption scheme for AC units with a capacity of less than 72,000 BTU/hour used in office and residential buildings. The excise tax exemption scheme was to assist domestic AC producers (both Thai and international brands) and reduce retail prices, as ACs were no longer considered luxury goods in Thailand. Before the exemption, when ACs were classified as luxury goods, they were subject to exercise duty under Part II: Electrical Appliance of the *Excise Tarif Act B.E. 2527* (1984) at an ad valorem rate ceiling of 30%. In 1997, the excise tax rate on RACs was cut to 15% to promote the competitiveness of the Thai industrial sector and assist domestic AC producers.[17]

The Philippines: In September 2019, the Philippines introduced the *Corporate Income Tax and Incentives Rationalization Act* (CITIRA). Currently, the Philippine CIT is the highest in ASEAN. CITIRA's goal is to reduce CIT by 10% over the next 10 years as well as rationalize specific tax incentives.[xl] It also aims to increase foreign investment, stimulate job growth, and increase the regional competitiveness of small and medium-sized enterprises. Under CITIRA, regions beyond Manila will be prioritized, which will help the Philippines develop the infrastructure and supply chains necessary to compete with other ASEAN countries.[xli]

Malaysia: In 2020, Malaysia's budget focused on grants and tax incentives for Fortune 500 companies focused on high-end technology, production, or value-added industries. These grants and incentives aimed to attract investments from international companies, especially from China.[xlii] Companies that qualified needed to invest a minimum of $1.1 billion USD into Malaysia and in return the government was to provide $238 million USD in incentives over 5 years.[xliii] Furthermore, Malaysia has established a panel to fast-track investments for US and Chinese businesses looking to move operations out of China.[xliv] **Additionally, a 10-year tax exemption was introduced for investors in the electronics and electrical industries (including AC producers).**[xlv]

Indonesia: In 2001, Indonesia introduced tax incentives through the Energy Efficiency Initiative, which aimed to promote energy efficiency projects through investment tax allowance, accelerated capital allowance, import duty exemption, and sales tax exemption for energy efficiency products.[xlvi] Furthermore, in 2019 Indonesia introduced GR 45, which includes several tax incentives for businesses that invest in "labor-intensive industries, training programs, and research and development."[xlvii] As a way of encouraging a shift to more efficient technologies and products, taxpayers who engage in research and development initiatives can receive a tax facility of 300% in gross income reduction of the total costs incurred.[xlviii]

FREE TRADE ZONES

Free trade zones, otherwise known as foreign trade zones, are special economic zones (SEZs) where goods may be imported, stored, handled, produced, or re-exported in a duty-free area.[xlix] They are generally found in areas that possess geographic advantages for trade, such as seaports, airports, etc. The countries in our study also have their own specific trade zones, which are outlined in this section.

17 Interview with experts conducted by IIEC in April 2023.

Indonesia: Indonesia has 10 industrial SEZs with a minimum investment threshold of IDR 10 billion ($690,000 USD), excluding land and buildings.[l] Incentives include tax allowances, corporate income tax reductions, income reductions, import duty exemptions, and simplified business licensing, as well as access to double tax treaties.[li]

The Philippines: The Philippines has SEZs called Ecozones, which can include industrial estates (IEs), export processing zones (EPZ), and/or free trade zones, in addition to tourist/recreational centers.[lii] There are currently 76 production economic zones. Benefits include an income tax holiday of 4 to 7 years depending on the location and industry, special corporate income taxes (SCIT), enhanced deductions, tax-and-duty-free imports, value-added tax exemption on importation, local tax exemptions, non-immigrant visas, and foreign national employment. Companies with production, assembly, or processing activities where 70% of the production is exported can qualify as an economic zone export producing enterprise.

Malaysia: Malaysia has three types of free trade zones: free industrial zones (FIZs), free commercial zones, and service free zones.[liii] The FIZ is most relevant and is a special economic zone where businesses can produce goods for export and are exempted from the payment of excise duty, sales tax, and service tax. In order to qualify, a company must export at least 80% of its outputs and raw materials; special exceptions approved by the Ministry of Investment, Trade and Industry can reduce export requirements to 60%.[liv]

Thailand: Thailand has two types of free trade zones: industrial estates and SEZs. There are 62 industrial estates — which are mainly for industrial activities and provide exemption from import duties — and 10 SEZs — which are mainly for export activities. One of the most significant SEZs in Thailand is the Thai-Chinese Rayong Industrial Zone. Developed in 2006, it is located at the AUX AC production base in Thailand and is one of the first China-backed overseas economic and trade cooperation zones.[lv] Incentives in this zone include exemption from income tax and machinery import tariffs.

ANNEX V: NATIONAL ENERGY EFFICIENCY POLICIES IN THE FOCUS COUNTRIES

COUNTRY	LEGAL FRAMEWORK	MEPS & LABELING POLICY	SCOPE & MEPS
Indonesia	Regulation of the Minister of Energy and Mineral Resources No. 14 of 2021 on Application of Minimum Energy Performance Standards for Energy Consuming Appliances	Minister of Energy and Mineral Resources Decision No. 103.K/EK.07/DJE/2021 on Minimum Energy Performance Standards and Energy Savings Label for Air Conditioners	• Single split, wall-mounted • CSPF 3.10 for CC ≤ 7.9 kW
Malaysia	Energy Commission Act 2001 Electricity Supply Act 1990 Electricity Regulation 1994 (Amendments 2013) Regulation 101A (3)	Guide on Minimum Energy Performance Standard Requirements for Air Conditioners with Cooling Capacity ≤ 7.1kW	• Split-type, wall-mounted, non-ducted • CSPF 3.10 for CC < 4.5 kW • CSPF 2.90 for 4.5 kW ≤ CC ≤ 7.1 kW
The Philippines	Act 11285: An Act Institutionalizing Energy Efficiency and Conservation, Enhancing the Efficiency Use of Energy, and Granting Incentives to Energy Efficiency and Conservation Projects (2019)	(Mandatory) Implementing Guidelines of the Philippine Energy Labeling Program for the Air Conditioners (2021)	• Window & split-type • CSPF 3.08 for CC < 3.33 kW • CSPF 2.81 for 3.33 kW ≤ CC < 9.99 kW
Singapore	Energy Conservation Act (Chapter 92C)	Energy Conservation (Regulated Goods and Registered Suppliers) Regulations 2017 Energy Conservation (Prescribed Regulated Goods) Order 2017 Energy Conservation (Regulated Goods and Registered Suppliers) (Amendment No. 2) Regulations 2021	Window: • COP ≥ 3.78 for window up to 8.8 kW Single split: • COP > 4.04 for fixed-speed • WCOP > 4.04 & COP ≥ 3.34 inverter
		Revised MEPS levels (effective from April 2025)	Single split: • COP ≥ 4.86 for fixed-speed • WCOP ≥ 4.86 for inverter

COUNTRY	LEGAL FRAMEWORK	MEPS & LABELING POLICY	SCOPE & MEPS
Thailand	The Energy Conservation Promotion Act 1992 (revised in 2007)	TIS-2134-2553 Room Air Conditioners: Energy Efficiency	Window: • EER 2.82 for CC < 8.0 kW • EER 2.53 for 8.0 kW ≤ CC < 12.0 kW Split-type: • EER 2.82 for CC < 8.0 kW • EER 2.82 for 8.0 kW ≤ CC < 12.0 kW
		Draft 2134-25XX (under development since 2021)	Window & split fixed-speed: • CSPF 3.19 for CC < 8.0 • CSPF 3.15 for kW 8.0 kW ≤ CC < 12.0 kW Split inverter: • CSPF 3.90 for CC < 8.0 kW • CSPF 3.46 for 8.0 kW ≤ CC < 12.0 kW
Vietnam	Energy Efficiency and Conservation Law (2011)	TCVN 7830:2015	Window • CSPF 2.80 Single split: • CSPF 3.10 for CC < 4.5 kW • CSPF 3.00 for 4.5 kW ≤ CC < 7.0 kW • CSPF 2.80 for 7.0 kW ≤ CC < 12.0 kW
		TCVN 7830:2021 (in effect, starting in 2025)	Window: Not included Single split: Unchanged[18]

18 In the new policy, only 4- and 5-star label categories have increased; MEPS are unchanged.

ANNEX VI: AGREEMENTS & POLICIES ON OZONE-DEPLETING SUBSTANCES & HIGH-GWP REFRIGERANTS

INTERNATIONAL AGREEMENTS

THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

The Vienna Convention was adopted on 22 March 1985 as a precursor to the Montreal Protocol. It entered into force on 22 September 1988 and served as a framework for efforts to protect the globe's ozone layer.[lvi]

THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

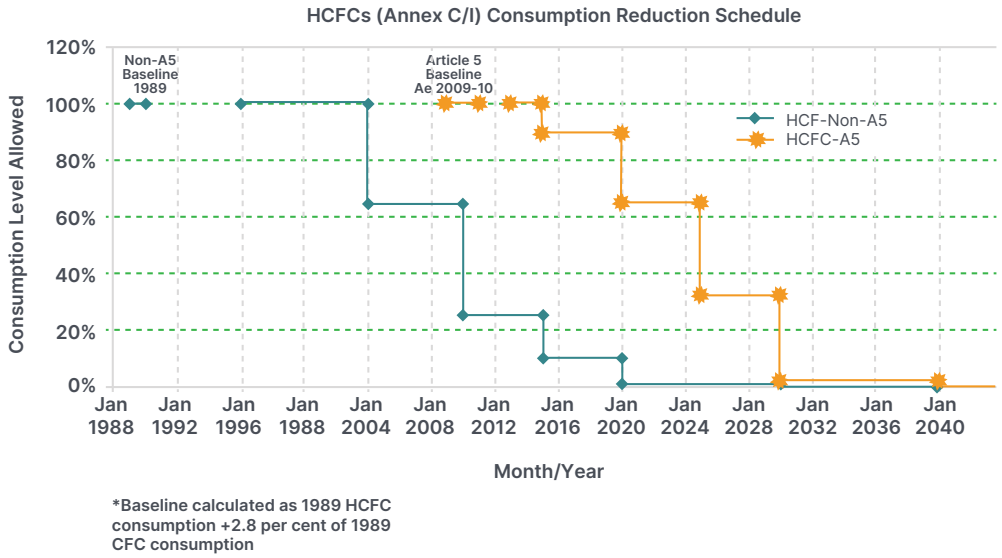
The Montreal Protocol, which was signed in 1987 and entered into force in 1989, is the landmark international treaty that controls the global production and consumption of ozone-depleting substances (ODSs).[lvii] The three main substances regulated under the Protocol are CFCs, HCFCs, and HFCs. These ODSs have various applications, most notably as refrigerants in air conditioners and refrigerators. When released into the atmosphere, ODSs damage the stratospheric ozone layer[lviii] and contribute directly to climate change, as they are powerful GHGs that have a much higher GWP than CO_2.

Since its inception, the MP has been ratified by all 196 nation-states and the European Union and amended five times,[lix] the fifth of which is the Kigali Amendment, which incorporates HFCs. All six countries in this study have ratified the MP and established national ozone units (NOUs) to regulate ODSs within their borders.

Phase Out Schedule for Article 5 Countries

The MP sets the phase-out schedule for different ODS groups, which include HCFC-22, and covers both the production and consumption of ODSs. The countries in this study do not produce R-22 and are only subject to a consumption phase-out schedule, which began in 2013 for Article 5 countries. These

FIGURE 1: MONTREAL PROTOCOL'S HCFC CONSUMPTION PHASE OUT SCHEDULE



Source: UNEP 2016.

countries follow the stepwise reduction shown in Figure 1 until the complete phase-out of HCFCs by 2030:

- In 2015, the countries were to reach a 10% consumption reduction as compared to the baseline, which is an average for the 2009–2010 levels
- In 2020, they were to reach a 35% reduction
- In 2025, they were to reach a 67.5% reduction
- In 2030, they were to reach a 100% reduction

Through 2040, there is an allowance of 2.5% of baseline consumption, when averaged over 10 years (2030–2040), for servicing refrigeration and air conditioning equipment existing on 1 January 2030.[lx]

THE KIGALI AMENDMENT

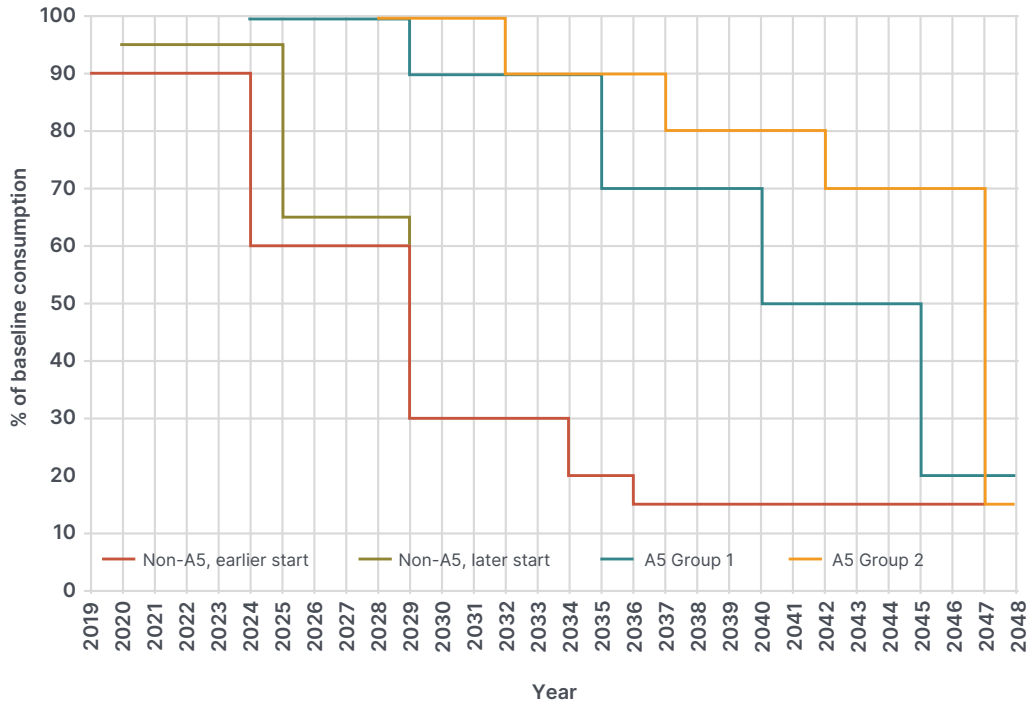
HFCs have been widely used as alternatives to CFCs and HCFCs because they do not deplete the ozone layer. However, like CFCs and HCFCs, HFCs contribute significantly to climate change. Two common refrigerants, R-32 and R-410A, belong to this group. The most recent amendment to the MP was the Kigali Amendment. It was finalized in 2016 and entered into force on 1 January 2019. It aims to decrease the production and consumption of HFCs internationally by at least 80% by 2047. The Amendment was ratified by 151 parties as of 29 July 2023. Five of the six countries in this study have ratified the Kigali Amendment as of 29 July 2023 (Indonesia, Malaysia, the Philippines, Singapore, and Vietnam).

Phase Out Schedule for Article 5 Countries

All six focus countries are a part of Article 5, Group 1 countries (blue line in Figure 22) that are to freeze HFC production and consumption, starting in 2024, and follow a stepwise phase-out schedule:[lxi]

- In 2029, reduce consumption to 90% of the baseline[19]
- In 2035, reduce consumption to 70% of the baseline
- In 2040, reduce consumption to 50% of the baseline
- In 2045, reduce consumption to 20% of the baseline

FIGURE 2: KIGALI AMENDMENT PHASE-DOWN SCHEDULE[LXII]



19 The baseline for Article 5 countries (in group 1) is determined from 65% of the HCFC baseline and average HFC consumption in 2020–2022.

TABLE A-14: INTERNATIONAL & NATIONAL POLICIES REGULATING ODS

COUNTRY	MONTREAL PROTOCOL	KIGALI AMENDMENT	NATIONAL OZONE OFFICE	NATIONAL OZONE REGULATIONS
Indonesia	June 1992 (Ratified)	December 2022 (Ratified)	Ministry of Environment and Forestry (KLHK)	Minister of Trade Regulation No. 83/M-DAG/PER/10/2015 concerning Provisions for the Import of Ozone Layer Depleting Substances[lxiii]
Malaysia	August 1989 (Acceded)	October 2020 (Ratified)	Ozone Protection Section (OPS), Department of Environment, Ministry of Natural Resources and Environment	Environmental Quality (Refrigerant Management) Regulations 2020[lxiv]
The Philippines	July 1991 (Ratified)	November 2022 (Ratified)	Philippines Ozone Desk (POD), Environment Management Bureau (EMB)	Revised Regulations on the Chemical Control Order for Ozone-depleting Substances (ODS): Department of Environment and Natural Resources (DENR) Administrative Order 2013–2025[lxv]
Singapore	January 1989 (Acceded)	June 2022 (Ratified)	National Environment Agency	Environmental Protection and Management Act: Environmental Protection and Management (Ozone-Depleting Substances) Regulations G.N. No. S 604/2000[lxvi]
Thailand	July 1989 (Ratified)	-	Ozone Protection Unit, Ministry of Industry	There are no specific ODS laws or regulations currently in place, but the Ministry of Commerce issued a ban on the production of RACs with HCFC-22 starting March 2018[lxvii]
Vietnam	January 1994 (Acceded)	September 2019 (Approved)	Ministry of Natural Resources and Environment (MONRE)	Decree No. 06/2022/ND-CP Providing Regulations on Reduction of Greenhouse Gas Emissions and Protection of the Ozone Layer[lxviii]

NATIONAL ODS PROGRAMS & POLICIES

Information on ODS regulation implementation was collected through interviews in Indonesia, Malaysia, The Philippines, Thailand, and Vietnam as well as desktop research. All six countries have NOUs and are members of the Southeast Asia Network of Ozone Officers (SEA Network), in addition to Brunei, Cambodia, Lao PDR, Myanmar, and Timor Leste. The SEA Network was established in 1993 with support from the Swedish International Development Cooperation Agency (SIDA). Since 2010, it has been supported by the Multilateral Fund under the UNEP Compliance Assistance Programme (CAP).[lxix],[lxx]

All countries have national regulations that control the production, importation, and sale of ODSs. Three countries — Indonesia, Malaysia, and Thailand — have banned the import and production of RACs with HCFCs. Per the SEA Network, the overall HCFC consumption in member countries has achieved a 64% reduction from the HCFC baseline level, which is ahead of their legal obligations under the MP.[lxxi]

Indonesia: *Minister of Trade Regulation No. 83/M-DAG/PER/10/2015* prohibits the use of HCFC-22 and HCFC-141b in the production of air conditioners and bans the import of HCFC-22–based equipment. The ban was passed to support local industries in maintaining competitiveness against HCFC–based products.[lxxii] Per the interviewed industry experts, the regulation has been quite effective in controlling ODS imports. The legal basis for implementing the protection of the ozone layer in Indonesia is in the clauses of *Law No. 32 of 2009 Concerning Environmental Protection and Management* in Articles 57 and 63.[20]

Malaysia: *Environmental Quality (Refrigerant Management) Regulations 2020* prohibits the production and assembly of refrigeration equipment or air conditioners of 25,000 Btu/hr or less using CFCs and HCFCs. It also regulates the disposal of specified refrigerants and controls import/export. The full list of specified refrigerants can be found in the policy.[lxxiii] In 2022, this regulation was amended to ban the import and production of RACs with R-22.[lxxiv]

The Philippines: *DENR Administrative Order 2013-25 Revised Regulations on the Chemical Control Order for Ozone-Depleting Substance* provides the legal infrastructure to implement the Philippine HCFC Phase Out Management Plan (HPMP). It also prohibits the import of R-22 for producing RACs except for the servicing sector by 1 January 2020.[lxxv] Under HPMP Phase II, the Philippines aimed to ban produce and import of R-22–based RACs with a cooling capacity of less than 36,000 Btu/hr.[lxxvi] However, the ban has not been adopted yet.

Singapore: *Regulations G.N. No. S 604/2000* prohibits the import and export of CFCs and HCFCs from/to certain countries. The Act was amended in 2021 under the Bill to Mitigate Emissions of Refrigerants with High Global Warming Potential (GWP) Used in Refrigeration and Air-Conditioning (RAC) Equipment,[lxxvii] which bans the supply and import of new household RAC equipment[21] that uses refrigerants with GWP over 750, beginning October 2022.

Thailand: There are currently no ODS regulations in Thailand, but there are certain ozone limits in place. The Ministry of Commerce issued a ban on the production (Factory Act B.E 2535) and imports of RACs with R-22 (*Product and Import-Export Act B.E. 2522*) with a cooling capacity under 50,000 BTU/hr (14.5 kW), effective as of 31 March 2018. R-22 ACs are also not allowed to be sold in the market since 31 December 2017.[lxxviii]

Vietnam: *Decree No. 06/2022/ND-CP* outlines GHG reduction measures, including domestic carbon credit exchanges and GHG emission quotas, and regulates HCFCs and HFCs. It also outlines significant measures for mitigating the use of ODSs and an ambitious plan for establishing a domestic carbon market in Vietnam. This Decree is part of a suite of policies under the country's climate change adaption measures provided under the *Law on Environmental Protection* (2020).[lxxix]

20 Interview with expert conducted in April 2023.
21 Single-phase, non-ducted, single-split, or multi-split room air-conditioners, with a cooling capacity of 17.6kW or lower. Single-phase variable refrigerant flow (VRF), casement, and window type air-conditioners are excluded from the scope.

ANNEX VII: MULTILATERAL FUND SUPPORT FOR REFRIGERANT TRANSITION

The Multilateral Fund (MLF) for the Implementation of the Montreal Protocol provides grants and concessional loans to Article 5 countries that have a per capita consumption rate of less than 0.3kg of ODS a year.[lxxx] Eligible activities include technical assistance, closing ODS production plants and converting industrial lines, disseminating information, and training and capacity building to support phasing out ODS.

Donors replenish the fund every three years, with four primary implementing agencies: UNEP, UNDP, United Nations Industrial Development Organization (UNIDO), and The World Bank (WB), in addition to bilateral agencies in non-Article 5 countries.

TABLE A-15: MLF-APPROVED FUNDING FOR ONGOING PROJECTS AS OF 31 DECEMBER 2021

PROJECT TITLE	IMPLEMENTING AGENCY	APPROVED FUNDING (USD)
VIETNAM		**$7,297,528**
HFC phasedown–related projects	IBRD	$197,950
HFC phasedown–related projects	UNEP	$39,550
HCFC phase out management plan	IBRD	$6,482,451
HCFC phase out management plan	Japan	$215,129
Institutional strengthening	UNEP	$362,448
INDONESIA		**$7,037,934**
HCFC phase out management plan	IBRD	$2,428,279
HCFC phase out management plan	UNDP	$3,866,659
Institutional strengthening	UNDP	$742,996
MALAYSIA		**$4,016,390**
HFC phasedown–related projects	IBRD	$513,600
HCFC phase out management plan	UNDP	$3,119,987
Institutional strengthening	UNDP	$382,803
THAILAND		**$2,554,592**
HCFC phase out management plan	IBRD	$1,605,000
Institutional strengthening	IBRD	$949,592
PHILIPPINES		**$1,335,822**
HFC phasedown–related projects	UNDP	$235,400
HCFC phase out management plan	UNIDO	$868,572
Institutional strengthening	UNEP	$231,850
SINGAPORE		**$0**

MLF SUPPORT FOR REFRIGERANT TRANSITION IN RAC PRODUCTION

A significant portion of MLF funding is directed towards HPMP implementation, part of which is specifically focused on supporting the RAC-producing sector to transition away from R-22 to next-generation refrigerants. Stakeholders, including governments and industries in recipient countries, select the transition refrigerant. In the countries analyzed in this study, MFL supported the transition to R-32, which has a lower GWP and is only slightly flammable when compared to R-410A.[lxxxi],[22] The alternatives have been less attractive: R-290, which has negligible GWP, is a highly flammable refrigerant whereas R-410A has a high GWP.

In most of the focus countries, the support for industry refrigerant transition was provided during HPMP Phase I and was overseen by one of the implementing agencies including WB, UNIDO, and UNDP. The following section provides an overview of the support for five countries, including the level of support, funding received, anticipated impact, and other details on the transition.[lxxxii]

Indonesia: During Phase I of the HPMP (2011–2018), five enterprises completed their conversion to HFC-32 (Panasonic,[lxxxiii] one RAC, and four commercial AC producers).[lxxxiv] R-32 was selected as a priority refrigerant and the conversion was completed in 2015. MLF provided support worth $636,198 USD. The estimated impact was the phase-out of 353.46 mt (19.44 ODP tonnes) of HCFC-22.[lxxxv] Sixteen enterprises in the AC sector decided to convert to R-410A technology with their own resources, returning the initial MLF funding that was provided for conversion to R-32.[lxxxvi]

Malaysia: Initially, the transition to R-32 in the RAC sector was planned during Phase II of the HPMP (2017–2022).[lxxxvii] However, around $2,475,225 USD in funding was reallocated to support HCFC's transition in the foam sector.[lxxxviii]

The Philippines: During Phase I of the HPMP (2012–2015), the Philippines agreed to control the growth of R-22. During Phase II (2017–2021), it proposed to eliminate the production and import of R-22. MLF provided support worth $2,521,955 USD to achieve 15% of the baseline level by 2020.[lxxxix] Four RAC producers (Carrier, Koppel, Hitachi, and Panasonic) participated in the project to transition to R-32. However, due to certain challenges, the project was not completed.[xc] A status report from the 85th Meeting of the Executive Committee of the MLF in 2020 indicated that delays were caused by the change in the agency from WB to UNIDO and changes in the producers' finances.[xci]

Thailand: During Phase I of the HPMP (2013–2018), 11 AC producers completed the conversion of their facilities to R-32–based equipment and started commercial-scale production.[xcii] MLF support was worth $31,280,110 USD. [xciii] By 2017, consumption of R-22 in Thailand had decreased to 45.9% of the 2013 levels.[xciv]

Vietnam: During Phase II of the HPMP (2016–2020), four AC producers (Hoa Phat, Midea, Nagakawa, and Reetech) completed their conversion from HCFCs to R-32 and R-290.[xcv] The MLF support for the transition was worth $4,075,777 USD.[xcvi]

22 R-32's flammability is 80% less than that of R-290.

ANNEX VIII: SERVICING SECTOR POLICIES & SUPPORT PROGRAMS

NATIONAL POLICIES GOVERNING REFRIGERANTS & HAZARDOUS WASTE

Although this report focuses on the dumping of new, non-waste, and inefficient equipment using high-GWP refrigerants in Southeast Asia, it is useful to understand — from a lifecycle refrigerant management perspective — the hazardous waste policies relevant to refrigerants destined for disposal in each of the countries covered in this report.[23] Refrigerants and their management can be subject to various national policies including ODS and hazardous waste policies. Some analyzed countries consider refrigerants destined for disposal (HCFCs and HFCs) as hazardous waste, so the recovery, recycling, and disposal/destruction of refrigerants are governed by hazardous waste policies. In other countries, there are no policies governing refrigerant end-of-life management.[24] The overview of the relevant policy landscape in six countries is discussed in this section.

Indonesia: Ministry of Environment and Forestry Regulation No. 6 of 2021 on the Procedures and Requirements for the Management of Hazardous Wastes regulates the storage, recovery, transport, use, treatment, accumulation, dumping, and cross-border movement (Basel Convention) of hazardous waste.[xcvii] Currently, there is no regulation on spent refrigerant handling.

The Philippines: The *DAO 2013-22 Revised Procedures and Standards for the Management of Hazardous Waste*[xcviii] *regulates hazardous waste generators; transporters; treatment, storage, and disposal facilities; recordkeeping; personnel training; and import (Basel Convention). This policy does not classify refrigerants as hazardous waste. However, the disposal and destruction of the R-22 refrigerant are covered under DENR Administrative Order 2013-25 Revised Regulations on the Chemical Control Order for Ozone Depleting Substances*, which specifies that the export of waste containing ODS should be governed by the appropriate national regulations on hazardous waste management as well as the Basel Convention. The regulation provides brief guidance on in-country ODS destruction technologies but no requirements for refrigerant disposal/destruction have been specified.

Malaysia: Environmental Quality (Refrigerant Management) Regulations 2020 PU(A) 79 regulates handling refrigerants in existing or new installations — including training requirements for reclamation, recycling, and retrofitting — and prohibits use in the installation of new building chillers and refrigeration systems, as well as the movement of refrigerants outside of Malaysia. Malaysia has regulated CFCs since 1999 and included HCFCs in 2020. Refrigerants must be disposed of in prescribed premises per the *Environmental Quality (Prescribed Premises) Regulations PU(A) 140/1989*, failing which, either a penalty of 100,000 Ringgit ($22,935 USD) or imprisonment for up to two years, or both, is imposed.

Singapore: In 2021, Singapore mandated the recovery and proper disposal of used refrigerants from dismantled air conditioners. In 2022, Singapore published the *Environmental Public Health (Toxic Industrial Waste) (Amendment) Regulations* (the "Regulations"), which added "spent refrigerants" to the list of toxic industrial wastes and subjected them to follow requirements for toxic industrial waste.

Thailand: Hazardous Substance Act B.E. 2535 (1992) sets out the purpose of controlling hazardous substances in terms of production, importation, exportation, sales, transportation, use, or other purposes. The *Notification of Ministry of Industry, Subject: List of Hazardous Substances B.E. 2556* (2013) specifies a list of hazardous substances and the authorities responsible for the control of these hazardous substances. It classifies R-22 as a hazardous substance (B.E. 2556 Annex List 5.1 Controlled Substances) and is under the responsibility of the Department of Industrial Works.

23 Generally speaking, new equipment — as opposed to end-of-life equipment that is destined for disposal or treatment — is not within the scope of waste requirements and treaties.
24 The secondhand RAC markets in the focus countries are not significant enough and, hence, were not covered in this report.

Vietnam: *Decree No. 06/2022/ND-CP* regulates the collection, recycling, reuse, and disposal of controlled substances, including HCFCs and HFCs.[xcix] Starting 1 January 2024, it recommends recycling and reusing the collected controlled. If a substance cannot be recycled or reused, it should be disposed of in accordance with hazardous waste management regulations. Circular No. 36/2015 on the management of toxic and hazardous waste controls HCFC and HFCs.[c]

BASEL CONVENTION ON TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES & THEIR DISPOSAL

Also from the perspective of lifecycle refrigerant management and on a related note to the aforementioned national policies, the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal*, simply known as the Basel Convention, is an international treaty that seeks to reduce hazardous waste generation and restrict the movement of hazardous waste between the countries. The treaty, entered into force in 1992, was a response to the discovery of toxic waste shipments in the 1980s from industrialized countries to East Europe, Africa, and other parts of the world where environmental regulations were not as stringent.[ci] The Basel Convention covers a wide range of hazardous wastes, including ODS[25] and electronic waste, as well as two types of other wastes, namely household waste and incinerator ash. As of May 2023, there are 190 parties to the Convention. All six countries in this study have either ratified or acceded to the Basel Convention.

The Basel Convention aims to minimize the movement of hazardous waste. The Parties must not export hazardous waste and other wastes, if they have sufficient disposal and recycling facilities in their countries, except when the wastes are needed as raw materials for recycling or recovery industries in the importing countries. Parties to the Convention are not allowed to ship hazardous waste and other wastes to non-parties unless there are environmentally sound agreements on hazardous waste management between these countries.

TABLE A-16: BASEL CONVENTION RATIFICATION & ENTRY INTO FORCE

COUNTRY	RATIFIED/ ACCEDED	ENTERED INTO FORCE
Philippines	October 1993 (Ratified)	January 1994
Indonesia	September 1993 (Acceded)	December 1993
Vietnam	March 1995 (Acceded)	June 1995
Thailand	November 1997 (Ratified)	February 1998
Malaysia	October 1993 (Acceded)	January 1994
Singapore	January 1996 (Acceded)	April 1996

Per ICF International's *Study on the Collection and Treatment of Unwanted Ozone Depleting Substances in Article 5 and Non-Article 5 Countries* (2008), waste ODS in appliances as well as ODS in bulk is covered under Basel Convention's definition Y45 (organohalogen compounds). The Convention specifies that if controlled substances of the Montreal Protocol are reclaimed and purified to usable purity specifications prescribed by international and/or national organizations (e.g., the International Standards Organization), they do not fall under its scope. Wastes containing ODS should be managed in an environmentally sound manner, and any movements across boundaries for destruction or recycling must comply with provisions of the Basel Convention.[cii]

25 Basel convention only covers ODS waste in three cases. One, it possesses a hazard characteristic listed in Annexes III — such as being flammable, explosive, or toxic — I, or VIII. Two, it contains other materials at levels that exhibit one of the hazardous characteristics listed in Annex III. Three, in cases when the Convention Party considers it hazardous waste under domestic legislation, has officially notified the Secretariat of it and is involved in the import, export, or transit of the waste.

Annex Endnotes

i JRAIA. 2022. *Estimates of World Air Conditioner Demand*. Tokyo: The Japan Refrigeration and Air Conditioning Industry Association. https://www.jraia.or.jp/english/statistics/file/World_AC_Demand.pdf.

ii WCO. 2022. *HS Nomenclature 2022 Edition*. Brussels: World Customs Organization. World Customs Organization (wcoomd.org).

iii UNEP. 2016. *HS Nomenclature (HS Codes) for HCFCs and Certain Other Ozone Depleting Substances: Post-Kigali Update - OzonAction* [Fact Sheet]. Nairobi: United Nations Environment Programme. 7784HSCodes_EN.pdf (unep.org).

iv WCO, *HS Nomenclature*.

v UNEP, *HS Nomenclature*.

vi WCO, *HS Nomenclature*.

vii Ibid.

viii EPA. Overview of Requirements for Importers of Hydrofluorocarbons (HFCs) factsheet. Overview of Requirements for Importers of Hydrofluorocarbons (HFCs) (epa.gov).

ix UNEP. 2020. *Cheat Sheet: Proposed Additional HS Code Sub-headings for HFCS in Advance of the 2022 HS Code Update - OzonAction Policy Brief*. Paris: OzonAction, United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/31293.

x UNEP, *HS Nomenclature*.

xi The ASEAN Secretariat. n.d. "About ASEAN." Last accessed September 4, 2023. https://asean.org/about-asean.

xii The ASEAN Secretariat. n.d. "What We Do." Last accessed September 4, 2023. https://asean.org/what-we-do.

xiii The ASEAN Secretariat. n.d. "Trade in Goods." Last accessed September 4, 2023. https://asean.org/trade-in-goods/.

xiv Medina, Ayman Falak. 2021. "ASEAN's Free Trade Agreements: An Overview." *ASEAN Briefing*, January 21, 2021. https://www.aseanbriefing.com/news/aseans-free-trade-agreements-an-overview/.

xv Flick, Keith, and Kalyan Kemburi, eds. 2012. *ASEAN-China Free Trade Area: Challenges, Opportunities, and the Road Ahead*. Singapore: S. Rajaratnam School of International Studies. https://www.rsis.edu.sg/wp-content/uploads/2000/01/Monograph22.pdf.

xvi The ASEAN Secretariat. n.d. "The Regional Comprehensive Economic Partnership (RCEP)." Last accessed September 4, 2023. https://asean.org/our-communities/economic-community/integration-with-global-economy/the-regional-comprehensive-economic-partnership-rcep/.

xvii The ASEAN Secretariat. 2022. "RCEP Agreement Enters into Force." January 1, 2022. https://asean.org/rcep-agreement-enters-into-force/.

xviii McBride, James, Noah Berman, and Andrew Chatzky. 2023. "China's Massive Belt and Road Initiative," *Council on Foreign Relations*, February 2, 2023. https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative.

xix Ibid.

xx Yu, Kaho. 2021. "The Belt and Road Initiative in Southeast Asia after COVID-19: China's Energy and Infrastructure Investments in Myanmar." *ISEAS Perspective* 2021/39. https://www.iseas.edu.sg/wp-content/uploads/2021/03/ISEAS_Perspective_2021_39.pdf.

xxi Zheng, Wang. 2022. "Assessing the Belt and Road Initiative in Southeast Asia amid the COVID-19 Pandemic (2021-2022)." *ISEAS Perspective* 2022/57. https://www.iseas.edu.sg/articles-commentaries/iseas-perspective/2022-57-assessing-the-belt-and-road-initiative-in-southeast-asia-amid-the-covid-19-pandemic-2021-2022-by-wang-zheng/.

xxii Wojciech, Adamczyk. "Reasons for Sino-Indonesian Cooperation." *Warsaw Institute*, February 17, 2022. https://warsawinstitute.org/reasons-sino-indonesian-cooperation/.

xxiii China Daily. 2019. "AUX Inaugurates Plant in Thailand." *Ningbo*, August 28, 2019. http://ningbo.chinadaily.com.cn/2019-08/28/c_404025.htm.

xxiv The ASEAN Secretariat. n.d. "ASEAN Customs." Overview. Last accessed September 4, 2023. https://asean.org/our-communities/economic-community/asean-customs/.

xxv Ibid.

xxvi ASEAN Customs Transit System. n.d. "Information on (ACTS)." Last accessed September 4, 2023. https://acts.asean.org/acts.

xxvii WCO. 2020. *Compendium of Authorized Economic Operator Programmes*. Brussels: World Customs Organization. https://www.wcoomd.org/-/media/wco/public/global/pdf/topics/facilitation/instruments-and-tools/tools/safe-package/aeo-compendium.pdf?db=web.

xxviii Directorate General of Customs and Excise. 2021. "Daftar Perusahaan AEO Indonesia." http://repository.beacukai.go.id/download/2022/02/c390ee2d016329296c86fd7de9366a10-list-of-aeo-indonesia.pdf.

xxix Malaysia National Trade Repository. n.d. "Authorized Economic Operator (AEO)." Last accessed September 4, 2023. http://mytraderepository.customs.gov.my/en/Pages/at_loat.aspx.

xxx PortCalls Asia. 2023. "PH, China Sign AEO Mutual Recognition Agreement [Press Release]." *PortCalls Asia*, January 9, 2023. https://www.portcalls.com/ph-china-sign-aeo-mutual-recognition-agreement/.

xxxi Standard Section, Customs Standard Procedures, and Valuation Division, Authorized Economic Operator. n.d. "Authorized Importers and/or Exporters." Last accessed September 4, 2023. https://aeo.customs.go.th/content_special.php?link=aeo_broker_list.php&ini_menu=menu_list_operator&left_menu=menu_list_operator_170307_01&lang=en&left_menu=menu_list_operator_170307_01.

xxxii Vietnamese National Trade Repository. n.d. "List of Priority Business in 2021." Last accessed September 4, 2023. https://vntr.moit.gov.vn/storage/3-information-pages/aeo/en/2-list-of-vn-aeo-in-2021.pdf.

xxxiii Singapore Customs. 2022. "ASEAN Customs Chiefs Launch Joint Action Plan to Mutually Recognise Programmes to Facilitate Cargo Clearance [Media Release]." *Singapore Customs*, June 7, 2022. https://www.customs.gov.sg/files/Singapore_Customs_Press_Release_07_June_Final.pdf.

xxxiv InSYNC. *Singapore Customs Newsletter*. Issue 20, September/October 2012. https://www.customs.gov.sg/news-and-media/publications/inSYNC_Issue20_ecopy.pdf.

xxxv Reuters News. 2023. "China, Philippines Customs Sign AEO Agreement to Facilitate Trade." *Zawya*, January 5, 2023. https://www.zawya.com/en/world/china-and-asia-pacific/china-philippines-customs-sign-aeo-agreement-to-facilitate-trade-svnv6qkh.

xxxvi HKTDC Research. 2022. "China and Thailand Sign AEO Mutual Recognition Pact." *HKTDC Research*, April 8, 2022. https://research.hktdc.com/en/article/MTAyNDc5MDI5NQ.

xxxvii China Daily. 2021. "China in AEO talks with Malaysia and Thailand." *China International Import Expo*, September 26, 2021. https://www.ciie.org/zbh/en/news/exhibition/news/20210926/29525.html.

xxxviii LG. n.d. "Sustainability." Last accessed September 4, 2023. https://www.lg.com/global/sustainability/for-the-planet.

xxxix GHG Protocol. 2013. "Use of Sold Products." In *Technical Guidance for Calculating Scope 3 Emissions (version 1.0)*. Washington D.C.: World Resources Institute & Geneva: World Business Council for Sustainable Development. https://ghgprotocol.org/sites/default/files/2022-12/Chapter11.pdf.

xl Malvenda, Michael. 2019. "Trade War Incentive Schemes in ASEAN." *ASEAN Briefing*, November 21, 2019. https://www.aseanbriefing.com/news/trade-war-incentive-schemes-in-asean/.

xli Ibid.

xlii Medina, Ayman Falak. 2019. "Malaysia 2020 Budget Courts Investments from MNCs, China." *ASEAN Briefing*, October 17, 2019. https://www.aseanbriefing.com/news/malaysias-2020-budget-courts-investment-from-mncs-china/.

xliii Ibid.

xliv Malvenda, "Trade War Incentive Schemes."

xlv Ibid.

xlvi UNEP. 2016. *Scoping Study on Intra-ASEAN Value Chain Cooperation and Trade in Energy Efficiency and Renewable Energy Technologies*. Nairobi: United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/22756/Intra-ASEAN_Energy_Efficiency.pdf?sequence=1&isAllowed=y.

xlvii EY. 2019. "Tax News Update: U.S. Edition [Release]." https://taxnews.ey.com/news/2019-1370-indonesia-announces-300-percent-super-deduction-for-r-and-d-and-other-incentives.

xlviii Malvenda, "Trade War Incentive Schemes."

xlix Britannica Money. n.d. "Free Trade Zone." Last accessed September 4, 2023. https://www.britannica.com/money/free-trade-zone.

l The National Council for the Special Economic Zone of the Republic of Indonesia. n.d. "KEK Industri." Last accessed September 4, 2023. https://kek.go.id/kek-industri.

li Dawborn, David, Vik Tang, Teguh Arwiko, and Rebecca Ayuyantrie. 2021. "Indonesia's New Investment List Increases FDI Opportunities for Foreign Investors." *Herbert Smith Freehills Notes*, March 5, 2021. https://hsfnotes.com/indonesia/2021/03/05/indonesias-new-investment-list-increases-fdi-opportunities-for-foreign-investors/.

lii Philippine Economic Zone Authority. 1994. "Special Economic Zone Act." https://www.peza.gov.ph/special-economic-zone-act.

liii Paul Hype Page. n.d. "Free Trade Zones in Malaysia: Purpose and Types." Last updated on May 10, 2023. https://www.paulhypepage.my/free-trade-zones-in-malaysia-purpose-and-types/.

liv Industrial Malaysia. n.d. "What is a Free Trade Zone in Malaysia and the Benefits." Last accessed September 4, 2023. https://www.industrialmalaysia.com.my/article/free-trade-zone-malaysia.

lv HKTDC Research. n.d. "Overseas Economic and Trade Cooperation Zones on the Belt and Road." Last accessed September 4, 2023. https://beltandroad.hktdc.com/en/

sme-corner/industrial-park.

lvi Ozone Secretariat. n.d. “The Vienna Convention for the Protection of the Ozone Layer.” Last accessed May 17, 2023. https://ozone.unep.org/treaties/vienna-convention.

lvii US Department of State. n.d. “The Montreal Protocol on Substances That Deplete the Ozone Layer.” Last accessed May 17, 2023. https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/.

lviii OzonAction. n.d. “About Montreal Protocol.” Last accessed September 4, 2023. http://www.unep.org/ozonaction/who-we-are/about-montreal-protocol.

lix Andersen, Stephen, Durwood Zaelke, Kristen Taddonio, Richard ‘Tad’ Ferris, and Nancy Sherman. 2021. “Ozone Layer, International Protection.” Max Planck Encyclopedias of International Law [MPIL]. https://opil.ouplaw.com/display/10.1093/law:epil/9780199231690/law-9780199231690-e1767.

lx Ozone Secretariat. n.d. “Annex C - Group I: HCFCs (Consumption).” Last accessed May 19, 2023. https://ozone.unep.org/treaties/montreal-protocol/annex-c-group-i-hcfcs-consumption.

lxi GIZ. n.d. “Green Chillers and Energy Efficiency.” Last accessed September 4, 2023. https://www.giz.de/en/worldwide/44015.html.

lxii UNEP. 2016. *Introduction to the Kigali Amendment* [Fact Sheet]. Paris: OzonAction, United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/26869/7876FS01Intro_EN.pdf?sequence=1&isAllowed=y.

lxiii Lembong, Thomas Trikasih. 2015. *Regulation Number 83/M-DAG/PER/10/2015 Concerning Provisions for Import of Ozone Layer Depleting Substance*. Jakarta: Ministry of Trade. https://jdih.kemendag.go.id/peraturan/stream/571/3.

lxiv Aoki, Kenji. 2020. “Malaysia Promulgates Regulations Regarding Refrigerant Management.” *Enviliance Asia*, March 2, 2020. https://enviliance.com/regions/southeast-asia/my/report_2298.

lxv DENR. 2013. *Administrative Order No. 29*. Quezon City: Department of Environment and Natural Resources.

lxvi Environmental Protection and Management Act (Chapter 94A), Environmental Protection and Management (Ozone Depleting Substances) Regulations: G.N. No. S 604/2000. 2008. https://sso.agc.gov.sg/SL/EPMA1999-RG9.

lxvii UNEP. 2018. “Project Proposal: Thailand.” In *82nd Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, December 3–7, 2018*. http://www.multilateralfund.org/82/English/1/8259.pdf.

lxviii Thanh, Le Van. 2022. *Decree No. 06/2022/ND-CP on Mitigation of Green House Gas (GHG) Emissions and Protection of Ozone Layer*. Hanoi: Government of the Socialist Republic of Viet Nam. https://faolex.fao.org/docs/pdf/vie212269.pdf.

lxix UNEP. n.d. “South East Asia Network of Ozone Officers.” Last accessed September 4, 2023. https://www.unep.org/ozonaction/south-east-asia.

lxx UNEP. n.d. “Who We Are.” Last accessed September 4, 2023. https://www.unep.org/ozonaction/who-we-are.

lxxi UNEP, “Ozone Officers.”

lxxii Zulhasni, Bitul. 2019. “Update on the Implementation the Montreal Protocol Sharing Successful Practices, Challenges and Needs–INDONESIA.” In *SEAP Network Meeting of National Ozone Officers, Second OzonAction Global Inter-Regional and Parallel Networks Meeting for National Ozone Officers, Paris, February 17–19, 2019*. https://www.ozonactionmeetings.org/system/files/country_presentation_indonesia_dft.pdf.

lxxiii DOE. 2020. “Environmental Quality Management Regulations.” Ayer Hitam: Attorney General’s Chambers, Malaysia. https://www.doe.gov.my/en/2021/10/26/environmental-quality-refrigerant-management-regulations-2020-2/.

lxxiv 3E. 2022. “Malaysia Enforces New Approval Procedures for HCFCs.” *3E*, July 28, 2022. https://www.3eco.com/resource-center/blog/malaysia-enforce-new-approval-procedure-hcfcs-refrigerators-and-air.

lxxv DENR. 2013. *Administrative Order No. 2013-25*. Quezon City: Department of Environment and Natural Resources. https://faolex.fao.org/docs/pdf/phi152434.pdf.

lxxvi DENR. 2021. “UNIDO Kickoff Stage 2 of HCFC Phaseout [Release].” September 22, 2021. https://www.denr.gov.ph/index.php/news-events/press-releases/3280-denr-unido-kick-off-stage-2-of-hcfc-phase-out.

lxxvii NEA. 2021. *Environmental Protection and Management (Amendment) Bill to Mitigate Emissions of Refrigerants with High Global Warming Potential (GWP) Used in Refrigeration and Air-Conditioning (RAC) Equipment*. Singapore: National Environmental Agency. https://www.nea.gov.sg/docs/default-source/default-document-library/circular-on-epm(amendment)-bill-to-mitigate-emissions-of-refrigerants-with-high-gwp-used-in-rac-equipment.pdf.

lxxviii UNEP, “Project Proposal: Thailand.”

lxxix Nguyen, Oanh, and Thahn Hai Nguyen. 2022. “Vietnam: New Decree on Greenhouse Gas Reduction, Ozone Layer Protection and Carbon Market Development.” *Baker McKenzie*, March 9, 2022. https://insightplus.bakermckenzie.com/bm/projects/vietnam-new-decree-on-greenhouse-gas-reduction-ozone-layer-protection-and-carbon-market-development/.

lxxx UNEP. 2016. “Article 5.” In *The Montreal Protocol on Substance that Deplete the Ozone Layer*. Nairobi: United Nations Environment Programme. https://ozone.unep.org/treaties/montreal-protocol/articles/article-5-special-

situation-developing-countries.

lxxxi Konghuayrob, Supharuek, and Kornvalee Khositkullaporn. 2016. "Performance Comparison of R32, R410A and R290 Refrigerant." In *16th International Refrigeration and Air Conditioning Conference, West Lafayette, July 11–14, 2016*. https://docs.lib.purdue.edu/iracc/1577/.

lxxxii Ex-M Team. 2022. "R410A vs R32: Differences, Phase-Out, Retrofit 2022." *Ex-Machinery*, April 21, 2021. https://ex-machinery.com/Blog/r410a-vs-r32-differences-phase-out-retrofit-2022/.

lxxxiii UNEP. 2011. "Project Proposal: Indonesia." In 64th *Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, July 27–29, 2011*. http://www.multilateralfund.org/MeetingsandDocuments/currentmeeting/64/English/1/6434.pdf.

lxxxiv UNEP. 2016. "Project Proposal: Indonesia." In *76th Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, May 9–13, 2016*. http://www.multilateralfund.org/76/English/1/7636.pdf.

lxxxv Ibid.

lxxxvi Ibid.

lxxxvii UNEP. 2019. "Project Proposal: Malaysia." In *84th Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, December 16–20, 2019*. http://www.multilateralfund.org/84/English/1/8454.pdf.

lxxxviii Sidik, Salahudin Bin, and Mohamed Fauzi Bin Abdul Aziz. 2019. "Update on the Implementation the Montreal Protocol Sharing Successful Practices, Challenges and Needs–Malaysia." In *SEAP Network Meeting of National Ozone Officers, Second OzonAction Global Inter-Regional and Parallel Networks Meeting for National Ozone Officers, Paris, February 17–19, 2019*. https://www.ozonactionmeetings.org/system/files/country_presentation_malaysia_fin.pdf.

lxxxix UNEP. 2012. "Project Proposal: Philippines. In *68th Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, December 3–7, 2012*. http://www.multilateralfund.org/68/English/1/6837.pdf.

xc MLF. 2023. "92nd Meeting of the Executive Committee." Last accessed September 4, 2023. http://www.multilateralfund.org/MeetingsandDocuments/meetingsarchive/default.aspx.

xci Interviews with stakeholders conducted in April–May 2023.

xcii Sukchai, Natawan. 2019. "Update on the Implementation the Montreal Protocol Sharing Successful Practices, Challenges and Needs–Thailand." In *SEAP Network Meeting of National Ozone Officers, Second OzonAction Global Inter-Regional and Parallel Networks Meeting for National Ozone Officers, Paris, February 17–19, 2019*. https://www.ozonactionmeetings.org/system/files/country_presentation_thailand_fin.pdf.

xciii UNEP. 2012. "Project Proposal: Thailand." In *66th Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, April 16–20,* 2012. http://www.multilateralfund.org/66/English/1/6647.pdf.

xciv Ibid.

xcv Hoang, Nguyen Thi My. 2019. "Update on the Implementation the Montreal Protocol Sharing Successful Practices, Challenges and Needs–Vietnam." In *SEAP Network Meeting of National Ozone Officers, Second OzonAction Global Inter-Regional and Parallel Networks Meeting for National Ozone Officers, Paris, February 17–19, 2019*. https://www.ozonactionmeetings.org/system/files/country_presentation_viet_nam_fin.pdf.

xcvi UNEP. 2021. "Project Proposal: Vietnam." In *87th Meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Montreal, June 28–July 2, 2021*. http://www.multilateralfund.org/87/English/1/8740.pdf.

xcvii Aoki, Kenji. 2021. "Indonesia Establishes Regulation Detailing the Management Requirements for Hazardous Waste." *Enviliance Asia*, April 1, 2021. https://enviliance.com/regions/southeast-asia/id/report_5056.

xcviii DENR. 2013. "Revised Procedures and Standards for the Management of Hazardous Waste (Revising DAO 2004-36)". Last accessed September 4, 2023. https://emb.gov.ph/wp-content/uploads/2018/06/dao-2013-22.pdf.

xcix Aoki, Kenji. 2022. "Vietnam Enacts New Management Regulations on Ozone Depleting Substances." *Enviliance Asia*, March 1, 2022. https://enviliance.com/regions/southeast-asia/vn/report_5470#:~:text=Vietnam%20enacts%20new%20management%20regulations%20on%20ozone%20depleting%20substances,-Vietnam%20Ozone%20Depletion&text=AOKI%20Kenji%20.

c GIZ. 2019. *Greenhouse Gas Inventory of the Refrigeration and Air Conditioning Sector in Vietnam*. Viet Nam: Deutsche Gesellschaft für Internationale Zusammenarbeit.

ci Basel Convention. n.d. "E-waste: Overview." Last accessed September 4, 2023. http://www.basel.int/Implementation/Ewaste/Overview/tabid/4063/Default.aspx.

cii ICF International. 2008. *Study on the Collection and Treatment of Unwanted Ozone-depleting Substances in Article 5 and Non-Article 5 Countries*. Nairobi: Ozone Secretariat, United Nations Environment Programme. https://ozone.unep.org/Meeting_Documents/oewg/28oewg/ICF_Study_on-Unwanted_ODS-E.pdf.

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CLASP 1401 K Street NW Suite 1100 Washington DC 20005 USA +1 202 750 5600 info@clasp.ngo clasp.ngo