The Potential of Solar Photovoltaic Application in Johor Bahru

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Abstract. Renewable energy play important role for sustainable development as it can conserve the energy and protect the natural environment from the pollution. Utilization of renewable energy will help to generate the power and convert it into electricity in order to fulfill the human needs. Solar energy which is one of renewable energy source that is used widely in developed country. Malaysia has a big potential on utilize the solar energy as an alternative power source because this country received plenty of sunshine with an average of 12 hours per day. So, the usage of solar photovoltaic technology in residential house, commercial building and office building must be increased in order to maximize the usage of renewable energy. The aim of this study is to identify the potential of solar photovoltaic application in Johor Bahru. Data was collected through questionnaire survey around Johor Bahru and the targeted respondents to this questionnaire survey are professional employees which related to solar photovoltaic industry. Result obtained from questionnaire survey were tabulated and analyzed by using SPSS version 18.0 tools and average index method. The findings highlighted the benefits on solar photovoltaic application and the problems that related to solar photovoltaic implementation in building. This study also revealed that the factors and strategies listed have big potential to encourage wide utilization of solar photovoltaic application in building.

Introduction

Nowadays, renewable energy is on the rise of it usage especially in Malaysia. Utilization of renewable energy will generate the power and convert it into electricity in order to fulfill the human needs. Even the population of human increase and the non-renewable energy decrease, the usage of renewable energy still unsatisfactory in term of total energy consumption in Malaysia. The renewable energy play important role for sustainable development as it can conserve the energy and protect the natural environment from the pollution.

As known, Malaysia is a tropical country awarded with a lot of sunshine over the year, for instance Malaysia received plenty of sunshine with an average of 12 hours of sunshine per day. Thus, it is possible to implement the solar technology towards green building by using the renewable energy. Solar energy is promising clean source, renewable energy and it has the big potential of any alternative power source to solve Malaysian energy problems. Based on Shafiq et al. (2011), the eastern and northern region of Malaysia has big potential for the application of solar energy because of the solar radiation level is high throughout the year. So, the usage of solar photovoltaic especially in Johor residential house, commercial building and office building must be increased in order to maximize the usage of renewable energy.

The renewable energy in Malaysia becomes important on its utilization so that the natural environment and ecology system could be preserved. The application of solar photovoltaic in building will give more benefits especially towards environmental aspects such as reducing the global warming and greenhouse gas emissions. Even the cost for the installation of solar photovoltaic is expensive, but the upcoming benefits will cover the commencement cost. This is because the low cost for maintenance of solar photovoltaic and low bills cost for that building involved.

The government and supplier should provide more strategy and campaign in order to promote the use of solar photovoltaic in Malaysia. This is because the application of renewable energy technology is more efficient and comprehensive which is suitable with weather and condition in Malaysia. Therefore, a study is carried out to find out how factors and strategies will affect the potential of solar photovoltaic application in building based on the respondent's perspective. How the solar photovoltaic will benefit the user and what are the problems that related to solar photovoltaic implementation in building?

The aim of this study is to investigate the potential of solar photovoltaic application in Johor Bahru. The objectives of this study are: (1) to identify the benefits of solar photovoltaic application in the building, (2) to identify the problem in implementing solar photovoltaic in Johor Bahru and to determine the potential of solar photovoltaic application in building from respondent's perspective.

Previous Studies

The definition of renewable energy is energy that derived from natural processes which not involve the consumption of exhaustible resources such as fuels [1]. The utilization of renewable energy is based on the resources available which follow the geographical condition at certain places. The examples of renewable energy are solar, geothermal, biomass, wind and hydropower. The utilization of renewable energy is important as can conserve the energy and also protect natural environment and ecosystem from the pollution. The renewable energy also used for the sustainable development as the benefits it brought to surroundings especially for environmental, economy and society. Malaysia get more chances to utilize the renewable energy as the alternative way to generate power based on its potential and resources available. Solar energy shows big potential to generate electricity after hydropower because Malaysia is located at Equator which could provide the sunshine at least 12 hours per day.

Table 1**:** Renewable energy potential in Malaysia [1]

Renewable energy	**Potential (MW)**
Hydropower	22000
Solar PV	6500
Biomass-biogas	1300
Mini-hydro	500
Municipal solid waste	400

Solar Energy Solar energy is a process of electromagnetic radiation that is created by light and heat which is emitted by the sun. By using specific technology, the radiations of sunshine are able to be collected and turn it into usable forms of solar energy such as heating or electricity generation. As the global energy crisis is on rise, the need of energy conversion is important especially solar energy utilization which is the best way to preserve the natural fossil-fuel and reduce the usage of non-renewable energy. Solar energy is ideal for usage in residential house, commercial building and large scale industrial units. The direct energy that comes from sun in its purest form only requires the conversion into electrical energy using the technology provided such as solar panels.

Solar Photovoltaic Solar photovoltaic is a system that converts light energy into electricity with the used of solar energy resources [2]. With the energy crises on the year 1970, some organization shows the significant efforts to develop solar photovoltaic for residential and commercial building uses (Florida Solar Energy Center). In the same year, the applications and demand for solar photovoltaic systems had increased in order to power rural clinics, water pumping, refrigeration and telecommunications. So, the solar photovoltaic becomes major portion of the present world market for photovoltaic products.

Solar photovoltaic will use panels that made of semiconductor cells which then can power the electrical devices as long the panels receive the sunray. Applications of solar cell technology by using solar energy would generate the electricity which allows the user to use alternative way when the main electricity supplier had a problem. In order to collect abundant of solar radiation, the most practical way is to generate the electricity from solar that will channeled to the grid by using an inverter [3].

Solar photovoltaic normally use amorphous silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride and other materials in order to capture the solar energy and stored it. Generally, the photovoltaic cells are connected either in series or parallel circuits so that the systems will produce higher currents, voltages and raise the power levels. Photovoltaic modules consist of photovoltaic cell circuits which are sealed by environmentally protective laminate. Then, photovoltaic panels include one or more photovoltaic modules that installed as a pre-wired and field-installable unit. Lastly, the photovoltaic array is the complete power-generating unit that combined any number of photovoltaic modules and panels.

In addition, there are three types of photovoltaic arrays which are used based on their characteristics to collect the solar energy (Solar Cell Array Design Handbook). Flat-plate arrays, tracking arrays and concentrator arrays are the examples of photovoltaic arrays.

Benefits of Solar Photovoltaic. Solar energy that is widely applied and gets more attention compared to others renewable energy sources is more effective because it sources are free, abundant and environmental friendly. Same as solar photovoltaic that brings a lot of benefit to environmental, economic and society. This is because the solar photovoltaic energy is clean, silent, abundant and sustainable which is safer than other traditional electricity generation systems.

From environmental aspect, solar photovoltaic systems are design to reduce the global warming impacts which will reduce the carbon emission. Carbon dioxide (CO_2) emission of Malaysia in 2008 was about 118 million tones and for the small scale of carbon emission are approximately 7.2 tones per capita [4]. The emission of CO_2 has been increase from time to time. For every kWh of electricity produced, solar photovoltaic systems could save 0.53 kg of CO_2 emission.

From economic aspect, users of solar photovoltaic could save the cost for the long term aspects because there is less maintenance cost and reduce electricity bills as the usage of electricity also lower. Solar photovoltaic cost is currently reduced in order to fulfill the economic viability and environmental sustainability. This will attract more public to change the lifestyle into sustainable practice by having the solar photovoltaic system. With the incentives by government, all solar photovoltaic users are allowed to sell the electricity generated to Tenaga Nasional Berhad (TNB) using the Feed-in-Tariff (FiT) scheme. This will cover the upfront cost of solar photovoltaic installation by having a contract on FiT scheme.

For the society, solar photovoltaic gives best solution for its application in building because the solar photovoltaic panels are totally silent. This is because the main components involved in solar photovoltaic system are charge controller, battery bank and inverters which all of them are not produce sound and also pollution free. Then, the installation of solar photovoltaic is easy to install on rooftop of house or building without any interference to public lifestyle. Solar photovoltaic panels also can be installed to any size based on the electricity capacity that can be generated and the area of building rooftop.

Problems in implementing Solar Photovoltaic. There are many problems that related to solar photovoltaic implementation in building. For example, the cost of solar photovoltaic is too expensive plus its installation cost. This is because the materials and spare parts used must be imported from other country such as Japan, German, China and others. Thus, the cost of solar photovoltaic that can be purchased in Malaysia will increase. So, it will affect the lower income users on having it.

There is few number of bank or agency which provides the loan for the new solar photovoltaic user [5]. In 1999, Germany had introduced a zero percent of interest rate for soft loan in order to help and attract more users to use the solar photovoltaic technology with the low cost [6]. This show that the loan from bank is important for new users of solar photovoltaic as the cost of its initial system is expensive.

Lastly, the public awareness is still low for the utilization of renewable energy. The public show less confident to use the solar photovoltaic as the technology that can provide more benefits towards sustainability. This is because the government and private sector are lack of efforts to raise the public awareness such as campaign, exhibition and media advertisement. Therefore, those problems will prevent the number of user who is applying the solar photovoltaic technology.

The potential of Solar Photovoltaic utilization in Malaysia. Normally, Malaysia industry will use large amount of fossil fuels to generate electricity which comprise of natural gas and coal. Fossil fuel is the non-renewable energy which can exhausted if the amount of usage is uncontrolled and continuously. So, the need of renewable energy is compulsory as it can be the alternative energy resources while reduces the dependency on the fossil fuels usage for electricity generation. In addition, there are various types of renewable energy in Malaysia which could encourage more users to become the producers.

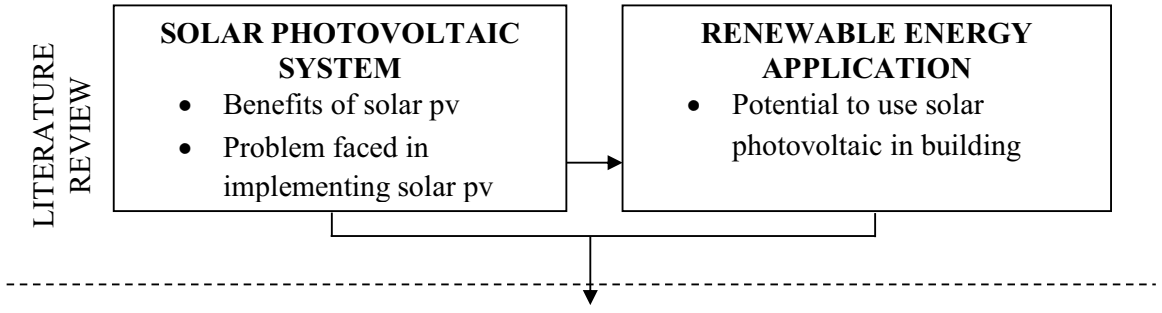
Malaysia has high potential in utilization of renewable energy such as biomass, biogas, municipal waste, mini hydro and solar photovoltaic. But, the most energy sources with high potential in satisfying the energy need of Malaysia is solar photovoltaic [7]. This is because the geographical location of Malaysia is strategic such as large quantity of solar insolation per year, ranging from 1400 kW h/m^2 to 1900 kW h/m^2 [8] and with longer sun hours which more than 10 hours per day [9].

Other than that, Malaysia government also has implemented the Feed-in-Tariff (FiT) scheme under Sustainable Energy Development Authority (SEDA). For any producers of renewable energy especially solar energy, FiT scheme will allow the owner to get paid for the amount of electricity generated in kilowatt-hour (kWh). Normally, the FiT scheme contract is last until 20 years. This incentive from government will increase the number of users in renewable energy industry especially for small scale electricity generation.

As known, solar photovoltaic system has high cost of its initial system and it becomes a barrier to new consumers of renewable energy. With that reason, the cost of solar photovoltaic are continuously been reduced by the government. For example, the cost of solar photovoltaic generator has declined approximately 50% between 2010 and 2014 (Renewable Energy Policy Network). If the cost of solar photovoltaic continues declining, probably more public willing to take part for becomes renewable energy producers.

Methodology

The flow in Figure 5 shows the flow of progress for the study.



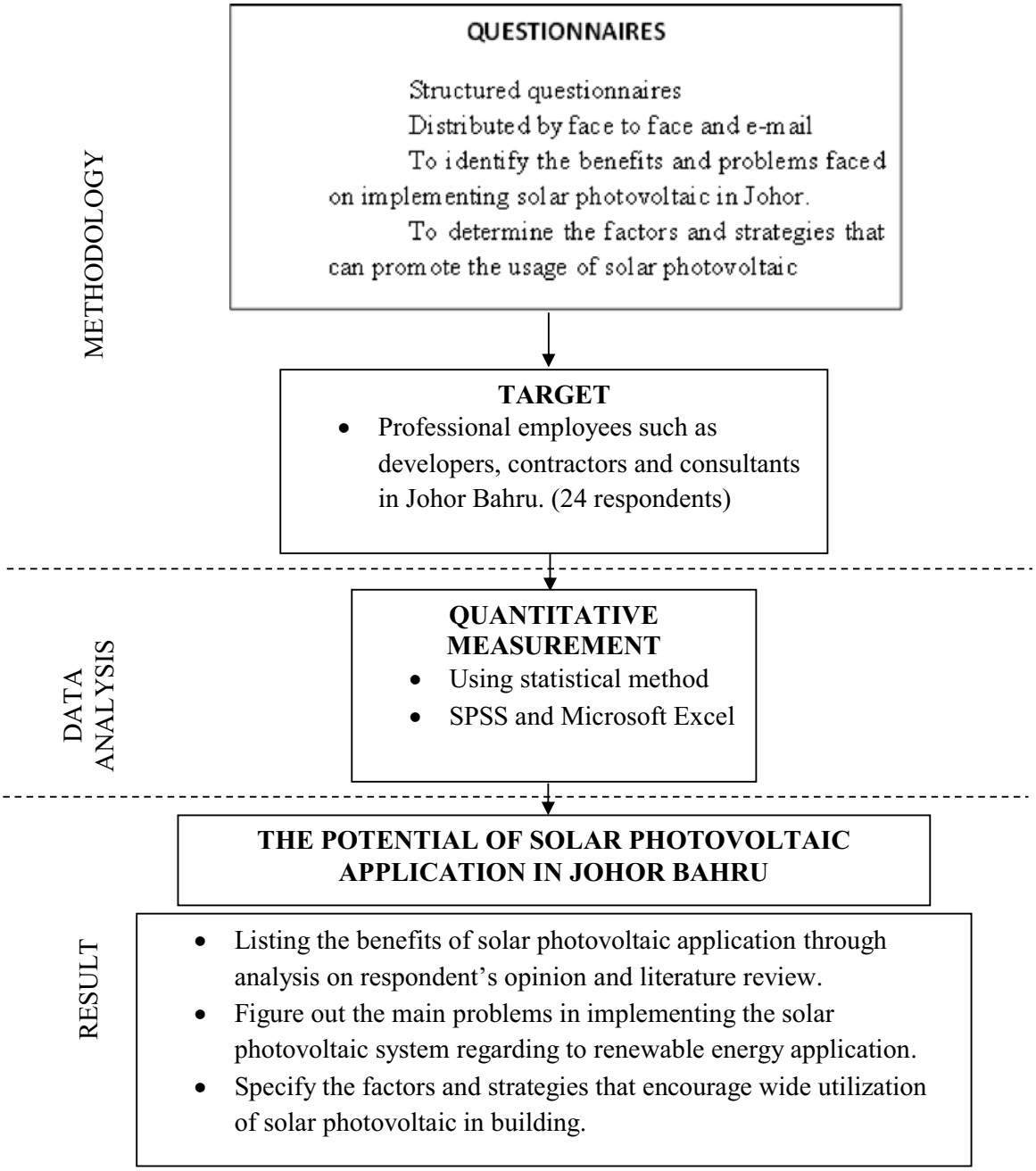


Figure 1: Methodology Flow Chart

Average index
The average index formula is:

$$\text{Average index} = (\sum a_i x_i)/(\sum x_i)$$

Where,
a_i = weighting given to each factor by frequency of respondents, i
x_i = number of respondents for i = 1,2,3,4,5

Data Analysis

This chapter discusses on the background of respondents and perceptions on the potential of Solar Photovoltaic application in Johor Bahru. The primary data was obtained through

questionnaires which were sent across Johor Bahru through email and mostly by personal handover. The analysis of the respondent's perception was generated from the 24 respondents.

The analysis was separated into three sections according to the objectives of the study. All the collected data then was analysed using Statistical Packages for Social Science (SPSS) version 18 and Microsoft Excel 2010. These software were used in order to find the mean, standard deviation, average index value, percentage and other values related to Likert scale question. The data also are shown in meaningful arrangement with table and chart.

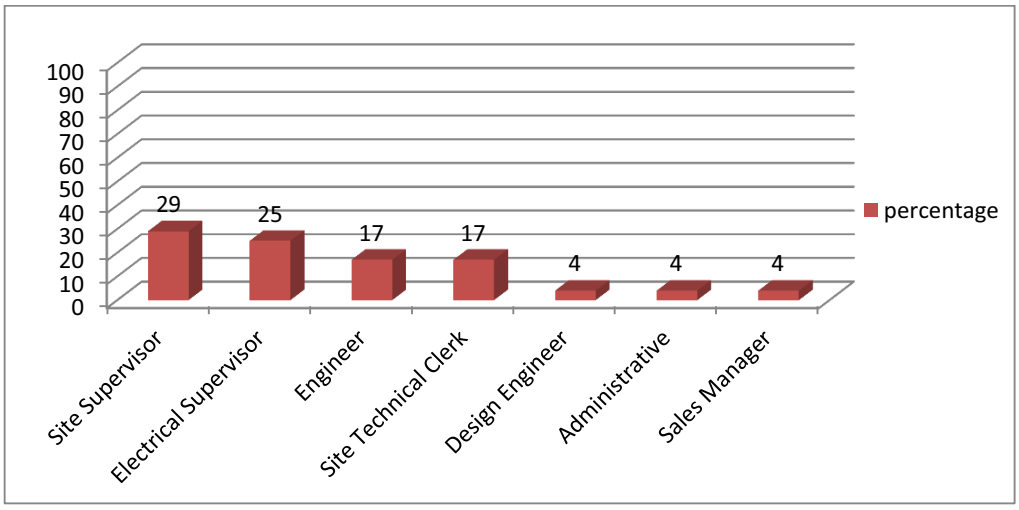


Figure 2: Respondent's Current Job Position

Demographic Information Figure 2 shows the percentage distribution for the respondent's current job position. The most of respondents work as site supervisor which is 29%. This is followed by 25% are electrical supervisor, 17% are engineer and site technical clerk while the rest are others job specification related to the solar photovoltaic industry that shared the same percentage distribution which is 4%.

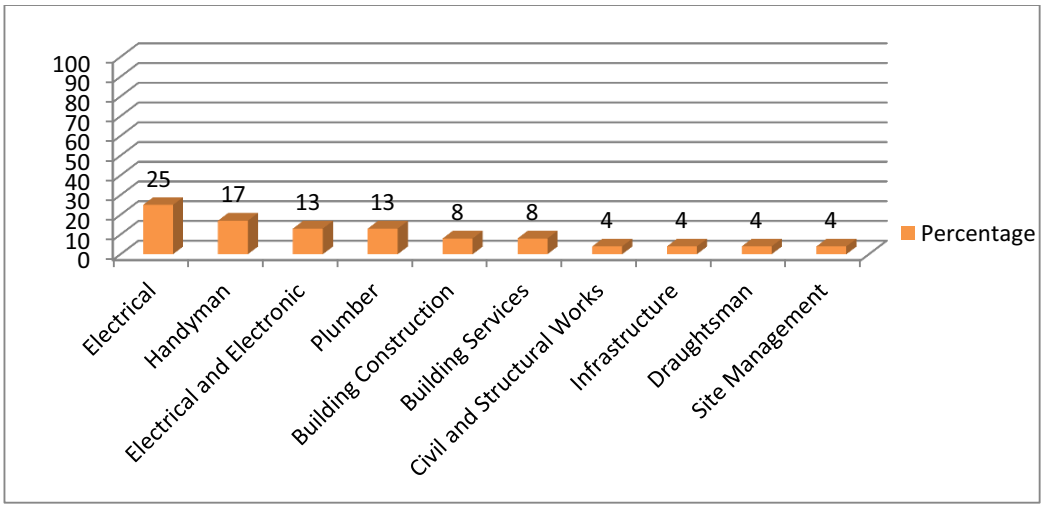


Figure 3: Respondent's Field of Expertise

Based on Figure 3, it shows the percentage distribution for the respondent's field of expertise which contribute to their understanding in solar photovoltaic application. From the figure above, it shows the most of respondents are expert in electrical (25%). This is followed by 17% of respondents who are in handyman expertise that work on site. Then, the respondents from electrical

and electronic, and plumber expertise shared the same percentage distribution which is 13%. It is clearly seen that the respondents are mostly expert in electrical field because solar photovoltaic system is under electrical study area.

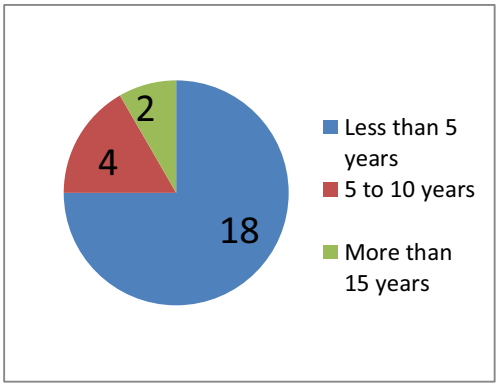


Figure 4: Respondent's working experience in construction industry

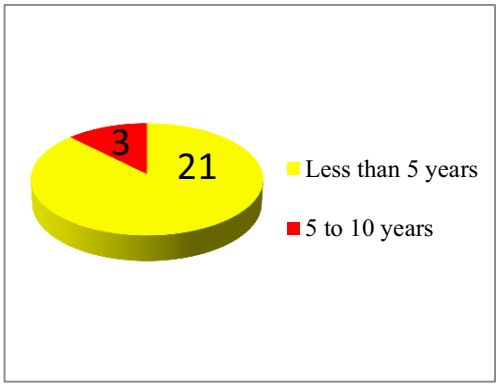


Figure 5: Respondent's involvement in solar photovoltaic construction

From the data collected, Figure 4 above show the frequency of the respondent's working experience in construction industry by year. Majority of the respondents has working experience less than 5 years which are 18 out of 24 respondents. This followed by 4 respondents have working experience in range of 5 to 10 years and 2 respondents have more than 15 years working experience. None of the respondent has working experience around 10 to 15 years.

By referring Figure 5 above, majority of the respondent's involvement in solar photovoltaic construction method in building is less than 5 years which is 21 respondents. The rest are between 5 to 10 years (3 respondents) who work in solar photovoltaic field area. This is because the application of solar photovoltaic for industry and construction in Malaysia is new and less person who has great experience in solar photovoltaic system.

Benefits of Solar Photovoltaic. From Figure 6, the benefits of solar photovoltaic application in building such as provide the clean energy is the strongly agreed benefit among others with the mean of 4.54. This is because, solar photovoltaic system used directly sunray to generate energy which could produce the electricity. Whereby, other benefits such as reduce global warming and climate change, reduce carbon emission, and so on are also found to be agreed benefits with the mean exceeding 3.5. But, there is only one benefit with neutral level of agreement which is low installation cost with the mean of 3.13. It shows that the installation cost is not contributed to the benefits of solar photovoltaic application in building from respondent's perspective.

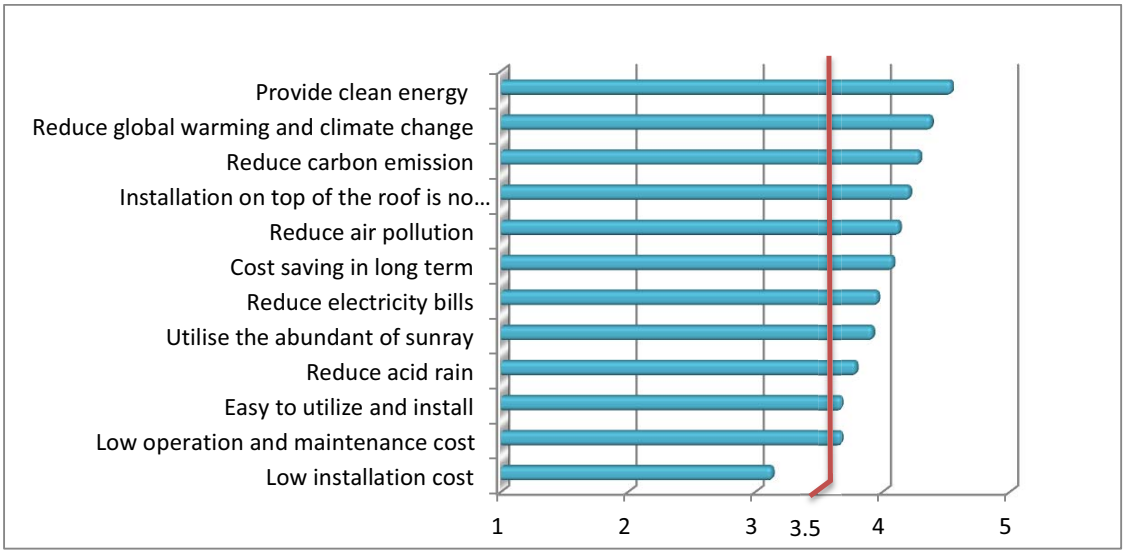


Figure 6: Mean for the benefits of solar photovoltaic

Problem related to Solar Photovoltaic implementation in building. Figure 7 show the mean value of the data distribution on problems related to solar photovoltaic implementation in building. Most respondents agreed that high cost of its initial system is the biggest problem in solar photovoltaic application in Malaysia with the mean of 4.38. The others problems such as lack of campaign, low public awareness and so on have the same level of agreement which is exceeding 3.5 of mean score. There is only one problem that show neutral level of agreement based on respondent's answers which is high maintenance cost of solar photovoltaic with the mean of 3.46. So, cost played the most important factor that will determine whether the application of solar photovoltaic is able to encourage wide utilization or otherwise. While the high maintenance cost is less contribute to the problems faced as solar panels only require very little maintenance (few times per year) since there are no moving parts and only inspected for dirt and debris**.**

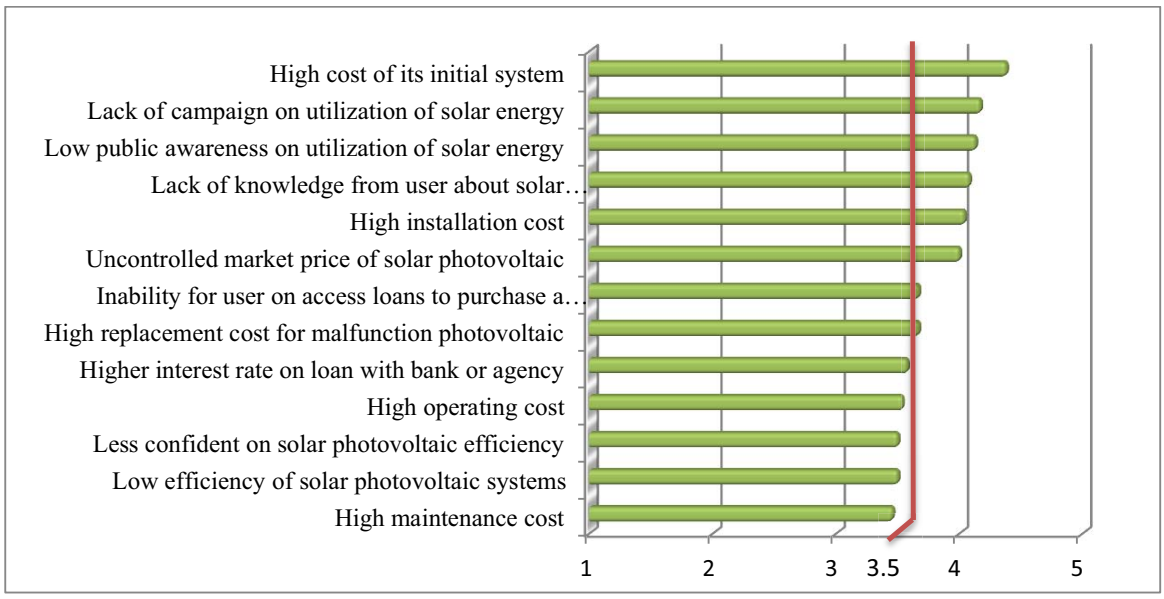


Figure 7: Mean for the problems related to solar photovoltaic implementation in building

The potential of Solar Photovoltaic application in Johor Bahru. In order to determine the potential of solar photovoltaic application in Johor Bahru, the factors and strategies that encourage the wide

utilization of solar photovoltaic in building are used as a benchmark with respect to the respondent's perspective.

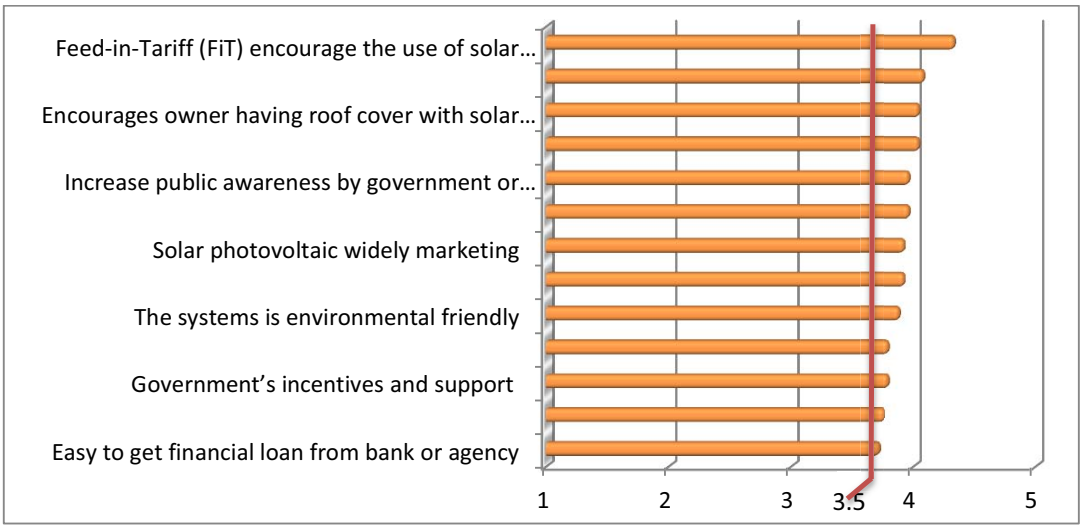


Figure 8: Mean for the factors that encourage the utilization of solar photovoltaic

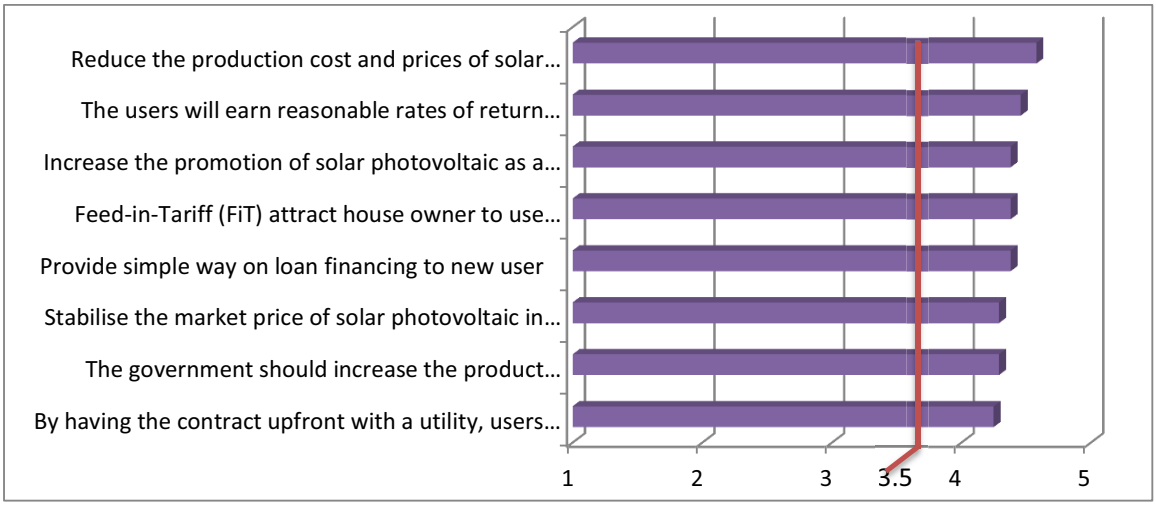


Figure 9: Mean for the strategies to increase the utilization of solar photovoltaic in building

From Figure 8, it is clearly seen that most of the factors are important to encourage wide utilization of solar photovoltaic which has mean score exceeding 3.5. It show that the respondents agreed with the listed factor which could contribute to wide application of solar photovoltaic in building in Malaysia. The highest mean score of the factor that encourages the use of solar photovoltaic is Feed-in-Tariff (FiT) system with the mean of 4.33. FiT is the system that implemented by Sustainable Energy Development Authority (SEDA) which provide the return rates to the renewable energy users. This means that the users can sell their electricity that generated from solar photovoltaic to Tenaga Nasional Berhad (TNB). The second highest mean score is declining of solar photovoltaic panel price which is 4.08.

Figure 9 above shows the strategies that should be implemented in order to increase the utilization of solar photovoltaic in Malaysia. Most of the respondents strongly agree that by reduce the production cost and prices of solar photovoltaic would be the best strategies with the mean score of 4.58. This strategy could increase the number of users in solar photovoltaic system as they can afford to buy the solar panel service and become one of renewable energy users in Malaysia. The lowest strategies is by having the contract upfront with a utility, users are able to take loan from the

bank with discounted rate with only 4.25 mean score but overall of the strategies still can be consider as agreed level of agreement since they exceeds mean score of 3.5.

Conclusion

Conclusion for Objectives 1

The benefits of solar photovoltaic application in building are as below:

- Provide clean energy
- Reduce global warming and climate change
- Reduce carbon emission
- Installation on top of the roof is no disturbance for human movement
- Reduce air pollution
- Cost saving in long term
- Reduce electricity bills
- Utilise the abundant of sunray
- Reduce acid rain
- Easy to utilize and install
- Low operation and maintenance cost

Conclusion for Objectives 2

The problems that related to solar photovoltaic implementation in building are:

- High cost of its initial system
- Lack of campaign on utilization of solar energy
- Low public awareness on utilization of solar energy
- Lack of knowledge from user about solar photovoltaic systems
- High installation cost
- Uncontrolled market price of solar photovoltaic
- Inability for user on access loans to purchase a solar system from bank or agency
- High replacement cost for malfunction photovoltaic
- Higher interest rate on loan with bank or agency
- High operating cost
- Less confident on solar photovoltaic efficiency
- Low efficiency of solar photovoltaic systems

Conclusion for Objectives 3

The factors that encourage wide utilization of solar photovoltaic in building are as below:

- Feed-in-Tariff (FiT) encourage the use of solar photovoltaic
- Declining solar photovoltaic panel price
- Encourages owner having roof cover with solar photovoltaic panel
- Suitable weather condition
- Increase public awareness by government or agency
- Allows the user to participate as an energy producer
- Solar photovoltaic widely marketing
- The users can sell electricity generated to the grid
- The systems is environmental friendly
- Consistent solar radiation
- Government's incentives and support
- Unlimited solar radiation

- Easy to get financial loan from bank or agency

The strategies that should be implemented in order to increase the utilization of solar photovoltaic in building are as below:

- Reduce the production cost and prices of solar photovoltaic
- The users will earn reasonable rates of return from FiT scheme
- Increase the promotion of solar photovoltaic as a renewable energy sources
- Feed-in-Tariff (FiT) attract house owner to use solar photovoltaic
- Provide simple way on loan financing to new user
- Stabilise the market price of solar photovoltaic in comparison between local product and imported product
- The government should increase the product innovation of solar photovoltaic technology
- By having the contract upfront with a utility, users are able to take loan from the bank with discounted rate

Recommendations

- Reduce the cost of solar panels besides control the market price of solar photovoltaic.
- Developers plays important role to promote the usage of solar photovoltaic in building.
- Launching the awareness programme and the utilization campaign of renewable energy.

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