Accelerating the Global Shift to Energy-Efficient and Climate-Friendly Appliances and Equipment

Market Assessment of High-Efficient & Climate-Friendly Air Conditioners in Malaysia

Prepared for

UNITED FOR EFFICIENCY (U4E)

By

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Acronyms and Abbreviations

AC	Air Conditioner
ACE	ASEAN Centre for Energy
AMS	ASEAN Member States
APAC	Asia Pacific Accreditation Cooperation
APAEC	ASEAN Plan of Action for Energy Cooperation
CCC	Clean Cooling Collaborative
COA	Certificate of Approval
CO_2	Carbon dioxide
CSPF	Cooling Seasonal Performance Factor
DOSM	Department of Statistics Malaysia
DSM	Department of Standards Malaysia
EC	Energy Commission, Malaysia
EER	Energy Efficiency Ratio
GEF	Global Environment Facility
GHG	Greenhouse Gas
HES	Household Expenditure Survey
HS code	Harmonized Commodity Description and Coding System
ILAC	International Laboratory Accreditation Organization
MACRA	Malaysian Air-Conditioning & Refrigeration Association
MEPS	Minimum Energy Performance Standard
MEPSL	Minimum Energy Performance Standard and Labelling
MV&E	Monitoring, Verification, and Enforcement
RAC	Room Air Conditioner
SE4ALL	Sustainable Energy for All
S&L	Standards and Labelling
U4E	United for Efficiency
UN Comtrade	United Nations Commodity Trade
UNEP	United Nations Environment Program

1 EXECUTIVE SUMMARY

The "ASEAN Cool Initiative," funded by the Clean Cooling Collaborative (CCC), is designed to significantly speed up the adoption of the ASEAN regional roadmap on room air conditioners (RACs), pushing countries directly towards the ambitious Regional Phase II levels of CSPF 6.09 Wh/Wh. Led by United for Efficiency (U4E) in collaboration with the ASEAN Centre for Energy (ACE), the International Institute for Energy Conservation (IIEC), and Lawrence Berkeley National Laboratory (LBNL), this initiative extends beyond mere adoption, providing essential technical assistance and capacity building to effectively implement Minimum Energy Performance Standards (MEPS) and labelling across the region. A pivotal component of this initiative is the market assessment for RACs conducted by IIEC in Malaysia, under the U4E-IIEC partnership. This assessment plays a key role in ensuring that Malaysia's policies on cooling efficiency are harmoniously aligned with both the ambitious regional targets and national goals, thereby directly contributing to the emission reduction objectives set forth in the ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II (2021-2025).

The AC market in Southeast Asia is set for rapid growth, expected to increase sixfold by 2040, with potential ownership rising to 300 million units from 50 million in 2020. With the overall AC ownership rate at a low average of 18% in 2019 across the region, there is a pressing need to shift towards energy-efficient AC technologies to manage the anticipated growth in demand. The adoption of such technologies, as per the U4E Country Savings Assessment Model's leapfrog scenario, could lead to substantial savings of 268 TWh in electricity use by 2040, equating to US$ 31.5 billion in annual savings and the avoidance of 209 million tonnes of CO_2 emissions. Additionally, with ACs being among the most energy-intensive household appliances, as identified in the 6th ASEAN Energy Outlook, and expected to account for up to 12.4% of total energy consumption by 2050 without policy intervention, it is imperative to promote energy-efficient models and enhance policy frameworks. This strategy, including the elevation of MEPS and the harmonization of energy efficiency standards and labelling across ASEAN, aligns with the Energy Efficiency and Conservation (EE&C) objectives of the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025, presenting MEPS as an effective method to boost energy efficiency in the region.

The market assessment employed a comprehensive approach, combining quantitative and qualitative methodologies to gather data on RAC models in Malaysia. Data collection involved multiple sources, including the national product registration system, customs departments for import/export insights, online sales platforms, retailer surveys, and manufacturer/importer surveys. Additionally, interviews with industry associations and home energy consumption surveys were conducted. This multifaceted approach allowed for the review of cooling capacities, efficiency values, product usage patterns, market profiles, and cost-benefit analyses to evaluate the impacts of implementing more stringent MEPS for RACs in Malaysia.

Country Background:

Malaysia had an estimated population of 33.4 million in 2023, with 8.4 million households recorded in 2022. The housing landscape in 2022 exhibited various preferences and lifestyles, with terrace houses (also known as townhouses or row houses) being the most prevalent at 39.1%, followed by detached houses at 32.9%. Flats, apartments, semi-detached houses, condominiums, and other housing types also contributed to the diverse housing market. The majority of households consisted of three members, with an average monthly household expenditure of around RM 5,150. Water, electricity, gas, and other fuels (23.2%), food and beverages (16.3%), restaurant and accommodation

services (16.1%), and transport (11.3%) were the main expenditure categories, indicating significant spending patterns within the population. With its sizable population and diverse housing landscape, Malaysia presents a significant market for RACs, with factors such as climate, household size, and expenditure patterns influencing the demand and usage of cooling appliances within the country.

EE Legal & Regulatory Framework for RACs in Malaysia

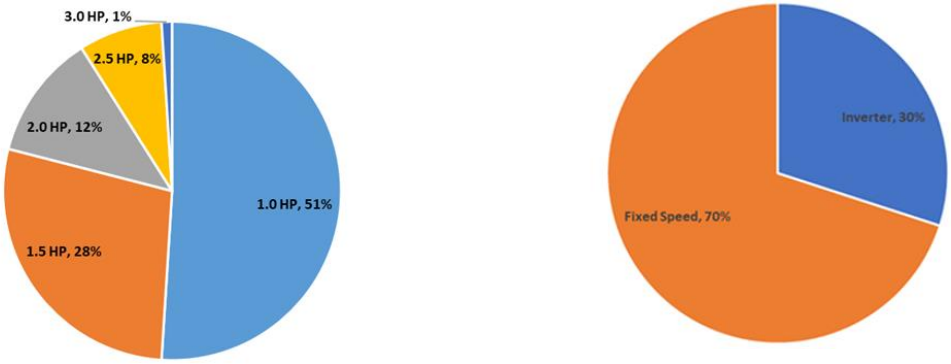
The Malaysian government has instituted a voluntary Energy Efficiency (EE) rating and labelling system for RACs since 2009. With the Amendment 2013 to the Electricity Regulation 1994, the Energy Commission (EC - Suruhanjaya Tenaga) gained regulatory authority over energy performance of RAC products. The EC, in collaboration with the Department of Standards Malaysia (DSM), oversees the development of MEPS. Initially referencing Energy Efficiency Ratio (EER) as the efficiency metrics, the first mandatory MEPS and labelling requirements covered single split wall-mounted RACs up to 7.1 kW was published by EC. In 2018, a revised guide has recognized the Cooling Seasonal Performance Factor (CSPF) as the efficiency metric. The updated MEPS and labelling requirements continue to cover a similar range of RAC capacities (i.e., up to 7.1 kW), and the efficiency requirements are still divided into two categories, i.e., CC < 4.5 kW and 4.5 kW ≤ CC ≤ 7.1 kW. The MEPS requirements are designated as a 2-star rating, i.e., CSPF of 3.10 Wh/Wh for units less than 4.5 kW (a 4% increase from the previous MEPS) and 2.90 Wh/Wh for units ≤ 7.1 kW (a 14% increase from the previous MEPS).

RAC Market Profile in Malaysia:

With a household ownership rate of RACs at 54% in 2019, the market boasts a significant consumer base, primarily in the residential sector. Despite fluctuations, RAC sales totalled approximately 790,000 units in 2021, with consistent growth in imports from China (93% in 2022), and Vietnam emerging as the largest recipient, comprising 49% of the exports. Leading brands like Daikin and Panasonic play pivotal roles, accounting for over 80% of the total market share, with Daikin, Panasonic, and ACSON being recognized as registered local manufacturers. South Korean brands also secure a market share. Retail distribution channels encompass physical stores and online platforms, with a noticeable trend towards online retail. Manufacturers and importers estimate that RACs sold in the residential sector make up approximately 50% of total sales, while commercial buildings account for around 30%. R32 refrigerant is the most commonly used refrigerant for new RACs in Malaysia.

Distribution of RAC Models in the Market

The most popular cooling capacity is 1 HP (2.49 - 2.78 kW or 8,500 – 9,500 Btu/h), followed by 1.5 HP (3.37 – 3.66 kW or 11,500 – 12,500 Btu/h). According to the RAC manufacturers and importers in Malaysia, fixed-speed RAC products still dominate the Malaysian market, comprising about 70% of all RACs sold. Although 65% of off-the-shelf models are inverter type, fixed-speed models remain popular due to pricing concerns, especially among residential consumers. In the commercial sector, government incentives such as subsidies and tax credits drive the preference for inverter models.

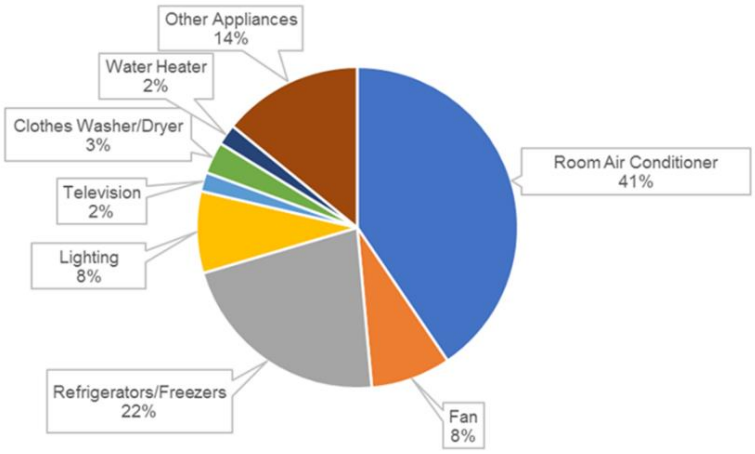


RAC Models Sold - Data estimates from manufacturers/importers, 2023

In terms of EE, according to data gathered from a survey of retailers, the average CSPF for RAC models in Malaysia varied across different cooling capacities. For 1.0 HP units (2.49 - 2.78 kW or 8,500 – 9,500 Btu/hr), the CSPF averaged 5.34 for inverter models and 3.52 for fixed-speed models. Transitioning to 1.5 HP units (3.37 – 3.66 kW or 11,500 – 12,500 Btu/h), inverter models demonstrated an average CSPF of 5.58, while fixed-speed models averaged 3.48. For 2.0 HP units (4.5 – 5.2 kW or 15,000 – 18,000 Btu/hr), the average CSPF was 5.60 for inverters and 3.40 for fixed-speed models. In the 2.5 HP category (6.00 – 6.59 kW or 20,500 – 22,500 Btu/h), inverter models had an average CSPF of 5.96, while fixed-speed models averaged 3.55. Notably, among the surveyed models, certain inverter models already exceeded the CSPF of 6.09.

Household Electricity Consumption of RAC

Analysis of energy end-use found that the major energy end-uses among these surveyed households primarily include cooling (RACs and fans), refrigeration (refrigerators/freezers), and lighting. In general, cooling appliances (RACs, fans, and refrigerators/freezers) in each household contribute 40% to 70% of the annual electricity consumption. All surveyed households own at least one RAC, and most of these households have three ACs. The daily usage hours of the RACs used in a household are about 5.4 hours on average. Inverter compressors are more popular for newer units (1-5 years) installed among the surveyed households, while fixed-speed compressors were predominant in older units.



Average Shares of Different Energy End-Uses in 15 Surveyed Households

Cost and Benefits of Higher Efficiency RAC Adoption in Malaysia:

The cost-benefit analysis highlights the financial and environmental advantages of selecting air conditioners with higher EE, particularly those with a CSPF value of 6.09. These models, despite their higher initial purchase price, offer shorter payback periods and substantial long-term energy savings, making them attractive investments for both residential and commercial settings. Opting for air conditioners with a CSPF of 6.09 significantly reduces cumulative GHG emissions over the RAC's 12-year lifetime, with reductions totalling 3,429 kgCO2 for households and 4,302 kgCO2 for small commercial buildings, highlighting the environmental benefits of higher EE units.

The analysis underscores the significant difference in payback periods between new purchases and early replacements, with higher EE models demonstrating the most financial benefit.

- **New Purchases**: Compared with other lower efficiency models, units with a CSPF of 6.09 have the shortest payback periods, 4.2 years for residential and 3.4 years for small commercial buildings, due to their substantial annual electricity cost savings compared to models with lower CSPF values.
- **Early Replacements**: The financial viability of early replacement with high EE models is challenged by longer payback periods, though models with a CSPF of 6.09 show a comparatively better scenario, with payback periods of 13.8 years for residential and 11 years for small commercial buildings.

The results also reveal that while higher EE units (CSPF 6.09) come with higher upfront costs, they lead to considerable savings in life cycle costs and GHG emission reductions, thus providing both financial and environmental incentives. However, the analysis indicates that incentives may be crucial to encourage the adoption of more efficient RACs due to their initial price difference.

Recommendations:

To promote greater adoption of higher efficiency RACs and encourage early replacement, the following recommendations are proposed.

Integrated Policy Approach	Strategies
Standards & Regulations	• **Enforce stringent MEPS**: Ensure the enforcement of MEPS for RACs to forcefully steer the market toward more efficient technologies, guaranteeing consumers access to better efficiency options and pushing manufacturers to innovate and improve efficiency standards. This aligns with the ASEAN Regional Policy Roadmap for Energy-Efficient RACs, aiming for a Phase II CSPF of 6.09 by 2025.
Finance & Financial Delivery Mechanisms	• **Offer compelling financial incentives for early replacement**: Governments or utility companies should provide rebates or tax credits to incentivize the early replacement of less efficient RACs with higher-efficiency models. This initiative effectively offsets the higher upfront costs, similar to the SAVE program, specifically tailored for the early replacement scenario. Further studies should be conducted on the detailed design phase to determine the extent of financial assistance and the program criteria.

Integrated Policy Approach	Strategies
	• **Establish highly accessible financing options such as low-interest loans covering all types of purchases**: Provide seamless access to low-interest loans or flexible installment plans to enable consumers to spread out the cost of purchasing a higher-efficiency RAC over time, ensuring affordability and accessibility for all income levels. • **Implement robust financial support measures for manufacturers**: Enact powerful tax incentives for local production and institute duty-free policies specifically for high-efficiency inverter AC products, actively fostering eco-friendly design and driving the rapid development of a circular economy. • **Roll out impactful home energy audit programs**: Execute public programs focused on EE, such as comprehensive energy audits or home retrofit initiatives, offering personalized recommendations and incentives for upgrading to higher efficiency appliances, including RACs.
Supporting Policies	• **Raise awareness on energy savings**: Launch aggressive educational campaigns to inform and empower consumers about the long-term energy savings potential of higher efficiency RACs, encouraging them to prioritize EE in every purchasing decision. • **Foster deep collaboration with retailers**: Forge strategic alliances with retailers to vigorously promote higher efficiency RACs through engaging marketing campaigns and exclusive promotions, effectively boosting consumer awareness and driving widespread adoption of efficient models.
Monitoring, Verification & Enforcement	• **Monitor e-commerce channels:** There should be a dedicated effort to monitor e-commerce platforms. This strategy aims to ensure that online sales of RACs comply with MEPS and labelling requirements, safeguarding that consumers are presented with EE options across all purchasing channels.

By integrating these strategies, the proposed recommendations aim to significantly increase the adoption of high-efficiency RACs, facilitating a shift towards more sustainable cooling solutions while addressing both upfront cost barriers and the need for broader market transformation.

2 INTRODUCTION

2.1 Project Background

Since 2020, the United for Efficiency (U4E), has been working with ASEAN Centre for Energy (ACE) and ASEAN Member States (AMS) to help establish a regional, and national, roadmap for Air Conditioners (AC) and to work towards harmonized testing standards and energy efficiency levels. In 2023, the "ASEAN Cool Initiative", funded by the Clean Cooling Collaborative (CCC), was introduced to accelerate the implementation of the ASEAN Regional Policy Roadmap for Energy Efficient Room Air Conditioners by providing technical assistance and capacity building on Minimum Energy Performance Standards (MEPS) and labels in the region.

The ASEAN Cool Initiative, led by U4E in collaboration with ACE, International Institute for Energy Conservation (IIEC), and Lawrence Berkeley National Laboratory (LBNL), aims to accelerate the adoption of the ASEAN regional roadmap on air conditioners to enable countries to go straight to the more ambitious Regional Phase II levels (i.e., CSPF 6.09 Wh/Wh). It is noteworthy that all AMS have implemented or specified a minimum Energy Efficiency Ratio (EER) of 2.9 W/W and ISO Cooling Seasonal Performance Factor (CSPF) of 3.08 Wh/Wh as MEPS for AC with a cooling capacity below 3.52 kW. AMS also have shown significant progress in implementing the previous regional policy roadmap for AC. Indonesia, Malaysia, Philippines, Thailand, and Vietnam have adopted ISO 5151 and ISO 16358 as national standards. Meanwhile, Cambodia, Laos, and Myanmar use ISO 5151 and ISO 16358 as references in drafting MEPS regulation.

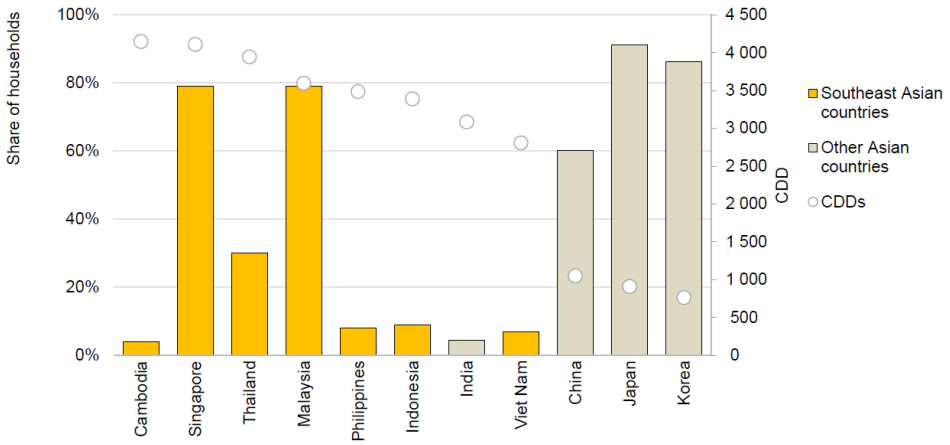
Under the U4E stewardship, IIEC is responsible for carrying out the Room Air Conditioners (RACs) market assessment in Malaysia. The assessment plays a pivotal role in harmonizing Malaysia's policies with the regional and national targets on cooling efficiency, ultimately propelling Malaysia towards a more sustainable and energy-efficient future. The market assessment study in Malaysia, as the output from this project, will serve as a recommendation for replication of the study in other AMS. On the other hand, ACE is responsible for ensuring that the project implementation is aligned with the regional level activities, as well as supporting the development of MEPS and labels in Malaysia, including raising awareness of Malaysian stakeholders through country consultations and regional workshops.

This project synchronization is integral, directly supporting the overall objective of the ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II (2021-2025) to reduce energy intensity by 32% in 2025 compared to 2005 levels. It will deliver Action Plan 1.1 to develop and implement regional and national policy roadmap for MEPS under Outcome-based Strategies (OBS) 1 for Expand, Harmonise, and Promote Energy Efficiency Standards and Labelling on Energy-related Products.

2.2 Overview of Air Conditioners in ASEAN

The AC market in Southeast Asia is expected to grow rapidly, reaching up to six times its current level. By 2040, the region could have 300 million AC units, compared to 50 million in 2020. While AC ownership in the region is still relatively low with an average of 18% of households owning an AC in 2019, Malaysia and Singapore have much higher ownership rates, reaching almost 80% similar to Japan and Korea[1] (ACE and IEA, 2022), as shown in Figure 2-1.

[1] ACE and IEA (2022), Roadmap Towards Sustainable and Energy-Efficient Space Cooling in ASEAN, June 2022

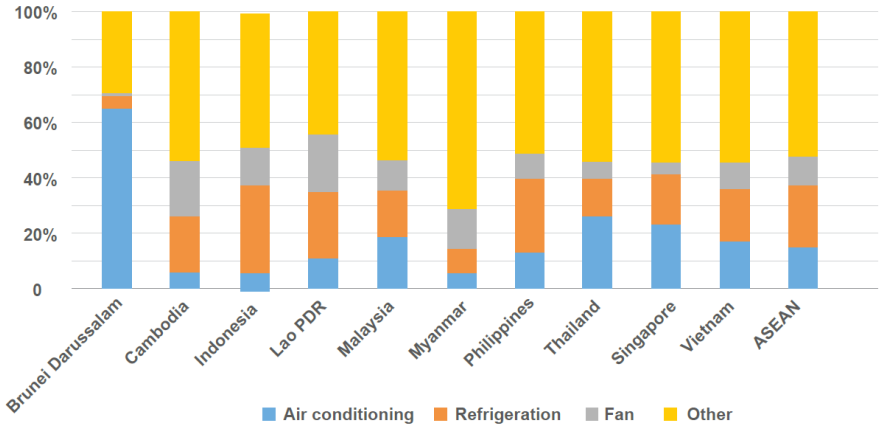


Source: Roadmap Towards Sustainable and Energy-Efficient Space Cooling in ASEAN, 2022[1]

Figure 2-1: Share of Households Using Air Conditioning by Country

As AC ownership increases, residential electricity demand in the region is projected to hit 300 TWh by 2040[1]. To address this growing demand, there is an urgent need for a shift towards energy-efficient AC technology. According to the U4E Country Savings Assessment Model in the leapfrog scenario, the potential savings from widespread adoption of energy-efficient AC could reduce electricity use by 268 TWh in 2040, which is worth annual savings of US$ 31.5 Billion and avoiding 209 million tonnes of CO_2 emissions in 2040.

Furthermore, the 6th ASEAN Energy Outlook identifies the distribution of household appliances in ASEAN countries, showing that AC contributes as one of the highly energy-intensive appliances, alongside refrigerators and fans. As depicted in Figure 2-2, the distribution of AC in Malaysia accounts for almost one-fifth of household appliances[2], and the use of AC is likely to become even more widespread in the future as incomes rise.

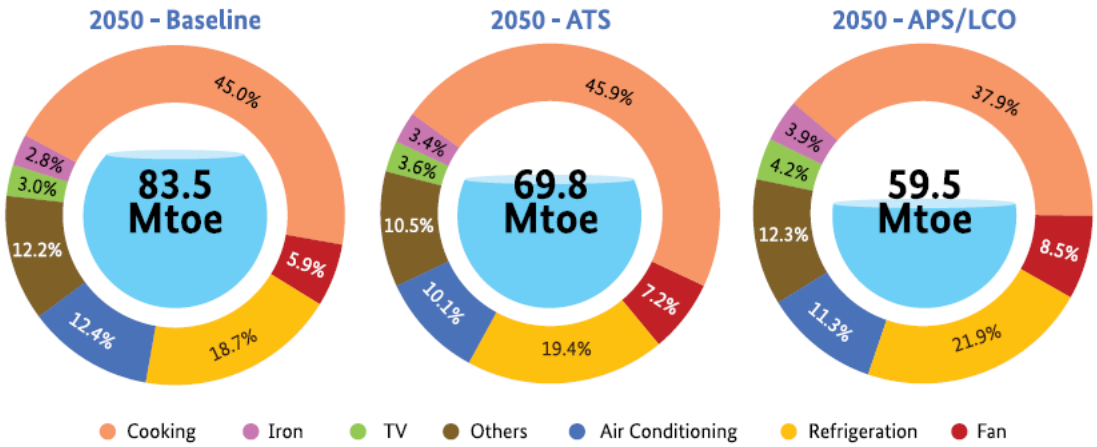


Source: The 6th ASEAN Energy Outlook, 2020[2] (ACE, 2020)

Figure 2-2: Cooling and AC Share of Residential Electricity Demand

[2] ACE (2020). The 6th ASEAN Energy Outlook (AEO6). ASEAN Centre for Energy (ACE), Jakarta.

Estimated consumption of household electrical appliances in 2050 shows the total end-use energy will reach 83.5 Mtoe, without any policy intervention. AC is estimated to contribute 12.4% of total energy. Meanwhile, the AMS Targets Scenario (ATS) and APAEC Target Scenario (APS) estimate that AC will account for 10.1% and 11.3% of energy consumption, respectively[3]. These data refer to the study from the 7th ASEAN Energy Outlook, as shown in Figure 3-3.



Source: The 7th ASEAN Energy Outlook, 2022[3] (ACE, 2022)

Figure 2-3: Share of Residential Appliances Energy Consumption in 2050 Across Scenarios

In response to rising energy consumption from AC, promoting energy-efficient models and bolstering related policies in ASEAN are crucial. This includes raising Minimum Energy Performance Standards (MEPS) and harmonizing energy efficiency standards and labelling for AC across the region. These efforts directly support the goals of ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025, particularly for the Energy Efficiency and Conservation (EE&C) programme area. Additionally, MEPS stands out as the best practice and the most efficient approach to drive up energy efficiency.

2.3 Objectives and Market Assessment Methodology

The main objectives of the market assessment are to review and determine cooling capacities and efficiency values of off-the-shelf RAC models, as well as to identify typical household RAC adoption and usage patterns in Malaysia.

This market assessment employed a multi-faceted approach that ensured a thorough and diverse data collection process, combining quantitative and qualitative methodologies to comprehensively collect data and assess RAC market. The analysis involved leveraging market data to construct the overall RAC market profile in Malaysia, and evaluating product technical data to assess efficiency levels, popular technologies and cooling capacities. The cost-benefit analysis utilized product usage data, product efficiency vis-à-vis energy consumption data, and energy cost data to determine impacts of more stringent MEPS for RACs in Malaysia.

The data collection methodology involved compiling data from the national product registration system, the customs department (for import and export insights), online sales platforms, retailer surveys and in-store visits, and manufacturer/importer surveys. The manufacturer/importer survey was based on a purposive or selective sample, which included 5 large manufacturers/importers

[3] ACE (2022). The 7th ASEAN Energy Outlook (AEO7). ASEAN Centre for Energy (ACE), Jakarta.

providing their opinions on adopting the higher MEPS levels of CSPF (Cooling Seasonal Performance Factor) 6.09 and validating AC market data. Additionally, interviews with the Malaysian Air-Conditioning & Refrigeration Association (MACRA) were conducted to provide insights and valuable perspectives on the Malaysian RAC market. Moreover, 15 home energy consumption surveys were conducted to evaluate household electricity consumption profiles and typical energy efficiency (EE) performance of household electrical appliances, specifically RACs.

Types of data and their collection methodologies are summarized in Table 2-1.

Table 2-1: Types of Data and Collection Methodology

	Product technical data	Product price data	Market share / unit sales by product	Product usage data	Energy cost data	Macro Socio-economic data	Environmental data - Refrigerants	Other analysis specific data
Product registration systems	✓		✓				✓	
Customs (Import and Export Information)		✓	✓					
Internet sales (Online Retail Information)	✓	✓	✓				✓	
Retailer survey/ In-store visit	✓	✓	✓				✓	
Utilities				✓	✓			
Expert interviews (e.g., industry associations, compliance testing labs)	✓		✓					
Surveys, questionnaires (e.g., manufacturers/ importers)	✓	✓	✓					
Home energy consumption surveys	✓			✓		✓		✓
Census data						✓		✓

3 COUNTRY BACKGROUND

3.1 Geographical Area

Malaysia, a Southeast Asian country, spans approximately 329,847 square kilometers, with a 4,680 km coastline bordering Singapore and southern Thailand. Peninsular Malaysia is separated by about 540 km of the South China Sea from the Malaysian states of Sabah and Sarawak, which share the island of Borneo with Indonesia and Brunei Darussalam. The capital city is Kuala Lumpur, with Putrajaya serving as the Federal Government center. Malaysia comprises three federal territories (W.P Kuala Lumpur, W.P. Putrajaya, and W.P. Labuan) and 13 states (including Selangor, Melaka, Johor, Pulau Pinang, Terengganu, Negeri Sembilan, Pahang, Sarawak, Perak, Perlis, Kedah, Kelantan, and Sabah). The country shares land borders with Thailand, Indonesia, and Brunei, while maritime borders exist with Singapore, Vietnam, and the Philippines (see Figure 3-1).

Source: Malaysian Meteorological Department, 2018[4]

Figure 3-1: Map of Malaysia, Indicating its Location in the South China Sea

3.2 Population and Household Characteristics

According to the Department of Statistics Malaysia (DOSM), the total population of Malaysia in 2023 is estimated to be at 33.4 million as compared to 32.7 million in 2022.

In 2022, Malaysia had 8.4 million households, marking a 5% increase from the 8.0 million households recorded in 2019. Selangor had the highest number of households accounting for 1.9 million households, followed by Johor with 1 million households, Sabah with 0.77 million households (see Table 3-1).

[4] Mazni Binti Azis (2018), Malaysian Meteorological Department (MMD), Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), November 2018

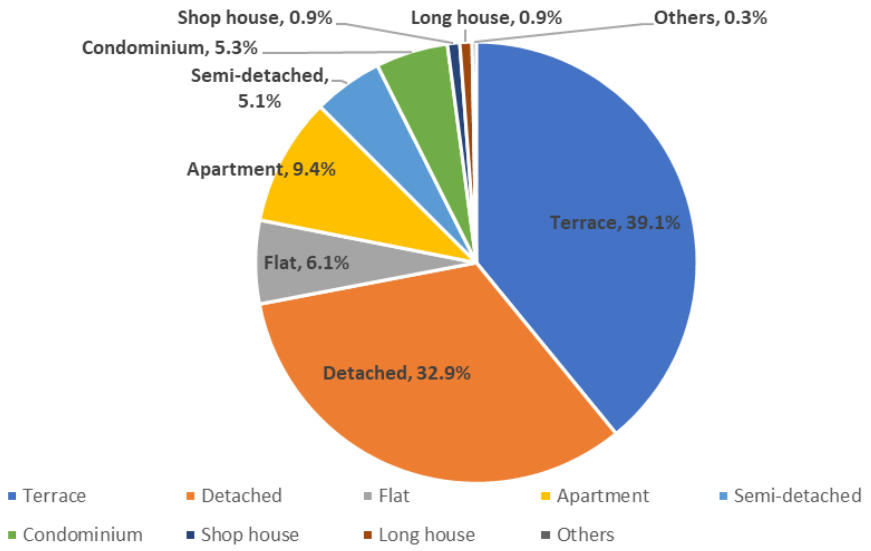
Table 3-1: Number of Households by State and Strata, Malaysia, 2019 and 2022

('000)

State	2019			2022		
	Total	**Urban**	**Rural**	**Total**	**Urban**	**Rural**
Malaysia	8,001.7	6,372.6	1,629.2	8,384.9	6,441.4	1,943.5
Johor	966.0	769.2	196.8	1,041.6	819.4	222.2
Kedah	520.7	382.2	138.5	546.9	369.6	177.3
Kelantan	354.5	185.4	169.0	364.2	165.0	199.3
Melaka	239.9	228.6	11.4	269.8	245.9	23.9
Negeri Sembilan	291.8	223.8	68.1	327.7	228.7	94.0
Pahang	371.3	230.7	140.6	400.4	217.0	183.3
Pulau Pinang	489.7	471.4	18.4	497.5	462.7	34.8
Perak	663.3	537.7	125.5	666.6	491.3	175.2
Perlis	60.8	41.2	19.5	76.7	42.2	34.5
Selangor	1,804.2	1,700.0	104.2	1,865.9	1,789.9	76.0
Terengganu	261.9	178.9	83.0	288.1	185.0	103.1
Sabah	701.8	441.9	289.9	766.1	420.9	345.3
Sarawak	663.4	371.8	291.7	636.7	363.6	273.1
W.P. Kuala Lumpur	552.7	552.7	n.a.	588.7	588.7	n.a
W.P. Labuan	26.0	23.4	2.6	21.6	20.0	1.6
W.P. Putrajaya	33.7	33.7	n.a	31.5	31.5	n.a

Source: Household Expenditure Survey (HES) 2022, conducted by the Department of Statistics Malaysia (DOSM, 2023)

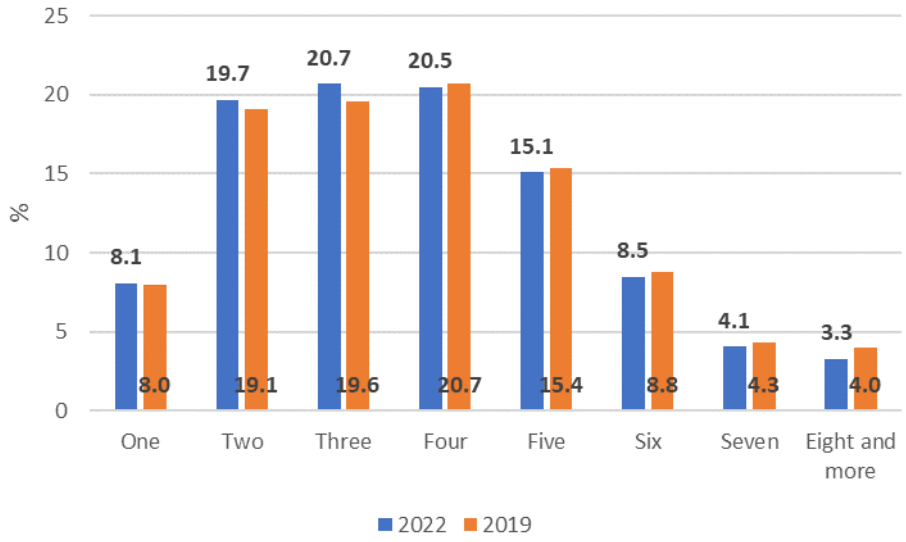
In 2022, the Malaysian housing landscape exhibited a diverse range of housing types, reflecting various preferences and lifestyles. Terrace houses (also known as townhouses or row houses) accounted for the largest portion at 39.1%, emphasizing their popularity among Malaysian households. Detached houses followed closely at 32.9%, reflecting a significant preference for standalone, spacious residences. Flats and apartments collectively accounted for 15.5% of the housing scenario, with flats representing 6.1% and apartments at 9.4%. Semi-detached houses constituted 5.1%, offering a middle ground between detached and attached residences. Condominiums, a prevalent form of multi-story housing, contributed 5.3% to the overall housing market. Additionally, less common housing types such as shop houses, and other forms collectively made up a smaller percentage, at 3.1%, indicating a diversity of living arrangements available within the Malaysian housing market (see Figure 3-2).



Source: Household Expenditure Survey Report 2022, Department of Statistics Malaysia

Figure 3-2: Type of Living Quarters, 2022

In 2022, the majority of households consisted of three members, accounting for 20.7%. Households with four members represented 20.5%, while those with two members made up 19.7%. When compared to 2019, there was a slight shift in the predominant household size in Malaysia from four members to three members in 2022 (see Figure 3-3).



Source: Household Expenditure Survey Report 2022, Department of Statistics Malaysia (DOSM)

Figure 3-3: Percentage of Households by Size, Malaysia, 2019 and 2022

On average, the monthly household expenditure was around RM 5,150 in 2022. At the federal and state levels, the highest average monthly household consumption expenditure was recorded in the

Putrajaya Federal Territory[5] (RM 8,897). Five (5) other areas also recorded household consumption expenditure above the national average (RM 5,150), namely Kuala Lumpur Federal Territory (RM 7,823); Selangor (RM 6,770); Melaka (RM 5,707); Johor (RM 5,342) and Pulau Pinang (RM 5,322)[6]. According to expenditure allocation made by households, composition of expenditure pattern (66.9%) still focuses on four main groups of expenditure which are housing, water, electricity, gas and other fuels (23.2%), food and beverages (16.3%); restaurant and accommodation services (16.1%); and transport (11.3%).

Table 3-2: Composition of Monthly Household Consumption Expenditure by Strata, Malaysia, 2022

Expenditure Group	Total		Urban		Rural	
	(RM)	(%)	(RM)	(%)	(RM)	(%)
01 Food and Beverages	841	16.3	848	15.0	818	24.0
02 Alcoholic Beverages and Tobacco	95	1.8	98	1.7	83	2.4
03 Clothing and Footwear	140	2.7	150	2.6	107	3.2
04 Housing, Water, Electricity, Gas and Other Fuels	1,193	23.2	1,350	23.8	674	19.8
05 Furnishings, Household Equipment, and Routine Household Maintenance	242	4.7	272	4.8	143	4.2
06 Health	141	2.8	154	2.7	94	2.8
07 Transport	584	11.3	639	11.3	403	11.8
08 Information and Communication	337	6.6	376	6.6	208	6.1
09 Recreation, Sport and Culture	156	3.0	178	3.1	82	2.4
10 Education Services	68	1.4	78	1.4	36	1.0
11 Restaurants and Accommodation Services	831	16.1	944	16.6	457	13.4
12 Insurance and Financial Services	208	4.0	244	4.3	88	2.6
13 Personal Care, Social Protection, and Miscellaneous Goods and Services	314	6.1	344	6.1	216	6.3
Composition of monthly household consumption expenditure (01-13)	**5,150**	**100.0**	**5,675**	**100.0**	**3,409**	**100.0**

Source: Household Expenditure Survey (HES) 2022, conducted by the Department of Statistics Malaysia

[5] Federal Territory (Malay: Wilayah Persekutuan or W.P.)

[6] https://www.dosm.gov.my/portal-main/release-content/household-expenditure-survey-report--malaysia--states-

3.3 EE Legal & Regulatory Framework for RACs in Malaysia

The Malaysian government has implemented a voluntary EE rating and labelling system for RACs since 2009. The amendment of the Electricity Regulation 1994, known as (Amendment 2013[7]) Regulation 101A (3), which was gazetted on 3rd May 2013, granted the Energy Commission (Suruhanjaya Tenaga) the authority to regulate RAC products (EC, 2013). Since then, the Energy Commission (EC) has been responsible for developing Minimum Energy Performance Standards (MEPS) and collaborates with the Department of Standards Malaysia (DSM) to establish these as national standards. In addition, EC also oversees the labelling requirements for RAC products. The Malaysian national standards are voluntary by nature until they are made mandatory through regulatory authorities by means of regulations, local by-laws, or any other similar ways.

Once the MEPS and labelling requirements are made mandatory, all manufacturers and importers must demonstrate the compliance with the MEPS and other requirements (such as safety) and affix the Energy Label onto the products before it can be sold to consumers. All relevant test reports together with the application for the Certificate of Approval (COA) shall be submitted to the Energy Commission for review and approval. Product test reports shall be issued by test laboratories duly recognized by the Department of Standards Malaysia, which is the National Standards Body and the National Accreditation Body[8], a member of both International Laboratory Accreditation Organization (ILAC) and Asia Pacific Accreditation Cooperation (APAC).

3.3.1 MEPS and Labelling Requirements for RACs, 2014 - 2018

The first mandatory MEPS and labelling requirements for RAC in Malaysia referenced Energy Efficiency Ratio (EER) as the efficiency metrics for non-inverter (fixed-speed) and inverter RACs and covered single split wall mounted RACs with cooling capacity (CC) up to 7.1 kW (about 25,000 Btu/h). The 2014 requirements divided RAC CC into two categories, i.e., up to 4.5 kW and 4.5kW ≤ CC ≤ 7.1kW, and the EER requirements for each category are summarized in Table 3-3. Note that the MEPS requirements for both categories were specified at 2-star rating, i.e., 2.80 W/W for CC < 15,000 Btu/h and 2.35 W/W for 15,000 < CC < 25,000 Btu/h.

Table 3-3: MEPS and Labelling Requirements for RAC in Malaysia, 2014 - 2018

Star Rating	Efficiency Rating in EER (Btu/h/W)	
	Rated CC < 4.5kW	**4.5kW ≤Rated CC ≤ 7.1kW**
5	≥ 11.94	≥ 10.71
4	11.16 -11.93	9.83 -10.70
3	10.37 - 11.15	8.94 – 9.82
2 (MEPS)	9.56 - 10.36	8.03 – 8.93
1	9.00 - 9.55	7.50 - 8.02

Source: Electricity (Amendment) Regulations 2013

[7] Electricity (Amendment) Regulations 2013. URL: https://www.st.gov.my/en/details/policies_details/8/2

[8] https://www.msonline.gov.my/about-us/corporate-info/background

3.3.2 MEPS and Labelling Requirements for RACs, 2019 to Date

In 2018, the Energy Commission approved a revised MEPS and labelling requirements[9] recognizing the Cooling Seasonal Performance Factor (CSPF), measured in Wh/Wh, as the RAC efficiency metrics, and CC of RACs in kilowatt (kW) instead of Btu/h. The 2018 MEPS and labelling requirements still cover the similar range of RAC CC, (i.e., up to 7.1 kW or about 25,000 Btu/h) and the efficiency requirements are still divided for two categories, i.e., CC < 4.5 kW and 4.5kW ≤ CC ≤ 7.1kW. The MEPS requirements are still designated as minimum 2-star rating, i.e., CSPF of 3.10 Wh/Wh for units less than 4.5 kW (a 4% increase from the previous MEPS) and 2.90 Wh/Wh for units ≤ 7.1 kW (a 14% increase from the previous MEPS) (EC, 2018).

Table 3-4: MEPS and Labelling Requirements for RAC in Malaysia, 2019 to Date

Star Rating	Tested CSPF (Wh/Wh)	
	Rated CC < 4.5kW	**4.5kW ≤Rated CC ≤ 7.1kW**
5	≥5.30	5.10≤
4	4.60 ≤CSPF<5.30	4.00≤ CSPF<5.10
3	3.30 ≤ CSPF<4.60	3.10≤ CSPF<4.00
2 (MEPS)	3.10 ≤ CSPF<3.30	2.90 ≤ CSPF<3.10
1	<3.10	<2.90

Source: Energy Commission, March 2018

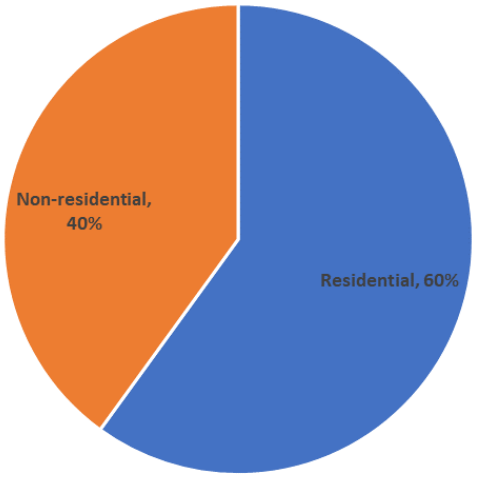
[9] Guide on Minimum Energy Performance Standard Requirements for Air Conditioner with Cooling Capacity ≤ 7.1kW, March 1, 2018. URL: https://www.st.gov.my/contents/2021/MEPS/20210108%20-Guide%20on%20MEPS%20for%20AC%20(UPDATED).pdf

4 ASSESSMENT OF RAC MARKET

4.1 RAC Market Profiles

Malaysia's rapid economic development has led to an increased demand for residential air conditioning, making it crucial to understand the stock of RACs in the country. According to the Department of Statistics Malaysia (DOSM), Malaysia had about 8.4 million households in 2022, with a reported household ownership rate of RACs at 54% in 2019[10] (DOSM, 2019). This would imply a residential RAC stock of more than 4.5 million units. Meanwhile, the UNEP U4E country savings assessment estimates a national RAC stock of about 10.5 million units in the residential and non-residential sectors in 2021. The model considers factors such as population growth, economic indicators, and technological advancements.

Information obtained through an interview with one manufacturer offers another perspective. The manufacturer suggested that RACs installed in the residential sector constituted approximately 60% of the total, with the remaining 40% attributed to the non-residential sector (see Figure 4-1). This estimation places the overall RAC stock at around 7.5 million units, using the ownership rate of RACs at 54%. According to manufacturers' opinions, R32 is the most common refrigerant type for RACs currently sold in the market.



Source: Data estimates from manufacturers/importers, 2023

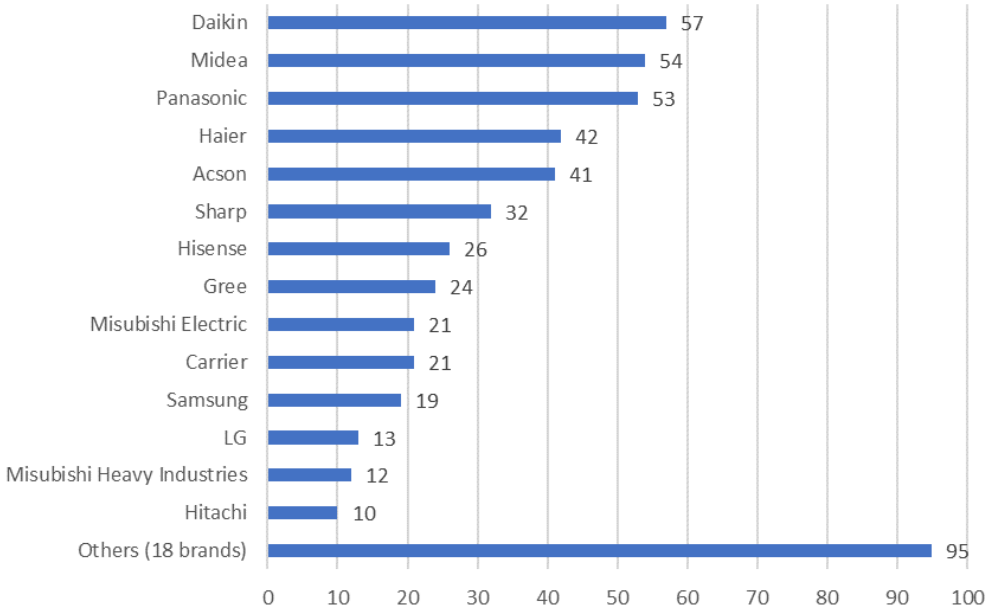
Figure 4-1: Shares of RACs installed in Residential and Non-Residential Sectors

In Malaysia, as per the Energy Commission, Acson, Daikin, and Panasonic are the registered manufacturers producing air conditioners locally. However, according to MACRA, only Daikin and Panasonic are recognized as the local manufacturers operating within the country. It is noted that Daikin also manufactures air conditioners under the Acson brand. Acson Malaysia Sales & Service Sdn Bhd operates as a subsidiary of Daikin Malaysia Sdn Bhd, which has been under the ownership of Daikin Industries Ltd. since September 2006.[11].

[10] Household Income & Basic Amenities Survey Report 2019, Department of Statistics Malaysia

[11] URL: https://www.acson.com.my/about-us

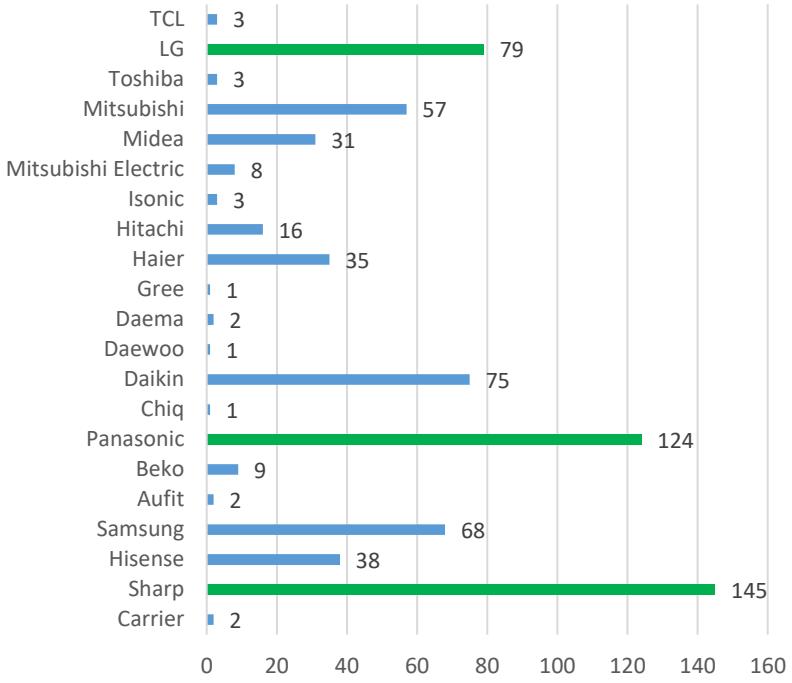
Figure 4-2 provides a brief overview of popular brands and their respective number of RAC models with cooling capacity up to 32,000 Btu/hr certified by the Energy Commission. In total, there were 520 certified RAC models, as of October 2023. Daikin accounted for the largest share, with 57 certified models, followed by Midea (54 models) and Panasonic (53 models).



Source: Energy Commission's Air Conditioner Certified Database

Figure 4-2: Number of RAC Models Certified, Cooling Capacity up to 32,000 Btu/hr (as of October 2023)

The retailer surveys compiled 703 models of RACs available from 20 online and physical retail shops in Malaysia. There are 21 RAC brands, with different cooling capacities and product features through these retailers. The top 3 brands based on a number of models available off-the-shelf are Sharp (145 models), Panasonic (124 models) and LG (79 models). The other major brands are Daikin (75 models) and Samsung (68 models). The total number of models offered by these five major brands accounts for 69% of the total models in the market.

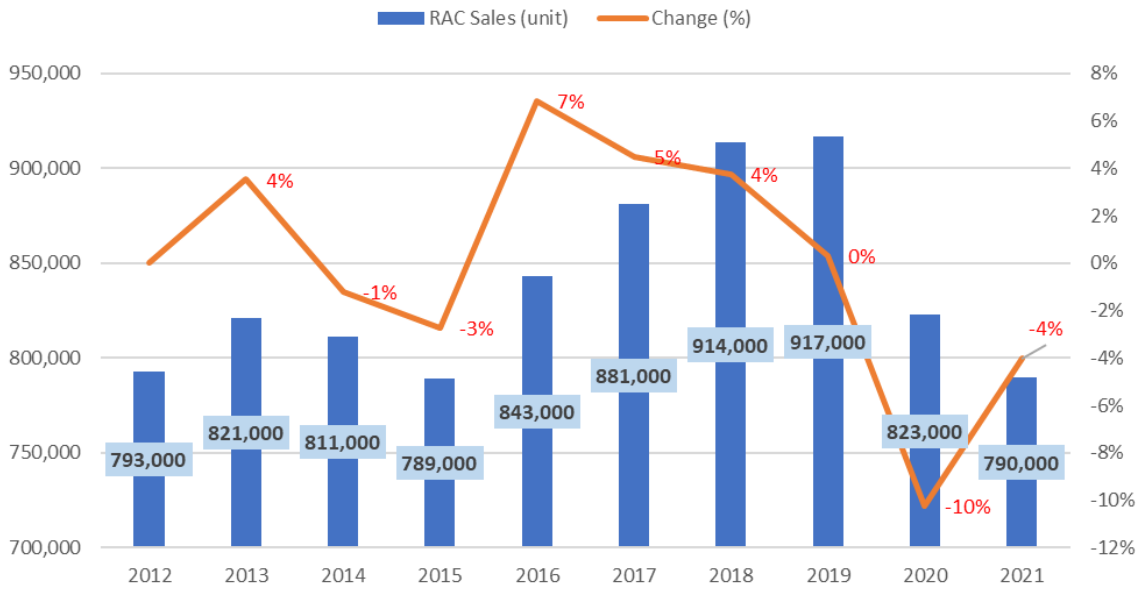


Source: IIEC Retailer Surveys, 2023

Figure 4-3**: **Brands and Number of RAC Models Available through Surveyed Retailers, 2023

4.2 Annual Shipments of RACs

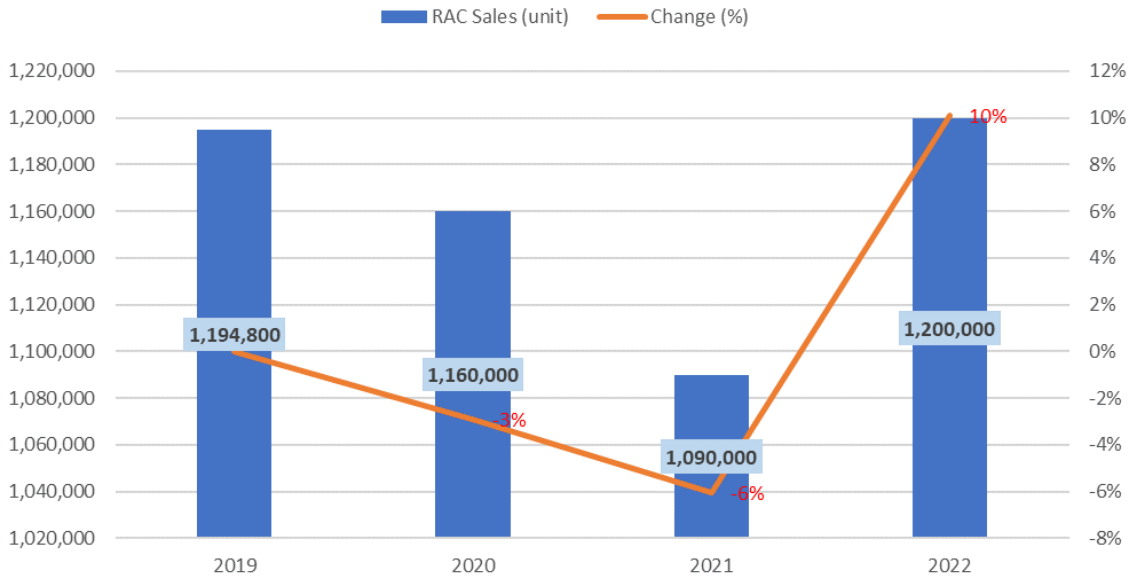
The demand for RACs experienced fluctuations over the past decade (see Figure 4-4). From 2014 to 2019, there was a general downward trend, with a notable decrease in 2019. In the later years (2020-2021), demand continued to decrease, but at a slower rate compared to 2019. In 2021, the RAC sales totalled around 790,000 units. This represents a 4% decrease from the previous year (2020), when the sales were 823,000 units. This decline in sales could be attributed to various factors. For instance, economic conditions, consumer preferences, and even external factors like the COVID-19 pandemic could have influenced the demand for RACs in 2021. Based on JRAIA (2022), Daikin and Panasonic lead the market, and cumulatively accounted for over 80% of the total market share in Malaysia. South Korean brands are also involved in securing market share.



Source: JRAIA, 2022

Figure 4-4: Sales of RACs in Malaysia, 2012 – 2021 (Units)

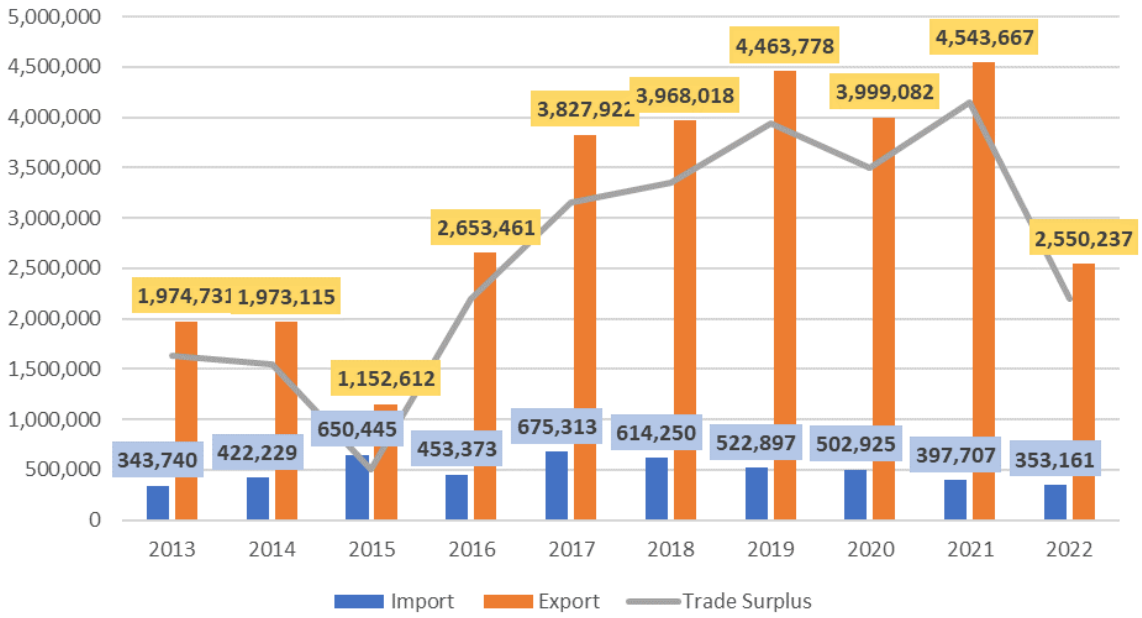
Figure 4-5 provides sales data from 2019 to 2022 based on manufacturers/importers' estimates, showing a significant variance of 23-29% compared to estimates by JRAIA (see Figure 4-4). In 2019, JRAIA estimated sales at 917,000, while manufacturers estimated a 3% growth rate for 2020, assuming 2019 sales of approximately 1,194,800 units (a 23% difference). In contrast, JRAIA's 2020 estimate was 823,000, reflecting a 10% decline from 2019, whereas manufacturers anticipated 1,160,000 units (a 29% difference), indicating a milder 3% decline. The 2021 estimates show a contrast as well, with manufacturers estimating around 1,090,000 units, while JRAIA estimated 790,000 (a 28% difference). Looking ahead to 2022, manufacturers estimate sales at 1,200,000, signalling a positive increase of approximately 10% from 2021.



Source: Data estimates (2019-2022) from manufacturers/importers, 2023

Figure 4-5: Sales Estimates of RACs in Malaysia, 2019 – 2022 (Units)

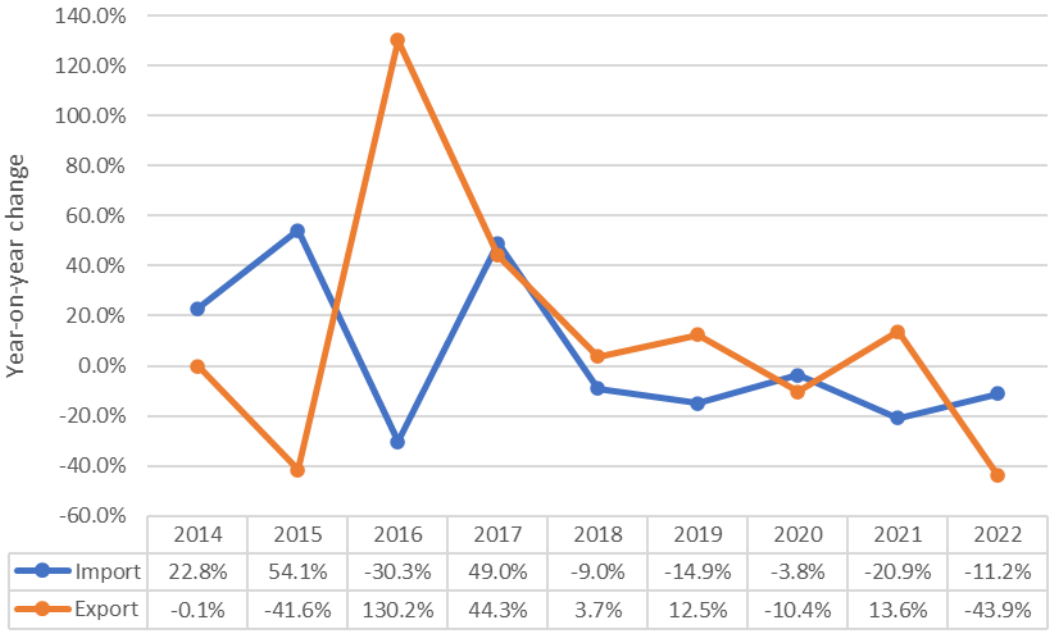
There are fluctuations in both import and export volumes from year to year (see Figure 4-6 and Figure 4-7). Generally, there is a trend of increasing exports, with a few exceptions (e.g., 2014-2015 and 2019-2020). Import figures show a more varied pattern, with some years showing increase and others showing decrease. The year 2015-2016 saw a substantial increase in exports, possibly indicating increased demand from international markets; while 2019-2020 saw a decrease in both imports and exports, possibly influenced by global economic conditions and/or the COVID-19 pandemic.



Source: Department of Statistics Malaysia, 2023

Figure 4-6: Overall Trade of RACs from 2013 - 2022 (HS Code: 8415101000[12])

[12] Air conditioners (32,000 BTU/hr and below)



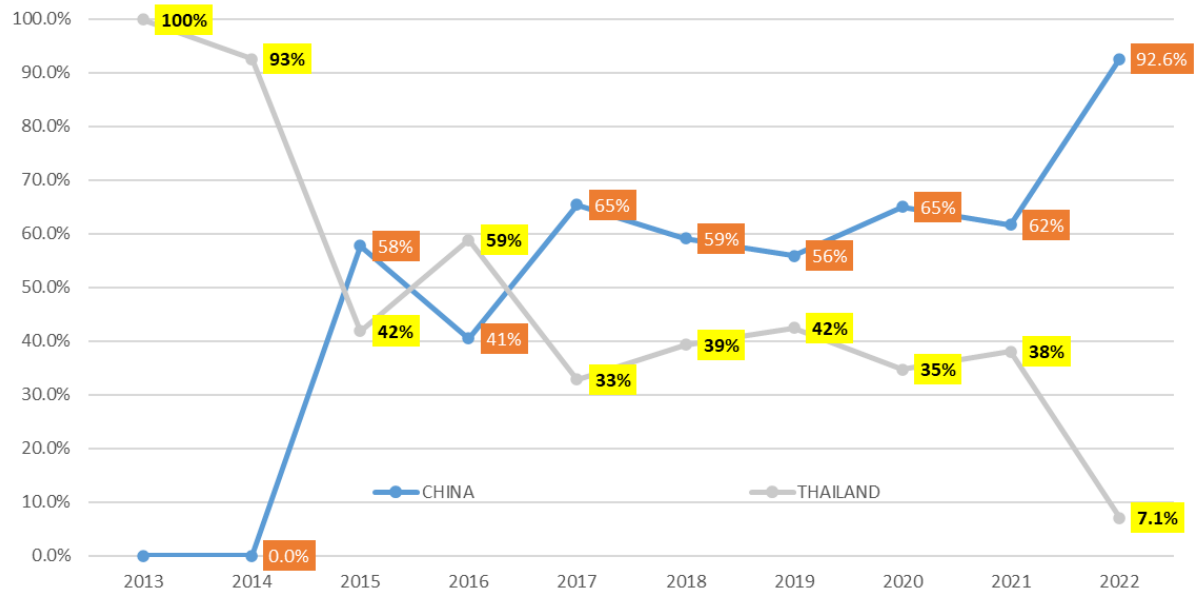
	2014	2015	2016	2017	2018	2019	2020	2021	2022
Import	22.8%	54.1%	-30.3%	49.0%	-9.0%	-14.9%	-3.8%	-20.9%	-11.2%
Export	-0.1%	-41.6%	130.2%	44.3%	3.7%	12.5%	-10.4%	13.6%	-43.9%

Source: Department of Statistics Malaysia, 2023

Figure 4-7: Percent Change of Imports and Exports of RACs from 2013 - 2022 (HS Code: 8415101000[13])

In 2021, it is estimated that Malaysia's annual demand for RACs (790,000 units) was equally fulfilled by imports and locally produced products. As shown in Figure 4-8, the import trends of RACs from China and Thailand in Malaysia from 2014 to 2022 displayed contrast trajectories. Imports from China consistently surged, showing substantial annual increase and notably rising by 93% from 2014 to 2022, indicating consistent and substantial growth throughout this period. Leading Chinese brands, such as Gree, Haier, and Midea are exhibiting robust performance in Malaysia. In contrast, there is a notable fluctuation in the percentage of RAC imports from Thailand. The trend starts at 100% in 2013, indicating that all RAC imports were sourced from Thailand at that time. Subsequently, there is a decreasing trend, reaching its lowest point of 7.1% in 2022.

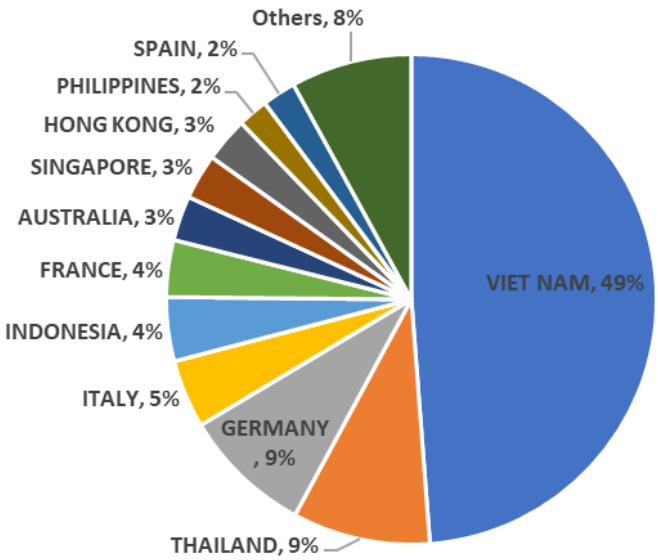
[13] Air conditioners (32,000 BTU/hr and below)



Source: Department of Statistics Malaysia, 2023

Figure 4-8 : Percentage of Imports of RACs by Country in Malaysia from 2013 – 2022 (Unit)

On the export front (see Figure 4-9), Malaysia's RAC industry displayed a diverse portfolio, with Vietnam emerging as the largest recipient, making up 49% of the exports. Notably, Thailand and Germany each received 9% of the exported units, while Italy, Indonesia, France and several other countries contributed to the remaining share (see Table 4-1). The demand and export patterns highlight the global reach of Malaysia's RAC industry, with a significant portion of its production being distributed to various countries, particularly within the Southeast Asian region. This underscores the competitiveness and demand for Malaysian air conditioning products in the international market. According to JRAIA, Panasonic, one of the key players in RACs production in Malaysia, with an annual production capacity of around 1.8 million units, primarily produces RACs for overseas markets.



Source: Department of Statistics Malaysia, 2023

Figure 4-9 : Percentage Share of Exports of RACs by Country in Malaysia in 2022 (Unit)

Table 4-1: Exports of RACs by Country in Malaysia in 2022 (Unit)

Country	Quantity (Unit)
Vietnam	1,246,709.00
Thailand	232,118.00
Germany	218,760.00
Italy	114,940.00
Indonesia	107,785.00
France	95,890.00
Singapore	75,915.00
Australia	75,459.00
Hong Kong	75,189.00
Philippines	59,131.00
Spain	56,705.00
Others	191,636
	2,550,237

Source: Department of Statistics Malaysia, 2023

4.3 Retailer Survey of MEPS and Appliance Energy Efficiency

The retailer survey was conducted in September 2023 to support the estimation of annual shipments and trends in the RAC market. It aimed to provide key product characteristics such as cooling capacities, technology type, popular models, efficiency levels, energy rating levels, retail prices, types of refrigerants, and sales data, currently available in the Malaysian market.

4.3.1 Retail Distribution

The retail distribution of RAC products in Malaysia involves various channels and players. **Error! R eference source not found.** provides an overview of how air conditioners are typically distributed in the country:

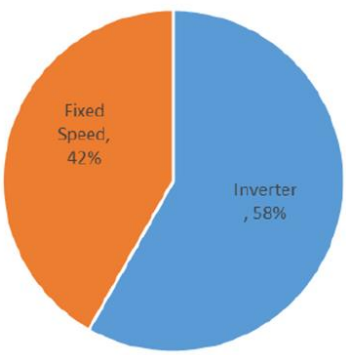
Table 4-2: Retail Distribution of Air Conditioner Products in Malaysia

Retail Distribution	Description
Electrical and Electronics Stores and Showrooms	Large retail chains specializing in home appliances, electronics, and air conditioning systems. Examples include Harvey Norman, Senheng, TBM, SenQ and Best
Department Stores	Many department stores, like AEON, offer a range of home appliances, including air conditioners

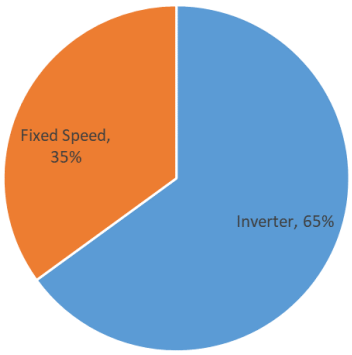
Retail Distribution	Description
Online Marketplaces	E-commerce platforms like Lazada, Shopee, and PrestoMall offer a wide selection of air conditioners. Customers can browse, compare prices, and make purchases online
Specialized HVAC Retailers	These are specialized retailers that focus solely on heating, ventilation, and air conditioning systems. They cater to both residential and commercial customers
Home Improvement Stores	Chain like HomePro offers a range of home improvement products, including air conditioning units and accessories
Authorized Dealers and Distributors	Manufacturers of air conditioners often have authorized dealers and distributors who sell their products directly to consumers
Contractors and Installers	HVAC contractors and installers also serve as retailers, offering air conditioning units along with installation services
Supermarkets and Hypermarkets	Some large supermarkets and hypermarkets like Lotus's and Giant carry a selection of air conditioners, especially during promotions or seasonal events
Online Platforms of Manufacturers	Many air conditioner manufacturers have their own online platforms where customers can purchase directly
Second-hand Markets	There is also a market for second-hand air conditioners, which can be found in classified advertisements, online marketplaces, and second-hand appliance stores

4.3.2 Availability of RACs by Technology and Cooling Capacity

This section compares the 2021 RAC model registry with RAC models available in retail stores to assess the alignment between registered or manufactured models and actual consumer choices in the market. Based on the number of models available in the surveyed retail stores, 65% of off-the-shelf models are inverter type, while the number of certified models registered in 2021 found that 58% were inverter type (see Figure 4-10). The surveyed retailers do not carry window-type RACs.



Certified RAC Models, 2021



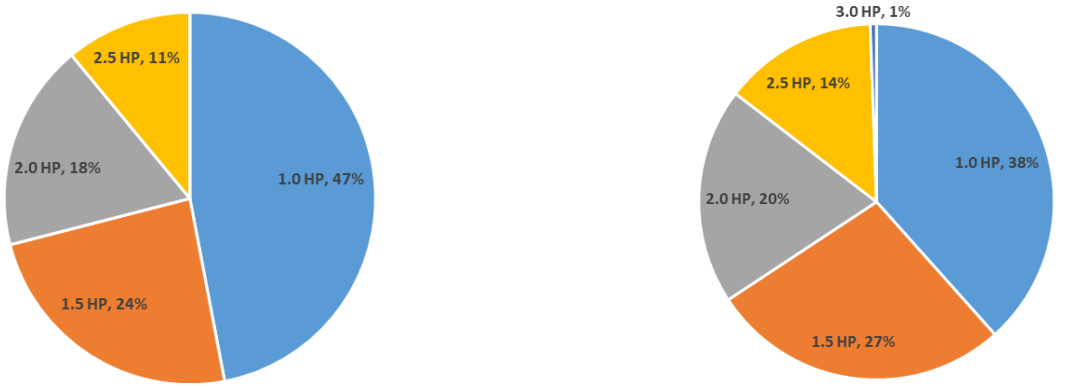
RAC Models Available in Retail Stores, 2023

Source: Certified Models in 2021 and IIEC Retailer Surveys in 2023

Figure 4-10: Share of RAC Models by Technology

It should be noted that retailers, installers and consumers in Malaysia usually quote cooling capacity of RACs horsepower (HP) which refers to average electrical power consumption by an RAC. Conversion of electrical power inputs in HP to cooling capacity in kW or Btu/h involves an assumption of EER, and the conversion in this report was carried out using a range of EERs as the conversion factors, rather than applying a single EER value for all RAC classifications. As a result, each HP designation signifies a spectrum of cooling capacities: i.e., 1.0 HP (2.49 - 2.78 kW or 8,500 – 9,500 Btu/h); 1.5 HP (3.37 – 3.66 kW or 11,500 – 12,500 Btu/h); 2.0 HP (5.12 – 5.42 kW or 17,500 – 18,500 Btu/h); 2.5 HP (6.00 – 6.59 kW or 20,500 – 22,500 Btu/h); and 3.0 HP (7.03 – 8.79 kW or 24,000 – 30,000 Btu/h)

The most popular cooling capacity is 1 HP (2.49 - 2.78 kW or 8,500 – 9,500 Btu/h) with 1.5 HP (3.37 – 3.66 kW or 11,500 – 12,500 Btu/h) ranked as the second most popular. Similarly, RAC models in the certified database in 2021 demonstrate that the combined total of 1 HP and 1.5 HP units accounts for almost three-fourths of all certified models. Specifically, 1 HP units constitute 47%, while 1.5 HP units make up 24%. These two capacities appear to be the most popular for cooling in Malaysia. (see Figure 4-11).



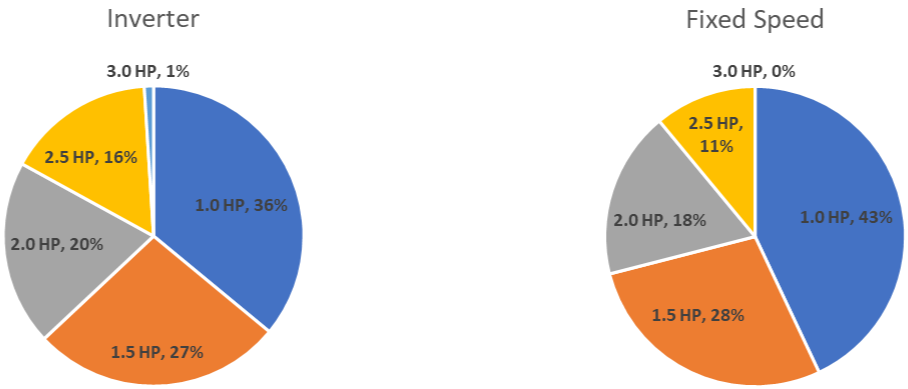
Certified RAC Models, 2021 ***RAC Models Available in Retail Stores, 2023***

Source: Certified Models in 2021 and IIEC Retailer Surveys in 2023

Figure 4-11: Share of RAC Models by Cooling Capacity

Figure 4-12 illustrates the distribution of inverter and fixed-speed RAC types based on their respective cooling capacities. Within the inverter category, the units with 1.0 HP (2.49 - 2.78 kW or 8,500 – 9,500 Btu/h) capacity hold the largest share at 36%, followed by 1.5 HP (3.37 – 3.66 kW or 11,500 – 12,500 Btu/h) units at 27%. Following these, 2.0 HP (5.12 – 5.42 kW or 17,500 – 18,500 Btu/h) and 2.5 HP (6.00 – 6.59 kW or 20,500 – 22,500 Btu/h) capacities also show notable presence. Conversely, 3.0 HP (7.03 – 8.79 kW or 24,000 – 30,000 Btu/h) units have minimal representation in the surveyed inverter category.

Similarly, within the fixed-speed category, 1.0 HP units dominate with 43% share, followed by 1.5 HP units at 28%. Subsequently, 2.0 HP and 2.5 HP capacities also exhibit considerable presence. However, 3.0 HP units could not be found in this particular survey of fixed-speed RACs. Overall, when considering popular cooling capacities based on models in retail stores (see Figure 4-12), it is evident that smaller cooling capacities are more popular than larger sizes for both inverter and fixed speed models.



Source: Retailer Survey conducted by IIEC (2023)

Figure 4-12: Percentage Share between Inverter and Fixed Speed by Cooling Capacity, 2023

4.3.3 Distribution of Model Efficiencies

Table 4-3 provides breakdown of RACs available in the market in 2023 by compressor type in each major category of cooling capacity and the average of the RAC efficiency in that cooling capacity category. The average CSPF values of inverter RACs consistently outperformed their fixed-speed counterparts across all cooling capacities. For instance, the average CSPF for 1.0 HP inverter models is 5.34, notably higher than the 3.65 average CSPF of fixed-speed units or about 46% more efficient. This discrepancy in efficiency was evident across different capacities, such as the 2.0 HP models, where inverter RACs boasted an average CSPF of 5.60 compared to the 3.4 CSPF seen in fixed-speed units. This represents an approximately 65% increase in efficiency for inverter models over fixed-speed units in the 2.0 HP capacity category.

The trend continued with higher capacities; inverter RACs consistently exhibited superior efficiency, with the 3.0 HP inverter models showcasing an average CSPF of 5.44, while no reported off-the-shelf models were attributed to fixed-speed units in this category. This stark contrast underscores the clear advantage of inverter RACs over fixed-speed models, highlighting their notably higher average CSPF values and emphasizing their role in driving enhanced EE in the Malaysian air conditioning market of 2023.

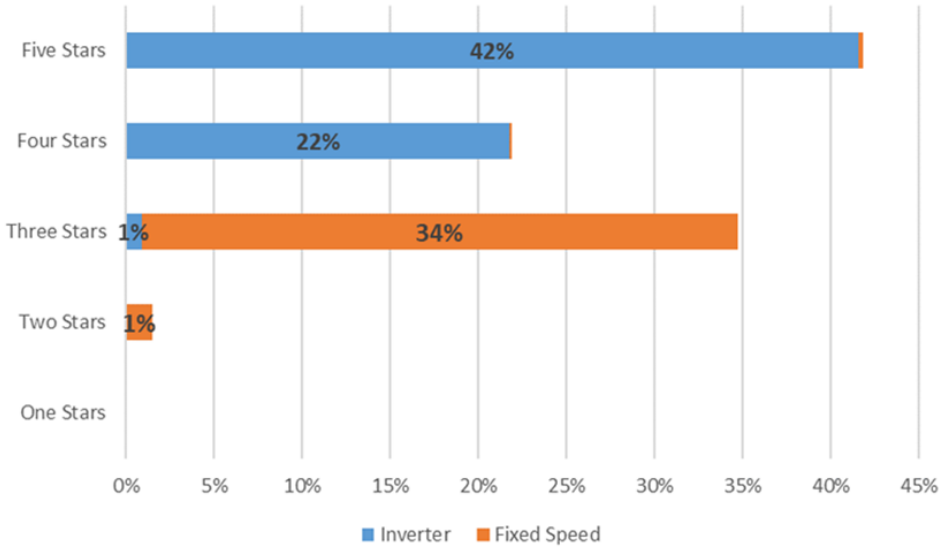
Table 4-3: Average CSPF (Wh/Wh) of RAC Models Available in Malaysia in 2023

Cooling Capacity	Inverter	Fixed Speed
1.0 HP	5.34	3.52
2.6 kW		
(9,000 Btu/hr)		
1.5 HP	5.58	3.48
3.5 kW		
(12,000 Btu/hr)		
2.0 HP	5.60	3.40
4.5 – 5.2 kW		
(15,000 – 18,000 Btu/hr)		

2.5 HP	5.96	3.55
6.1 kW		
(21,000 Btu/hr)		
3.0 HP	5.44	
7.1 kW		
(24,000 Btu/hr)		

Source: Retailer Survey conducted by IIEC (2023)

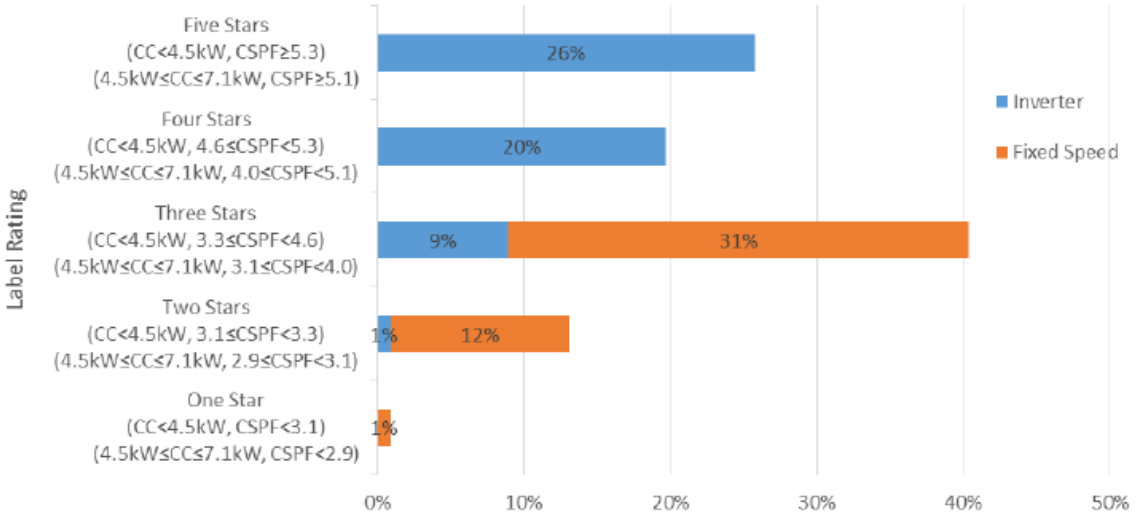
Figure 4-13 presents the breakdown of RACs available off-the-shelf in 2023, categorized by compressor type within each star rating. Inverter compressors notably dominate the 4-Star and 5-Star ratings, constituting 22% and 42%, respectively. Conversely, fixed speed compressors prevail in the 3-Star rating, accounting for 34%. There are no fixed speed compressors observed in the 4- and 5-Star RACs, while inverter compressors are absent in the 2-Star RACs (MEPS level) and only represent 1% in the 3-Star rating. When considering RAC models available in the surveyed retail stores, Sharp and Panasonic offer the highest number of inverter 5-star models, while Daikin, Mitsubishi, and LG predominantly provide inverter 4-star models.



Source: Retailer Survey conducted by IIEC (2023)

Figure 4-13: Percentage of Star Rating by Compressor of RACs Available in Malaysia in 2023

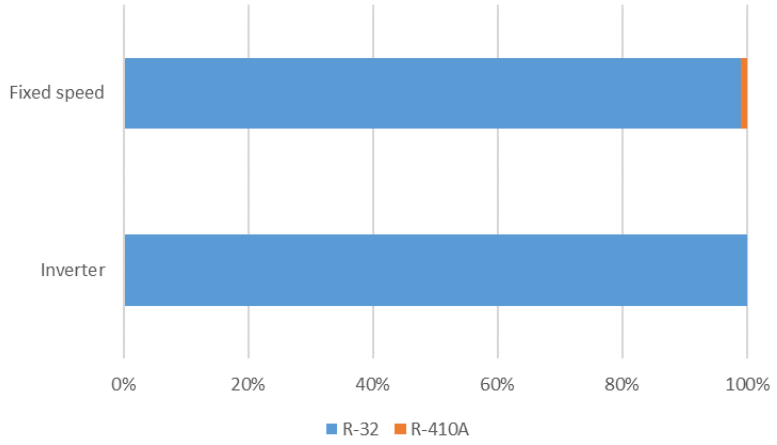
Similarly, concerning the distribution of certified RAC models in 2021 (see Figure 4-14), there are no fixed speed compressors observed in the 4- and 5-Star energy ratings. Inverter compressors dominate these higher energy ratings, accounting for 20% and 26% in the 4-Star and 5-Star energy ratings, respectively. Fixed speed compressors are more prevalent in the lower star ratings at 2-Star (12%) and 3-Star (31%) energy-rated RACs.



Source: Energy Commission, 2021

Figure 4-14: Percentage of Star Rating by Compressor of Certified RAC Models in Malaysia in 2021

Currently, almost all of the RACs (single split systems) available in the retail shops have R-32 refrigerant for both Inverter and Fixed speed RACs.



Source: Retailer Survey conducted by IIEC (2023)

Figure 4-15: Percentage of Refrigerant by Compressor of RACs Sold in Malaysia in 2023

4.3.4 Retail Prices

Typical RAC products available in Malaysia and retail prices are shown in Figure 4-16 and Table 4-4.

Source: Retailer Survey conducted by IIEC (2023)

Figure 4-16: RAC Products available in Retail Stores in Malaysia

Variations of RAC retail prices in Malaysia are influenced by cooling capacity and compressor type (see Table 4-4). For 1.0 HP (2.49 - 2.78 kW or 8,500 – 9,500 Btu/h) units, fixed-speed (non-inverter) models exhibit a lower CSPF of 3.20, with a price range of 788 – 1,759 RM (165-369 USD). In contrast, inverter units of the same cooling capacity with a higher CSPF of 7.81 are priced between 999 – 3,278 RM (210 – 688 USD).

Similarly, for higher capacities like the 1.5 HP (3.37 – 3.66 kW or 11,500 – 12,500 Btu/h) units, fixed-speed models have a CSPF of 3.64 and a price range of 999 – 2,799 RM (210 – 589 USD), while inverter

models boast a higher CSPF of 6.42 and are priced from 1,397 – 3,297 RM (293 – 692 USD). Notably, as the cooling capacity increases, such as in the 2.0 HP (5.12 – 5.42 kW or 17,500 – 18,500 Btu/h) and 2.5 HP (6.00 – 6.59 kW or 20,500 – 22,500 Btu/h) units, the prices rise accordingly, with inverter models being generally tagged with higher prices due to their higher EE.

Additionally, while specific CSPF and pricing data for 3.0 HP (7.03 – 8.79 kW or 24,000 – 30,000 Btu/h) units is not provided for fixed-speed models, inverter models with a CSPF of 5.44 are priced between 3,098 – 4,699 RM (651 – 987 USD).

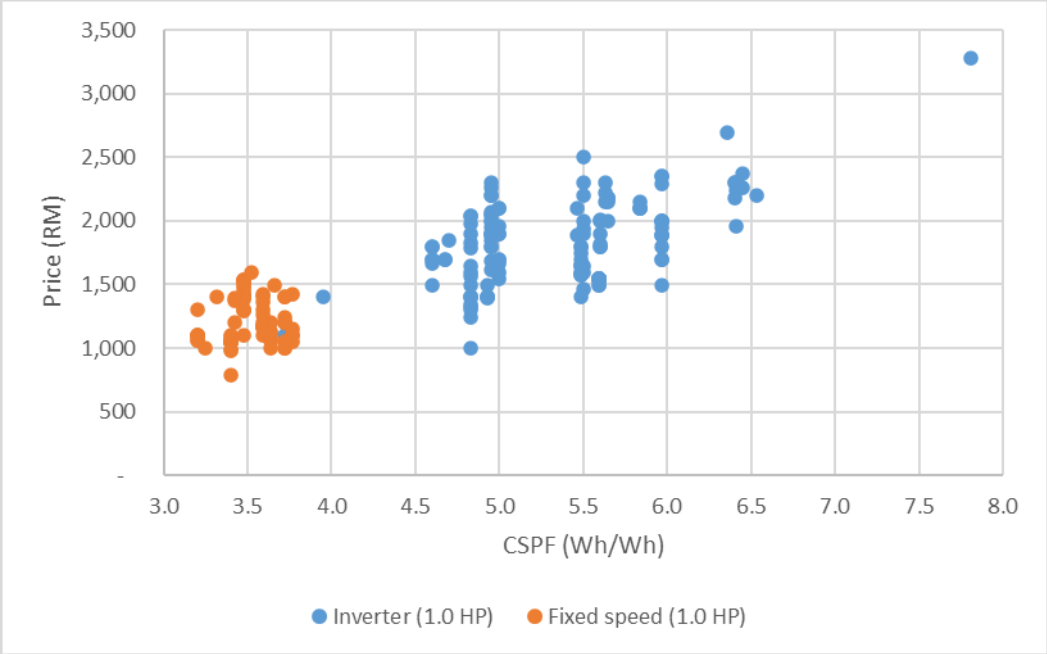
Table 4-4: RAC Retail Prices in Malaysia

Cooling Capacity	Inverter			Fixed speed/non-inverter			Price Difference between Inverter & Fixed Speed (%)
	Highest CSPF	Lowest CSPF	Selling Price	Highest CSPF	Lowest CSPF	Selling Price	
1.0 HP 2.6 kW (9,000 Btu/hr)	7.81	3.72	999 – 3,278 RM (210 – 688 USD) Average: 1,812 RM (380 USD	3.98	3.20	788 – 1,759 RM (165-369 USD) Average: 1,530 RM (320 USD)	12.5% - 40%
1.5 HP 3.5 kW (12,000 Btu/hr)	6.42	4.60	1,397 – 3,297 RM (293 – 692 USD) Average: 2,232 RM (468 USD)	3.64	3.26	999 – 2,799 RM (210 – 589 USD) Average: 1,216 RM (255 USD)	16.5% - 32%
2.0 HP 4.5 – 5.2 kW (15,000 – 18,000 Btu/hr)	6.96	3.69	2,097 – 4,499 RM (440 – 945 USD) Average: 3,350 RM (702 USD)	3.73	3.13	1,899 – 3,999 RM (399 – 840 USD) Average: 2,450 RM (513 USD)	4.6% -15.9%
2.5 HP 6.1 kW (21,000 Btu/hr)	6.46	4.60	2,547 – 5,182 RM (535 – 1,088 USD) Average: 3,865 RM (810 USD)	3.98	3.03	2,509 – 4,549 RM (527 – 955 USD) Average: 2,935 RM (615 USD)	0.7% - 15.9%
3.0 HP 7.1 kW (24,000 Btu/hr)	5.44	5.19	3,098 – 4,699 RM (651 – 987 USD)			n/a	

Cooling Capacity	Inverter			Fixed speed/non-inverter			Price Difference between Inverter & Fixed Speed (%)
	Highest CSPF	Lowest CSPF	Selling Price	Highest CSPF	Lowest CSPF	Selling Price	
			Average: 4,132 RM (866 USD)				

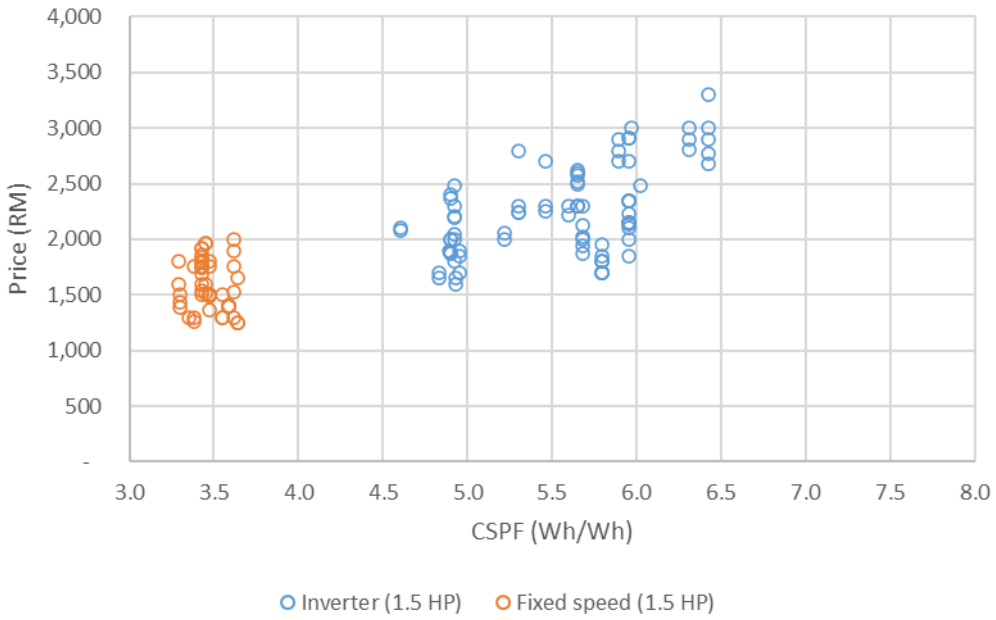
Source: Retailer Survey conducted by IIEC (2023)

Figure 4-17 and Figure 4-18 depict a clear correlation between the pricing of inverter RACs and increasing EE levels, as measured by CSPF, in popular cooling capacities of 1 and 1.5 HP. However, there is no clear correlation among fixed-speed models for both cooling capacities. Therefore, as the EE level increases in inverter RACs, their prices tend to correlate positively due to the higher efficiency. Figure 4-17 shows that the price of around RM 1,000 (209 USD) corresponds to an inverter RAC with a CSPF of 4.8, whereas for fixed-speed RACs with a CSPF is 3.7. This suggests that for the same price point, consumers can obtain a more energy-efficient inverter RAC compared to a fixed-speed model.



Source: Retailer Survey conducted by IIEC (2023)

Figure 4-17: Comparison of CSPF Levels and Prices for Inverter and Fixed-Speed RAC Models with a Cooling Capacity of 1 HP



Source: Retailer Survey conducted by IIEC (2023)

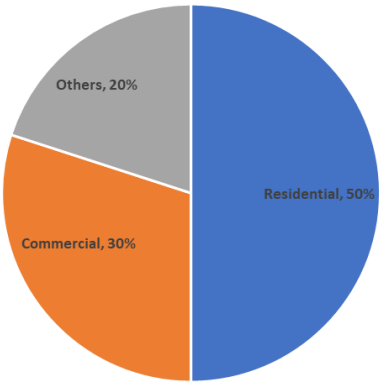
Figure 4-18: Comparison of CSPF Levels and Prices for Inverter and Fixed-Speed RAC Models with a Cooling Capacity of 1.5 HP

4.4 Manufacturer/Importer Survey

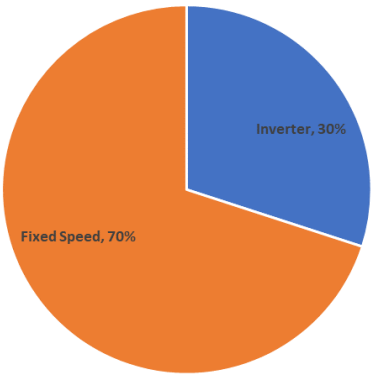
4.4.1 Market Shares by Technology and Cooling Capacity

Manufacturers and importers estimated that RACs sold in the residential sector make up approximately 50% of the total sales, with commercial buildings accounting for around 30%. Notably, fixed-speed RAC products continue to dominate the Malaysian market, comprising about 70% of all RACs sold (see Figure 4-19). Contrastingly, as described earlier, a retailer survey offers a nuanced perspective on the prevalence of AC models within retail stores. The survey reveals a higher occurrence of inverter models compared to fixed-speed models available off-the-shelf.

Projections from manufacturers suggest an anticipated growth rate of 8-10% for inverter models in the year 2024, indicating a positive trend amid prevailing challenges. From the manufacturer's standpoint, the primary challenge hindering the widespread adoption of inverter models lies in the limited technical knowledge among contractors concerning their installation. Consequently, manufacturers emphasize the critical importance of capacity-building initiatives to address this obstacle.



Share of RAC Sold by Sector, 2023



Share of RAC Sold by Compressor Type, 2023

Source: Data estimates from manufacturers/importers, 2023

Figure 4-19: Estimates of Market Distribution of RACs, 2023

In terms of RACs sold by technology, fixed-speed models are sold for both residential and commercial use, with an estimated distribution of 70% for residential applications and 30% for commercial use. Manufacturers acknowledge that while inverters are known for their energy efficiency, they typically come with higher price tags in the market. This is attributed to advanced compressor types, sophisticated control technology, and the additional Printed Circuit Board (PCB) in the outdoor unit. For consumers, especially those with a more basic technical understanding, price remains a paramount concern. This factor contributes to the greater popularity of fixed-speed models among residential consumers. In the commercial sector, the preference for inverter models is likely influenced by government incentives such as subsidies and tax credits.

Table 4-5 presents a breakdown of RACs sold in the market in 2023, based on estimates from manufacturers/importers, categorizing by compressor type (inverter and fixed speed) and cooling capacity. Inverter RACs notably dominate in lower capacity segments, particularly in the 1.0 HP and 1.5 HP categories, representing 47% and 26-31% of the market share respectively. Conversely, fixed-speed RACs maintain competitive positions across various capacity categories, ranging from 54-55% in 1.0 HP to 23-31% in 1.5 HP. This indicates a balanced market presence between the two technologies, with inverter models gradually gaining traction in higher capacities while fixed-speed models remain prevalent across the board.

Table 4-5: Breakdown of RACs Sold in the Market by Compressor in each Capacity, 2023

Capacity	Inverter	Fixed speed
	% Share	% Share
1.0 HP	47%	54-55%
1.5 HP	26-31%	23-31%
2.0 HP	11-16%	8-11%
2.5 HP	9-11%	5%
3.0 HP	1%	1-2%

Source: Data estimates from manufacturers/importers, 2023

4.4.2 Constraints and Challenges in Adopting More Stringent MEPS and Labelling Requirements

The Energy Commission (EC), is considering a substantial update to the MEPS for RACs, aiming to align with ISO CSPF 6.09 which is the MEPS level for RACs recommended in the ASEAN regional policy roadmap. The survey aimed to assess whether manufacturers and importers anticipate any technical constraints or challenges in achieving this goal, along with their suggested timelines. Opinions from manufacturers/importers regarding technical constraints and challenges in achieving the CSPF level of 6.09 for RACs are summarized in the table below.

Table 4-6: Summary of Manufacturers/Imports Responses on Constraints and Challenges in adopting More Stringent MEPS and Labelling Requirements

Issues	Description
Timeline	The suggested timeline for implementing the MEPS updates ranges from 2030-2035. Respondents believe this timeframe aligns with their capacity to address technical challenges, implement necessary technological advancements, and ensure a smooth transition to higher efficiency standards. The Energy Commission must establish a clear timeline and regulations for MEPS compliance. This will provide manufacturers and importers with the necessary time to prepare and adhere to the regulations effectively.
Supporting Activities	**Promotion of High Energy-Efficient Products to the Public**: Emphasis on the importance of raising public awareness and promoting the adoption of higher MEPS levels. Educate consumers about the potential benefits of high-efficiency units, such as energy savings and long-term cost-effectiveness, which can help justify any initial investment and mitigate concerns about expensive after-sales service. **Clear and Up-to-Date Information on MEPS Regulations, Standards, and Compliance Requirements** – There is a need for comprehensive and current information on MEPS regulations, standards, and compliance requirements to ensure adherence and understanding of the regulatory landscape. **Availability of Environmental Certifications** – This would support the promotion and recognition of the importance of the company's commitment to energy efficiency and sustainability.
Financial and Fiscal Incentives	1. *Incentives for Consumers to Buy High-Efficiency Inverter Models (e.g., SAVE program):* Manufacturers/importers suggest an incentive to encourage consumers to purchase of high-efficiency inverter models, citing examples like the SAVE program (See Box 1). 2. *Fiscal Incentive to Support Local Production of High-Efficiency Products (e.g., Inverter):*

	Manufacturers/importers recommend government-provided tax incentives for companies investing in energy-efficient technologies. Tax incentives are deemed necessary to offset costs associated with upgrading technologies and processes to meet higher MEPS levels. 3. Duty Free for 5-stars products 4. Financial support for eco-friendly design
Capacity Building Needs	These include how to select appropriate equipment such as heat exchangers, compressors, and advanced control equipment, all rated as medium to high in importance. Additionally, the integration of advanced control systems with IT sensors and instrumentation, understanding climate conditions and load characteristics, and employing advanced control algorithms are highlighted as crucial areas requiring attention. Furthermore, ensuring the availability of personnel with in-house technical resources and accessing external professional expert support are deemed essential for effectively implementing higher-efficiency AC units, both rated as medium to high in importance.

Box 1: Overview of SAVE Program

The *Sustainability Achieved Via Energy Efficiency (SAVE)* program was first launched as a pilot initiative in 2010, by the Minister of Energy, Green Technology, and Water, Malaysia. It aimed to boost sales of energy-efficient appliances by offering rebates for purchasing 5-Star energy-rated home appliances like refrigerators and **air conditioners**, along with the installation of energy-efficient chillers for commercial buildings. The main objective of the SAVE Program is to foster a culture of efficient energy use among the public and businesses, with the primary goal of reducing energy costs and consumption on a daily basis, as well as managing the growth of energy demand for effective Demand Side Management. Additionally, the program seeks to increase the market share of energy-efficient appliances and eventually phase out inefficient models, thereby reducing greenhouse gas emissions. Moreover, the SAVE Program serves to educate Malaysians on the importance of using energy-efficient appliances and practicing energy efficiency to lower energy consumption, while also encouraging manufacturers to produce more energy-efficient appliances for the market (SEDA, 2011). The SAVE 2.0 and 3.0 programs were launched in 2021 and 2022 respectively.

The current iteration of the SAVE program*, **SAVE 4.0**, launched in 2023, focuses on promoting energy efficiency in households through e-Rebates for the purchase of **4 and 5-star energy-efficient air conditioners** and refrigerators.*

Program Benefits:

- Grants a maximum of RM400 e-Rebate for eligible households.
- Applicable to energy-efficient appliances with 4 or 5-star energy efficiency labels.

Eligibility Criteria:

1. Malaysian citizenship.
2. Users/owners of registered domestic electrical accounts with utility companies (TNB, SESB, SEB, NUR POWER SDN. BHD.).

3. Purchase of energy-efficient electrical appliances with 4 and 5-star labels from December 2023 to December 2024.
4. 1 electricity bill account can apply for 1 e-rebate per electrical appliance (first come, first served).
5. Available for 250,000 households.
6. Tenants in rental housing can apply but require the owner's permission.

Objectives of the SAVE 4.0 Program:

1. Increase the presence of 4 and 5-star energy-efficient appliances in the market.
2. Raise public awareness and encourage the adoption of energy-efficient appliances, reducing electricity consumption.

Implementation Period:

- One year, from December 2023 to December 2024.

Application Process:

Method 1: Direct Purchase via Registered Retailers

- Consumers purchase from registered retailers under SAVE 4.0.
- Visit www.saveenergy.gov.my/public/retailer for details.
- Bring electrical bills and NRIC.
- Retailers verify eligibility and apply e-rebate on behalf of consumers.
- Eligibility limited to 4 & 5-star rated appliances, granting a discount of RM200 e-rebate.

Method 2: Online Purchase via e-Commerce Platforms

- Consumers can make eligible purchases through e-Commerce platforms.
- Details available at https://www.seda.gov.my/saveprogram/.

Important Notes:

- The program aims to benefit 250,000 households.
- Tenants in rental housing can apply with the owner's permission.
- For the latest updates and detailed guidelines, refer to the official program source: https://www.seda.gov.my/saveprogram/.

5 HOME ENERGY CONSUMPTION SURVEY

The home energy consumption surveys aimed to analyze and assess household electricity consumption patterns and the usage of RACs and other appliances. These surveys were conducted in November 2023 in collaboration with the Malaysian Green Technology and Climate Change Corporation (MGTC) to support field data collection. The datasets consolidated by the project team were populated and analyzed to study the energy consumption of existing appliances/equipment and the breakdown of energy end-use.

5.1.1 Characteristics of Surveyed Households

The surveyed households include a mix of condominiums/apartments, single-storey houses, two-storey houses, five-storey houses, and six-storey houses. The sampling aimed to achieve diversity in household types/structures, sizes and area covered by air-conditioning systems, allowing for a comprehensive assessment of energy consumption patterns across various residential setups in Selangor.

Table 3-4 provides details on the distribution of 15 surveyed households conducted for a home energy consumption survey in Selangor. This area was selected due to its high population density (having the highest number of households in Malaysia). These households encompass different types of residential structures with various characteristics, such as the type of house, the number of individuals residing in them, total floor area, and air-conditioned space.

These sampled houses accommodate a varying number of individuals, ranging from 1 to 7 people. The total floor area of the sampled houses exhibits significant diversity, spanning from 466 sq.ft in condominiums/apartments to 4,500 sq.ft in a 5-storey house. Moreover, the air-conditioned area within these households also demonstrates variability, ranging from 264 sq.ft to 2,531 sq.ft.

Table 5-1: Characteristics of 15 Surveyed Households for Home Energy Consumption Surveys in Selangor

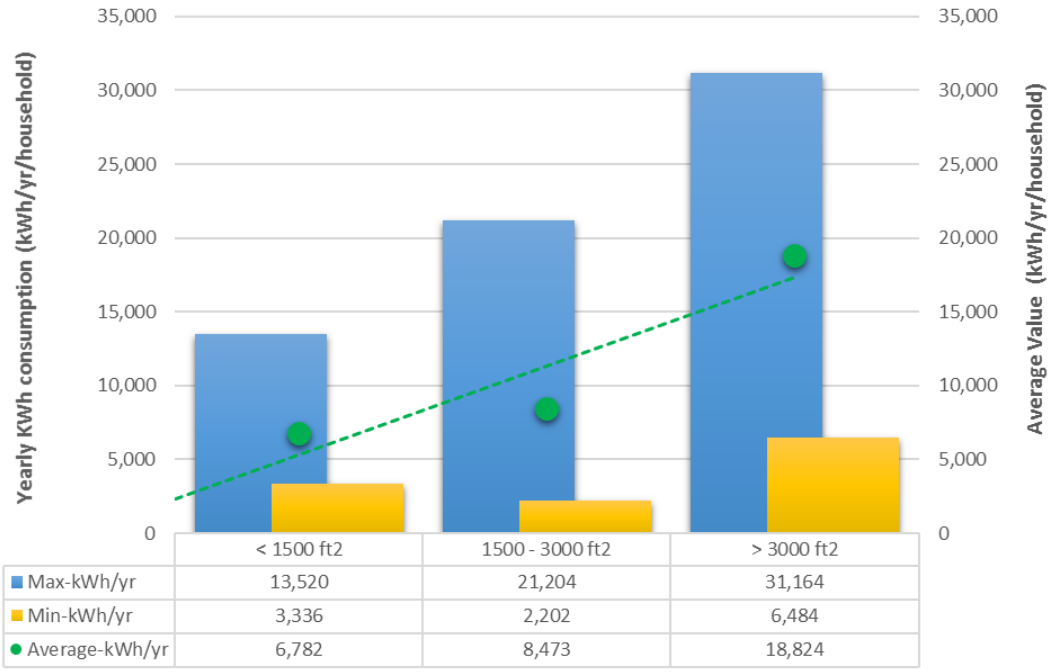
Type of House	Number of Households	Number of People per Household	Total Floor Area (ft2)	Air-conditioned Area (ft2)
Condominium/Apartment	2	1 - 4	466 – 1,066	264 - 466
1-Storey House	3	2 - 4	1,150 – 2,583	629 – 1,147
2-Storey House	8	3 - 7	1,195 – 2,220	264 – 1,145
5-Storey House	1	5	4,500	2,531
6-Storey House	1	2	3,200	600

Source: IIEC Home Energy Survey, 2023

Figure 5-1*: *Surveyed Households in Selangor

5.1.2 Household Electricity Consumption Profile

As shown in Figure 5-2, electricity consumptions in the surveyed households illustrate an escalating trend in average annual electricity consumption as the area size increases. Larger households, typically over 3500 sq.ft, tend to exhibit considerably higher electricity consumption compared to smaller and moderately sized residences.

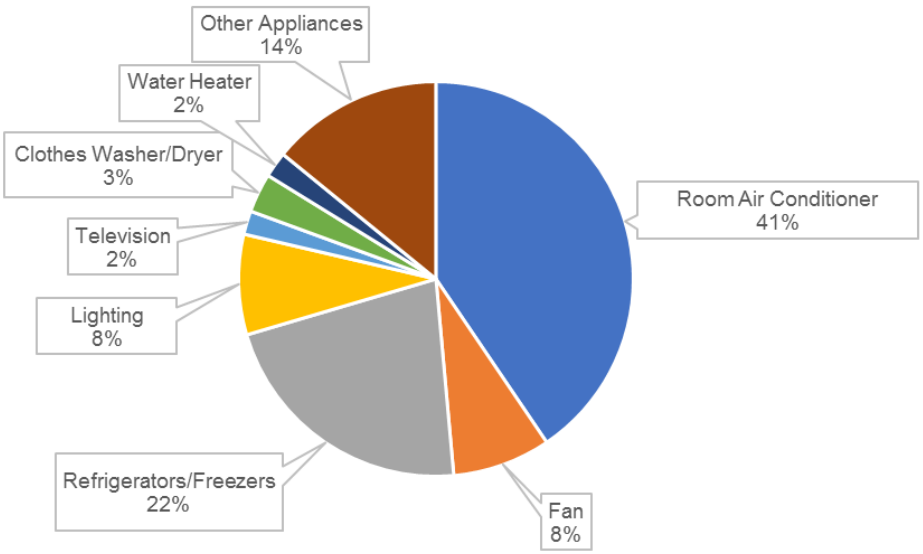


	< 1500 ft2	1500 - 3000 ft2	> 3000 ft2
Max-kWh/yr	13,520	21,204	31,164
Min-kWh/yr	3,336	2,202	6,484
Average-kWh/yr	6,782	8,473	18,824

Source: IIEC Home Energy Survey, 2023

Figure 5-2: Average Annual Electricity Consumption by Area Size (kWh/yr/household)

Analysis of energy end-use found that the major energy end-uses among these surveyed households primarily include cooling (RACs and fans), refrigeration (refrigerators/freezers) and lighting. In general, cooling appliances (RACs, fans and refrigerators/freezers) in each household contribute 40% to 70% of the annual electricity consumption.

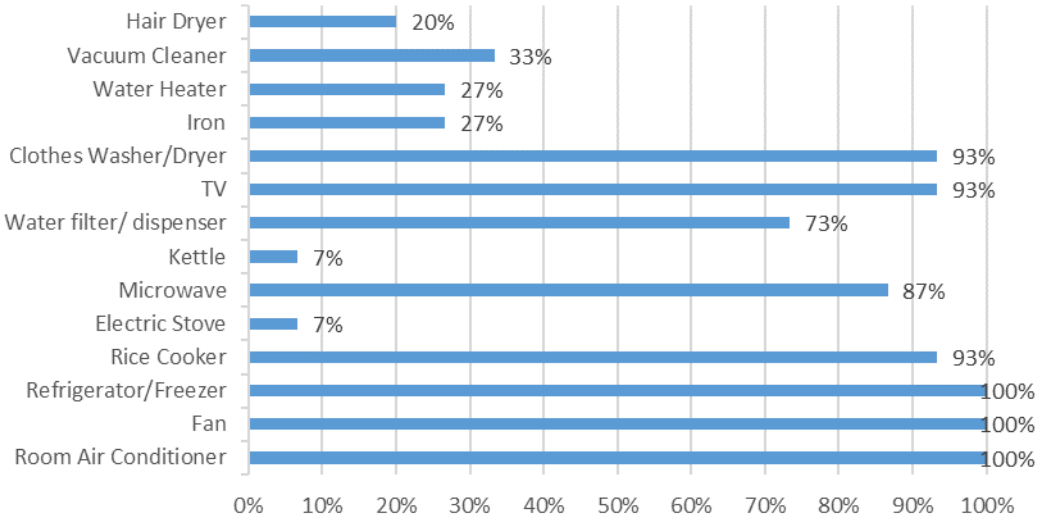


Source: IIEC Home Energy Survey, 2023

Figure 5-3**: **Average Shares of Different Energy End-Uses in 15 Surveyed Households

5.1.3 Penetration and Ownership of Key Household Appliances

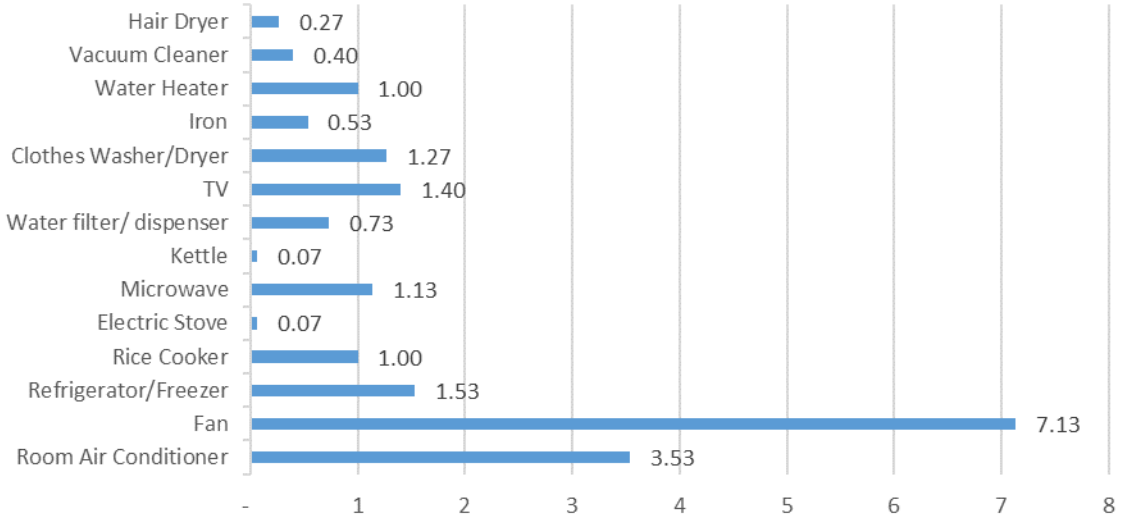
The penetration rates depicted in Figure 5-4 for various home appliances among the 15 surveyed households reveal that the three most popular appliances—AC, fan, and refrigerators/freezers—have attained a remarkably high penetration rate of 100%, signifying their universal ownership within the surveyed households.



Source: IIEC Home Energy Survey, 2023

Figure 5-4**: **Penetration Rate of Household Appliances in 15 Surveyed Households

Analysis of the appliance saturations indicates that, on average, households possess more than one unit of those appliances. For instance, the microwave, clothes washer, refrigerators/freezers, TV, fan, and air conditioner show the saturation rates of more than one, signifying an average ownership of more than one unit of those appliances per household. Conversely, appliances like hair dryers, kettles, electric stoves, and vacuum cleaners demonstrate relatively lower saturation rates, suggesting they are less commonly owned or present in fewer households within the surveyed sample. This might indicate a lower prevalence or demand for these appliances among the households surveyed.



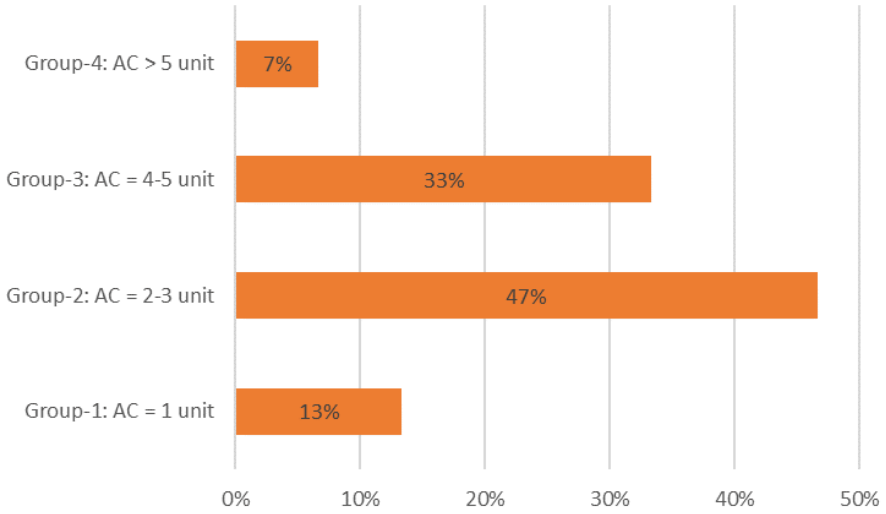
Number of Household Appliances (unit)

Source: IIEC Home Energy Survey, 2023

Figure 5-5*: Saturation *of Household Appliances in* 15 *Surveyed Households

5.1.4 Adoption and Usage of Room Air Conditioner

All surveyed households own at least one RAC, and most of these households have three ACs, as shown in the figure below. Daily usage hours of the RACs used in a household is about 5.4 hours on average.

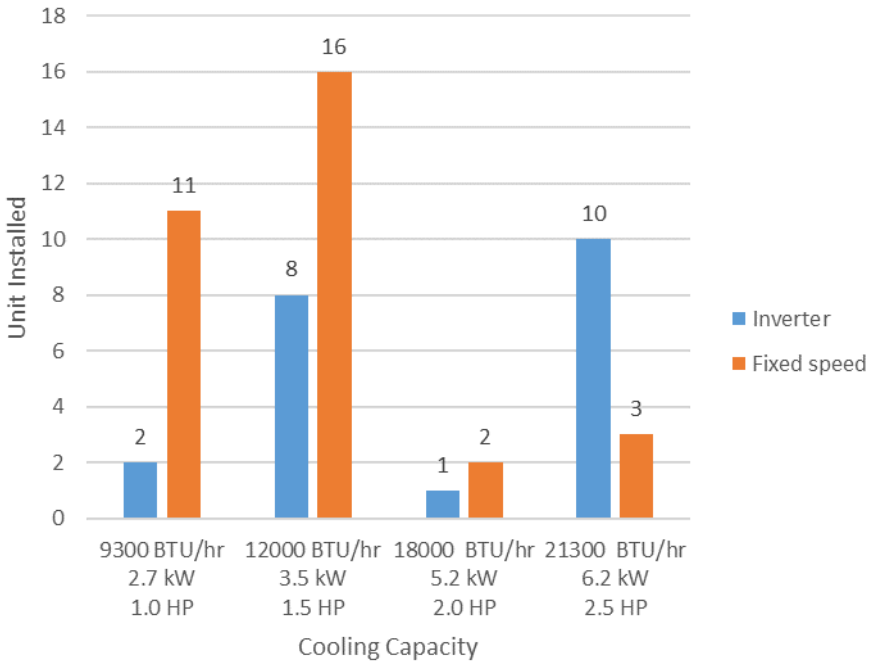


Source: IIEC Home Energy Survey, 2023

Figure 5-6*: *Penetration Rate of Room ACs

Figure 5-7 provides a breakdown of the installed RACs in the surveyed households based on their cooling capacities measured in BTU/hr and the type of compressor (Fixed speed or Inverter). Inverter compressors were notably more prevalent in the higher cooling capacity RACs (over 18,000 BTU/hr or

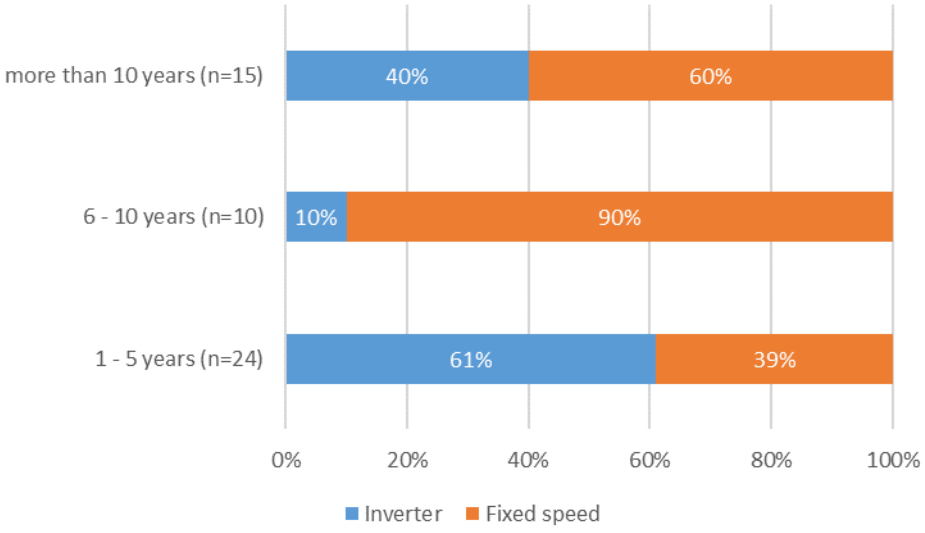
about 2 HP/ 5.2 kW), while the use of fixed-speed compressors is more common in lower capacity RACs, particularly 9,000 (1 HP or about 2.64 kW) and 12,000 BTU/hr (1.5 HP or about 3.5 kW).



Source: IIEC Home Energy Survey, 2023

Figure 5-7*: *Profiles of Room Air Conditioner Installation in 15 Surveyed Households

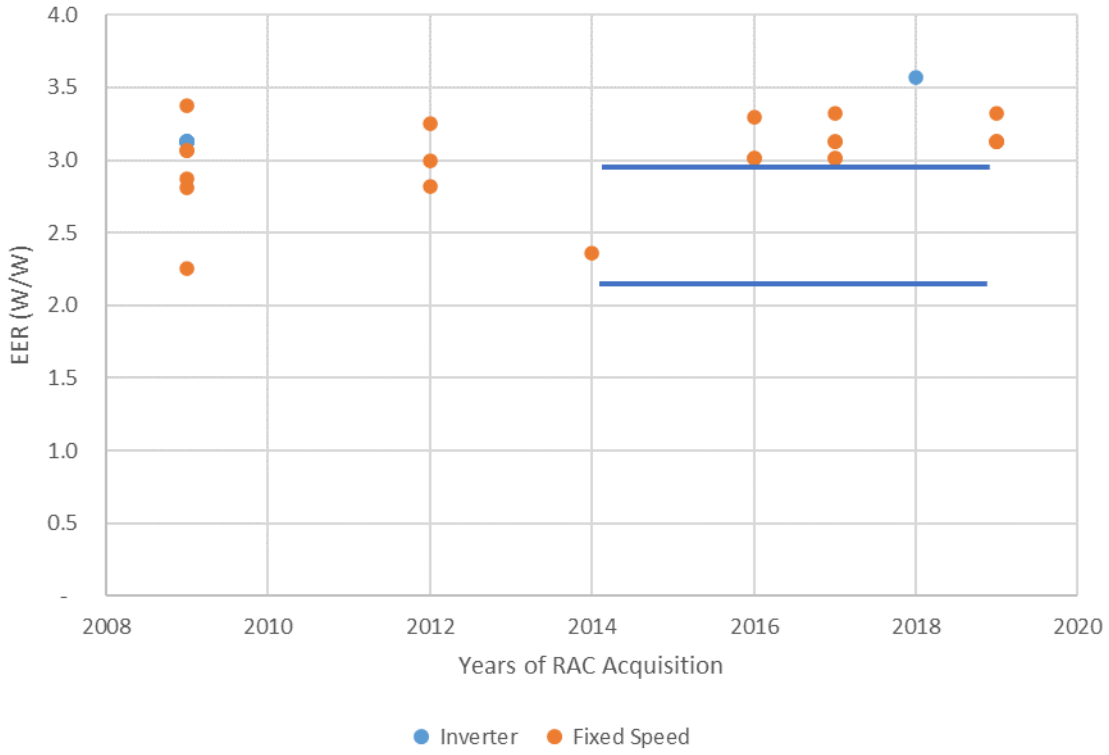
Of the total 15 surveyed households, only one could not provide information on the ages of RACs, representing 4 units out of 53 or 8% of the total collected RAC units. Figure 5-8 summarizes the RAC purchasing behaviors over the past decade categorized by compressor types. The results suggest a trend where inverter compressors are more popular for newer RAC units (1-5 years), while fixed-speed compressors are more prevalent in older units.



Source: IIEC Home Energy Survey, 2023

Figure 5-8: Share of RAC's Compressor Types over Various Usage Durations

As discussed in Section 2.3, the pre-2019 MEPS values in Malaysia are based on the Energy Efficiency Ratio (EER) metric. MEPS values for RACs with cooling capacities equivalent to or below 4.5 kW (2 HP or 15,000 BTU/hr) were set at 2.80 W/W, while those with capacities more than 4.5 kW or up to 7.1 kW (24,000 BTU/hr or 3 HP) were set at 2.35 W/W. Figure 5-9 provides insights into the EER values of RACs installed in surveyed households before 2019. These RACs comprise both fixed speed and inverter compressors, with the majority being fixed-speed compressor RACs. The observed EER values range from a minimum of 2.3 to a maximum of 3.6, with the average EER across all surveyed RACs at 3.2. Some RACs installed before 2014 have efficiency values below 2.80 W/W. It is important to note that the EER values of some RACs were computed based on cooling capacities and unit power consumptions provided in the product technical specifications.

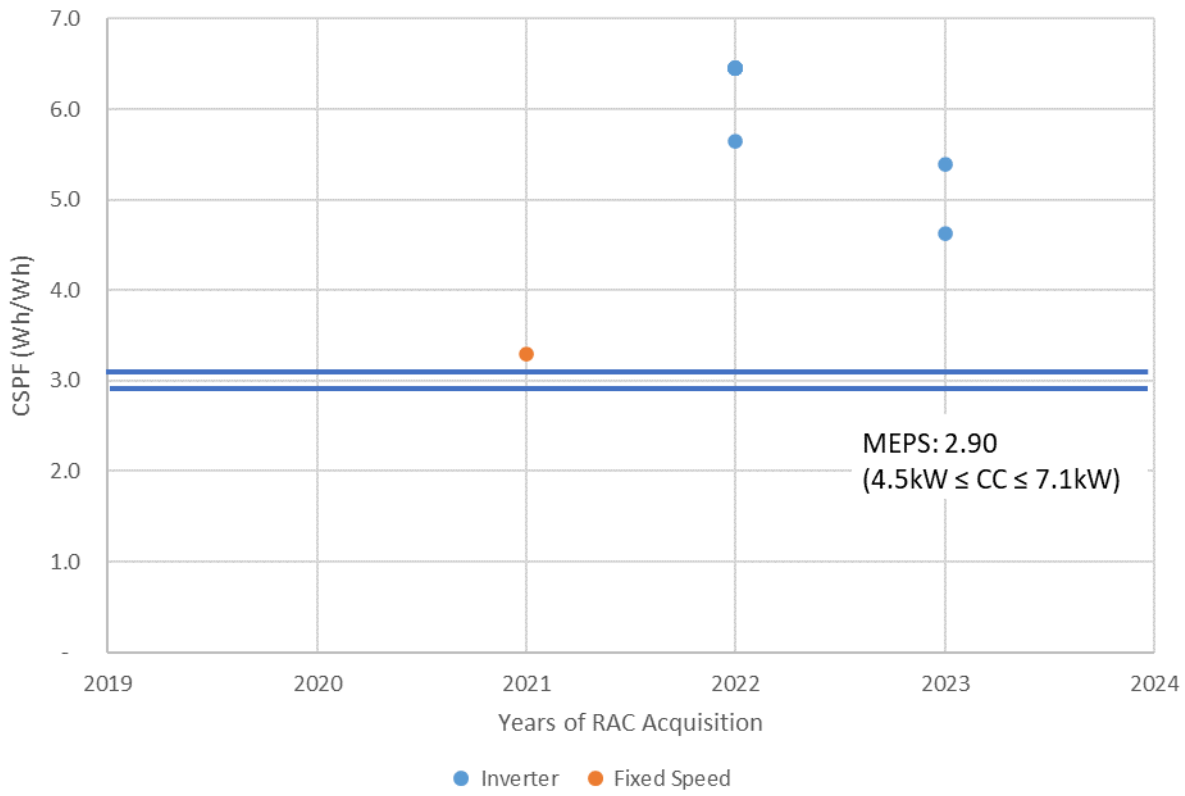


Source: IIEC Home Energy Survey, 2023

Figure 5-9: Energy Performance (EER) of RACs Installed in the Surveyed Households before 2019, (Before Transitioning from EER to CSPF Value)

In 2019, Malaysia adopted the Cooling Seasonal Performance Factor (CSPF) as the efficiency metric for RAC. Figure 5-10 displays the CSPF values of RACs installed in surveyed households after 2019. It is important to note that only one RAC, installed in a surveyed household after 2019, operated with a fixed-speed compressor. The CSPF values range from a minimum of 3.30 (fixed speed) to 6.46 (inverter). These findings underscore that the surveyed RACs, especially the inverter models, generally demonstrate significantly higher CSPF values, signifying superior performance compared to the MEPS level. For RACs with cooling capacities equivalent to or below 4.5 kW (2 HP or 15,000 BTU/hr), the

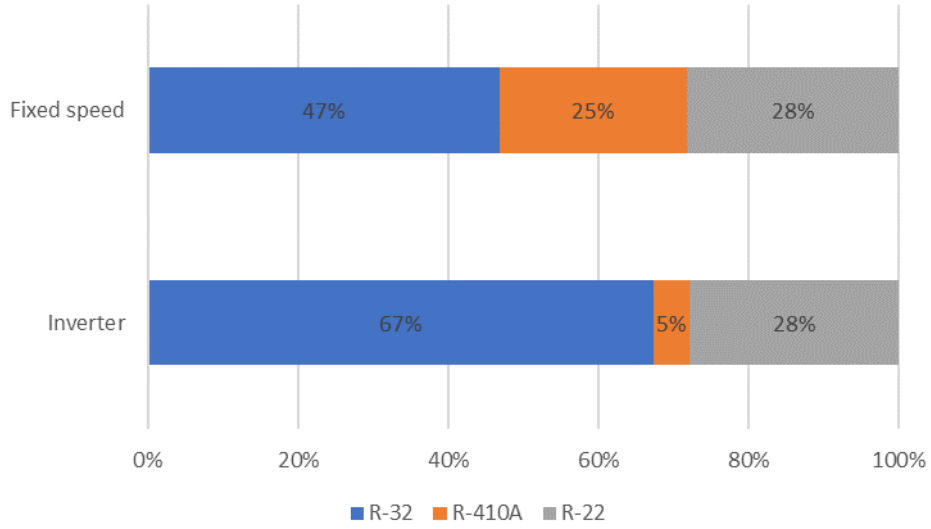
MEPS level is set at 3.10 Wh/Wh, and for those with capacities more than 4.5 kW (2 HP or 15,000 BTU/hr) or up to 7.1 kW (24,000 BTU/hr or 3 HP), it stands at 2.90 Wh/Wh.



Source: IIEC Home Energy Survey, 2023

Figure 5-10: Energy Performance (CSPF) of RACs Installed in the Surveyed Households after 2019, (After Transitioning from EER to CSPF Value)

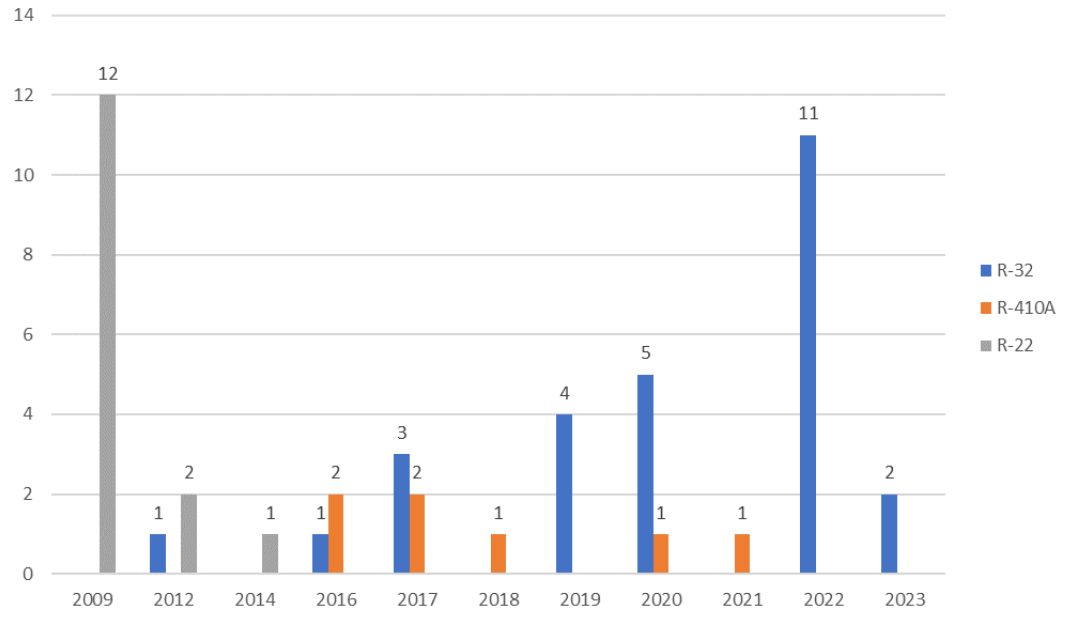
Figure 5-11 demonstrates the variety of refrigerants utilized in both fixed-speed and inverter RACs. RAC units with R-32 refrigerant are the most common among the surveyed households. R32 is also used in both fixed speed and inverter RACs. Surprisingly, R22 RAC units are more prevalent than the R410A units among the surveyed households.



Source: IIEC Home Energy Survey, 2023

Figure 5-11**: **Comparison of Refrigerant Usage in Fixed-Speed and Inverter RAC Installations

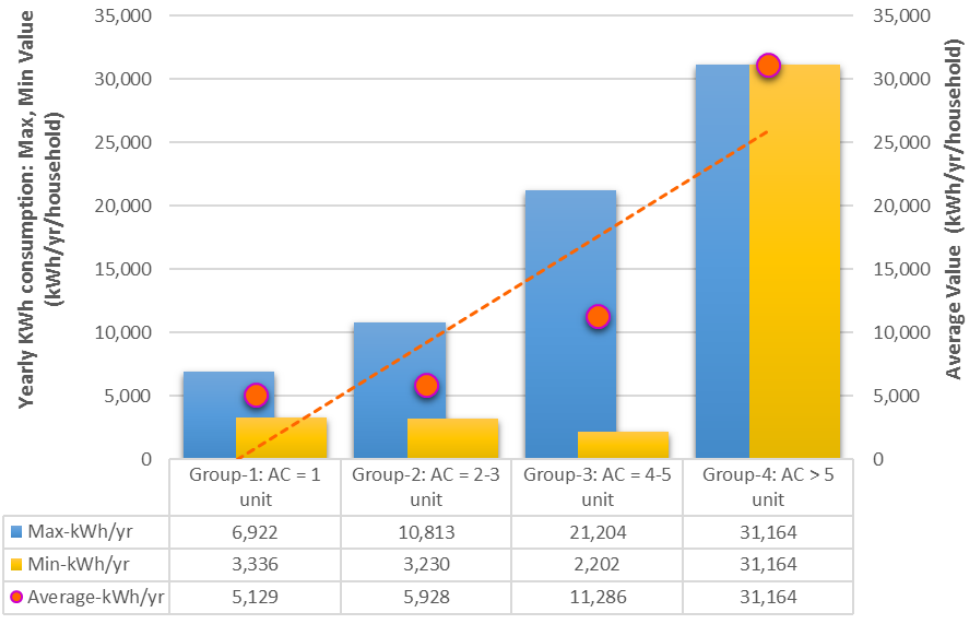
To gain more insights into the acquisition year of RACs with each refrigerant type, Figure 5-12 shows that no RACs with R-22 refrigerant were installed after the year 2014, implying that R-22 refrigerant had already been phased out in Malaysia. RACs with R-410A refrigerant were installed until 2021, while those with R-32 refrigerant gained popularity starting in 2019 and have been continuously installed since 2012 to the current date.



Source: IIEC Home Energy Survey, 2023

Figure 5-12**: **Comparison of Refrigerant Usage by RAC Acquisition Years

The comparison among households with varying numbers of RACs reveals a clear relationship between the quantity of RAC units and the corresponding electricity consumption. The households, with a single RAC unit, exhibit the lowest annual electricity energy consumption among the groups, ranging between 3,336 kWh (Min) to 6,922 kWh (Max), with an average of 5129 kWh. This indicates the significant impact of multiple air conditioning units on overall electricity consumption within residential settings (see Figure 5-13).



	Group-1: AC = 1 unit	Group-2: AC = 2-3 unit	Group-3: AC = 4-5 unit	Group-4: AC > 5 unit
Max-kWh/yr	6,922	10,813	21,204	31,164
Min-kWh/yr	3,336	3,230	2,202	31,164
Average-kWh/yr	5,129	5,928	11,286	31,164

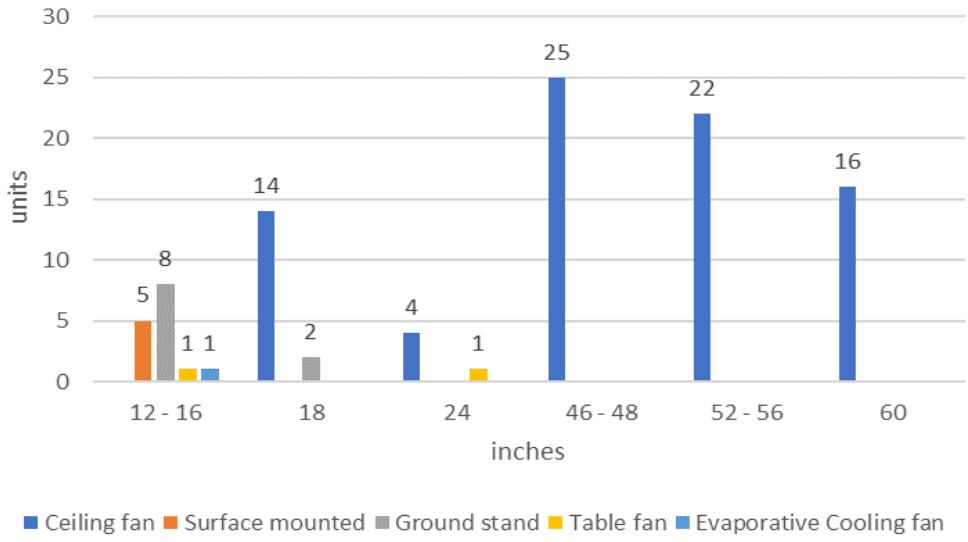
Source: IIEC Home Energy Survey, 2023

Figure 5-13**: **Correlation between RAC Units and Annual Energy Consumption

5.1.5 Adoption and Usage of Other Appliances

5.1.5.1 Electric Fan

Electric fans are the most popular cooling appliances among the 15 surveyed households with a total of 107 electric fans installed. This is equivalent to 7.13 units of electric fans per household. The most popular types are ceiling fans with diameters of 46 - 48 inches.

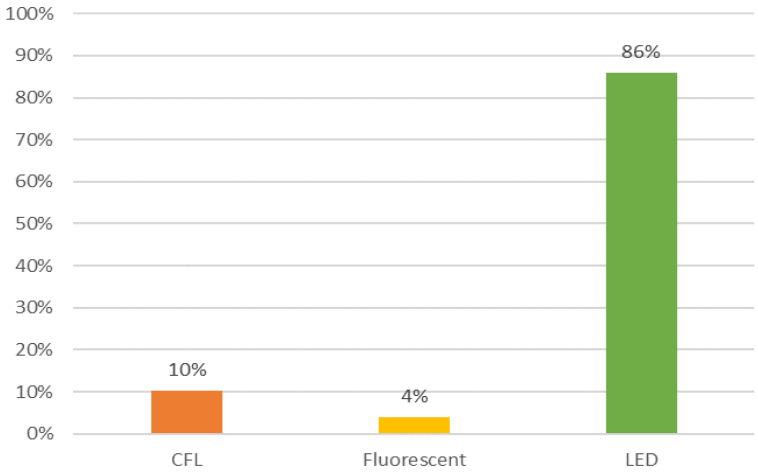


Source: IIEC Home Energy Survey, 2023

Figure 5-14**: **Profiles of Electric Fans used in 15 Surveyed Households

5.1.5.2 Lighting

The average number of light points in the 15 surveyed households is 30.1 light points. Among these households, LEDs are the most popular lighting technologies surpassing the usage of CFLs and Fluorescent Lamps (FLs). The usage of incandescent lamps is negligible.

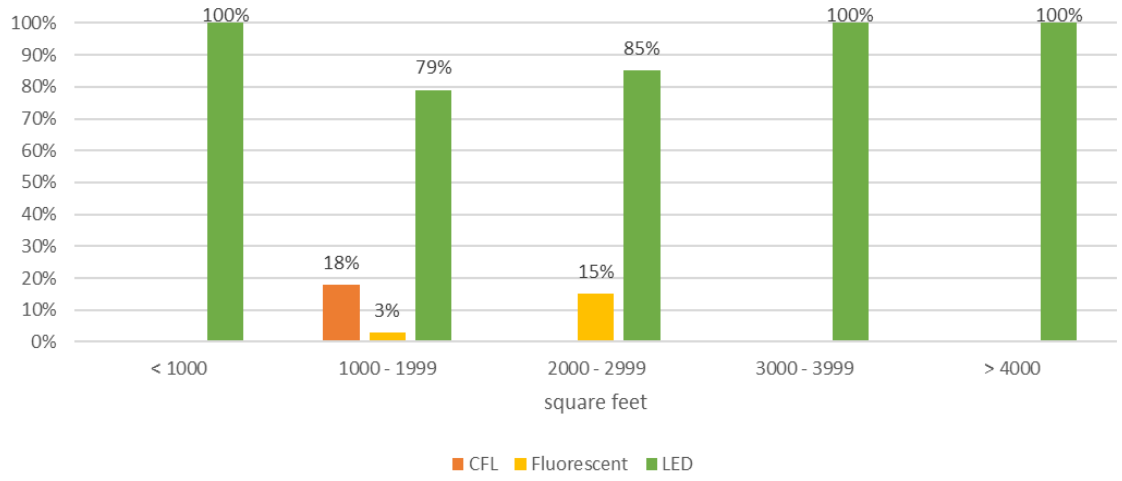


Source: IIEC Home Energy Survey, 2023

Figure 5-15**: **Utilization of Lighting Technologies in 15 Surveyed Households

Figure 5-16 illustrates adoption of LED lighting across households of varying sizes. Smaller households exclusively embrace LED lighting, while larger households also prioritize LED as their primary lighting choice, completely overtaking the usage of CFLs and Fluorescent Lamps (FLs). There is still a partial

integration of FLs, covering a smaller percentage (ranging from 3% to 15%) of the total floor area in households within the 1,000 – 1,999 sq.ft range and the 2,000 – 2,999 sq.ft range.

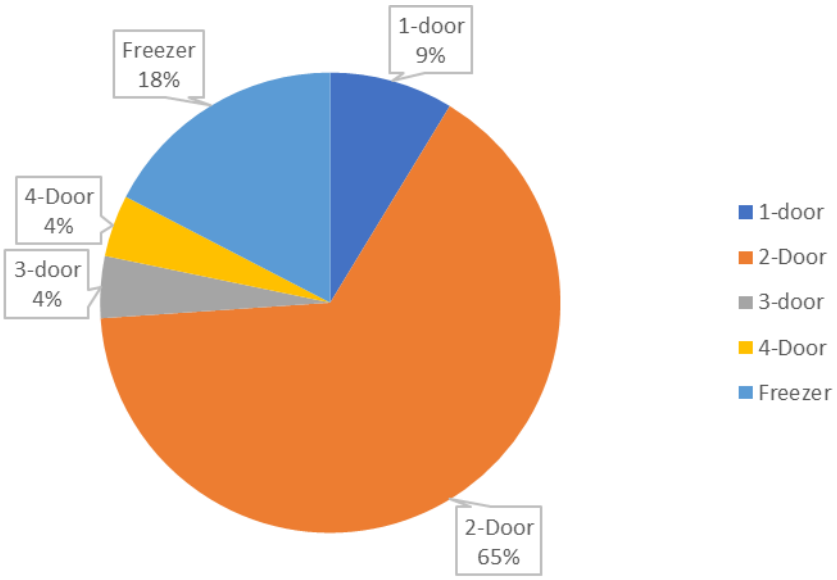


Source: IIEC Home Energy Survey, 2023

Figure 5-16**: **Utilization of Lighting Technologies in Household classified by Number of Total Floor Area (sq.ft)

5.1.5.3 Refrigerator/Freezer

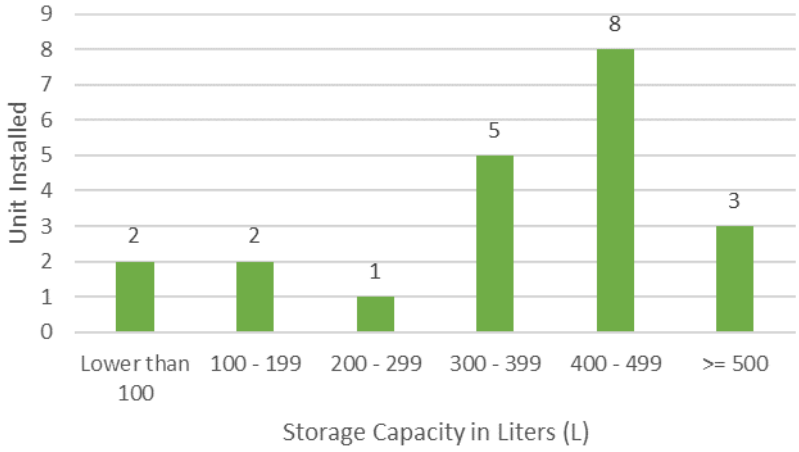
All the surveyed households own at least one refrigerator/freezer, and a total of 23 refrigerators/freezers are found in these households. The most popular type of refrigerators/freezers among the 15 surveyed households are 2-door refrigerators/freezers, accounting for 65% (see Figure 5-17).



Source: IIEC Home Energy Survey, 2023

Figure 5-17**: **Types of Refrigerators/Freezers used in 15 Surveyed Households

The most popular storage capacities are between 400 – 499 liters, as shown in Figure 5-18. This suggests a household preference for storage capacity that is neither too small nor excessively large. However, the scarcity of smaller-sized units might imply a lesser demand for compact refrigerators, while the limited number of larger-sized units suggests a less preference for extensive storage capacity in these surveyed households (see Figure 5-18).

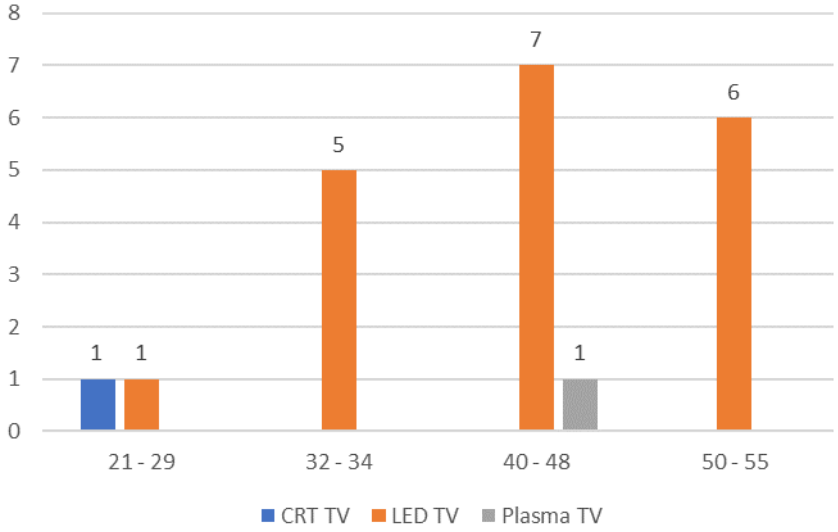


Source: IIEC Home Energy Survey, 2023

Figure 5-18**: **Profiles of Refrigerators/Freezers used in 15 Surveyed Households

5.1.5.4 Television

14 out of 15 surveyed households own a total of 14 TVs, with 95% of them being flat-screen TVs. The most popular screen sizes fall within the range of 40-48 inches.



Source: IIEC Home Energy Survey, 2023

Figure 5-19**: **Profiles of Televisions used in 15 Surveyed Households

6 COST BENEFIT ANALYSIS

This section aims to evaluate the financial implications of transitioning to EE Room Air Conditioners (RACs) in residential and small commercial buildings in Malaysia. By comparing the costs and benefits of EE models against standard efficiency off-the-shelf models, this analysis seeks to provide the benefits of transitioning to more energy-efficient RAC models, not only in terms of reduced electricity consumption but also life cycle cost savings for residential and commercial consumers.

6.1 Scenarios, Assumptions and Parameters for Cost Benefit Analysis

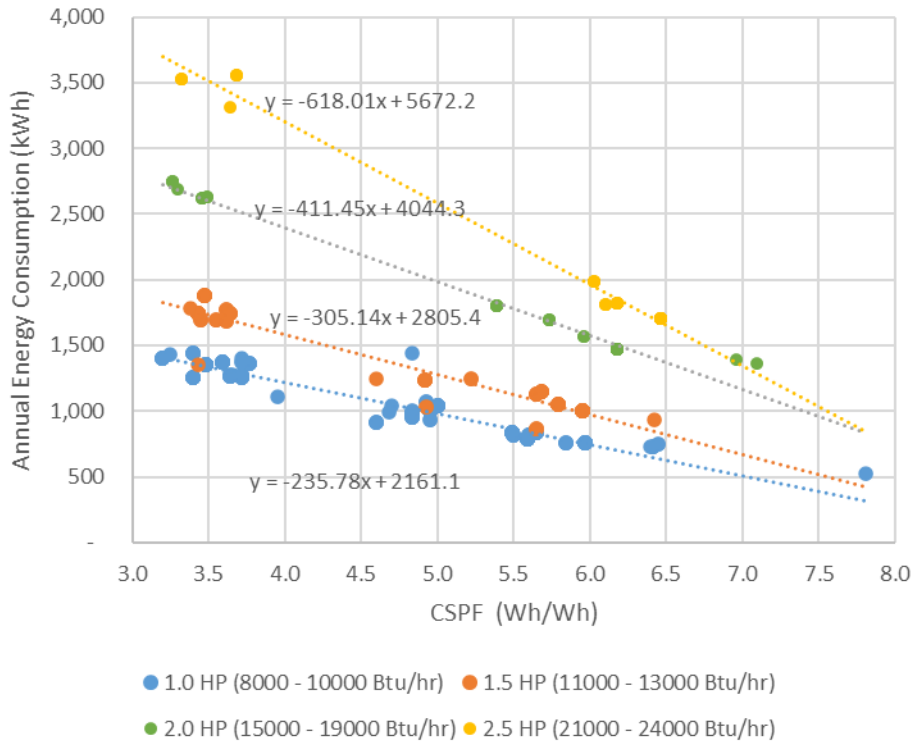
In assessing the cost benefits of EE RACs, it is imperative to establish a framework that considers possible purchasing scenarios, assumptions and parameters. EE RACs, particularly those with higher CSPF, hold the promise of significant energy savings and reduced environmental impact compared to standard efficiency models. However, to evaluate their cost-effectiveness in different purchasing scenarios, it is crucial to define the baseline CSPF or *energy performance of existing RAC and average energy performance of RAC models commonly found in the market.* These will serve as the reference points for comparison with *EE scenarios*. The key assumptions, parameters and purchasing scenarios necessary for evaluating the cost benefits of high EE RACs are discussed in the following sub-sections.

6.1.1 Estimation of Annual Electricity Consumption

The annual electricity consumptions in kWh of RACs with different cooling capacities and CSPF levels were estimated based on the relationships between annual energy consumption data and CSPF values of fixed-speed and inverter RACs registered with the Energy Commission. As shown in Figure 6-1, the kWh-CSPF data can be grouped into 4 clusters and each of which represents the common RAC cooling capacity in Malaysia. It is found that the relationships between annual energy consumption and CSPF are somewhat linear and can be represented as the following equations:

- 1 HP (8,000 – 10,000 Btu/hr): Annual Energy Consumption = -232.12xCSPF + 2155.1
- 1.5 HP (11,000 – 13,000 Btu/hr): Annual Energy Consumption = -304.61xCSPF + 2802.3
- 2.0 HP (15,000 – 19,000 Btu/hr): Annual Energy Consumption = -411.45xCSPF + 4044.3
- 2.5 HP (21,000 – 24,000 Btu/hr): Annual Energy Consumption = -618.01xCSPF + 5672.2

It should be noted that annual energy consumption values determined from the above equations are based on 12 operating hours per day, and these will be normalized to reflect the average 5.4 operating hours per day in residential buildings based on the results of the home energy consumption, and the average 10 operating hours per day in small commercial buildings.



Source: IIEC, 2023

Figure 6-1: Relationships between Annual Energy Consumption (kWh) and CSPF Value

6.1.2 Purchasing Scenarios

This cost benefit analysis categorized the common purchasing scenarios in Malaysia into: 1) "new purchase"; and 2) "early replacement". In the new purchase scenario, consumers acquire new RACs for newly constructed or retrofitted buildings or for replacement of the end-of-life RACs in existing buildings. In the early replacement scenario, consumers replace existing and still operational RAC units with newer, more efficient models before the end of their expected lifespan. More details on these two scenarios are described in Table 6-1.

Table 6-1: Purchasing Scenarios

Scenario	Description	Analysis Approach
New Purchase	The new purchase scenario typically occurs when: • **Building a new home:** Homeowners or developers install RACs during the construction phase of a new home or building. • **Expanding existing properties:** Individuals or businesses add new rooms or spaces to their	Under the new purchase scenario, consumers have options to choose new RACs with different efficiency levels. The benefits of EE RACs will be evaluated against the standard efficiency models, and the payback period of incremental costs incurred will be evaluated by dividing the incremental cost with the annual energy savings

Scenario	Description	Analysis Approach
	existing properties and require RACs for cooling purposes. • **Replacing end-of-life RACs:** Existing RACs reach their end-of-life prompting consumers to replace with new RACs.	realized. The life cycle cost of each new purchasing option will also be computed to compare the overall cost of ownership of each RAC throughout its expected lifetime.
Early Replacement	The early replacement scenario may arise when: • **Adopting advanced efficiency and features:** Consumers seek to take advantage of advancements in RAC technology, such as higher efficiency ratings or enhanced features, by replacing older units with newer models. • **Motivated by EE incentives:** Consumers are motivated by EE incentives, such as rebates or tax credits, to upgrade to more efficient RACs before their current units reach the end of their lifespan.	Under the early replacement scenario, consumers usually seek better energy performance and function RACs to replace the existing ones. The financial viability of the early replacement scenario will be determined through comparison of lower operating and (potentially) maintenance cost of the new RACs against continued use of existing units. The simple payback periods will be evaluated through the energy saving benefits of new RACs and the net investment cost of the new RACs (i.e., the sum of purchasing prices, uninstallation cost of existing unit, installation cost of new unit, etc. less the salvage value of the existing units). The life cycle cost for each new RAC with different efficiency levels will also be computed.

6.1.3 Parameters and Assumptions

The key parameters and assumptions for the cost benefit analysis under each purchasing scenario are summarized in Table 6-2.

Table 6-2: Key Parameters and Assumptions for Analysis

Key Parameters	*Assumptions*
RAC Type and Cooling Capacity	Split unit with a cooling capacity of 1.5 HP (3.37 – 3.66 kW or 11,500 – 12,500 Btu/hr), based on the most commonly used cooling capacity and compressor type from home energy consumption survey data
Energy Performance	Existing RACs: • Fixed speed RAC with CSPF of 3.34 New RACs: • Market Average: Fixed speed RAC with CSPF of 3.43 • ASEAN MEPS 2023: Inverter RAC with CSPF of 3.7 • ASEAN MEPS 2025: Inverter RAC with CSPF of 6.09
Annual Operating Hours	Estimated daily usage hours of the RACs used in a household are about 5.4 hours on average, or 1,971 hours per year based on home energy consumption survey data. For small commercial buildings, the estimated daily operating hours based on normal business hours are 10 hours or 2,470 hours per year.
Electricity Tariff (Residential Building)	Average electricity cost for residential consumers with RACs is estimated at: 42.15 cents per kWh. This is based on the average electricity consumption of 770 kWh per month from the home energy consumption surveys and the following electricity tariff schedules. Domestic Tariff (RM)[14] • For the first 200 kWh (1 - 200 kWh) per month 21.80 cents/kWh • For the next 100 kWh (201 - 300 kWh) per month 33.40 cents/kWh • For the next 300 kWh (301 - 600 kWh) per month 51.60 cents/kWh • For the next 300 kWh (601 - 900 kWh) per month 54.60 cents/kWh • For the next kWh (901 kWh onwards) per month 57.10 cents/kWh
Electricity Tariff (Small Commercial Buildings)	The average electricity cost for small commercial buildings with RACs is at 50.90 cents per kWh, based on Malaysia's Tariff B classification for consumption over 200 kWh per month. Commercial: Tariff B – Low voltage commercial tariff (RM)[15]

[14] https://www.mytnb.com.my/residential/understand-your-bill/pricing-tariff

[15] https://www.mytnb.com.my/business/understand-your-bill/pricing-tariff

Key Parameters	Assumptions
	• For the first 200kWh (1-200kWh) per month 43.50 cents/KWh • For the next kWh (201kWh onwards) per month 50.90 cents/KWh
Purchasing Price	• 1,549 RM (324 USD) for a market average model, fixed speed RAC with CSPF of 3.43 • 1,637 RM (342 USD) for an inverter RAC with CSPF of 3.70 (ASEAN MEPS 2023) • 2,189 RM (458 USD) for an inverter RAC with CSPF of 6.09 (ASEAN MEPS 2025)
Maintenance & Repair Costs	Average 100 RM per year
Emission Factor	0.758 $kgCO_2e/kWh$[16]
Expected RAC Lifetime	12 years[17]
Discount Rate	3.285% - Malaysia Discount Rate: Treasury Bills: 12 Months data was reported at 3.285 % pa in Jan 2018[18].

6.2 Analysis Results

This section presents the financial analysis results of the adoption of EE RACs in both residential and small commercial settings in Malaysia. The financial analysis primarily focuses on the evaluation of simple payback period and life cycle cost of different purchasing scenarios, as discussed below.

6.2.1 Annual Electricity Consumption & Electricity Cost Over Lifetime

Table 6-3 present the estimated annual energy consumptions of an RAC in Malaysian households and small commercial buildings. Note that the estimated annual electricity consumptions are based on the estimated daily usage of 5.4 hours in households and 10 hours in small commercial buildings, as described in Table 6-2.

[16] Energy Commission 2021 Grid EF (https://www.mgtc.gov.my/lcos-personal-calculator/)

[17] ASHRAE Handbook - Fundamentals, 2013

[18] https://www.ceicdata.com/en/malaysia/discount-rates/discount-rate-treasury-bills-12-months

Table 6-3: Per Unit Annual Electricity Consumption in Households and Small Commercial Buildings

CSPF (Wh/Wh)	Annual Electricity Consumption (kWh)		Annual Electricity Cost (RM)	
	Household	Small Commercial Building	Household	Small Commercial Building
3.34 (Existing)	803	1,007	339	512
3.43 (Market Average)	785	984	331	501
3.70 (ASEAN MEPS 2023)	754	945	318	481
6.09 (ASEAN MEPS 2025)	426	534	180	272

6.2.2 Payback Period

While EE RACs may have higher upfront costs, they result in lower operational expenses due to reduced energy consumption. Evaluating the payback period helps determine how long it takes for the energy savings generated by the more efficient unit to offset its initial higher cost. This section compares the payback periods associated with the new purchase and early replacement scenarios.

6.2.2.1 New Purchase

As described earlier, residential and small commercial consumers have multiple choices when purchasing new RACs. Table 6-4 summarizes the incremental costs, annual electricity cost savings and payback periods of inverter RACs with the efficiency levels of 3.70 CSPF and 6.09 CSPF purchased by residential consumers against the market average fixed-speed model with the efficiency level of 3.43 CSPF. The comparison of the payback periods of these new purchases reveals that an RAC with a CSPF of 6.09 exhibits a relatively short payback period of 4.2 years, with a higher initial investment price difference of 640 RM. Conversely, opting for an RAC with a CSPF of 3.70 results in a longer payback period of 6.7 years, with a smaller initial investment price difference of 88 RM.

Table 6-4: Per Unit Payback Period of EE RACs for New Purchase in Malaysian Households

CSPF (Wh/Wh)	Incremental Cost (RM) – EE Model vs Market Average Model (3.43 CSPF)	Annual Electricity Cost Savings (RM)	Payback Period (Year)
3.70 (ASEAN MEPS 2023)	88	13	6.7
6.09 (ASEAN MEPS 2025)	640	151	4.2

Table 6-5 provides the analysis results for adopting EE RACs in small commercial buildings in Malaysia. The payback periods of new EE RAC purchases in small commercial buildings are shorter than households due to longer operating hours. An RAC with a CSPF of 6.09 offers a short payback period of about 3.4 years, while a new RAC with a CSPF of 3.70 has a longer payback period of 5.3 years.

Table 6-5: Per Unit Payback Period of EE RACs for New Purchase in Small Commercial Buildings in Malaysia

CSPF (Wh/Wh)	Incremental Cost (RM) – EE Model vs Market Average Model (3.43 CSPF)	Annual Electricity Cost Savings (RM)	Payback Period (Year)
3.70 (ASEAN MEPS 2023)	88	17	5.3
6.09 (ASEAN MEPS 2025)	640	190	3.4

6.2.2.2 Early Replacement

The analysis of the payback periods for early replacement considers the net total investment cost of new RACs and electricity cost savings resulting from adopting RACs with better efficiency than the existing ones (see Table 6-6 and Table 6-7).

In summary, the analysis of the early replacements in both households and small commercial buildings demonstrate the financial challenges due to extremely long payback periods.

Table 6-6: Per Unit Payback Period of EE RACs for Early Replacement in Malaysian Households

CSPF (Wh/Wh)	Net Investment Cost (RM)	Annual Electricity Cost Savings (RM) - EE Model vs Existing Model (3.34 CSPF)	Payback Period (Year)
3.43 (Market Average)	1,549	8	204.7
3.70 (ASEAN MEPS 2023)	1,637	21	78.7
6.09 (ASEAN MEPS 2025)	2,189	159	13.8

Table 6-7: Per Unit Payback Period of EE RACs for Early Replacement in Small Commercial Buildings in Malaysia

CSPF (Wh/Wh)	Net Investment Cost (RM)	Annual Electricity Cost Savings (RM) - EE Model vs Existing Model (3.34 CSPF)	Payback Period (Year)
3.43 (Market Average)	1,549	9	163.3
3.70 (ASEAN MEPS 2023)	1,637	26	62.8
6.09 (ASEAN MEPS 2025)	2,189	199	11

6.2.3 Life Cycle Cost

The life cycle cost (LCC) in this report considers the net present value (NPV) of the total cost of owning a new RAC over a 12-year period, which includes the purchasing price, electricity cost and maintenance/repair cost. Note that the LCC analysis does not differentiate the LCCs of RACs purchased under the new purchase and early replacement scenarios. Moreover, this LCC analysis does not consider the existing RACs in operation due to the uncertainty of the remaining lifetime. Table 6-8 summarizes LCC analysis results for owning new RACs with efficiency levels of 3.43, 3.70 and 6.09 CSPF.

Table 6-8: Per Unit Life Cycle Costs of New RACs in Households and Small Commercial Buildings in Malaysia

CSPF (Wh/Wh)	Purchase Price (RM)	Households		Small Commercial Buildings	
		Life Cycle Cost for 1,971 Hours of Use (RM)	LCC Savings Compared to Market Average RAC with 3.43 CSPF (%)	Life Cycle Cost for 2,470 Hours of Use (RM)	LCC Savings Compared to Market Average RAC with 3.43 CSPF (%)
3.43	1,549	5,058	N/A	6,441	N/A
3.70	1,637	5,038	0.4%	6,366	1.2%
6.09	2,189	4,466	11.7%	5,217	19%

As shown in Table 6-8, the RAC models with higher CSPF values generally have lower LCCs compared to the RACs with low CSPF values. In case of households and small commercial buildings in Malaysia, owning an RAC with 6.09 CSPF efficiency values offers the lowest LCC, although the 6.09 CSPF unit is 29% more expensive than the market average fixed speed model with CSPF of 3.43. Owning the 3.70 CSPF unit is only slightly cheaper (5%) than the market average model throughout its lifetime.

6.2.4 Greenhouse Gas Emissions

Table 6-9 summarizes annual greenhouse gas (GHG) emissions based on the estimated annual electricity consumptions and the emission factor published by the Energy Commission.

Table 6-9: Per Unit Annual GHG Emission in Households and Small Commercial Buildings

CSPF (Wh/Wh)	Annual Electricity Consumption (kWh)		Annual GHG Emission (kgCO2)	
	Household	Small Commercial Building	Household	Small Commercial Building
3.34 (Existing)	803	1,007	609	763

3.43 (Market Average)	785	984	595	746
3.70 (ASEAN MEPS 2023)	754	945	572	716
6.09 (ASEAN MEPS 2025)	426	534	323	405

Note: Emission Factor = 0.758 kgCO2/kWh

Figure 6-2 provides a comparison of GHG emission reduction potential when replacing existing RACs with 3.43, 3.70 and 6.09 CSPF RACs. Upgrading to an existing RAC unit with a CSPF of 6.09 could result in a significant reduction of 36% in GHG emissions.

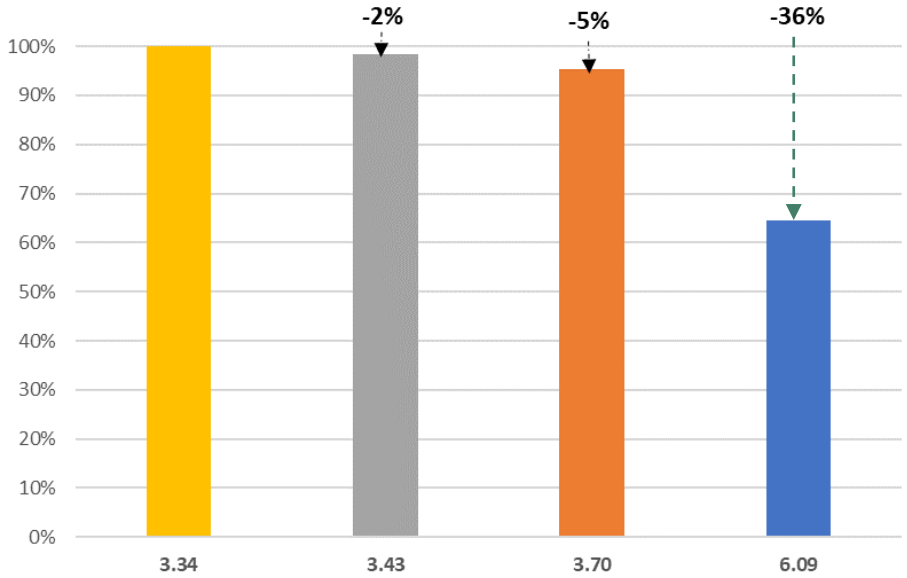


Figure 6-2: GHG Emission Reduction Potential for RACs with Different CSPF

Table 6-10 summarizes cumulative GHG emissions and total reduction potential over the RAC lifetime of 12 years. Opting for a CSPF of 6.09 yields substantial cumulative GHG emission reductions over the RAC lifetime, totalling 3,429 kgCO2 per unit for households and 4,302 kgCO2 for small commercial buildings, showcasing the significant environmental benefits of highly EE units. Marginal improvements of RAC efficiencies from a CSPF of 3.34 to a CSPF of 3.43 and 3.70 only lead to the modest reduction of GHG emissions.

Table 6-10: Per Unit Cumulative GHG Emission in Households and Small Commercial Buildings

CSPF (Wh/Wh)	Cumulative GHG Emission (kgCO2)		Potential GHG Emission Reduction (kgCO2)	
	Household	Small Commercial Building	Household	Small Commercial Building
3.34 (Existing)	7,304	9,160	N/A	N/A
3.43 (Market Average)	7,140	8,950	164	209
3.70 (ASEAN MEPS 2023)	6,858	8,596	446	564
6.09 (ASEAN MEPS 2025)	3,875	4,857	3,429	4,302

Note: Emission Factor = 0.758 kgCO2/kWh

7 CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

Through market research and examination, key findings and insights are summarized below:

RAC Market in Malaysia:

- The demand for Room Air Conditioners (RACs) in Malaysia experienced fluctuations over the past decade, with a general downward trend from 2014 to 2019. Based on JRAIA, the annual sales volumes of RACs in Malaysia from 2020 to 2021 were about 800,000 units. The annual sales estimated by manufacturers/importers significantly varied with the market size of about 1 million units annually.

- Malaysia's RAC industry shows fluctuations in both import and export volumes, influenced by factors like global economic conditions and the COVID-19 pandemic. China emerged as the primary source for RAC imports, contributing 92.6% of imported units in 2022. Vietnam was the largest recipient of Malaysia's RAC exports, accounting for nearly half (49%) of total RAC exports in 2022.

- There are three registered local RAC manufacturers in Malaysia: Acson, Daikin, and Panasonic. It's worth noting that Daikin also manufactures RACs under the Acson brand.

- While manufacturers and importers estimated that fixed-speed models dominate sales in the Malaysian RAC market, comprising approximately 70% of all units sold annually, retailer surveys reveal a wide selection of inverter-type RAC models in the retail market, with 65% of off-the-shelf models being inverter type. This percentage of the retail market's inverters aligns closely with the percentage of certified models registered in 2021.

- Based on manufacturers and importers' opinions, price remains the most significant factor influencing consumer choice, with fixed-speed models being more popular among residential consumers due to their lower cost, while government incentives likely drive the preference for inverter models in the commercial sector.

- In both certified models and retailer inventories, 1.0 HP and 1.5 HP units are the most popular, comprising almost three-fourths of all models. This aligns with the share of RACs sold in the market, based on manufacturers' and importers' feedback.

- Across various cooling capacities, inverter RACs consistently outperformed fixed-speed units in terms of energy efficiency, as indicated by their higher average CSPF values. For example, in the 1.0 HP capacity category, the average CSPF for inverter models is 5.34, significantly higher than the 3.65 average CSPF of fixed-speed units.

- There is a noticeable trend where retail stores are enhancing their channels by having online platforms. This necessitates scrutiny of products available through online channels, indicating an increased need to monitor and regulate the offerings from this channel.

Household Energy Consumption Pattern:

- Cooling appliances (i.e., RACs and fans), refrigeration (refrigerators/freezers), and lighting are the primary energy end-uses in the 15 surveyed households, collectively contributing 40% to 70% of the annual electricity consumption. All surveyed households own at least one RAC.

Manufacturers/Imports Responses on Constraints and Challenges in adopting More Stringent MEPS and Labelling Requirements:

- Manufacturers and importers propose pushing back the implementation timeline for 6.09 CSPF to 2030 and 2035, citing that these align with their capacity to address technical challenges and implement necessary technological advancements. It's imperative for the Energy Commission (EC) to establish clear timelines and regulations for MEPS compliance, providing manufacturers and importers with ample time to prepare and adhere effectively.

- Key support and resources needed include the promotion of high energy-efficient products to the public, with an emphasis on raising awareness and educating consumers about the benefits of higher MEPS levels. Additionally, ensuring access to clear and up-to-date information on MEPS regulations, standards, and compliance requirements is crucial. Moreover, availability of environmental certifications would reinforce companies' commitment to energy efficiency and sustainability.

- Financial and fiscal incentives for inverter production are essential, with specific initiatives recommended such as promotion incentives for consumers, tax incentives for local production, and duty-free policies for high-efficiency products. These measures are vital for facilitating the transition to higher efficiency standards and promoting sustainable practices in the RAC industry.

- Capacity building needs for the uptake of higher-efficiency AC units involve several key technical aspects, including the selection of appropriate equipment such as heat exchangers, compressors, and advanced control equipment. Additionally, crucial areas requiring attention include the integration of advanced control systems with IT sensors and instrumentation, understanding climate conditions and load characteristics, and employing advanced control algorithms. Furthermore, ensuring the availability of personnel with in-house technical resources and accessing external professional expert support are deemed essential for effectively implementing higher-efficiency AC units.

Advancing Energy Efficiency through Higher Efficiency RAC Adoption in Malaysia

The analysis of adopting higher energy-efficient RACs in Malaysia, encompassing both residential and small commercial contexts, reveals compelling advantages in terms of energy savings, financial implications, and environmental benefits. By comparing models with varying CSPF values, the analysis underscores the importance of higher-efficiency RACs.

- In the residential settings, where air conditioners operate for an average of 5.4 hours/day, models with 6.09 CSPF efficiency demonstrate significantly shorter payback periods, making them appealing investments despite higher initial costs. Similarly, in commercial buildings with longer operating hours (10 hours/day), RACs with 6.09 CSPF values exhibit notably shorter payback periods, indicating substantial benefits for commercial applications.

7.2 Recommendations

The following multi-faceted approach and strategies should be considered to promote greater adoption of higher efficiency RACs and make early replacement of such units a worthwhile investment.

- **Enforce stringent MEPS:** Ensure the enforcement of MEPS for RACs to forcefully steer the market toward more efficient technologies, guaranteeing consumers access to better efficiency options and pushing manufacturers to innovate and improve efficiency standards. This aligns with the ASEAN Regional Policy Roadmap for Energy-Efficient RACs, aiming for a Phase II CSPF of 6.09 by 2025.

- **Offer compelling financial incentives for early replacement:** Governments or utility companies should provide rebates or tax credits to incentivize the early replacement of less efficient RACs with higher-efficiency models. This initiative effectively offsets the higher upfront costs, similar to the SAVE program, specifically tailored for the early replacement scenario. Further studies should be conducted on the detailed design phase to determine the extent of financial assistance and the program criteria.

- **Establish highly accessible financing options such as low-interest loans covering all types of purchases:** Provide seamless access to low-interest loans or flexible installment plans to enable consumers to spread out the cost of purchasing a higher-efficiency RAC over time, ensuring affordability and accessibility for all income levels.

- **Implement robust financial support measures for manufacturers:** Enact powerful tax incentives for local production and institute duty-free policies specifically for high-efficiency inverter AC products, actively fostering eco-friendly design and driving the rapid development of a circular economy.

- **Raise awareness on energy savings:** Launch aggressive educational campaigns to inform and empower consumers about the long-term energy savings potential of higher efficiency RACs, encouraging them to prioritize EE in every purchasing decision.

- **Roll out impactful home energy audits programs:** Execute public programs focused on EE, such as comprehensive energy audits or home retrofit initiatives, offering personalized recommendations and incentives for upgrading to higher efficiency appliances, including RACs.

- **Foster deep collaboration with retailers:** Forge strategic alliances with retailers to vigorously promote higher efficiency RACs through engaging marketing campaigns and exclusive promotions, effectively boosting consumer awareness and driving widespread adoption of efficient models.

- **Monitor e-commerce channels:** There should be a dedicated effort to monitor e-commerce platforms. This strategy aims to ensure that online sales of RACs comply with MEPS and

labelling requirements, safeguarding that consumers are presented with EE options across all purchasing channels.

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9 ANNEX

9.1 Manufacturer/Importer Questionnaire

Survey on High-Efficient and Climate-Friendly Air Conditioner Market in Malaysia

Introduction:

The International Institute for Energy Conservation (IIEC) kindly requests your support for its assignment to provide Technical Assistance (TA) to conduct an impact assessment of adopting higher minimum energy performance standard (MEPS) and labels. This questionnaire aims to: 1) validate air conditioning market data and 2) assess the impact of AC manufacturers and importers in adopting higher levels of MEPS for Room Air Conditioners (RACs)

This project is being executed in collaboration with the Energy Commission, Malaysia, and the United Nations Environment Programme's United for Efficiency Initiative (UNEP-U4E), with the aim of supporting the Clean Cooling Collaborative (CCC), a philanthropic initiative of the ClimateWorks Foundation dedicated to achieving efficient, climate-friendly cooling for all. The primary goal of this study is to conduct a thorough analysis and provide recommendations concerning the **Minimum Energy Performance Standard (MEPS) and Labels** specified in the ASEAN Regional Policy Roadmap for Energy Efficient Room Air Conditioners.

[DISCLAIMER] All data and information will be treated as high level confidential and will only be used as part of aggregate data **for the analysis needed in the project and will not be provided and sold in any way to a third party. We would like to thank** you in advance for your time and cooperation. If you have any inquiries about the conduct of the survey, about the assignment, or would like to sign a non-disclosure agreement (NDA), do not hesitate to contact our team through (Ms.) Aungsanant Thipthaweecharn at athipthaweecharn@iiec.org.

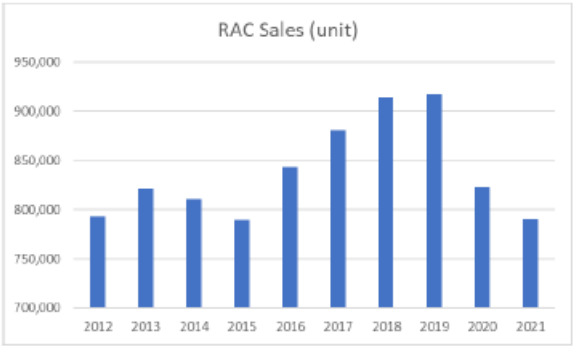
Contact Information

First Name:	
Surname:	
Informant's gender:	☐ Male ☐ Female ☐ N/A
Contact number:	
Email:	
Company Name:	
Business Type:	☐ Import ☐ Local production ☐ Both
Position/Department:	
Company Address:	
Brands:	

1

Part I: Market Data Validation - Overview of market information

1) **The chart below shows the estimated RAC (single split system) market size in Malaysia in 2012 - 2021.**



Source: JRAIA data

Do you agree with the estimates shown in the chart?

Scale				
1 *Strongly Disagree*	2 *Somewhat Disagree*	3 *Neither Agree nor Disagree*	4 *Somewhat Agree*	5 *Strongly Agree*
☐	☐	☐	☐	☐

If you disagree (or Neither Agree nor Disagree), please provide the estimated sales data for 2020, 2021, and/or 2022 and the estimated annual market growth rate.

	sales (unit)	*annual market growth rate (%)*
2020	_____	_____
2021	_____	_____
2022	_____	_____

2) **An estimated 65% of RAC (single split systems) models sold in the market had inverter compressors, while the remaining 35% had fixed-speed compressors"**

Inverter	65 %
Non-inverter/fixed speed	35 %

Source: Retailer Survey conducted by IIEC (2023)

Do you agree with the estimates?

Scale				
1 *Strongly Disagree*	2 *Somewhat Disagree*	3 *Neither Agree nor Disagree*	4 *Somewhat Agree*	5 *Strongly Agree*
☐	☐	☐	☐	☐

If you disagree (or Neither Agree nor Disagree), please provide the estimated sales data for inverter and non-inverter/fixed speed in the market.

2

Inverter	_____%
Non-inverter/fixed speed	_____%

3) **The table below focuses on the breakdown of RACs sold in the market in 2023 by compressor in each capacity level and the average of the most common energy efficiency rating in that cooling capacity range.**

Capacity	Fixed speed/Non-inverter		Inverter	
	%Share	Energy Efficiency Level (CSPF) of the most common AC model sold	%Share	Energy Efficiency Level (CSPF) of the most common AC model sold
1.0 HP	43%	3.40	36%	4.83, 5.97
1.5 HP	28%	3.47, 3.59	27%	5.95
2.0 HP	18%	3.26, 3.35	20%	6.18
2.5 HP	11%	3.56	16%	6.46
3.0 HP	0%		1%	5.19

Source: Retailer Survey conducted by IIEC (2023)

Do you agree with the estimates?

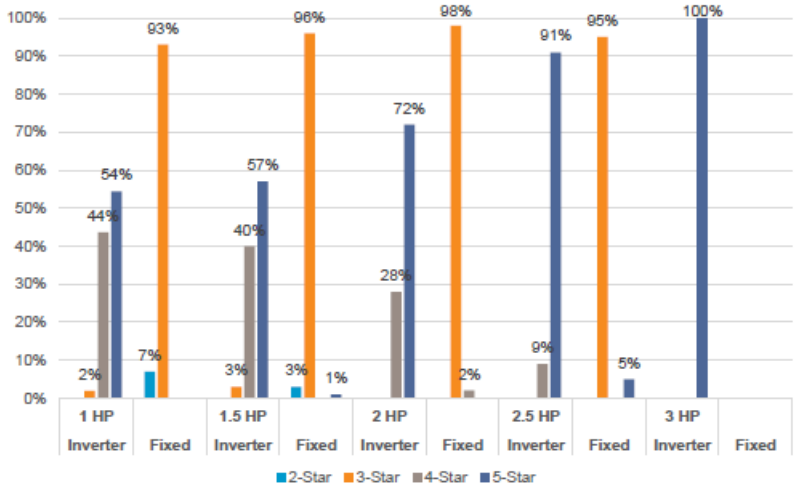
Scale				
1 *Strongly Disagree*	2 *Somewhat Disagree*	3 *Neither Agree nor Disagree*	4 *Somewhat Agree*	5 *Strongly Agree*
☐	☐	☐	☐	☐

If you disagree (or Neither Agree nor Disagree), please provide the estimated sales data.

Capacity	Fixed speed/Non-inverter		Inverter	
	%Share	Energy Efficiency Level (CSPF) of the most common AC model sold	%Share	Energy Efficiency Level (CSPF) of the most common AC model sold
1.0 HP	%		%	
1.5 HP	%		%	
2.0 HP	%		%	
2.5 HP	%		%	
3.0 HP	%		%	

4) **The chart below shows the breakdown of RACs sold in the market in 2023 by the compressor in each capacity level and the percentage of the energy rating in that cooling capacity range.**

3



Source: Retailer Survey conducted by IIEC (2023)

Do you agree with the estimates shown in the chart?

Scale				
1 *Strongly Disagree*	2 *Somewhat Disagree*	3 *Neither Agree nor Disagree*	4 *Somewhat Agree*	5 *Strongly Agree*
☐	☐	☐	☐	☐

If you disagree (or Neither Agree nor Disagree), please provide your comments

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5) Currently, almost all of the RACs (single split systems) available in the retail shops have R-32 refrigerant for both Inverter and Fixed speed RACs.

%AC models by Refrigerant type		
Refrigerants	Inverter	Fixed speed
R-32	100%	99%
R-410A	-%	1%
Other.....	%	%

Source: Retailer Survey conducted by IIEC (2023)

4

Do you agree with the estimates?

Scale				
1 *Strongly Disagree*	2 *Somewhat Disagree*	3 *Neither Agree nor Disagree*	4 *Somewhat Agree*	5 *Strongly Agree*
☐	☐	☐	☐	☐

If you disagree (or Neither Agree nor Disagree), 5), in your view, what is the distribution of AC products sold by refrigerant type in the current market? – Please specify in the table below.

%AC models by Refrigerant type		
Refrigerants	Inverter	Fixed speed
R-32	%	%
R-410A	%	%
Other.....	%	%

6) The estimated stock (installed RACs) in 2021 and/or 2022

2021	_____10.5 millions_____
2022	_____10.9 millions_____

Do you agree with the estimates?

Scale				
1 *Strongly Disagree*	2 *Somewhat Disagree*	3 *Neither Agree nor Disagree*	4 *Somewhat Agree*	5 *Strongly Agree*
☐	☐	☐	☐	☐

In your view, what is the most currently installed refrigerant type for RACs? _____

Can you provide insights into how the pricing of AC units aligns with their energy performance? Are there specific models or technologies that offer a better balance between cost and energy efficiency?

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If you have any additional suggestions, or comments, or would like to share regarding market data validation, please specify.

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Part II: Opinions on Adopting higher minimum energy performance standard (MEPS) and labels

The Energy Commission (Suruhanjaya Tenaga) is planning to update the Minimum Energy Performance Standards (MEPS) levels for RACs to meet the ISO Coefficient of Performance (CSPF) level of 6.09. Do you foresee any technical constraints or challenges in reaching this level?

☐ **No**

☐ **Yes,**

Timeline that you believe suits your capacity:

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1) Challenges aspects that you will face:

Potential circumstances that may face	Level of impact					
	Insignificance (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)	Not Applicable
Cost Considerations: Increased costs associated with sourcing and producing appliances that meet the higher MEPS requirements. This includes investment in new technologies, materials, or manufacturing processes	☐	☐	☐	☐	☐	☐
Supply Chain Adjustments: (Importers) Need to work closely with manufacturers and suppliers to ensure compliance with the new MEPS levels - Finding new suppliers or reconfiguring existing supply chains.	☐	☐	☐	☐	☐	☐
Product Selection: Reassess their product offerings to focus on models that meet the higher MEPS standards. This may involve discontinuing older, less efficient models.	☐	☐	☐	☐	☐	☐
Market Competitiveness: Importers may face	☐	☐	☐	☐	☐	☐

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Potential circumstances that may face	Level of impact					
	Insignificance (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)	Not Applicable
competition from other companies that have also adopted the higher MEPS levels.						
Consumer Education: There might be a need to educate consumers about the benefits of higher MEPS levels, as well as any changes in product offerings. This involves marketing efforts or providing informational materials.	☐	☐	☐	☐	☐	☐
Product Testing and Certification: (Importers) need to invest in testing and certification processes to ensure that their products meet the required MEPS levels. This can involve additional time and financial resources.	☐	☐	☐	☐	☐	☐
Other, please specify	☐	☐	☐	☐	☐	☐

If you have any suggestions or comments you would like to share regarding the adoption of higher MEPS levels, please specify.

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Part III: Technical availability to improve of high-efficient ACs products and supporting needs

****If you are a manufacturer or your company produces AC locally, please answer this section. ****

2) What kind of capacity building do you think is necessary to uptake higher efficiency AC units?

Technical Aspect of Capacity Building Needs	Level of Capacity building need		
	Low	Medium	High
Selection of appropriate equipment type and size, with high-efficiency cycles and components.	☐	☐	☐
• Heat Exchangers (Indoor unit/Outdoor units)	☐	☐	☐
• Compressor	☐	☐	☐
• Advanced Control Equipment	☐	☐	☐
Advanced control systems require appropriate IT sensors and instrumentation.	☐	☐	☐
Knowledge and in-depth understanding of climate conditions load characteristics and psychometric process	☐	☐	☐
Advanced control algorithms.	☐	☐	☐
Personnel/in-house technical resources for product improvement to meet the higher energy efficiency level	☐	☐	☐
External professional expert to support R&D improvements to meet the high-energy efficiency rating	☐	☐	☐
Other, please specify.....	☐	☐	☐

3) what kind of support or resources would be most valuable to your company in the process of adopting higher MEPS levels?

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4) **What kind of technical and financial support do you need to transform the manufacturing process and make highly efficient RAC products? Please specify the priority level of supporting needs.**

Technical and financial support needs	Priority of supporting needs		
	Low	Medium	High
Technology Transfer for product design and product improvement, including capacity building	☐	☐	☐
Outreach to external professionals to further develop in-house resources	☐	☐	☐
Collaboration with the university for R&D/ Product prototyping and Equipment Testing	☐	☐	☐
Technical collaboration for the supply of high-efficiency components	☐	☐	☐
Financial Incentive for production line expansion and conversion to produce high-efficiency products.	☐	☐	☐
Financial support/Incentive policy mechanism/Tax reduction to increase inverter AC production	☐	☐	☐
Financial support for eco-friendly design and circular economy development	☐	☐	☐
Other, please specific.....	☐	☐	☐

5) **Do you need any financial support/Incentive policy mechanism/Tax reduction to/increase your inverter production? Why?**

☐ No
☐ Yes

If yes, are there any specific policies, incentives, or initiatives that you believe would facilitate the transition to higher MEPS levels?

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Thank you in advance for your cooperation.

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