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IeGRESAFE 2022

E-PROCEEDING OF

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"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

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ORGANISED BY

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THE LEVEL OF AWARENESS AND APPLICATION OF ENERGY-EFFICIENT STRATEGIES IN LANDED RESIDENCES OF MELAKA SUBURBAN

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Abstract

Population dynamics due to urban sprawl are one of the environmental consequences since population expansion in the city and changing lifestyles have affected energy supply demand in suburban areas, resulting in a growing conflict of energy consumption. The application of renewable energy (RE) and energy-efficient strategies is vital for environmental sustainability in residential buildings. This research aims to establish the importance of adopting energy-efficient and renewable energy onto residential buildings in monitoring carbon footprint due to urban sprawl. The objective is to investigate the level of awareness and application of energy-efficient strategies in landed residences of the Melaka suburban area and how these strategies contribute towards energy efficiency to meet the future energy demand. The questionnaire included various questions to provide an understanding of the residents' level of awareness towards the application of energy-efficient strategies in residential buildings and their actual implementations, such as the use of solar panels. Three different types of landed residential buildings in Taman Angsa Mas and Taman Kasawari were chosen to collect the building temperature data and assess the application of energy-efficient strategies among the residents. The result shows that the residents are aware of the importance of energy efficiency, supported by the finding that residential house integrated with solar panel has the lowest mean room temperature. This is due to the mechanism of solar panels, which preclude heat from being absorbed by the roof, thus resulting in less space cooling load with reduced energy consumption. The overall finding concludes that the application of solar panel systems improves the energy efficiency of landed residences and helps reduce the carbon footprint in suburban areas. With proven energy-efficient performance, the application of the solar panel system in landed suburban residences can be considered as part of future guidelines towards reducing carbon footprint due to future urban sprawl.

***Keywords**: Energy-Efficient, Renewable Energy, Residential Buildings, Carbon Footprint, Urban Sprawl*

INTRODUCTION

Background

Renewable energy (RE) is derived from natural resources that are naturally restored, such as sunlight, wind, rain, and geothermal heat. Solar photovoltaic (PV) systems generate alternative methods of harvesting electrical power from renewable energy in Malaysia. The application of solar panels in city residential areas saw a huge leap in demand due to a high level of awareness of energy efficiency and consumption (Koerner et al., 2022).

Due to the tropical climate in Malaysia, weather fluctuation significantly impacts a substantial increase in temperatures, thus necessitating more demand for space cooling by three times by 2050 (Azman et al., 2021). This creates a higher energy demand, putting more strain on the electrical power supply system in Malaysia. Population dynamics is one of the most crucial environmental consequences since population expansion and changing lifestyles have raised the demand for energy supplies, resulting in challenges such as growing conflict among energy users.

City development in Malaysia between the 1950s to 1970s has transformed the city skyline, underwent significant changes in land use, and followed by the emergence of new townships such as Sri Petaling in the mid-1970s that expanded around the city fringes due to urban expansion in Kuala Lumpur (Hidayati et al., 2021). This phenomenon is known as urban sprawl. The development of mass housing development resulted in the rapid growth of residential communities in the early 1990s. Rising population, economic growth, and changes in people's lifestyles lead to higher demand for electrical consumption (Kifle Arsiso et al., 2017).

Research Problem

As the city expands to the suburban areas, these areas need to resort to alternative energy resources to meet the future demand for electrical consumption due to urban sprawl (Aldhshan et al., 2021). Together with urban sprawl and increase of the energy demand, the readiness of the area around the city fringes to meet the future energy load should be taken into consideration by adopting energy-efficient strategies and renewable energy systems as alternative energy resources. These city fringe areas include city outskirts, suburban and rural areas. The failure to monitor energy consumption and not having alternative energy resources may cause energy depletion and power outages due to an imbalance in energy supply and distribution (Martin and Rice, 2021).

Integrating the power generation from renewable energy in suburban areas helps supply power demand and reduce carbon emissions (Dellosa and Barocca, 2021). Thus, RE is a potential alternative to electrifying these areas to meet current, and future energy demands as the city expand to the suburban area. Unfortunately, the implementation of energy-efficient practices and appliances such as solar panels as a renewable energy strategy is more prominent in the city area and less prevalent in the suburban area due to its high initial costs (Saad et al., 2022) and lack of awareness on the importance of using renewable energy resources as part of domestic practices (Elahi et al., 2022). This calls for the investigation of the level of awareness of the suburban residents and the implementation of renewable energy resources and energy-efficient practices to curb the exponential increase in carbon footprint due to urban sprawl.

Aim

This research aims to establish the importance of adopting energy-efficient and renewable energy in monitoring carbon footprint due to urban sprawl. The objectives are to:

i. To investigate the level of awareness of Melaka city suburban residents on renewable energy and energy consumption
ii. To examine how energy-efficient measures is being practiced by the suburban residents,
iii. To establish how the application of energy-efficient practices and renewable energy systems can reduce energy consumption in landed residential buildings

LITERATURE REVIEW

Renewable Energy System in Malaysia

The power source is readily available from various alternative resources to allow electrical conservation and energy consumption (Opare et al., 2019). The government influenced renewable energy development by establishing an updated energy framework and increased public awareness through local enforcement of a cleaner environment by reducing greenhouse gas emissions in Malaysia (Vaka et al., 2020). Malaysia has undergone initiatives to enhance hydropower, as seen by the proposal of 12 mega-dams in the Bornean state under the Sarawak Corridor of Renewable Energy (Tang, 2020). According to Cheam et al. (2021), Malaysian government recently achieved 20 percent renewable energy by 2025. Renewable energy sources available for generating electricity in Malaysia include mini hydro, biogas, solar photovoltaic (PV), solid wastes, and biomass (Hamzah et al., 2019), with combined total energy output from these resources were able to generate 11,227 GWh in 2020 (Aldhshan et al., 2021). Among all these resources, an immense contribution came from solar PV. With the development of 12 Green City Action Plans (GCAPs) by the government for major cities of Malaysia, the areas around the city fringes should consider transitioning towards a renewable energy system. While city areas are predominated by excessive electrical consumption issues, it is crucial to take a step ahead by using renewable energy systems and adopting energy-efficient strategies in suburban areas to prevent a significant increase in carbon footprint due to future urban sprawl.

Energy-Efficient Strategies in Malaysia

Solar energy has the most significant potential of any renewable energy source in Malaysia due to its strategic geographical location in the tropical region (Cheam et al., 2021). Due to the high initial adoption cost, the Malaysian government launched a range of solar power promotion programs and strategies by providing financial assistance to solar power consumers through subsidies. This initiative allowed solar PV owners to benefit from the sale of generated electricity to Tenaga National Berhad (TNB) (Cheam et al., 2021). The initiative is led by example by the Melaka state government following the Malaysia Green City Action Plan (GCAP) implementation, launched in 2013. The effort reached another milestone in 2020 when World Solar Valley (MWSW) operated on 7,248 hectares of land, generating 5MW worth of electricity to power economic activities such as manufacturing, commercial and domestic uses, and agriculture (Vadeveloo et al., 2021). One of the most viable renewable energy strategies in residential areas is installing solar panel systems (Muhibbullah, 2021). Although typically regarded as expensive due to its initial installation costs, the investment is feasible in the long run and results in zero-emission (Xin et al., 2022).

Solar Panel System in Malaysian Landed Residences

The application of renewable energy in residential buildings is the key to excellent environmental sustainability. It reduces greenhouse gas emissions produced by domestic use by eliminating the need to burn coal and other non-renewable energy resources to generate electricity. Photovoltaic (PV) modules on building rooftops provide shading against harsh sunlight, thus reducing the temperature input to the ceiling and building. Reduction of excess heat necessitates less space cooling load during hot weather and helps to conserve building energy (Alasadi et al., 2022) which contributes to reducing carbon footprints. Through PV solar panel system installation at home, residential customers can generate income by selling excess power generated from solar sources to the local electricity provider such as Tenaga Nasional Berhad (TNB) or Sabah Electricity Sdn. Bhd (SESB) (Razali et al., 2020). This initiative is implemented by the government effective from 2021 to 2023 under Net Energy Metering (NEM) Scheme 3.0 with a total quota allocation of 800MW to encourage solar energy harvest and increase Renewable Energy uptake (Zain Ahmed et al., 2021).

Typical terrace dwellings recorded a monthly usage of 455kWh (Abdul-Razak et al., 2019). In relation to mass housing development, the application of solar panels onto landed residential areas possesses a vast potential of solar energy catchment due to the volume of the mass housing within a single development time, the roof coverage of solar panels per unit house that can generate enough power supply without relying on non-renewable energy sources from the primary electricity provider. Landed mass housing development has a higher potential for solar power generation than multi-level housing development due to the availability of more roof areas for solar panel coverage per unit house. In contrast, multi-level housing development consists of more consumption per unit shared under the same roof with limited solar panel coverage. In the context of urban sprawl, such energy efficient and renewable energy harvesting can be implemented onto residential units in the suburban area where landed residential can be found, thus providing more potential for solar energy catchment.

METHODOLOGY

Data Collection Methods

The study employs the questionnaire survey, which included a variety of question formats allowing for an understanding of the application of energy-efficient practices and renewable energy systems in residential buildings. The observation will be conducted to perceive, evaluate, and interpret the knowledge of energy-efficient strategies of residential buildings from the individual perspective by going to the site and collecting the data. Three residential buildings in Taman Angsa Mas and Taman Kasawari were chosen based on their location in the suburban of Melaka to collect the building temperature data and application of renewable energy systems. The study was conducted one day on a weekday and one day on the weekend to discover the difference between both days.

Sample

Participants

The questionnaire participants of 30 residents in Durian Tunggal, Melaka, were randomly picked from three types of landed residential buildings for collecting the data on building temperature and the application of renewable energy systems. The considerable number of responses collected for this study is based on the viability of data collection during a limited research time and sufficient to provide preliminary information.

Location

The location of residential buildings chosen for this study is Taman Angsa Mas and Taman Kasawari in Durian Tunggal, Melaka. There are three types of houses: single-story terraces in Taman Kasawari is labelled as House A, double-story terraces in Taman Angsa Mas is labelled as House B, and double-story Semi-D in Taman Angsa Mas is labelled as House C. These selections reflect the focus of the study, which is targeted at landed residences in Melaka suburban locality.

Figure 1
The Solar Panels on House C's roof

(Source: Author)

Procedure

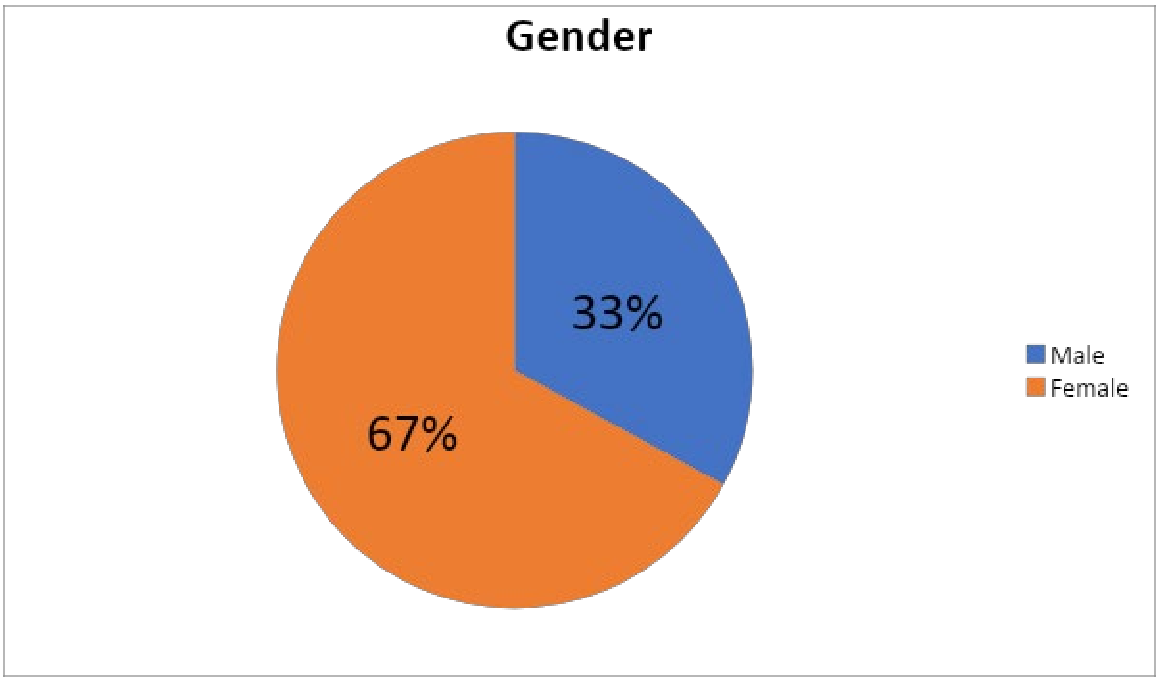
The questions were developed by determining the information required to achieve the aims and objectives and evaluating the research problem. The questionnaire consists of three sections: respondent background, basic knowledge, and level of awareness and application. The respondent background section was created to collect demographic data from respondents to study population dynamics. The second section was designed to evaluate respondents' knowledge of Renewable Energy (RE) and the respondents' level of awareness of electricity consumption. The final part was to investigate the use of RE in respondents' houses. The questionnaire from Google Form was distributed through WhatsApp and collected the data about applying renewable energy systems in their house for one week. Observation data are collected by measuring the temperatures from the selected residences. The temperatures were measured in the morning, noon, and night

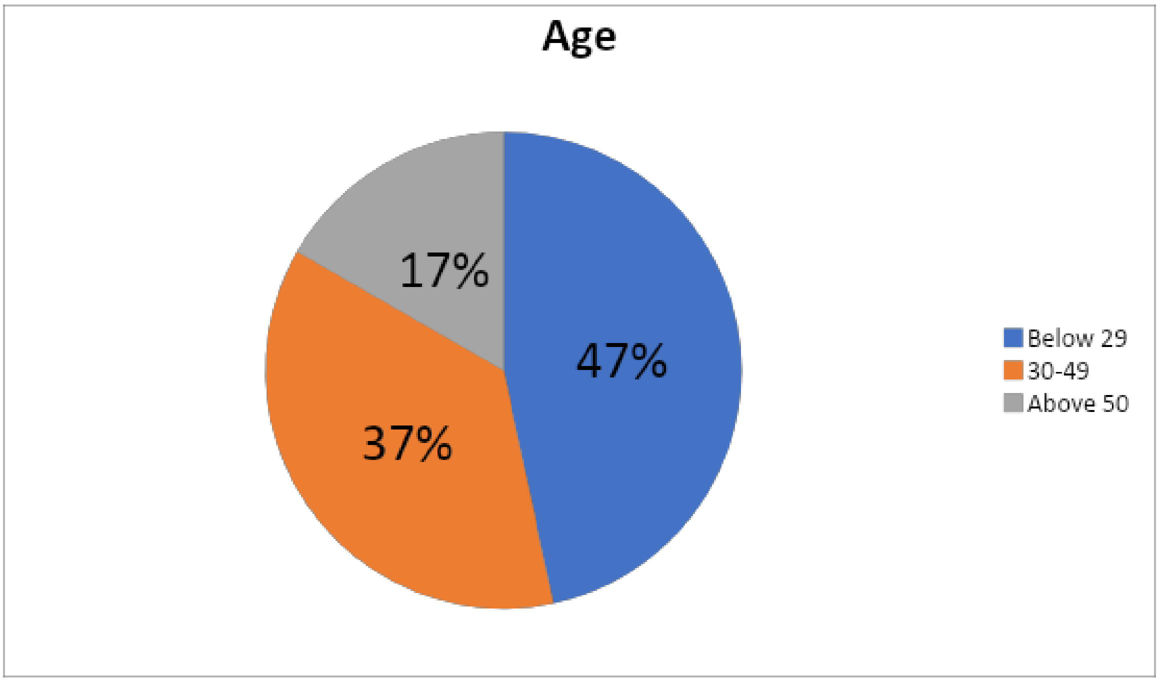
FINDINGS AND DISCUSSION

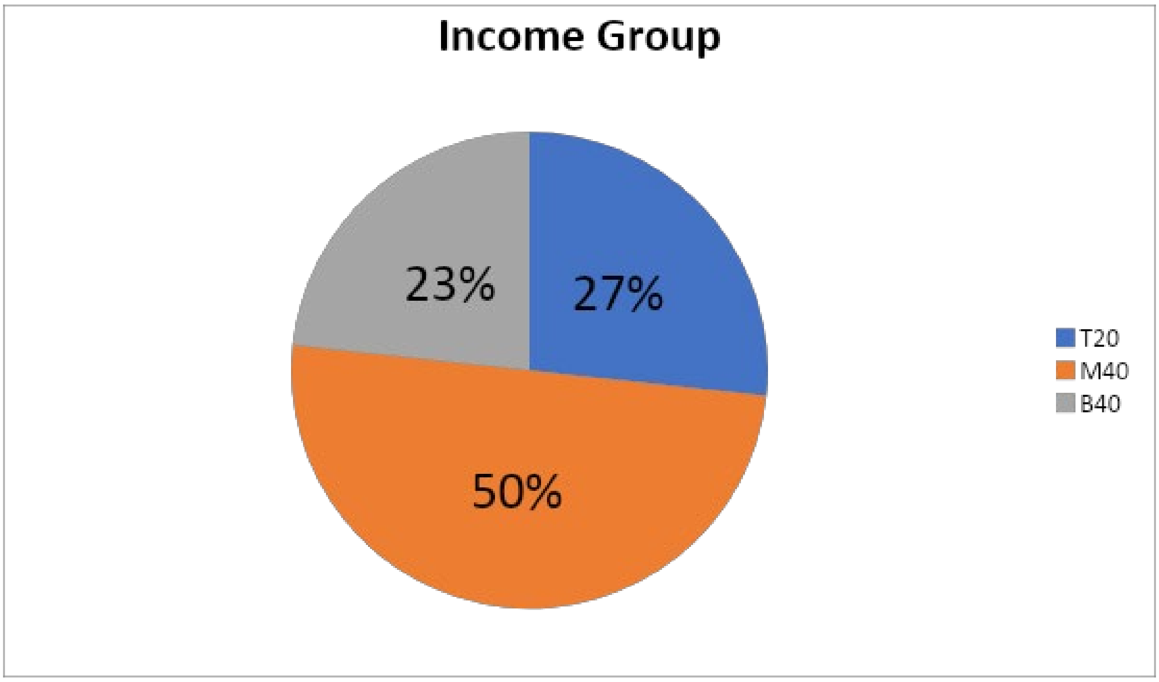
The data collection, a questionnaire survey, was divided into three (3) sections: respondent background, basic knowledge, and level of awareness and application of the energy-efficient strategies in the respective residential buildings.

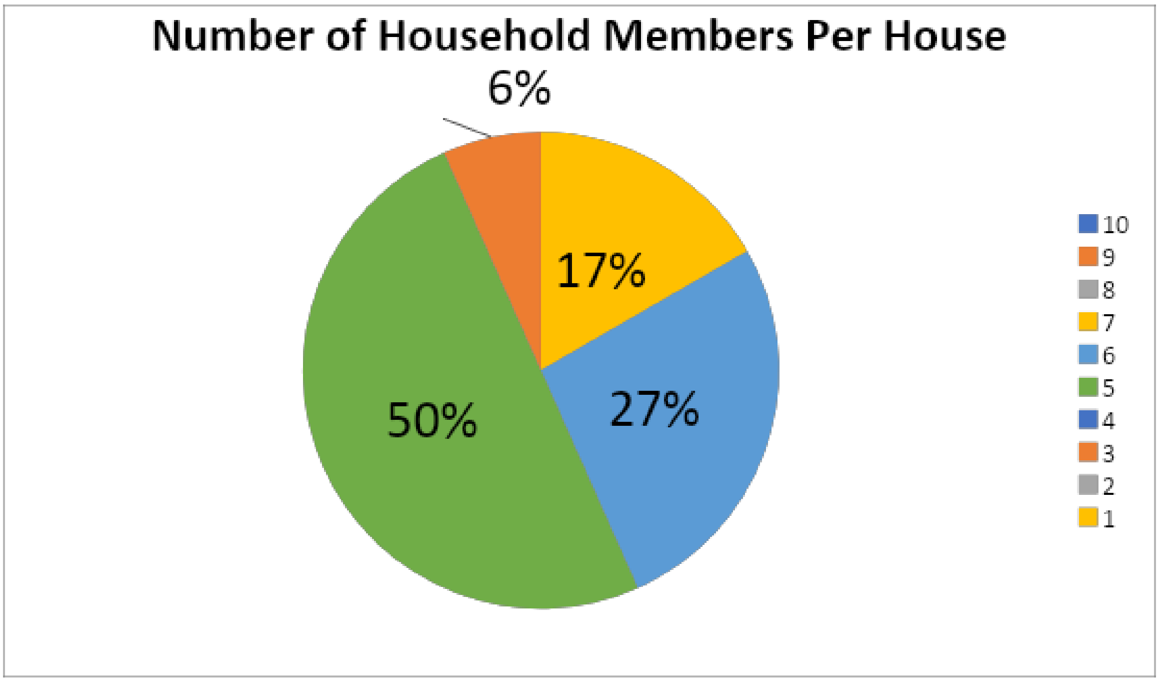
Respondent background

The questionnaire gathered respondents' demographic data, including gender, age, income classifications, number of household members, and type of house. 66.7% of the total respondents were females, and the other 33.3% were males. 46.7% of the respondents were below 24 years old, 36.7% were within the age group of 30 to 49 years old, and 16.7% were above 50. Meanwhile, 15 respondents have five members in the household, eight respondents have six members, five respondents have seven members, and the remaining two respondents have 3 and 8 members. Terrace houses live by 60% of respondents, 23.3% of respondents reside Semi-D houses, bungalow houses live by 13.3% of respondents, and only 3.3% of respondents live in house lots.


Gender
33%
67%
Male
Female


Age
17%
47%
37%
Below 29
30-49
Above 50

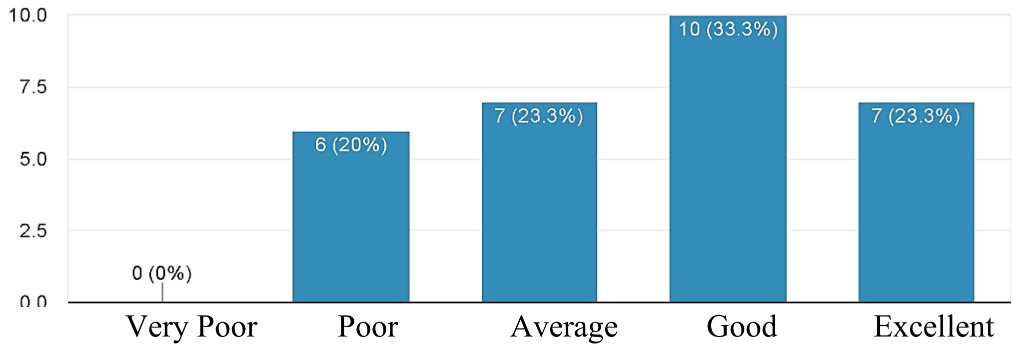

Income Group
23%
27%
50%
T20
M40
B40


Number of Household Members Per House
6%
17%
27%
50%
10
9
8
7
6
5
4
3
2
1

Basic knowledge and level of awareness

Figure 2

Level of Understanding of Malacca Residents' Renewable Energy

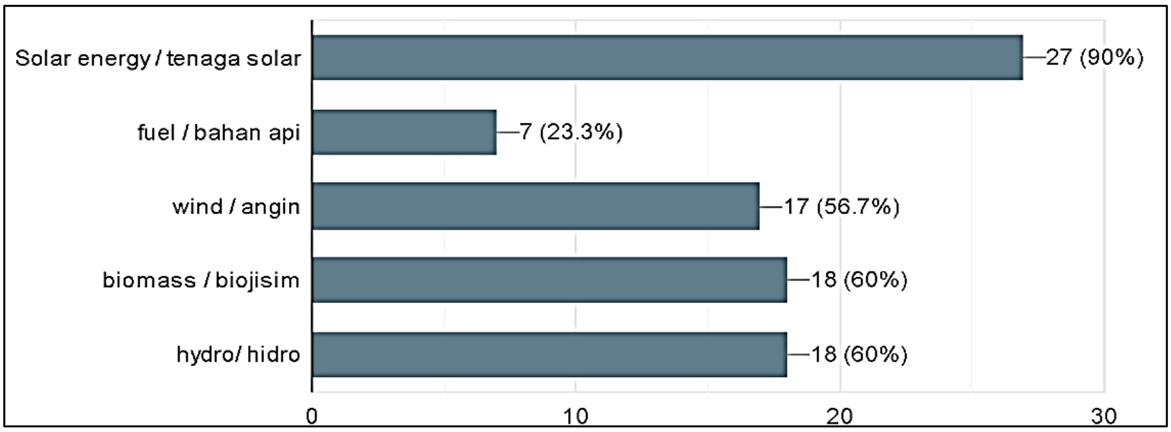


(Source: Author)

The figure 2 above shows the level of understanding of RE of Malacca residents, where Poor is indicated by most of the respondents (33.3%) recorded having good knowledge, fair and excellent performance 23.3% of respondents, and the remaining 20% of respondents have a poor understanding of RE.

Figure 3

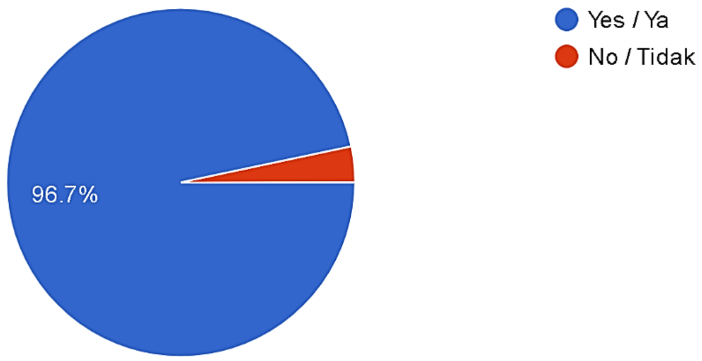
Respondents' Knowledge on The Type of Renewable Energy



(Source: Author)

Figure 3 above shows respondents what energy is RE. This data could be used to assess respondents' knowledge of renewable energy. The mean recorded for solar energy (0.90) was the highest among all power, thus concluding that most respondents are exposed to this RE. Meanwhile, biomass and hydro were recorded with a similar mean of 0.60, and wind (0.57). The lowest standard recorded for fuel is (0.23), which shows that some respondents misidentify Renewable Energy.

Figure 4
Respondents' Awareness of Electricity Usage and Bills



(Source: Author)

Figure 4 above shows the respondents are aware of electricity usage and bills. This data can reflect respondents' level of awareness toward electricity usage and bills. 96.7% of respondents were aware of their use and bills, while only 3.3% were unaware. It concluded that the level of awareness of respondents' usage and bills is high.

Table 1
Respondents' Actions to Reduce Their Electricity Consumption

Respondents	What do you do to save on electricity consumption?
Respondent 1	Shut down electrical & electronic devices such as TV when not in use to avoid excessive electrical consumption
Respondent 2	None
Respondent 3	None
Respondent 4	Turn on the fan when in use only
Respondent 5	Not installing air-conditioner at home
Respondent 6	Use 5-star rated electronic appliances (Energy efficient)
Respondent 7	None
Respondent 8	Turn of the stove and fan when not in use
Respondent 9	Use renewable energy
Respondent 10	Limiting the use of air-conditioner
Respondent 11	Avoid energy wastage
Respondent 12	Turn off the switch when not in use
Respondent 13	Using solar-powered lighting around lawn & garden area
Respondent 14	Only using an air conditioner during night-time, limit time using computers.
Respondent 15	Always turn off the switch when not in use
Respondent 16	Turn off the switch when not in use
Respondent 17	Turn off the switch and unplug the electrical appliances when not in use.
Respondent 18	Menggunakan tenaga dan air dengan secara terancang.
Respondent 19	Reduce electrical consumption.
Respondent 20	Turn off the electrical appliances when not in use.
Respondent 21	Turn off the switch after using electronic appliances, switch off the fan and lighting when not in use, reduce TV screen time and oven

Respondent 22	Turn off when not in use
Respondent 23	Turn off and unplug the electrical appliances when not in use.
Respondent 24	Reduce electrical consumption.
Respondent 25	Reduce any electrical usage during the day.
Respondent 26	Unplug all the electrical appliances when not in use.
Respondent 27	Turn off the lights when not in use
Respondent 28	Turn off the switch when not in use
Respondent 29	Practise energy-efficient strategies such as installing solar panel
Respondent 30	Install the solar panel

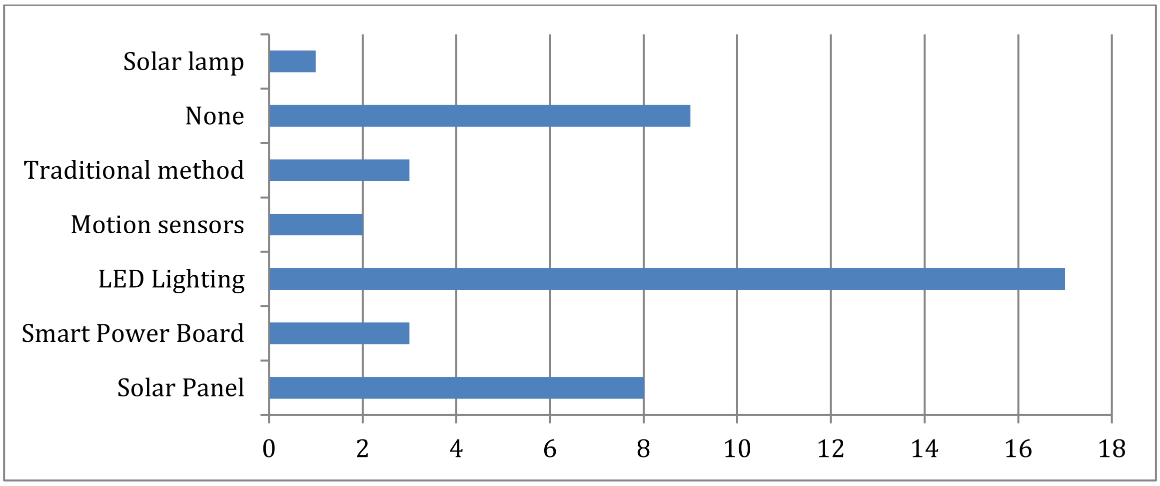
(Source: Author).

Table 1 above are the collected information about what respondents do to save on electricity and water consumption. 46.7% of respondents said they would turn off the switch and electronic devices when not in use. 30% of respondents indicated that they reduce electrical usage by only using air-conditioners at night, limiting electronic equipment time. They used renewable energy such as solar panels and solar light with a percentage of 13.3% of respondents. Three respondents do not do anything to save on electricity consumption. Respondent also used five stars rating energy efficiency electronic equipment. Only 1% of respondents did not put energy-efficient measures into practice, totalling 99% of the overall respondents are aware of the importance and put energy-efficient awareness into practice.

Application of Energy-Efficient and Renewable Energy

Figure 5

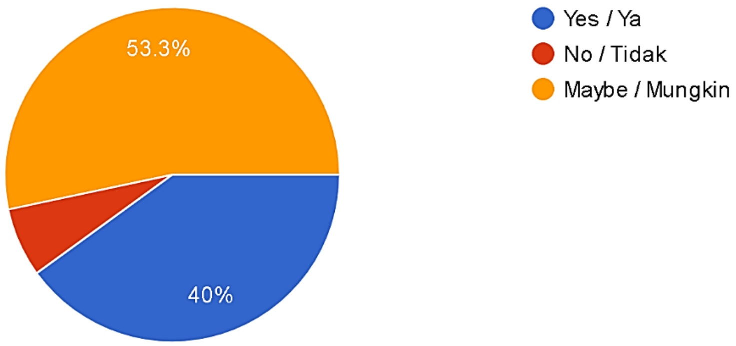
System or Technology Is Available in Respondent's House to Save Electricity Consumption



(Source: Author)

Figure 5 above shows the system or technology available in the respondent's house to save electricity. This data reflects the incorporation of systems or technology that saves electricity in residential buildings. The mean for LED lighting (0.57) was the highest among all the equipment, while the mean for solar lights or "lamp Solar" (0.03) and motion sensors (0.07) was the lowest mean recorded. Smart power board shared the same mean of 0.1. Lastly, 26.7% of respondents incorporate solar panels in their houses.

Figure 6
Respondents' Future Consideration in Using Renewable Energy System



(Source: Author).

Figure 6 above shows the respondent planning to use renewable energy technology system. 53.3% of respondents consider using RE technology and strategy because it is cost-efficient, saves electrical consumption, and is convenient for daily work, while having the second thought of RE technology being too expensive and that they currently do not have the consideration for future use of RE. 40% of the respondents were planning to use it because they wanted to lower their bills and be environmentally friendly. In comparison, 6.7% of respondents did not intend to use it without justification.

Table 2
Temperature of Three Residential Buildings in Taman Angsa Mas and Taman Kasawari, Durian Tunggal, Melaka

Type of house	Location	Date	Time	Room temperature (°C)	Outdoor temperature (°C)
Single Storey Terrace (House A)	Taman Kasawari	28/11/21 (Sunday)	6:30 - 8:30 a.m.	31	25
			1:30 - 4:30 p.m.	30	29
			8:30 - 11:59 p.m.	35	29
		29/11/21 (Monday)	6:30 - 8:30 a.m.	28	25
			1:30 - 4:30 p.m.	33	31
			8:30 - 11:59 p.m.	28	27
Double Storey Terrace (House B)	Taman Angsa Mas	28/11/21 (Sunday)	6:30 - 8:30 a.m.	24	25
			1:30 - 4:30 p.m.	31	29
			8:30 - 11:59 p.m.	30	29
		29/11/21 (Monday)	6:30 - 8:30 a.m.	26	25
			1:30 - 4:30 p.m.	31	31
			8:30 - 11:59 p.m.	29	27
Double Storey Semi D (House C)	Taman Angsa Mas	28/11/21 (Sunday)	6:30 - 8:30 a.m.	25	25
			1:30 - 4:30 p.m.	31	29
			8:30 - 11:59 p.m.	27	25
		29/11/21 (Monday)	6:30 - 8:30 a.m.	25	25
			1:30 - 4:30 p.m.	31	31
			8:30 - 11:59 p.m.	28	27

(Source: Author).

Table 2 above shows the temperature of three different residential building in Taman Angsa Mas and Taman Kasawari on weekdays (Monday) and weekends (Sunday). The mean temperature of Durian Tunggal is 31℃. The mean room temperature of house A on Sunday is 32℃, house B with 28.3℃, and the mean room temperature of house C is 27.7℃. While on Monday, the mean room temperature of house A is 29.7℃, house B is 28.7℃, and house C with 28℃. This data shows that house A has the highest mean room temperature while house C has the lowest mean room temperature for both days. The mean outdoor temperature for houses A and B on Sunday was 27.7℃, while house C with solar panels installed recorded a mean temperature of 26.3℃. On Monday, all houses shared the same mean outdoor temperature of 27.7℃. The result from house C showing a reduction of 4.7℃ from the mean temperature of Durian Tunggal locality supports the claim by Alasadi et al. (2022) that the solar panels preclude heat from being absorbed by the roof where it limits the additional heat from being generated. The reduced amount of heat cuts down the amount of cooling load required, thus helping to reduce energy consumption.

CONCLUSION

In conclusion, the awareness among the residents of Melaka suburban on the importance of energy-efficient strategies is evident from the use of Renewable energy and systems applied to residential buildings, especially the solar panel system. In the context of the locality of Melaka suburban, this finding opposes the claim made by Saad et al. (2022) and Elahi et al. (2021), where 99% of the suburban residents are aware of the importance of adopting energy-saving practices. The high level of awareness of the importance of energy-efficient strategies is translated into actual implementation, where the houses in Taman Angsa Mas are installed with solar panels.

Besides that, the result shows that houses with solar panels have the lowest mean room temperature than houses without solar panels. This result supports the claim by Alasadi et al. (2022) that solar panels prevent heat from being absorbed by a roof and, as a result, contains extra heat generated due to cooling load demand. The overall finding supports a statement by Koerner et al. (2022) that the application of solar panel systems improves the energy efficiency of landed residences and helps to reduce the carbon footprint and emissions in suburban areas. With proven energy-efficient performance, the application of the solar panel system in landed suburban homes is highly recommended as part of future guidelines towards monitoring the spread of carbon footprint due to future urban sprawl in Malaysia. This recommendation is in line with Green City Action Plan (GCAP), focusing on carbon footprint reduction measures in the Melaka locality.

Future research on this study can be extended on a larger scale, including a comparative analysis of the level of awareness and application of energy-efficient strategies between urban residents, city outskirts, and rural area residents. The outcome of the future research would contribute to the formulation of specific guidelines that cater to the different levels of awareness and energy-efficient practices for each locality according to varying stages of urban growth. With successful implementation, the projected carbon footprint impact can be reduced significantly due to the size of the residential development and contribute positively to the environment.

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