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# Reasons for low penetration on the purchase of photovoltaic (PV) panel system among Malaysian landed property owners

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ABSTRACT

The current study aims to explore the role of customer acceptance and attempts to investigate its effects on photovoltaic (PV) panel adoption among Malaysian landed property owners. Malaysia is rich in sunshine throughout the year with about 4.0–4.9 kW h/m2/day of solar radiation, a daily sunshine duration ranging from 4 to 8 h, but the extraction and utilization of sun light power is relatively less. A massive quantitative cross sectional research survey was conducted to understand customers' perceptions towards the predictors for the purchase intention of PV panel system. Out of 157 Malaysian respondents surveyed, 74 (47.1%) of the respondents have intention to install PV panel system for their landed property houses. The findings reveal that the respondents are keen on installing PV panel system provided they get some returns in the form of electricity through money back scheme. The technology barriers and environment concerns have negative impact on the purchase intention of photovoltaic (PV) panel system. Most of the respondents who have intention to purchase PV panel system are influenced by their friends, relatives or their close colleagues. The results also indicated that the size of the roof does not moderate the purchase intention of PV panel system. Further, the respondents of the study have suggested a variety of practical implications for both manufacturers and customers of PV panel system. PV panel manufacturers can work on lowering the cost by capturing maximum sun exposure using advanced technology and design the system with different modules for short and long term 'Use and Throw' technology installations. On the customer side, solar system installation requires a high capital investment and therefore Malaysian customers can be allowed to use employees' provident fund contribution withdrawal for the use of renewable energy towards contributing to the high rate of green energy applications.

## 1. Introduction

The growth of global warming leads to an irreversible climate change that draws a concern from the world's population [14]. Energy resources have two categories which are renewable and non-renewable. Non-renewable energy resources like coal, nuclear, oil and natural gas are available in limited quantity. Renewable energy resources such as solar, wind, water (Hydro), biomass, and geothermal which can be replenished by the environment over short period of time whereas non-renewable energy cannot be easily replenished by the environment. It is, in this context, the electricity generation through solar radiation plays an important role. Meanwhile, the global warming leads to an irreversible climate change which focuses attention currently by the world's population [14]. Malaysia's energy sector is heavily depended on non-renewable fuel such as natural gas and fossil fuels as a source of energy. Various efforts have been taken by the government of Malaysia to encourage investment in solar PV projects [41]. Based on Ellabban et al. [19], one of the major sources of clean renewable energy is solar power generated from sun exposure. Besides, a focus strategy on the installation of sustainable and renewable energy systems has been adopted by the industries around the world to reduce the greenhouse emissions [51]. According to Sun et al. [72], sunlight consists of photons solar energy which can be converted into electricity. Solar energy is radiant light and heat from the sun, which actually generates both light and heat simultaneously. Only the absorbed photons provide energy to generate electricity. Solar energy produces less negative impacts on the environment than other energy sources like fossil fuels, which are often produced with harmful side effects. The majority of typical PV device utilizes an individual junction type of cell to generate electricity [45]. A solar PV system includes multiple PV modules, referred to as solar panels [58]. A module consists of small solar cells and a typical single silicon cell produces 1 or 2 W of power. Generally, one square meter PV module can

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generate 150 W of power [57]. The number of solar modules that a family needs is dependent on the sq.ft. area in which they are living. The growth of solar PV global capacity has been rising exponentially over the years [6]. Elnugoumi and Bin [20] stated that, with the implementation of the motivation packages to bring in both foreign and local investors, the government identified solar energy as one of the growth areas to promote. As a result of such strategies, Bosch Malaysia plans to set up a new solar energy plant in Penang, Malaysia.

In the present study, an attempt is made to investigate some of the issues discussed in the earlier studies in the Malaysian context. According to Ab Kadir and Rafeeu [1], elimination of subsidies for non-renewable energy sources and extending support to renewable energy sources would develop rural electrification, environmental betterment and sustainable development in Malaysia. In fact, Malaysia has plenty of scope for small businesses and there would be more avenues for generating electricity through photovoltaic and solar thermal systems. Malaysia climatic condition, which is having sunshine throughout the year make it highly suitable for the development of solar energy [54,68]. Malaysia has a good mix of energy resources like oil, natural gas, coal and renewable energies such as biomass, solar and hydro. In spite of this plenty of resources, the country is dependent on fossil fuel for most of the industrial and transportation sectors. Hence, the current study focuses on the reasons for low penetration on the purchase of photovoltaic (PV) panel system in the landed property owners of Malaysia which is the potential source for electricity generation.

The current study is to investigate the factors influencing the usage of the natural solar energy resources through the installation of PV panel system. Solangi et al. [70] pointed out that there is a lack of awareness and knowledge of solar energy at all levels in the society and the cost of acquiring solar energy technology is initially exorbitant, poses a major setback in the utilization of PV panel system. Furthermore, there is no government subsidy in the form of incentive for people to purchase solar technology. Also, the technology which allows the use of solar energy as a renewable energy has less hazardous effects on health. Malaysia has advanced technology and developmental activities, but still, face challenges in bringing solar technology to the market due to somewhat heavy costs. It is up to the engineers to find ways to improve the efficiency of the technology to lower the manufacturing costs. Schaller et al. [65] and Blake-Beard et al. [16] to make solar energy economically competitive. Towards this, an attempt is made in the current study to focus on the technology barriers and its impact on the customer purchase plan intention towards the PV panel system. Besides, the environmental performance is another reason for the residents to avoid PV usage in Malaysia [73,81]. Therefore, the current study includes the effect of environmental influence and social influence factors Solangi et al. [70] on the purchase intention of PV panel system.

## 2. Literature review

Solar energy, a green and renewable energy source, the conversion of sunlight into electricity through the use of solar cell installed in a solar panel, is the most promising source of clean, renewable energy and it has the greatest potential of power source to solve the world's energy problems [1,68]. Solar energy is the most prominent among renewable sources, as it is an inexhaustible resource and its exploitation has thus far been ecologically friendly. Because solar energy is an inexhaustible, clean and safe source of energy, it has received much attention as one of the most promising candidate to substitute for the conventional fuels for electricity supply [31,47,82,83]. Alamdari et al. [7] stated that solar energy is the driving engine for economic development irrespective of the status of the country. Liao et al. [48] highlighted the importance of photovoltaic (PV) solar energy applications, the best way to harvest the sun's power, as the use of solar energy will reduce fossil fuel consumption. Al-Waeli et al. [8] remarked that environmental pollution and global warming problems can be reduced using renewable energy based on photovoltaic technology. PV is used to convert solar energy (light) to electrical DC energy, is more attractive for long term cost benefits and reduction of CO2 emissions. On the technical side, Asghar et al. [9] pointed out that the intrinsic stability of PV panel system includes the chemical and structural stability of the device which are subject to weather conditions like humidity, temperature and light exposure. According to Zhang et al. [87], solar energy reduces environmentally hazardous gasses which are commonly produced in electricity generation. Akikur et al. [4] suggested that renewable energy technology is one of the remedial measures for the global environmental concerns and for the increasing energy demands.

The applications of solar energy systems can be divided into two main categories namely solar photovoltaic and solar thermal. Photovoltaic systems convert sunlight into electricity using semiconductor materials. Solar thermal systems capture solar radiation using vacuum tubes or perforated vertical tubes, to heat water or air. The integration of solar energy with different kinds of systems is crucial in energy saving policy. It is known that concentrating solar power plants have the perspective to expand electricity production time using thermal energy storage systems [64]. Thermal energy storage systems would be charged in the peak of solar energy during the day-time, and the stored heat would be released at night time or during parts of the day when the solar power is not enough to produce electricity. Therefore, thermal energy storage systems have an important role in concentrating solar power plants even though it is one of the systems which has been less developed [62]. Jagoda et al. [38] stated that solar energy both photovoltaic and solar thermal is becoming increasingly popular with small businesses, while wind power is becoming an attractive energy source for medium sized enterprise.

Jacobsson and Johnson [37] and Biemann and Bada [15] have highlighted that social awareness and lack of understanding in the choice of end users are among the important reasons behind the slow growth of renewable energy in many countries. The less consumption of solar energy is attributed to the ignorance of the environmental, social and economic benefits [43,71]. PV panel system requires periodical maintenance by way of checking the collector shading, glazing and seal, collector soiling, fluid leaks at pipe connections and wiring connections, the storage tanks for cracks, leaks, rust or other signs of corrosion. According to a survey done in Arizona, solar panel adopters got the high average score of 5.42 out of 7 for maintenance, affecting the purchase decision compared to non-solar adopters score of 4.38 [86].

Meanwhile, the lack of local technical experts in solar system is another challenge as far as Malaysia is concerned and in turn, poses less confidence among the customers [20]. Meade and Islam [50], emphasized that households do not look into the features of the technology but look for psychological, social and institutional factors. The incentives to encourage the use of renewable energy sources, especially in the case of low-level electricity generation Muhammad-Sukki et al. [56] will boost the growth in the market and consequently resolve to some extent the problem of climate changes [18,79]. Zhai and Williams [86] remarked that customers gradually realize the environmental concern and moving towards the installation of solar PV system. Heiman and Lowengart [33] have pointed out on the customers' health hazard issues and Eriksen [21] highlighted health issue particularly to those who are electrically sensitive. Biemann and Bada [15] stated that environmental pollution from fossil fuels is a primary factor to drive towards renewable energy, in which case, the era of conventional electric power generation by natural gas becomes obsolete [51]. The concerned authorities and private industry in the globe are making a great effort in looking at the ways to reduce pollution from their business activities [20].

In a case study carried out in Canada, the majority of respondents find solar PV technology costly, but show willingness to purchase [13]. This gives an impression that people have a positive perception towards solar PV technology, but pull back because of the financial

constraint [24]. In a study carried out in China, approximately 23% respondents do not install solar PV at home due to high perceived cost [84]. A common barrier found in these studies is the problem of initial high cost for the installation of solar PV system [5,61]. Elnugoumi and Bin [20] found that lack of local technical experts of solar system is a major challenge in Malaysia which poses less confidence for customers to maintain solar system in the long run. Vincent-Akpu [78] argued that sound government policy, technical and financial capability acted as a major barrier to the development of renewable technologies. Nevertheless, there are many cases where studies have highlighted a contradiction between high-level objectives and limited acceptance by society, mainly related to social recognition issues and income [12]. At times, when birds release their droppings on the solar panels, creates a mess down the solar panel, resulting in unpleasant sight and a reduction in the efficiency of the solar panels. In fact, some home-owners in Malaysia have observed that solar panels are as ugly as the TV aerials or satellite dishes in some houses. In a study on customers' attitude towards solar power system, aesthetic considerations are identified as a barrier for solar PV installation [24]. However, for school based solar panel projects, aesthetics do not play an important role in affecting the purchase of solar panel [13]. Ultimately, the individual realization for the minimum usage of electricity is paramount in the current context. The present study considers a conceptual framework to understand what triggers the Malaysians on the purchase intention of PV panel in their residential area.

## 3. Conceptual research framework

The conceptualization of the research framework and the identification of the variables have been evolved from the face validity (experts' comments) and also from the extensive literature review provided in section-2. Theory of Planned Behaviour by Ajzen [3], Ajzen [2] which is also known as an extension theory of motivation action supports the proposed conceptual research framework. Accordingly, the present study is based on Social Influence (subjective norm of TPB), Technology barriers (behavioural control of TPB), environment concern (attitude of TPB), Economic returns (attitude of TPB), perceived cost/Pricing (behavioural control of TPB). Finally the dependent variable is the intention in TPB model is customer intention for the adoption of photovoltaic (PV) Panel system. Fig. 1 depicts the conceptual framework of the present study, where the dependent variable is the customer intention on the adoption of photovoltaic (PV) panel system. The study examines the cause and effect relationship between the dependent variable and five independent variables, namely social influence (SI), technology barriers (TB), environment concern (EC), economic returns (ER), and perceived cost/pricing (PC). Size of the roof is considered as the moderating variable.

### 3.1. Hypothesis development

Based on the literature review and the proposed framework shown in Fig. 1, the following research hypotheses are constructed:

#### 3.1.1. Social influence

A more recent study conducted in Greece actually reveals a greater acceptance of RES, with 85% positive views on photovoltaic systems and 80% on hydroelectric power and wind power. Since it is important for various emerging nations to understand the transmission process from conventional to renewable energy, this study reviews factors and theories relevant to pre-purchase attitude towards renewable energy use. For example, Biemann and Bada [15] identified barriers such as political issues, technical issues, economic issues environmental issues and social issues. However, Fredric [25] and Jacobsson and Johnson [37] argued that social awareness and lack of understanding of the choice of the end users are among the important reasons behind the slow growth of renewable energy revolution in many countries. Extant studies have investigated the two dimensions of theories while looking into factors influencing the attitude of the end users: the pre-purchase and the post-purchase behavior [39]. Peer pressure from friends and family members to buy solar panels, particularly, social influence is the degree to which an individual feels pressured by others to follow an innovation [34,35,76,77].

**H1.** Social Influence has positive impact on the customer intention on the adoption of PV panel system.

#### 3.1.2. Technology barriers

Lack of suitable and affordable technology may be the next barrier. On the other hand, the price of the technology must be cheap enough to encourage the public to invest. Lastly, there may not be appropriate socially or lack of political motivation [71]. Almost all usable items need maintenance and so to photovoltaic (PV) panel system which requires periodical maintenance by checking the collector shading, glazing and seal, collector soiling, fluid leaks at pipe connections and wiring connections as well as the storage tanks for cracks, leaks, rust or other signs of corrosion. The only question is to what extent an individual finds the maintenance troublesome which is why this is called perceived maintenance. Two important challenges have been drawn which is the Financial barrier and Technical barrier. For instance, majority of green energy projects implementation are depending on government's grants or subsidies. Renewable technology awareness is a concept where potential users can collect or have access to necessary information about the basic use, financial prospects and environmental impact of renewable energy [69]. A higher level of awareness enables the users to make informed decision and it also increases the level of acceptance among new users [53]. To make information cheap and accessible by mass users, government can

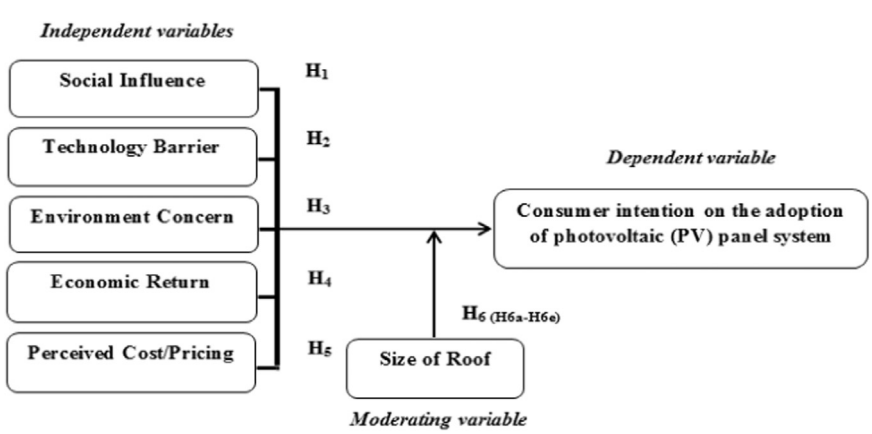


**Fig. 1.** Conceptual research framework with hypothesized relationships.

undertake extensive marketing plans [52]. Large scale training and community awareness programs can be carried out to facilitate an easy transition from conventional to modern renewable energy solutions [26]. At the same time, lack of local technical expert of solar system is a major challenge for Malaysia. It poses no confidence from local customer to maintain the solar system in the long run. Hence, this study is conducted to understand how the Technology barriers affect the intention to purchase photovoltaic (PV) panel system.

**H2.** Technology barrier has negative influence on the customer intention on the adoption of PV panel system.

#### 3.1.3. Environmental concern

The environmental concerns in this context refer to the level of individual's concern to the environmental surroundings which leads to conscious actions of recycling or purchasing green products [17]. Kim and Sejung Marina [44] favored collectivism as it emphasizes on environmental concerns for the well-being of human mankind and are highly driven by their core values embedded with the altruistic value [66]. The motivation behind these believes are due to self-efficacy in social cognitive theory [11]. Surprisingly, despite the higher cost for green products, environmental concern consumers are willing to pay more to address the environmental issues [74,46]. Therefore, this research will determine if environmental concern Malaysians influence the plan to purchase SWHS in their residential area. Previous research on health crisis shows that lower perception of quality results in product's deflated marginal utility which leads to the downward trend on the demand curve [49]. Issues of climates change and environmental pollution from fossil fuels are the main factors to drive towards renewable energy. In this way, the possibility of aided governmental decisions is minimized [73].

**H3.** Environment concern has negative influence on the customer intention on the adoption of PV panel system.

#### 3.1.4. Perceived economic returns

Malaysia is gifted with sunshine throughout the year with about 4.0–4.9 kW h/m2/day of solar radiation which indicated that there is huge potential of using solar energy as alternative source of energy into large scale solar power system [10]. Malaysia indeed has a strong potential of utilizing solar energy in large scale based on the location at equatorial region which has continuous supply of sunlight. However, main challenge is economic barrier which requires huge amount of capital investment for solar energy. Currently, Malaysia is adopting the 5th Fuel Diversification Policy (FDP) which was introduced in 1999 to reduce Malaysia's over-reliance on a specific fuel type and to achieve a more balanced supply mix among natural gas, oil, coal and hydropower. The country is embarking on a gradual change for fuel consumption from depending solely on one specific source of energy to a mix of fuel sources derived from hydropower and coal. For the Ninth Plan period [59], RM 1.8 billion is allocated for development of the energy sector while the investment expenditure by the NFPEs was huge [51]. Hence, government's strategy to reduce its over-reliance from oil and gas to coal and hydro power is achievable on a gradual basis.

**H4.** Economic return has positive influence on the customer intention on the adoption of PV panel system.

#### 3.1.5. Perceived pricing/cost

Different people look at cost differently depending on their financial background, education exposure and peers. When one purchased an item, how valuable a cost is does not solely depend on the money but also on each individual's perception, in terms of how much benefit it obtained. The non-solar panel adopters have optimistic attitude towards the perceived cost where benefit is more than the cost with the actual payback time is 21 years compared to solar panel lifespan of 25 years [85].

**H5.** Perceived pricing/cost has positive influence on the customer intention on the adoption of PV panel system.

#### 3.1.6. Size of the roof

Home owners do frowned at the large, unsightly, glaring solar panels on their rooftop. At times when birds release their droppings or perch on the solar panels, it creates a mess down the solar panel resulting in unpleasant sight & reduction of the efficiency of the solar panels. However, for school based solar panel projects, aesthetics does not play an important role in affecting the purchase of solar panel [13] Hence, social acceptance on solar panel aesthetic will be tested on how it affects the purchase of photovoltaic (PV) Panel system.

**H6 (H6a-H6e).** The size of roof moderates the relationship between independent variables and customer intention on the adoption of PV panel system.

### 3.2. Research methodology

The quantitative cross sectional research was employed in this study. Cross sectional studies are well known research design types that attempt to study the entire population or a subset of selected sample. The population for this study is considered as Malaysian citizens owning landed property since it is convenient for them to install PV panels compared to condominiums or apartment(s) owners. The respondent is represented by the head of family and the samples are taken from PV panel non-users. The sampling frame used in the study is convenience sampling using noon-probability sampling method. The survey questionnaire (Appendix A) consisted of scale measurements which were previously developed and validated in the literature. The questionnaire has been developed mainly using four research articles via Kaldellis et al. [42], Eronini [22], Eshchanov et al. [23], Zhai [85]. The questionnaire was administered to nearly 200 respondents in West Malaysia through direct personal interview method. The items in the questionnaire consist of relevant questions based on the conceptual framework, experts' opinion and literature review. The purpose of the questionnaire is to obtain and gather the required data for the purpose of predictive inference.

Most of the questions in the questionnaire are close-ended questions associated where the respondents can choose their choice among the alternatives provided in Likert scale measurements. Only a few open-ended questions were included in the section connected with socio-demographic variables, where the respondents can write their options. Double-barrelled, ambiguous, leading, loaded and socially undesirable questions were avoided in the questionnaire. Also, each question was oriented towards either in a positive direction or in a negative direction, but not duplicated in both ways. The negatively directed questions were re-coded while carrying out the data analysis. The questionnaire comprises of four sections and guidelines to complete the questions were specified. Section 1 in the questionnaire is the filtering questions of the research regarding the usage of photovoltaic (PV) Panel system. The questionnaire comprises of relevant descriptive information that have been gathered in parallel with the profile of the respondents. Section 2 describes information on the socio-demographic and economic variables of the respondents with nine questions. Section 3 is related to the measurement items of the independent variables based on technology barriers (TB), environmental concern (EC), perceived cost (PC), perceived economic returns (PER), social influence (SI). Section 4 has seven question items for customer intention (CI) on the adoption of photovoltaic (PV) Panel system (Dependent variable). Since, roof size is considered as a moderating variable, the actual size of the roof is included as a question in Section 2. The Likert scale measurement ranging from 1 (strongly disagree) to 5 (strongly agree) is used to measure independent and dependent variables. A pilot study was conducted initially with 32 respondents to identify the consistency of the survey instrument to

reduce measurement error and respondents' bias. The Cronbach's Alpha for all the identified variables in the conceptual framework was above 0.7 in the pilot study, fulfilling the threshold value [27].

## 4. Findings and results

Although 200 respondents were contacted, only 157 valid and usable questionnaires were included for the study. Out of 157 respondents, there were almost equal gender representations of about 49.6% were males and 50.4% were females. Majority of the respondents were Chinese (72.7%), followed by Malays (15.7%), Indians (9.9%) and others (1.7%). In terms of age, majority of the respondents were belonged to below 40 years (88.5%). The average monthly income is less than RM 2000 (22.3%), between RM2000-RM2999 (29.8%), followed by RM3000-RM3999 (24.8%) and more than RM4000 accounts for 23.1%. Majority of the respondents hold bachelor degree (76.9%). The factor analysis was applied to study the construct validity of the variables presented in the conceptual framework (Fig. 1). From the results of factor analysis, it was found that TB and EC merge into a single factor (TBEC) while all other variables emerge as a single factor among the set of independent variables. The dependent variable (CI) forms as a separate factor with all question items have main loadings above 0.5 [30]. Further, TBEC, PER, PC and SI are highly consistent with the Cronbach's Alpha of 0.88, 0.81, and 0.70 and 0.76 respectively, which fulfils the thumb rule value of 0.7 [60].

Table 1 shows the average and standard deviation values of all model variables which are measured on a five point Likert scale, ranging from 1 (being strongly disagree) to 5 (being strongly agree). From the descriptive statistics, the maximum average is for PER (3.671) and the least average is for SI (2.987). The customer intention (CI) to purchase PV panel has the average of 3.538 with a standard deviation of 0.807. Since, the solar power related technology is new, we can expect a better average over a period of time in future. It is worthwhile to mention that the roof size of the houses for the selected respondents has an average of 1745 sq. ft. which indicates that the respondent belongs to upper middle income group.

The bivariate correlation analysis using the Pearson's correlating coefficient among the study variables with their level of significance is summarized in Table 2. There is no multi co linearity issue as all the correlation coefficients between the independent variables are very low. The independent variables such as, technology barriers (TBEC), and the moderating variable roof size have negative values −0.064 and −0.006 on the customer intention (DV), but they are not found to be statistically significant. Besides, all other, the independent variables perceived economic returns (PER), perceived cost/pricing (PC) and social influence (SI) are positively and significantly correlated with customer intention to purchase PV panel system.

The regression analysis can be used to test the cause and effect relationships between the independent variables on and dependent variables. The first model (Model-1) test /ed/ gives the direct effect between independent variables and dependent variable. The multiple correlation is R and the coefficient of determination is $R^2$ (R-square). To test the significance of the population measure $R^2$, F-test has been used. In fact, the sample $R^2$suggests to what extent the independent constructs help to predict or explain the dependent construct. The $R^2$value ranges from 0 to 1 with higher levels indicating higher levels of predictive accuracy. It is difficult to provide rules of thumb for acceptable $R^2$value as this depends on the model complexity and the research discipline [28]. In scholarly research that focuses on marketing issues, $R^2$values of 0.75, 0.50, or 0.25 for endogenous latent variables can, as a rough rule of thumb, be respectively described as substantial, moderate, or weak [29]. In the present study, R2 value for customers' intention to purchase PV panel system is 0.694, F=84.483, $p < 0.01$ (Table 3). This indicate that the four predictor variables of TBEC, PER, PC and SI accounted for 69.4% of the variance in customers' intention to purchase PV panel system and it shows almost substantial predictive accuracy. Thus, the regression model fits well to the data (Model-1). Model-2 with the inclusion of moderating variable (Roof size) explains a meagre change in $R^2$ value of just 0.001 and the change in F value is 0.615 which is not statistically significant and therefore there is no improvement from Model-1. Hence, there is no moderating effect of size of the roof on the purchase intention of customers. The Durbin-Watson test value of 1.84 describes that the error term in the regression model is independent.

The Analysis of Variance (ANOVA) in Table 4 provides a statistical significance of the regression model. It also shows that the coefficient of determination ($R^2$) is significantly sufficient to conduct the test of significance in this study.

Table 5 shows the two regression models of the Independent variables and Dependent variable without moderating and with moderating variable. The results of Model-1 indicates that, perceived economic returns (PER) positively and strongly influence customer intention (CI) in the purchase of PV panel system (β=0.685, t=14.74, p=0.000). Secondly, Social Influence (SI) is positively and significantly influences customer intention (CI) in the purchase PV panel system (β=0.339, t=7.2, p=0.000). The Technology Barrier (TB) negatively influences customer intention (CI) while there is positive relationship between perceived cost and CI. From Model-II, it is clear that the size of the roof is not found to be significant, and therefore the roof of the house has no impact on the installation of PV panel system. The VIF value for all the variables is less than four, which ensures that there is no multi- co linearity problem on the selection of the independent variables in this study.

### 4.1. Interaction effects

Interaction Graph for moderating effect and independent variables on and the dependent variable result shows that the interaction between the size of the roof and Perceived Economic returns have negative impact on customer purchase intention of PV panel system. Hence, the hypothesis H6d is supported (Fig. 2). Those respondents who are living in a smaller house with lesser roof size favour more on the purchase intention of PV panel system since it is yet another source of income in generating electricity from sun light.

The interactions between the size of the roof and perceived cost have a negative impact on customer purchase intention of PV panel system. Hence, the hypothesis H6e is supported (Fig. 3). Those respondents who are living in a smaller house with lesser roof size favour show more purchase intention on the installation of PV panel system since the perceived price of the solar panel is low and therefore they can afford to purchase.

Prior to proceeding with results analysis of model it would be good to refresh the hypotheses developed in this study. Based on Theoretical Framework, there were ten (10) hypotheses developed. The results of the hypothesis testing are summarized in Table 6.

## 5. Discussion and conclusions

There is a potential market for the installation of Photovoltaic (PV) panel system in Malaysia as the country has the nature's gift of maximum sun exposure. The present study has been conducted to identify the root cause for the low penetration on the purchase of photovoltaic (PV) Panel system among Malaysian landed property owners. Pavlov [63] in his psychological experiments discovered Stimulus-Response Theory of be-

**Table 1**
Descriptive statistics.

| | Mean | Std. Deviation |
|---|---|---|
| CI | 3.538 | 0.807 |
| TBEC | 2.683 | 0.84 |
| PER | 3.671 | 0.785 |
| PC | 3.425 | 0.647 |
| SI | 2.987 | 0.784 |
| ROOF SIZE (sq.ft.) | 1744.600 | 1337.403 |

**Table 2**
Correlation coefficients of all constructs.

| | | AVECI | AVETBEC | AVEPER | AVEPCEC | AVESI | ROOF SIZE |
|---|---|---|---|---|---|---|---|
| Pearson Correlation Coefficient values | AVECI | 1 | −0.064 | 0.758** | 0.198** | 0.45** | −0.006 |
| | AVETBEC | −0.064 | 1 | −0.060 | −0.040 | 0.186** | −0.133* |
| | AVEPER | 0.758** | −0.060 | 1 | 0.117 | 0.174* | 0.035 |
| | AVEPC | 0.198** | −0.040 | 0.117 | 1 | 0.090 | 0.201** |
| | AVESI | 0.450** | 0.186** | 0.174* | 0.09 | 1 | −0.030 |
| | ROOF SIZE | −0.006 | −0.133* | 0.035 | 0.201** | −0.030 | 1 |

* $p < 0.05$.
** $p < 0.01$.

**Table 3**
The summary table for the coefficient of determination (R-square).

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | 0.833 | 0.694 | 0.686 | 0.45254 | 0.694 | 84.483 | 4 | 149 | 0.000** | |
| 2 | 0.834 | 0.695 | 0.685 | 0.45313 | 0.001 | 0.615 | 1 | 148 | 0.434 | 1.84 |

** $P < 0.01$.

**Table 4**
The summary of ANOVA for two models (n=157).

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 69.207 | 4 | 17.302 | 84.483 | 0.000 |
| | Residual | 30.515 | 149 | 0.205 | | |
| | Total | 99.722 | 153 | | | |
| 2 | Regression | 69.333 | 5 | 13.867 | 67.535 | 0.000 |
| | Residual | 30.388 | 148 | 0.205 | | |
| | Total | 99.722 | 153 | | | |

haviour and it supports the proposed framework. Watson [80] the founder of behavioural psychology, proposed a stimulus–response (S-R) theory. This theory indicates that the scenario can stimulate customers' psychology, and then affect customer behaviour. The predictors of the proposed framework namely social influence technology barriers, environment concern, economic returns and perceived cost serve as stimuli and customer intention for the adoption of photovoltaic (PV) Panel system as a response variable. However, the holistic research model of the present study was fully supported by Theory of Planned Behaviour by Ajzen [3], Ajzen [2], which is also known as an extension theory of motivation action. In the present study, Social Influence (as subjective norm of TPB), Technology barriers (as behavioural control of TPB), environment concern (as attitude of TPB), Economic returns (as attitude of TPB), perceived cost/Pricing (as behavioural control of TPB). Finally the dependent variable is the intention in TPB model would be customer intention for the adoption of photovoltaic (PV) Panel system. The result of the study reveals that about 46% of the 157 surveyed respondents shown their intention to purchase photovoltaic (PV) panel system. Findings from the current study indicates that the predictors namely perceived economic returns, perceived cost and social influence have positively and significantly influencing the customer purchase intention of Photovoltaic (PV) panel system while technology barriers and environment concern which are merged as a single factor show negative influence.

The predictor 'perceived economic returns' emerge as a significant factor because of the attraction on the latest introduction of buy back policy introduced by Tenaga Nasional Berhad (TNB), Malaysia. The scheme has interesting features like customers who purchase photovoltaic (PV) panel system need not pay electricity bill for their domestic usage of electricity, and they can also earn extra money for electricity generated using solar power. To further promote renewable energy in Malaysia, the Sustainable Energy Development Authority (SEDA) of Malaysia was established under Act 726 in 2011. It was inaugurated to achieve the purpose of administering and managing the Feed in Tariff implementation (FiT) method. FiT has been established as the most

**Table 5**
The results of the multiple regression analysis.

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t-value | VIF |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| **1** | (Constant) | 0.24 | 0.29 | | 0.83 | 1.05 |
| | AVETBEC | −0.08 | 0.05 | −0.08 | −1.77* | 1.05 |
| | AVEPER | 0.70 | 0.05 | 0.69 | 14.74** | 1.02 |
| | AVEPC | 0.11 | 0.06 | 0.08 | 1.84* | 1.08 |
| | AVESI | 0.35 | 0.05 | 0.34 | 7.20** | |
| **2** | (Constant) | 0.69 | 0.64 | | 1.07 | 1.07 |
| | AVETB | −0.07 | 0.05 | −0.08 | −1.64* | 1.06 |
| | AVEPER | 0.71 | 0.05 | 0.69 | 14.72** | 1.04 |
| | AVEPC | 0.10 | 0.06 | 0.08 | 1.70* | 1.08 |
| | AVESI | 0.35 | 0.05 | 0.34 | 7.15* | 1.05 |
| | Roof Size | 0.06 | 0.08 | 0.04 | 0.78 | |

Dependent Variable: AVECI; AVE: Average
* $P < 0.05$.
** $P < 0.01$.

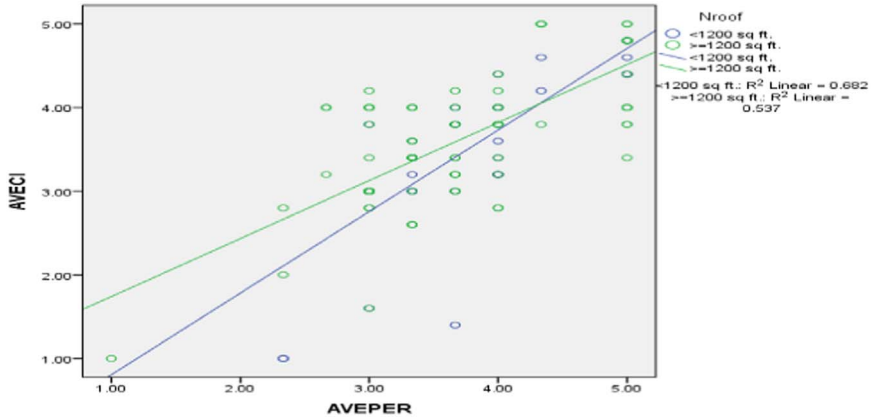


**Fig. 2.** Interaction effect of PER and RS on CI.

effective means of cost effective technique that proves renewable energy is better than other policy strategies such as quotas, direct incentives or voluntary goals [32]. It ensures that renewable energy becomes a viable and sound long term investment for individuals, companies and industries. The predictor social influence has a positive effect on the purchase intention of photovoltaic (PV) Panel system since people surrounding the respondents like relatives, friends and colleagues influence them on the purchase intention of photovoltaic (PV) panel system and the results go parallel lines with Jeon et al. [40]. The perceived cost has positive effect on customer intention to purchase photovoltaic (PV) panel system and the respondents were concerned on the flood season where the strong winds might take out the installed PV solar panel. Also, the respondents were concerned on the costing as they were not sure of the expected returns in the future. The cost factor for maintenance may be a recurring problem if the solar panel parts are not available on time as most of the spare parts were imported from developed countries such as Germany and France. Further for proper maintenance, the respondents were under the opinion that, for each and every technical knowhow they should resort to the original agency which is really a problematic one in reality.

The current study establishes the fact that technology barriers and environment concerns have negative effect on the purchase intention of photovoltaic (PV) panel system and these results coincide with Irland [36], Schuhwerk and Lefkokk-Hagius [67], Tsen [75] and Zhai [85]. According to the respondents, the technology barriers like grid installation, rust formation in cable wires and metal grid might create minor maintenance problems in the long run usage. Any technology repair requires expertise from the manufactures and therefore the customers were forced to seek help from the agents or distributors of the solar panel. Mourad [55] has commented that the environmental awareness is the key factor for purchase intention of green products. Young generation believes that consuming environmental friendly products reflects young customers' environmental consciousness. The majority of the current study respondents belong to 20–40 years of age group and they favour buying PV panel system in the future. The best place to introduce photovoltaic (PV) panel system is the new housing areas where younger generation would like to have full package with all amenities. Indeed, the greatest investigative association, NASA is utilizing sunlight based vitality for their essential wellspring of energy to assist the earth.

The size of the roof in the landed property has no direct influence on the purchase intention of PV panel system. In fact, the average roof size of the respondents is about 1800 sq ft and there are two models of PV installation in Malaysia. The first model covers the entire roof which costs around RM 54,000 and generates maximum electricity power from solar energy. The Malaysian government has come up with Equated monthly instalment (EMI) schemes to repay the loan amount given for buying PV panel system. But, the subscribers have to wait in the queue to get the loan amount and register with the Malaysian government body. The second model consists of partial installation of PV panel system whose configuration of generating electricity power is far less from the first model. Most of the landed property owners go for the second model because it costs about RM 3400, but generates electricity from solar energy only to replace the water heater. Unfortunately, the present study does not support on the moderating effect of roof size although there is an interaction effect between size of the roof and perceived economic returns. Those respondents who are staying in a smaller house with lesser roof size favour purchase intention for the installation of PV panel system. Since, this is the opportunity for them to get other source of income via generating electricity from sun exposure.

Adoption of photovoltaic (PV) Panel system has long term benefits to the customers and was highly perceived convictions among the respon-

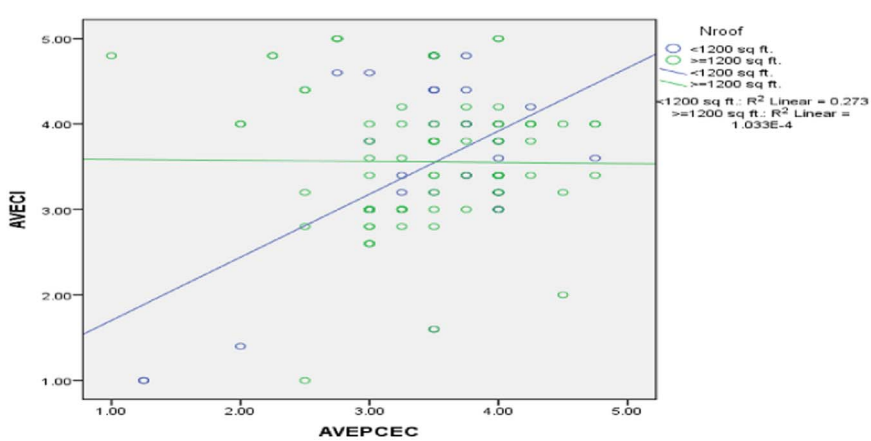


**Fig. 3.** Interaction effect of PC and RS on CI.

**Table 6**
Summary of the results for hypothesis testing.

| Hypotheses | | Decision |
|---|---|---|
| H1 | Social influence (SI) has a positive impact on the purchase intention of PV panel system | **Supported** |
| H2 & H3 | Technology barriers and Environment concerns (TBEC) have negative influence on the purchase intention of PV panel system | **Supported** |
| H4 | Perceived Economic returns (PER) have a positive influence on the purchase intention of PV panel system | **Supported** |
| H5 | Perceived cost/pricing (PC) has a positive influence on the purchase intention of PV panel system | **Supported** |
| H6a | The interactions between the size of the roof and social influence have impact on the customer purchase intention of PV panel system | Not Supported |
| H6b | The interactions between the size of the roof and technology barrier have impact on the customer purchase intention of PV panel system | Not Supported |
| H6c | The interactions between the size of the roof and environmental concern have impact on the customer purchase intention of PV panel system | Not Supported |
| H6d | The interactions between the size of the roof and perceived economic returns have a negative impact on the customer purchase intention of PV panel system | **Supported** |
| H6e | The interactions between the size of the roof and perceived cost have a negative impact on the customer purchase intention of PV panel system | **Supported** |

dents. In protecting the sustainable environment, the study respondents have realized the importance of purchasing environmental friendly products. Besides, the initial cost of installation photovoltaic (PV) panel system affects the intention to purchase. With the proper implementation of low interest rate financial loans, it is possible to improve the adoption of photovoltaic (PV) panel system. Interestingly, public awareness of environmental value and ecological lifestyles towards green products were positive. The findings of the present study are encouraging in identifying the relevant predictors for the purchase intention of PV panel system. Some respondent's feedback is that they have not heard about photovoltaic (PV) panel system as the information on the product is not widely spread through media unless one approaches the particular shop selling photovoltaic (PV) panel system. More publicity on photovoltaic (PV) panel system through social media networking and introducing PV technology into the education system is a welcome move according to the surveyed respondents.

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## Appendix A. Questionnaire items

| Strongly Disagree | Disagree | Neither disagree nor agree | Agree | Strongly Agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

| Item | Source | **Technology Barriers (TB)** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| TB1 | c | Photovoltaic (PV) Panel systems harm/disturb the people in their surroundings. | | | | | |
| TB2 | d | Photovoltaic (PV) Panel system has difficulties in maintenance | | | | | |
| TB3 | c | Photovoltaic (PV) Panel system harm/disturb plants in their surroundings | | | | | |
| TB4 | d | Photovoltaic (PV) Panel system has difficulties in maintaining supporting instruments like grid, cable, roof and so on | | | | | |
| TB5 | e | I have no intention to purchase Photovoltaic (PV) Panel system because it takes too much formalities to maintain | | | | | |
| TB6 | e | Maintenance requirements will affect my decision to purchases Photovoltaic (PV) Panel system in the future | | | | | |
| **Item** | **Source** | **Environmental Concern (EC)** | 1 | 2 | 3 | 4 | 5 |
| EC1 | e | I have no intention to purchase Photovoltaic (PV) Panel system because it does not benefit the environment | | | | | |
| EC2 | e | I have no intention to purchase Photovoltaic (PV) Panel system, it is not safe for animals | | | | | |
| EC3 | d | My intention to purchase on Photovoltaic (PV) Panel system will reduce global warming | | | | | |
| EC4 | e | Photovoltaic (PV) Panel system is very environmental friendly compared to electricity | | | | | |
| EC5 | d | Non availability of Photovoltaic (PV) Panel system spare parts will lead to problems | | | | | |
| **Item** | **Source** | **Perceived Cost (PC)** | 1 | 2 | 3 | 4 | 5 |
| PC1 | d | I have no intention to purchase Photovoltaic (PV) Panel system because it is expensive | | | | | |
| PC2 | e | I have no intention to purchase Photovoltaic (PV) Panel system because it won't save enough electricity to be worth spending | | | | | |
| PC3 | e | I have no intention to purchase Photovoltaic (PV) Panel system because I won't live here long enough to make it worth spending | | | | | |
| PC4 | e | Amount of saving on my investment affects my intention to purchase Photovoltaic (PV) Panel system in the near future | | | | | |
| PC5 | e | Length of stay in the same house affects my intention to purchase Photovoltaic (PV) Panel system | | | | | |
| Item | Source | **Perceived Economic Returns (PER)** | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PER1 | c | Electricity generated with Photovoltaic (PV) Panel system is cheaper compared to other sources. | | | | | |
| PER2 | c | Credit/loans are needed for household Photovoltaic (PV) Panel system | | | | | |
| PER3 | c | Global warming would be reduced if more of our electricity is generated from Photovoltaic (PV) Panel system | | | | | |
| PER4 | c | Photovoltaic (PV) Panel system can save on my monthly electricity bill | | | | | |
| PER5 | c | The cost of the Photovoltaic (PV) Panel system saves for itself than electricity | | | | | |
| PER6 | c | I can guarantee much electricity production from the Photovoltaic (PV) Panel system | | | | | |
| **Item** | **Source** | **Social Influence (SI)** | 1 | 2 | 3 | 4 | 5 |
| SI1 | a | I have intention to purchase Photovoltaic (PV) Panel system because I am influenced by social media | | | | | |
| SI2 | a | I have intention to purchase Photovoltaic (PV) Panel system because I am influenced by my family and friends | | | | | |
| SI3 | b | I have intention to purchase Photovoltaic (PV) Panel system because I am influenced by my office colleague | | | | | |
| SI4 | a | I often collect information from Photovoltaic (PV) Panel system from different companies | | | | | |

**Dependent Variable**.

| Item | **Source** | **Customer intention for the adoption of photovoltaic (PV) Panel system (CI)** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1 | d | Do the usage of photovoltaic (PV) Panel system saves money over time? | | | | | |
| 2 | d | Photovoltaic (PV) Panel system requires no maintenance | | | | | |
| 3 | d | Do photovoltaic (PV) Panel system benefits the environment? | | | | | |
| 4 | d | Do you show interest for photovoltaic (PV) Panel system to install on your rooftop? | | | | | |
| 5 | d | Have you exposed to photovoltaic (PV) Panel system? | | | | | |
| 6 | d | Do you plan to go for photovoltaic (PV) Panel system in your landed property in the near future? | | | | | |
| 7 | d | Do you have long term intention to buy photovoltaic (PV) Panel system for your landed property? | | | | | |

**Source for the question items**.

**a** Kaldellis JK, Kapsali M, Kaldelli E, Katsanou E. Comparing recent views of public attitude on wind energy, photovoltaic and small hydro applications. Renew Energy, 52, 197–208; 2013.
**b** Eronini N. The adoption of solar photovoltaic systems among industries and residential houses in Southern Nigeria [Doctoral dissertation, Mid Sweden University]; 2014.
**c** Eshchanov BR, Stultjes MGP, Eshchanov RA, Salaev SK. Prospects of renewable energy penetration in Uzbekistan—Perception of the Khorezmian people. Renew Sustain Energy Rev, 21, 789–797; 2013.
**d** Self-constructed questions
**e** Zhai P. Environmental, Policy and Social Analysis of Photovoltaic Technologies (Doctoral dissertation, Arizona State University); 2010.

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