SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Sustainable Development in Renewable Energy: Solar Energy Application in Malaysia

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ARTICLE INFO

Article history:
Received 9 February 2023
Received in revised form 29 August 2023
Accepted 4 December 2023
Available online 8 April 2024

Keywords:
Sustainable development, Renewable energy; Solar Energy; Solar Panel; Technology

ABSTRACT

The purpose of this study is to explore the benefits and types of solar panels in the market that can encourage the building management team to adopt the solar energy usage in Malaysia. Solar energy has been long introduced to the industry as a practical renewable technology, but the adoption rate is still low in Malaysia due to the dependence on oil and fossil fuels. Thus, costs and benefits of solar energy application and the best solar panels to be used in Malaysia have been explored for practitioners' reference to improve the adoption rate. Mixed method was adopted in this study. First, quantitative method was adopted where 200 sets of online questionnaire survey were distributed to the public to collect the information about the solar energy application. Next, a semi-structured interview was carried out to further investigate the reliability of collected data. Based on the findings of the questionnaires, the most significant benefits of solar energy are renewable and clean source of energy, eco-friendly, and cost saving. The results indicated that Mono-crystalline silicon cell is the most popular type of solar panel that widely used in Malaysia. However, the adoption of solar energy is low due to the high initial cost and insufficient knowledge and awareness among citizens. Through the results of this study, the adoption of solar energy can be doubled in future as the results reveal the factors and benefits that could help the policy makers to utilize the implementation of solar energy in residential buildings that massively consuming the energy in daily basis.

1. Introduction

Rapid urbanization in Malaysia has caused the increase in the demand for energy. This phenomenon is not only occurring in Malaysia but in all developed countries where the world population has hike to 2 billion. Thus, ensuring sufficient energy supply is current most trivial issue [1]. Moreover, majority of human activities are highly related to the energy where most of the works cannot be done without the supply of energy [2]. This raises the concern of the public on the energy sources and consumption where the generating of energy has caused environmental issues.

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https://doi.org/10.37934/araset.43.1.116

Environmental protection is urgently needed to reduce the consequences of overly energy generation. This is even significantly as Malaysia is currently undergoing sustainable development [3]. Since energy market is expanding rapidly in various countries, these countries have come out with their own incentives, legislations, and monitoring tactics. As the population growth has hasten the diminishing of available resources, adopting renewable energy has become inevitable [4]. There are several energy sources that are clean, sustainable, and accessible such as solar energy, wind, tides, rain, and geothermal heat which are renewable in natural. These energy source have grabbed attention of green energy's practitioners to achieve clean production and sustainable development [5], [6]. However, the world including Malaysia is still lack behind in the context of green energy adoption where the main source of solar power generation, solar photovoltaic (PV), only generated 1.5% of the world's total power production [2].

Malaysia has huge advantages in terms of its abundance of solar energy where Malaysia located on the Earth's equator as one of the areas that possesses the most abundant solar energy sources [7]. This provides a great opportunity for the development of solar energy [8]. However, this needs to be supported by the analysis of regional solar distribution and spatio-temporal variability which can show the gaps between the available solar energy resources and the actual utilization of solar power that going to bring obvious impacts for adopting green energy and planning long term development plan for solar energy implementation in Malaysia. The report of International Energy Agency said that the adoption of solar PV technologies between 2008 to 2050 can avoid 100 Gigaton of CO_2 from being emitted [9]. There are a lot of new buildings being constructed in Malaysia, especially high-rise buildings for residential and commercial purposes. However, the adoption of solar energy in buildings is rare where most of the residential and commercial buildings are still using traditional electricity provided by Tenaga Nasional Berhad (TNB). This is due to the low understanding among the buildings management team on the solar panels' installation and the concern on the initial and maintenance cost of the solar energy implementation. Therefore, this study intended to identify the benefits of solar energy adoption and to evaluate the most famous types of solar panel being used in Malaysia to boost the adoption of this green energy.

Nowadays, our nation is highly contaminated by fuel-based combustion gases to satisfy the energy demand. This is aligned with other developing nations situations as they are being forced to seek for alternative energy sources due to the increased in the demand of energy supply [4]. Based on International Energy Agency's prediction, the world needs to double up the energy supply in the next 40 years to fulfil the demand of the population [10]. Currently, Malaysia is practicing conventional approach to generate energy such as coal burning and water dam but due to the exponential increase in the demand of energy, Malaysia cannot count on these conventional approaches to fulfil the consumption anymore [11]. Renewable energy which also known as green energy should be utilized [1]. Solar energy as one of the renewable energies has been slowly adopted in Malaysia since 2010s due to the decline in the supply of fossil fuels [12]. Although the development of solar energy is increasing but there are also significant challenges such as high initial cost compared to the conventional fossil fuel system which causes fossil fuel system to dominate the main trend of global energy demand [1]. This is causing significant negative environmental impacts. This happened due to the air-conditioning systems and other large energy consumption such as factories [13], [14]. Therefore, solar energy should be adopted in buildings with the combination of energy-efficient techniques as it is an effective approach to apply green development [15], [16]. However, solar photovoltaics received less attention by researchers [17], [18].

High-rise buildings are consuming massive amount of electricity daily. The electricity is used in all kinds of residents' daily activities such as air-conditioning to cool down the room temperature and producing hot water supply. Since Malaysia is still relying on the traditional way to generate

electricity which going to cause pollution, this indirectly causing building sector to contribute a high percentage of the whole environmental pollutants and released gases that have tremendous influence on the atmosphere [19]. Due to the threats like pollutants and global warming caused from electricity generating through traditional approach, high-rise buildings started to gained attention in many countries as a platform to substitute renewable energy such as solar energy to be the pioneers in utilizing these sources [20, 21]. In addition, as buildings are consuming vast amount of energy, the future buildings should be constructed with the purpose of energy-efficient which can consume the least possible energy. Furthermore, this situation can be mitigated by utilizing the vast façade of the building where it has high possibility to adopt solar energy as the facilitating source for electricity supply. This is because solar energy is a permanent renewable energy source that can be used as an architectural point of view that utilizing the passive solar strategies [22]. Moreover, due to the height of the building and façade that majority made by glass, these high-rise buildings can easily collect the solar radiation. Therefore, high-rise buildings should attempt to maximize the advantages of solar radiation where this can be used as an alternative energy source in the building. To ensure high-rise buildings are adopting solar energy, the management team must be educated with sufficient knowledge on the benefits of solar energy and types of solar panels that can be used in high-rise buildings.

1.1 Strength of Solar Energy in High-rise Buildings

Ren, et al. [23] highlighted solar cell provides year-round efficiency and savings once installed. The finding shows that savings of electricity often occurs in the reduction of utility bills especially when the household using inter-grid system with continuously power supply. Akarsu and Serdar Genç [24] opined that some solar panels can generate extra electricity than the daily home consumption and this can eliminate the monthly electricity bill. The users can sell the exceed electricity to the grid to offset the utility bill resulting a cost saving. However, it depends on the size of the solar panels, its efficiency and orientation relative to the sun. Generally, solar PV system has a very long lifespan once installed. Bosman, et al. [25] mentioned that most of the solar panel manufacturers offer a long-term production warranty up to 20-25 years for PV array and 5-10 years for the inverters to attract the customers to purchase. There are little maintenance costs involving the replacement of inverter at least once prior to the end of the panel lifespan and regular cleaning works. Unlike other investments, the users start to enjoy the returns and add value to your house on the first day [25]. Furthermore, to ensure the returns and add value are maximized, once solar energy is adopted by the management team on the high-rise buildings, the buildings are considered as energy efficient buildings. As an energy efficient building, the design of the building is important such as considering the solar orientation of the installed solar panels to establish better solar radiation collection platform.

Energy is an essential factor in ensuring economic development which can generate wealth [7]. Thus, to improve the economic performances of a high-rise building, the solar panels can be installed on the roof of the high-rise buildings where this not only include the engineering design but also the architecture aspect. The roof must not only able to support the water tanks but also the solar panels to achieve the energy efficient in high-rise building. Future high-rise buildings construction should put this into the consideration. The installation of solar panels on the roof not only lead to economic efficiency but at the same time gaining environmental performance improvement [26]. This can be further achieved by analysing the energy consumption of the users where the usage can be analysed in different building parts such as the air-conditioning usage, heating insulation and hot water supply. This action helps to achieve the maximum overall comfort and living quality with the least possible energy and resources consumption [19]. As solar energy is renewable, it can be assumed that it will

never run out which can be exploit endlessly. However, this energy is not free as maintenance works need to be carried on the solar panels. The surface of the solar panels needs to be clean regularly to avoid dust from accumulated on it which will affect the solar radiation collection of the solar panels. All these need maintenance fees where experts are needed to do the cleaning services.

Florez and Ghazali [20] postulated that the maintenance work mainly involves cleaning the panels annually or twice a year and the cost ranges about RM300 to RM800. The end-users can save money on the maintenance works since there are no moving parts to breakdown in the solar system. Therefore, the necessary maintenance will be cleaning up the dust and debris build up on the panels to prevent performance of the solar panel system compromised like the sunlight radiant being blocked from contacting with the panels. So that the solar panels can perform maximum capacity of energy production. Besides, Malaysia government also introduced the Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE) to accelerating the investment in green technology equipment [27]. Wang, et al. [28] stated the ecosystems have been polluted seriously because of the emission of greenhouse gases (GHG) generated from the burning of fossil fuel. They also mentioned that it is important to go for eco-friendly energy source. Additionally, the current way of power generating by using fossil fuels is polluting the global water sources like river and ocean and causing acid rain. Some irresponsible service providers dispose the trashes to the river like coal ash which affect the river and the ecosystem. Shifting the power generator to solar energy can reduce the climate change. Solar power plants do not create air pollution or GHG during the process of energy generation. The increment of GHG can be evaded, as there is no combustion in the power generation process of solar energy.

1.2 Application of Solar Energy in High-rise Buildings

High-rise buildings are the main energy consumer in urban area where the energy is mainly used for air-conditioning and water heating purpose. Although constructing building which is energy efficient consume lesser energy, applying passive measures such as utilizing solar energy as the hybrid energy source is considerably reduce the primary energy consumption. This is because compared with other sources of green energy, solar energy gained more significant development towards practicability as Sun is a free source of limitless energy [29]. Implementation of solar energy going to reduce hazardous greenhouse gases from the conventional power generation [1]. Solar energy can be used for various purposes. For example, the solar energy can be used to generate the electricity with solar PV cell and to produce heat using solar thermal system. To differentiate among the two, the solar thermal system is simply converting the daylight into heat energy while the solar PV system turns the sunlight radiation into electricity [30]. Ren, et al. [23] highlighted that current solar cell is low in cost and having high energy conversion efficiency. In term of solar thermal energy, Liu, et al. [31] defined that the principle of solar thermal power generation is collecting the solar radiation through the reflectors and turning it into heat energy collection of hot charging. Subsequently, it is used to heat the heating device located in the heat transfer medium such as water heater.

Current sources of electricity generating such as coal and fuel are reducing greatly where the consumption of renewable energy is essential in ensuring the building can be ran in long term in the context of energy [14]. This justified the importance of the study on energy management and renewable energies are playing significant role in ensuring high-rise buildings can be sustainable to the environment. High-rise buildings will be environmentally friendly once adopting solar energy as their power sources. In addition, as the population in urban areas is growing significantly, more high-rise buildings are constructed as shelters where these buildings increasing become important in

adopting solar energy as alternative sources. Although it is important to adopt the implementation of solar energy in the early design decision that going to determine the building's future energy performance, but the post-rationalization of solar energy adoption is vital to be used as solutions with heavy energy demands [20]. This is significant due to the height of the high-rise buildings where they are more directly exposed to the weather such as solar radiations. Compared to the low-rise buildings, high-rise buildings have more potential to adopt solar energy. However, high-rise buildings need management team to pay special attention on these new technologies applied. This also obstructing the management team to develop high-rise buildings which is energy efficient and environmentally friendly. Thus, this further justified the immense consideration of the importance of this study.

Solar energy also can be used in clean water production through desalination from seawater. Elbar and Hassan [32] defined that the solar power desalination system removes minerals and salts from saline water and transform the air into fresh drinking water with the desalination process. Furthermore, the implementation of solar energy has lesser impact on cultivated soil and decrease the costs of the distribution grid transmission lines which eventually improve the life quality in remote areas [33], [34]. However, the generating of energy through solar energy is affected by weather such as storm and fog [1]. Thus, a proper modelling which can show an output simulation is essential to increase the efficiency of solar energy [35]. There are many benefits in adopting renewable energy where this is the trend of the future in building sector. Nowadays, there are many embedded systems that can be independent of the grid and can be combined as stand-alone generators within buildings which act as the alternative renewable energy for the building electricity usage. These generators can be utilized to work together with the solar panels where each of them can facilitate each other while providing sustainable energy to the high-rise buildings [36]. Thus, types of solar panel that used to collect the solar radiation is playing vital roles as well as different solar panel going to have different efficiency and outcome [37, 38].

1.3 Types of Solar Panel

Adopting correct solar panel in high-rise buildings will help the management team to save money while achieving economic returns in shorter period as there are various types of solar panel available in the market [39]. Management team needs to have deep understanding on the specifications of each solar panel which related to their initial cost, maintenance cost, warranty period, conversion rate and maintenance works as different solar panel will have different functionality and effects on the solar radiation collection while the conversion rate will be different [38]. Installing wrong solar panel will not bring convenient to the high-rise building management team but causing lost to the users and the management team. Thus, high-rise buildings in Malaysia should focus only on those solar panels that appropriate to be used in tropical climate where it can collect abundance solar radiation while sustain in the harsh weather such as heavy rain. Arnaout and Ii [40] highlighted that the solar photovoltaic (PV) systems are the devices which convert the solar energy to electrical energy by means of semiconductors in the PV cells. Considering the location of Malaysia benefiting from sunlight abundance, the solar PV systems gain the largest potential as a Renewable Energy (RE) source [41]. This study has explored two types of solar panels that most suitable to be used in Malaysia which include monocrystalline and polycrystalline solar modules.

Mono-Crystalline Solar Panel: Mono-crystalline (Mono-SI) solar panel is also called single crystalline silicon solar cell. It is the most popular type of solar panel used around the world [42]. Although it has the highest efficiency but is not economical due to high manufacturing cost. This cell is manufactured from single crystal of silicon through a process named Czochralski process [43].

During the manufacturing process, the silicon crystal is sliced from one large ingot and affixed onto a solar panel. The cost of this type of solar panel is slightly higher than the other types of solar panel due to its complicated process and longer timing to produce the mono-crystalline silicon [44]. Katyal, et al. [45] defined that Mono-SI PV module is the most efficient type of solar panel as when the sunlight reaches the panel, most of it turn into electricity and it is ideal to be installed on the roof. The efficiency of the cell is between 17% - 18% which highest among the other PV cells because the electrons have more spaces to move and create a better electricity flow [46].

Mono-SI panel has a black aesthetic which is good for sunlight efficiency. This type of solar cell maintain their efficiency in low light condition due to each solar cell is sufficient to continue generate electricity [47]. In term of durability, the PV systems are expected to remain its durability if they maintain a typical warranty which enables the PV system to maintain at least 80% of the original performance level after 25 years. According to Al-Habahbeh, et al. [48], Mono-SI modules usually come with 25 years guaranteed lifetime-warranty. However, Alani, et al. [49] highlighted that long period of exposing to high temperature will reduce the life span or loss some efficiency. This is because high stresses in the PV modules caused the module fails to function due to fatigue.

Polycrystalline Solar Panel: Polycrystalline (Poly-SI) solar panel which also known as multi crystalline silicon solar cell is made up from rectangle cells that blended by multiple pieces of silicon crystal. Sharma, et al. [46] defined that the Poly-SI PV modules composed several different crystals and transformed them into a single cell. Poly-SI cell's manufacturing process involves melting multiple silicon crystals and forming the panel itself. The molten silicon is casted into ingot and cut into a thin profile of wafer, subsequently assembled into complete solar cell [44]. Katyal, et al. [45] pointed Poly-SI has lower amount of silicon than the single silicon solar panels; hence, it is more cost-efficient and economical. Sharma, et al. [46] contended that the cell is a composition of molten silicon, and the efficiency is slightly lower as compared to the single silicon solar panel which lies between 12%-14%. In term of the sunlight efficiency, a Poly-SI will face problem during cloudy day. According to Gomesh, et al. [47], Poly-SI is not performing well in low light condition. The extra resistances caused by the inactive small crystals will results 50% loss in efficiency even only 20% of the part of solar panel is in the shade condition. Katyal, et al. [45] pointed if this solar panel is use, the overall construction design can cause reduction in efficiency if there are multiple shaded areas.

Both Poly-SI and Mono-SI solar panels are having same durability and reliability. For instance, unable to retain in high temperature for a long time. PV systems come with a 25 years' warranty once installed. A rigid mounting will protect and secure the Poly-SI. Sharma, et al. [46] highlighted durability of Poly-SI solar panel will only drop approximately 25% over 50 years once installed. Although the multi silicon solar panel is lesser efficient, it still becoming one of the popular types of solar panel used in worldwide including Malaysia because the cost for Poly-SI solar panel is more economical and efficient.

Figure 1 shows the conceptual framework of this study where the benefits of solar energy adoption and the most suitable solar panel to be used in Malaysia climate are acting as the independent variable while solar energy adoption rate is used as the dependent variable. The conceptual framework outlines the contribution of the study where this study believes if building management team is aware of the benefits of solar energy adoption and installing the correct solar panel in the building will increase the solar energy adoption rate in Malaysia significantly. Table 1 shows the main references for the benefits of solar energy adoption in this study.

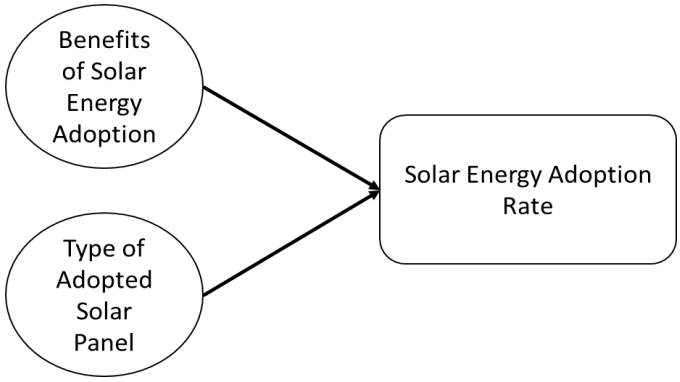

Fig. 1. Conceptual Framework

Table 1
Source of constructs

Benefits of solar energy adoption	Citations/sources
Renewable and clean source of energy	[1], [14], [4]
Eco-friendly	[1], [28]
Cost saving in electricity bill	[50], [22]
Diverse applications	[37], [31]
Investment return	[51], [27]
Low maintenance cost	[20], [25]
Mono-Crystalline Solar Panel	[39], [42], [45]
Polycrystalline Solar Panel	[39], [45], [46]

2. Methodology

This study employed a mixed method which combined both quantitative and qualitative data. Quantitative method was started first to confirm the collected information before the qualitative approach was started to collect the opinions from the expert in the industry. Questionnaire was employed as the quantitative data collection tool while interview was used to collect the qualitative information. The number of sample size is important to ensure the obtained results' reliability. This study has used the "10-time rule" to determine the sample size. According to Kavota, et al. [52], the "10-time rule" required the minimum respondents for quantitative research should be 10 multiply with the number of indicators in the study. As this study is having 21 indicators, that means at least 210 (21 indicators x 10-time rule) respondents should have respond to the questionnaire. On the other hand, the response rate is also important in a result to validate the reliability of the collected data. Poynton, et al. [53] and Nilson and Stedman [54] said that the normal response rate of online questionnaire is ranged from 20% to 30%, thus, this study aimed to reach this rate of response rate. Therefore, the questionnaires in this study were distributed to 1000 targeted respondents who living in Malaysia through email and internet platforms to ensure at least 200-300 respondents can response. These 1000 targeted respondents were chosen based on the types of building that they are currently staying as this will reflect the readiness of the respondents to adopt the solar energy application in their house.

The questionnaire intends to collect data related to the benefits of adopting solar energy and the most suitable solar panel to be used in solar energy harvesting in Malaysia to form the fundamental of questions for the interview session. After feedbacks from questionnaire were received, this study continued with the reliability, validity, descriptive and frequency analysis on the data collected from the questionnaire to reflect the actual conditions in Malaysia. The reliability of the data and internal consistency which based on how closely related a set of items were as a group was measured. Data

collected from the questionnaire were using a 5-points Likert scale were then analysed by Cronbach's Alpha analysis to measure the internal consistency, which refers to the reliability of multiple Likert questions in a questionnaire that forms a scale. Descriptive statistics were applied for all the data collected from the questions in the questionnaire and interview to indicate the mean and ranking of the data and identify the most critical element that should be considered. Besides, frequency analysis was categorized under descriptive analysis where it could indicate the frequency distribution of the data collected and determine the preferable element from the respondents. Descriptive analysis was carried out to identify the benefits of solar energy adoption, the type of solar panel that suitable to be used in Malaysia, and respondents' willingness to adopt solar energy. After all the examination and tests were completed, the research findings were tabulated and presented in the histogram, graph, table, or another suitable form.

Lastly, the study proceeded to the qualitative stage after all collected data has been assessed in quantitative stage. The results from the descriptive analysis were used as the fundamental to develop the interview questions used in the interview session. A semi-structured interview with a solar panel vendor was conducted to ensure the interviewee has freely expressed the opinions. Interviewee took part in an individual online interview due to the COVID-19 pandemic. The entire interview process is recorded using a sound recorder for research study purposes. The interviewee was asked about the benefits of solar energy adoption, the most suitable solar panel to be used in Malaysia and participant's opinion on the future of solar energy in Malaysia. The feedback from the interviewee was opened based on the interviewee' experiences and perspectives. Interview with the interviewee helps this study to gain more in-depth information on the effectiveness of using solar energy and reviews the most suitable solar panel to be used in Malaysia as the interviewee is the expert in the industry. Content analysis technique was used to categorize the information from the interview session. Next, based on this analysis approach, the common themes in the response were coded and reported. Finally, these themes and content analysis were summarized to show the opinions of interviewee. This is agreed by Mostafaeipour, et al. [55], where their research used the qualitative method to obtain experts' opinions. As a result, this method can provide more reliable information and efficient data to support the development of many respondents. Figure 2 shows the research flow chart of this study to ease the understanding of readers.

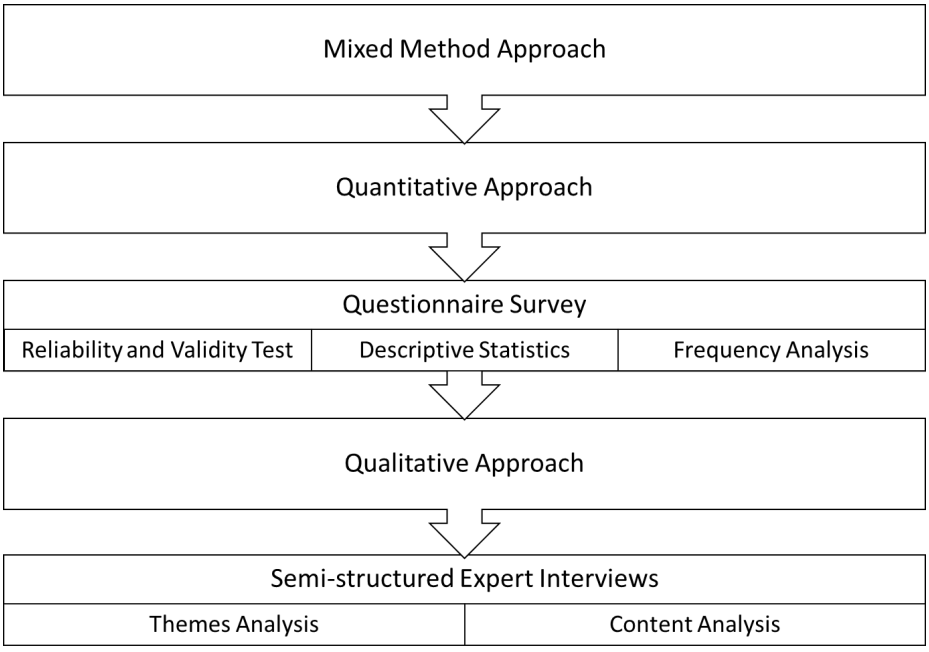

Fig. 2. Research flow chart

3. Result

The online questionnaire was distributed to a total of 200 public people. Table 2 shows the summary of data collection. Among the 200 questionnaires distributed, there were 139 valid and qualified responses received, resulting a response rate of 69.50%. Besides, 5 (2.50%) of the responses were disqualified as the respondents answered 'not sure' on the question related type of land title for their building. Lastly, 28.00% with a total of 56 targeted respondents did not response to the questionnaire form distributed.

Table 2
Summary of data collection

	Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Responded, valid & qualified	139	69.50	69.5	69.50
Responded but disqualified	5	2.50	2.50	72.00
No respond	56	28.00	28.00	100
Total	200	100	100	

Table 3 shows the summary of demographic detail of respondents. The respondents' general demographic information includes types of building that the respondents are staying currently, the land title of the building, the current ownership status of the building and current household occupancy is collected. Meanwhile, the subsequent questions are about whether the respondents are aware on the environmental changes caused by the fossil fuel, whether the respondents support the development of renewable energy, and whether the respondents have experience in using solar energy. The frequency analysis is used for data analysis in the section.

Table 3
Summary of demographic detail of respondents

Demographic Variable		Frequency	Percentage (%)
Types of Building	High-rise building (above 13-storey)	24	17.3
	Mid-rise building (between 5 to 12-storey)	21	15.1
	Low-rise building	94	67.6
	Total	139	100.0
Current Ownership Status	Renting	33	23.7
	Owning	106	76.3
	Total	139	100.0

Among the 139 responses received, 94 respondents (67.6%) involved are staying in low-rise building i.e., single/double storey terrace house, semi-detached house, detached house and/or building with or below 4-storey. 24 respondents (17.3%) reported that they are staying in high-rise building and 21 respondents (15.1%) involved are staying in mid-rise building.

The respondents were asked on whether they are renting or owning their building. The result is a total number of 106 respondents (76.3%) are owning their building while remaining 33 respondents (23.7%) are renting their building currently. The respondents' household occupancy is determined in the following question. Next, 5-points Likert scale questions related the benefits of solar energy adoption were asked in the questionnaire. The pros of the solar energy adoption include renewable and clean source of energy, cost saving in electricity bill, low maintenance cost, eco-friendly,

investment return and diverse applications. In this study, the reliability test is applied on the questions with 5-points Likert scale to study the internal consistency between individuals' items in the scale. The test is generated through Reliability Analysis. The result of Cronbach's Alpha reliability test for advantages of solar energy adoption is tabulated in Table 4.

The coefficient of Cronbach's Alpha for benefits of solar energy adoption is 0.823, which resulting a relatively good and high level of internal consistency for the scales of 6 items under benefits of solar energy application. This indicated that the data collected for the benefits of solar energy application is reliable and consistent for getting an accurate analysis result.

Table 4
Reliability Statistics

	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Benefits of solar energy adoption	0.823	0.831	6

Table 5 indicates the frequency and percentage on research constructs respectively. Out of the 139 respondents, there are 110 respondents (79.1%) answered "Yes" while only 29 respondents (20.9%) responded "No". Consequently, Table 5 indicated that majority of the respondents are aware on the environmental problems caused by the burning of fossil fuel. Next, respondents were asked to indicate whether they support the development of sustainable energy. From the data obtained, there is a total of 130 respondents (93.5%) supported the development of sustainable energy while only 9 respondents (6.5%) answered "No" in this question. Almost all respondents who participated in this questionnaire survey are standing on the ground of supporting the sustainable energy like solar energy.

Lastly, several questions were asked to investigate whether the respondents have experience in using solar energy. The result of this question shows 68.1% with a total 96 respondents have no experience in using solar energy while the remaining 43 respondents (30.9%) have experience on it. It can be concluded that the current adoption rate of solar energy in Malaysia is considered slightly low. This question is important for the data analysis for the benefits and challenges of solar energy adoption as they may have the reliable experience in applying solar energy. Henceforth, the benefits and challenges of solar energy adoption can be detected and reflected in this study. Primary data collected in regards the advantages of solar energy adoption through questionnaire survey is analysed. Table 6 shows the six benefits which had been studied and elaborated in detail and indicated the most agreed benefit of solar energy in the publics' point of view is renewable and clean source of energy, with the highest mean score of 4.2806, where this means most of the respondents were strongly agreed with the benefit. This result is in-line with Zhang, et al. [56] who defined that solar energy is a natural, renewable, and non-polluting source of energy. This followed by eco-friendly, with the second highest mean score of 4.2518. World Energy Outlook [57] supported the result and stated that the solar power generators will not create greenhouse gases which caused air pollution when generating power. Hence, the solar energy is said to be eco-friendly as the environmental problem can be reduced. The third most agreed advantage of solar energy adoption is cost saving in electricity bill with mean score of 3.9424. This has met the justification by Ren, et al. [23], stating the solar panel which used to generate home electricity can generate extra electricity in which the users are able to resell the exceed electricity to the grid and get a reduction in utility bill. This shows a result of cost saving in electricity bill if the users choose to apply solar energy. The remaining three benefits which include diverse applications (3.6475), investment return (3.6043) and low maintenance cost (3.3453) are considered as the benefits of solar energy with moderate significance.

Table 5
Frequency distribution of the research constructs

		Frequency	Percent	Valid Percent	Cumulative Percent
Awareness on the changes of environment	Yes	110	79.1	79.1	79.1
	No	29	20.9	20.9	100.0
	Total	139	100.0	100.0	
Support the development of sustainable energy	Yes	130	93.5	93.5	93.5
	No	9	6.5	6.5	100.0
	Total	139	100.0	100.0	
Previous experience in applying solar energy	Yes	43	30.9	30.9	30.9
	No	96	69.1	69.1	100.0
	Total	139	100.0	100.0	

Table 6
Benefits of solar energy adoption

Benefits of solar energy adoption	N	Mean	Mean Rank
Renewable and clean source of energy	139	4.2806	1
Eco-friendly	139	4.2518	2
Cost saving in electricity bill	139	3.9424	3
Diverse applications	139	3.6475	4
Investment return	139	3.6043	5
Low maintenance cost	139	3.3453	6

In the respondents' opinion, there are other benefits of solar energy adoption which include recognition by green building assessors and regulators for submission of green scoring, solar energy application is able to be provided to the rural areas that have abundance of sunlight with least skyscraper surrounding it which making electricity more readily available, and it is able to boost the economy sector if solar energy appliances are applied in Malaysia.

3.1 Respondents' Willingness in Adopting Solar Energy in Future Tables

Ultimately, respondents' willingness in adopting solar energy in future are investigated. Table 7 presents the frequency analysis result on the question.

Table 7
Frequency distribution of the respondents' willingness in adopting solar energy in future

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	68	48.9	48.9	48.9
No	7	5.0	5.0	54.0
Maybe	64	46.0	46.0	100.0
Total	139	100.0	100.0	

Out of the 139 respondents, the number of respondents who answered "Yes" is 48.9% which is slightly higher than 46% of respondents who responded "Maybe". Meanwhile, only 7 respondents answered "No". Therefore, it indicated that most of the respondents are willing to consider the implementation of the solar energy in future.

3.2 Qualitative Analysis

A semi-structured interview was conducted to obtain a more practical data with the expert who worked in solar panel manufacturing sector. This is to further justify the collected data from the quantitative method. The online interview was carried out with a solar panel vendor. A total of four questions were posted and the answers for the pre-set questions from the interviewee was analysed to support the data obtained from the questionnaire survey. Table 8 shows the summary of the questions and answers from interviewee during the online interview.

Table 8
Interviewee's feedback

Questions	Answers
Q1: What are the benefits of using solar energy?	Other than those in the books, solar energy is used to stabilize the operation cost fluctuation of a power generation plant.
Q2: What is the most popular type of solar panel being used in Malaysia?	Mono-crystalline silicon solar panel.
Q3: Why do you think the particular solar panel is widely used?	Higher peak efficiency.
Q4: With the acknowledgement of the current challenges, will you apply solar energy in future? Why?	Yes. Solar energy has a very big potential for improvement. I believe that one day, the efficiency will make the investment cost more acceptable by the community.

The result obtained for Question 1 indicates that the interviewee agreed that the benefits of solar energy can be found in the books and added that another benefit of solar energy is it can stabilize the fluctuation of the operation cost for a power generation plant. In fact, this is particularly true as every power plant has operating cost which include the cost of transformation of fossil fuels into electricity, transmission, and maintenance. In the meantime, the fossil fuel prices, especially for natural gas and petroleum fuels, may fluctuate during the period of high electricity demand, in which will contribute a higher cost in electricity generation of the power plant.

Questions 2 and 3 were posted on what the most popular type of solar panel is and why it is used in Malaysia. The interviewee responded that the type of solar panel which widely used in Malaysia is Mono-crystalline silicon solar panel. This is because it has the higher peak efficiency as compared to other types of solar panel. This finding is aligned with Katyal, et al. [45] and Sharma, et al. [46], because it is made up of a single crystal of silicon, causing the electrons can flow easier through the cell and makes the PV cell has the highest efficiency compared to the others.

4. Conclusion

It is important to practice sustainable development and consider about energy efficiency to save the resources to the next generation, especially in the building sector. The results indicated that many respondents are hesitating on the adoption of solar energy as only 48.9% of respondents are willing to adopt solar energy in the future while 5.0% and 46.0% of the respondents said no and maybe for the willingness of solar energy adoption in the future respectively. Although, the respondents are aware of the benefits and potential of solar energy, the outcomes of the adoption are uncertain. This caused the respondents have lesser faith in the solar energy adoption in Malaysia. Therefore, this research has explored the benefits of solar energy implementation, willingness of respondents to

adopt solar energy and the most suitable solar panels to be installed in Malaysia's buildings. The research finding indicated that the adoption of the solar energy will benefits the human and environment. A total of six benefits of the solar energy has been explored where the result discovered that the most significant benefits of solar energy application are renewable and clean source of energy, eco-friendly and cost saving in electricity bill. Furthermore, to encourage the installation of solar panel in buildings, two types of solar panel which included Mono-Crystalline Solar Panel and Polycrystalline Solar Panel were compared and discussed. The result showed that Mono-Crystalline solar panel is the most popular and suitable type of solar panel that should be applied in Malaysia.

The willingness of respondents to adopt solar energy in Malaysia is still low as majority of respondents are still hesitating due to the high initial cost and uncertainties in the operation and maintenance of the solar panels. However, the hesitation can be resolved through the outcomes of this research as the benefits of solar panel are significant. This situation was further enhanced by the results obtained from the qualitative result, through the interview session, the interviewee responded that the utilization of solar energy can stabilize the fluctuation of the operation cost for a traditional power generation plant. This study also provided a better overview and understanding on the types of solar panel available in the current market. The results help the publics who are considering installing solar panel to obtain more details of the Mono-crystalline solar panel and Poly-crystalline solar panel incorporating the difference between these two solar panels, subsequently, they can select the best and suitable solar panel for their usage. This study has concluded that Mono-crystalline solar panel is the best solar panel to be used in Malaysia due to the climate, maintenance cost and frequency aspects. Solar energy has been proven to have significant potential in Malaysia, thus, the findings can be utilized by the government and the private sector to improve the solar energy adoption rate by education and conducting more awareness programs for the public which can highlight all benefits of solar energy adoption in terms of economy, social and environment aspects.

Acknowledgment

This study was supported by the Faculty of Built Environment, Tunku Abdul Rahman University of Management and Technology under the Centre for BIM research.

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