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Factors Influencing Social Acceptance of Residential Solar Energy Technology

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***Abstract*- The world is facing many environmental problems such as global warming due to high demand of energy use, especially our dependency on fossil fuels. The Malaysian government has introduced various policies and programs to promote alternative green energy solutions such as solar energy to address this issue. However, social acceptance of solar energy could influence the feasibility of the energy as an alternative to satisfy the rising demand. Drawing from research survey and the academic literature, this paper explores the factors that could influence social acceptance of residential solar energy project in Malaysia. Data for this study were collected through a survey in Taiping, Perak; a city recognized as the top three most sustainable in the world by the International Tourismus-Börse in 2019. A total of 240 questionnaires were collected from the respondents in Taiping and the data were analysed using descriptive and correlation analysis. This study reveals that knowledge is able to determine society's perception and change their opposition towards solar energy. In addition, high cost could hinder society's acceptance of solar energy, thus their willingness to switch to the energy.**

***Keywords*-** social acceptance, solar energy, residential solar project, green energy

1. Introduction

Malaysia has pledged in the Paris Climate Agreement, to reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% relative to 2005 levels by 2030 [1]. The increase in global carbon emissions, which has been a major environmental, social, and economic issue, has led to more attention given to solar energy. This has resulted in, for example, the installation of 113,533 household solar systems in California, which has able to reduce 696,544 metric tons of CO2 emissions [2].

In Malaysia, solar energy applications can be divided into two main categories: solar thermal application and photovoltaic (PV) technologies. Up to early 2019, the cumulative grid-connected PV was 16,074.94 kWp with the array size 99,352.97 m2 [1]. There were 121 total monitored sites all around Malaysia including Labuan, Sabah, Sarawak and Putrajaya, consisting of industrial, commercial, community and residential solar PV [1].

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In order to attract more people to adopt the solar energy systems, the Malaysian government has introduced various programs to gain the trust from the public. It has introduced the RE Act 2011 to enforce the Feed-in Tariff (FiT) mechanism and the establishment of Sustainable Energy Development Authority (SEDA) Malaysia in the same year to ensure its successful applications. Moreover, the cost of the PV technology is declining and the ease of installation is being improved. With the new policies and promotions introduced by the government, this may help to change the perception of domestic and business users towards solar energy system in Malaysia and encourage them to switch to the alternative energy.

The weather in Malaysia, which is tropical-humid all year round, has huge potential for solar energy opportunities [3]. It is located near the equatorial zone that receives high average daily solar radiation (4500 kWh/m2), and about 10 hours of sunshine per day [4]. However, the high cost of solar PV installation as well as electricity tariff has contributed towards the low acceptance of solar energy [5]. The Malaysian government, therefore, has introduced various incentives and strategies to encourage the growth of this alternative energy under the 9th and 10th Malaysia Plan [5].

Over the past decade, social acceptance has been a prominent topic of research by energy social scientists [6]. Social acceptance refers to acceptance by the public since the term 'social' or 'societal' acceptance is continuously being used in connecting with the new energy technologies [7]. A study by Solangi, et al. [8] highlights social acceptance of solar energy in Malaysia. It explores public interest in the energy, public responses on the difficulties in consuming solar energy, and public expectations on enhancing solar energy usage in Malaysia.

This present paper differs from the existing study because its focuses on the factors that could influence the social acceptance of residential solar energy technology. Furthermore, it looks at social acceptance from the perspective of society's perception and resistance to solar energy (i.e. 'not in my backyard' NIMBY).

2. Literature Review

2.1 Solar energy development in Malaysia

The commitment to carbon emissions reduction can be achieved through diversification of energy sources for

electricity generation that focuses on alternative green energy such as solar. The Malaysia government through its Malaysia Plan has set various target and introduced policies that could be used to help spur the development of solar energy in the country.

In the Eight Malaysia Plan, the government formulated a five-fuel strategy, where renewable energy (RE) would contribute about 5% (600MW) of the electricity mix in 2015 [9]. This strategy continued in the ninth Malaysia Plan [10]. However, after a decade of implementation, the policy only resulted in 1% contribution [11]. The Tenth Malaysia Plan sets the target of 985 MW electricity generations from RE sources, where about 7% of the energy mix would come from solar PV (65 MW).

The government also introduced a feed-in tariff (FiT) program in 2011 for subscribers of electricity generated from RE [12]. In addition, it established an agency, Sustainable Energy Development Authority (SEDA), to handle the FiT fund, as well as to promote RE development in the country. The government targeted that RE would contributed 3GW of operational capacity for energy generation by 2020, where one-third will be from solar PV. Post-2020, solar energy is predicted to surpass all other REs in Malaysia in terms of cumulative installed capacity. Its role in the energy mix of the country will be even bigger by 2050, where third of the annual total electricity generation is expected to be from the energy source [8].

Khor and Lalchand [13] found that Malaysia was not able to enhance its solar energy use efficiently. Some of the factors that contribute towards this problem include high subsidies for fossil fuels, but low incentives were given for RE projects. In addition, solar energy development in Malaysia involved high capital expenditure, with long payback period and low tariff. This has caused low interest in RE projects among investors [13]. Furthermore, RE power purchase agreement has stringent conditions and requires lengthy negotiations [13]. These factors have negatively affected solar energy investment and uptake in the country.

Solar energy has been accessible among other renewable energy sources mainly because of its 'plug and plays' features. It is different than other sources of energy, which need mechanical support such as motors or generators (hydro, wind, wave) or chemical support (biofuels) [14]. In Malaysia, solar panels are being used along the North-South highways, telecommunication towers, and for street lighting [15].

2.2 Social acceptance

Public acceptance is an important issue that could influence the development and implementation of renewable energy technologies as well as the achievement of energy policy targets. Batel, et al. [16] highlights that acceptance can be examined from different perspective, namely in terms of technology, infrastructure or applications. In addition, it can also be viewed from different areas, such as political, markets, and in communities. Various terms have been used to describe acceptance issues in the academic literature. This includes public perception, public acceptance, social acceptance, not in my back yard (NIMBY), willingness-to-pay/use, and public support [17].

Perception can be viewed as social norms, which is a "person's perception of social pressure to perform or not perform the behavior under consideration" [18]. This concept posits that people will make their judgments and decisions based on the positive or negative feelings that arise in relation to objects, images, or other stimuli [19]. This norm will influence the way individuals in society behave towards development in their community that conform to or against what the society collectively perceived as appropriate.

NIMBY is defined as "the protectionist attitudes of and oppositional tactics adopted by community groups facing an unwelcome development in their Neighbourhood" [20]. The phrase "Not in My Backyard" is often used as a short term for local resistance and to explain objection as based on selfishness, irrationality or ignorance. In addition, it can also refer to situations in which individuals who support RE might also be the one against it [17].

The NIMBY concept has always been interpreted as a strong local opposition. This place-based approach conceives negative local responses toward developments [6]. It suggests that the perception of the people living in the affected places on a development proposal will determine their acceptance. This is influenced by whether the proposal is aligned with their feeling about and relationships with those places. Much of the existing scholarly research considering support or opposition to energy sources focuses on support for that energy source in a specific location [21]. As a result, there is a great deal of literature that considers the opposition to green energy in terms of a NIMBY framework.

2.3 Factors influencing acceptance of solar energy

The factors that can influence decision making for acceptance consist of public way of thinking, knowledge and attitudes [22]. In certain technologies, individuals' acceptance of the technology can be based on: (1) the overall evaluation of costs, risks and benefits, (2) moral evaluations, which is about the impact of the technology on the environment or society, and (3) on positive or negative feelings related to the technology, such as satisfaction or anger [22].

Lack of knowledge can affect the way individuals make decision. For instance, knowledge on RE technologies can change public attitudes, behavior, acceptance and willingness to use solar PV [23]. Societal changes are more difficult to be achieved than technological changes [23].

Another potential barrier to users' intention to use services or technologies is cost [24]. This means that users' total estimated costs including purchasing, maintaining, utilizing, and switching expenses can amplify their perceived degree of potential risks [25].

Perceived benefits relate to the perceived economic risks and benefits, distributive justice or the distribution of socio-economic risks and benefits among different social

groups [6]. This factor may influence their public perception of RE project [6].

Environmental impacts are the effects of the positive and negative environmental impacts also being considered as a factor that could influence social acceptance. It can lead community to believe that renewable energy give environmental benefits and encourage people to install switch to renewable energy [26].

Based on the study by Solangi et al. [8], the acceptance of solar energy relate to cost, knowledge, trust in the developer, and the success of existing solar energy projects. According to [27], the public in Pakistan are more interested in purchasing solar home systems only if the government subsidize part of its cost, had enough knowledge and awareness about the benefits. Besides, a research study in Bahrain also shows that high knowledge, low cost, positive benefits, positive environmental impacts, and trust lead to acceptance towards solar energy [23]. Environmental concern is also shown to have a positive effect on pro-environmental behavior [28]. Environmental reasons are among the motivations for collective energy action, where environmental awareness could increase support for local energy projects [29].

This paper proposes the following conceptual framework to identify the factors that influence societal acceptance of solar energy technology in Malaysia.

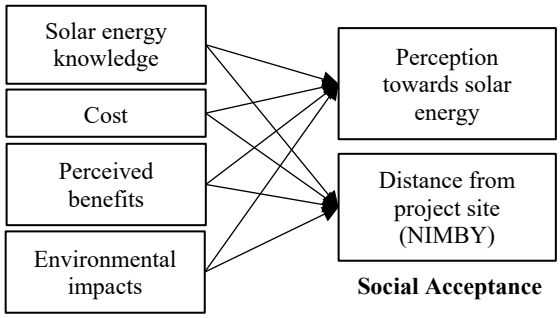

Figure 1: Conceptual framework of social acceptance of solar energy

3. Research Methodology

This is an explanatory study that used a cross-sectional survey to collect data necessary to understand the factors influencing societal acceptance of solar energy technology. The survey was conducted among the residents of Taiping, Perak. The city was awarded as the top three most sustainable cities in the world by the International Tourismus-Börse in 2019 [30]. Therefore, it is assumed that the city could be one that is more open towards switching to alternative energy.

Paper-based and online-based questionnaire were used to collect data in this study. The questionnaire used 5-point Likert scale ("Strongly Agree", "Agree", "Neutral", "Disagree", "Strongly Agree") to measure the factors and societal acceptance.

Table 1 shows the items used to measure the influencing factors and social acceptance.

Table 1: Variable measurement items

Construct	Descriptions	Sources
Knowledge	K1: I am familiar with solar energy	Park (2019); Patel & Rao (2016); Aris et al. (2015); Tahir et la. (2015)
	K2: I know about solar energy	
	SK3: Solar power plant helps to save the environment.	
Cost	C1: I think the purchasing cost of solar energy is more expensive than traditional types of electricity	Park (2019)
	C2: I think the maintenance cost of solar energy is more expensive than traditional types of electricity	
	C3: I think the repair and usage costs of solar energy are more expensive than traditional types of electricity	
Perceived benefits	PB1: There are a lot of benefits from installing solar power plant	Tahir et al. (2017); Patel & Rao (2016)
	PB2: Installing solar power plant will improve the comfort level	
	PB3: Solar panel on the rooftop can light supply electricity when there is no power	
Environmental impact	EI1: Installing solar energy will improve the environment, by reducing the emission gas	Bamgbade et al. (2017); Hanger et al. (2016) Bahaudin et al. (2017)
	EI2: The space that using to install the solar energy can hurt the environment	
Perception Towards Solar Energy	PSE1: Solar radiation in Malaysia is promising for solar energy applications	Al-Fatlawi et al. (2014); Yusof et al. (2015) Baharum et al. (2018)
	PSE2: I am interested in solar PV applications	
	PSE3: Solar energy awareness will increase if one (or more) solar energy project was carried out in my area	
	PSE4: I would like to start using photovoltaic-generated electricity in my home	
Distance from Project Site (NIMBY)	D1: Solar facilities are ugly and spoil the scenery	Carlisle et al. (2015); Hanger et al. (2016)
	D2: Building solar facility within view of my property will decrease its value	
	D3: Installing solar energy takes a lot of space	

Data collected from the survey was analyzed using descriptive and correlation analysis. The population size of Taiping is around 217,647 (World Population Review, 2019). Therefore, the sample size of this study is 382 (Krejcie & Morgan, 1970). 240 questionnaires were able to be collected, which makes the response rate to be about 63%.

Table 2: Demography of respondents

		Frequency	%
Gender	Male	86	35.8
	Female	154	64.2
Race	Chinese	13	5.4
	Indian	8	3.3
	Malay	219	91.3
Age	15 - 24 years old	83	34.6
	25 - 34 years old	102	42.5
	35 - 44 years old	44	18.3
	45 - 54 years old	9	3.8
	55 - 64 years old	2	0.8
Education	PMR/SPM	59	24.6
	STPM/Matriculation/Diploma	91	37.9
	Bachelor Degree	80	33.3
	Masters	10	4.2
Occupation	Unemployed	4	1.7
	Student	61	25.4
	Government	36	15.0
	Private sector	120	50.0
	Businessman	19	7.9
Monthly income	Less than RM1500	136	56.7
	RM1501-RM3000	49	20.4
	RM3001-RM4500	31	12.9
	RM4501-RM6000	16	6.7
	RM6001-RM7500	6	2.5
	RM7501 and more	2	0.8
House ownership	Owner	139	57.9
	Tenant	101	42.1

Table 2 shows the demography of the respondents of the survey. Based on the analysis, 58% of the respondents owned the house they live in. Among the respondents, four have solar panels installed at the homes.

4. Results

This section presents the results of the data analyses that were conducted to understand the factors that could influence social acceptance of solar energy technology. Descriptive analysis was used to describe the main variables of this study. Correlation analysis was used to identify the relationship between the influencing factors and societal acceptance.

4.1 Influencing factors

Four factors were examined in this study, namely knowledge, cost, perceived benefits and environmental impact. Table 3 shows the results of the descriptive analysis conducted.

Table 3: Mean score of influencing factors

Items	Mean	SD
K1: I am familiar with solar energy	3.90	0.83
K2: I know about solar energy	3.77	0.73
SK3: Solar power plant helps to save the environment	4.11	0.793
Knowledge	**3.93**	**0.633**
C1: I think the purchasing cost of solar energy is more expensive than traditional types of electricity	3.77	0.903
C2: I think the maintenance cost of solar energy is more expensive than traditional types of electricity	3.63	0.91
C3: I think the repair and usage costs of solar energy are more expensive than traditional types of electricity	3.66	0.94
Cost	**3.69**	**0.83**
PB1: There are a lot of benefits from installing solar power plant	3.95	0.84
PB2: Installing solar power plant will improve the comfort level	3.79	0.74
PB3: Solar panel on the rooftop can light supply electricity when there is no power	4.19	0.68
Perceived benefits	**3.98**	**0.62**
EI1: Installing solar energy will improve the environment, by reducing the emission gas	3.03	0.84
EI2: The space that using to install the solar energy can hurt the environment	2.97	0.91
Environmental impact	**3.00**	**0.79**

Overall, all factors have high mean score level, except environmental impact which is moderate. The results indicate that the respondents have rather high level of knowledge on solar energy. They are also of the opinion that solar energy requires high investment and maintenance costs compared to traditional power sources. In addition, the use of solar energy will benefit users in terms of comfort level and as an alternative during power cuts. Although solar energy could help reduce carbon emissions, it could cause negative impact on the environment; for example, land clearing for solar power plants installations.

4.2 Social acceptance

Table 4 shows the results of descriptive analysis of items used to measure social acceptance.

Table 4: Mean score of social acceptance

Items	Mean	SD
PSE1: Solar radiation in Malaysia is promising for solar energy applications	3.99	0.73
PSE2: I am interested in solar PV applications	3.75	0.64
PSE3: Solar energy awareness will increase if one (or more) solar energy project was carried out in my area	3.98	0.63
PSE4: I would like to start using photovoltaic-generated electricity in my home	3.81	0.70
Perception towards solar energy	**3.88**	**0.54**
D1: Solar facilities are ugly and spoil the scenery	3.47	1.09
D2: Building solar facility within view of my property will decrease its value	3.50	1.03
D3: Installing solar energy takes a lot of space	3.17	1.01
Distance from project site (NIMBY)	**3.38**	**0.83**

Social acceptance consists of two variables which is perception towards solar energy for the positive side and distance from project site (NIMBY) which is more in negative side. The average mean score of perception towards solar energy is 3.88, which is considered as high. This factor focuses on knowledge, interest and awareness towards solar application. NIMBY, on the other hand, scored moderate mean score, which is 3.38. Items used to

measure NIMBY focus on landscape which is scenery, value of property and space.

4.3 Correlation analysis

A spearman correlation test was conducted to identify the relationship between the influencing factors and social acceptance of solar energy technology. This analysis was chosen because the results of Kolmogorov-Smirnov normality test show that data for all variables are not normally distributed. Table 5 shows the results of the correlation analysis. The results of correlation coefficient value were interpreted according to the recommendation proposed by [31].

Table 5: Correlation between influencing factors and social acceptance

Variables	Perception towards solar energy	Not in my backyard (NIMBY)
Knowledge	0.60**	-0.14*
Cost	-0.25**	0.03
Perceived benefits	0.62**	0.11
Environmental impacts	-0.06	0.01

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The results show that knowledge and perceived benefits have a moderate significant positive correlation with perception towards solar energy. Cost, on the other hand, has a very low negative significant relationship with perception. The positive relationships indicate that as knowledge and perceived benefits of solar energy increase, communities' perception towards solar energy becomes more positive. The negative relationship between cost and perception suggests that higher cost of solar energy installation, for example, can cause negative perception towards the energy.

Meanwhile, only knowledge is shown to have a significant correlation with NIMBY. The negative correlation indicates that knowledge about solar energy and its impact on the environment could help reduce local opposition towards solar energy project or installation within communities.

Four factors were examined in this study, namely knowledge, cost, perceived benefits and environmental impact, to understand how they could influence social acceptance of solar energy technology. Social acceptance was studied from the perspective of society perception of solar energy as well as NIMBY concept of social opposition towards development or a technology.
Social acceptance can take place at different levels with respect to technology [16]. In this study, social acceptance is the dependent variable that consists of two variables. First variable is perception towards solar energy that describes the positive attitude of communities. Second variable is not in my backyard (NIMBY) that shows the negative side of the communities. NIMBY describes communities' attitude as "free-riding" because of their willingness to accept and support solar energy application, but will oppose a solar project if it is built in proximity to their house [32].

This study found that knowledge has a positive relationship with perception towards solar energy and negative relationship with NIMBY. The results are consistent with the studies conducted by Alsabbagh [23] and Solangi, et al. [8]. Rai and Beck [33] state that lack of knowledge can affect society's acceptance and confidence towards solar energy. Parkins, et al. [34] agrees that knowledge is crucial to the acceptance process. The factual knowledge of solar energy will increase public confidence in accepting solar technologies. Without knowledge, the residents will not agree with the solar energy technology.

Cost-related factors have always been a hindrance to people behavior [24]. Most of the past studies shown that this is due to people find it hard to spend their money into something that is costly. This is supported by the finding of this study, in which cost has a negative relationship with society perception towards their acceptance of solar energy. Abdmouleh, et al. [35] found that respondents in their study are reluctant to install solar energy due to cost. They would only be interested if the cost is affordable and the tariff of electricity is cheaper when solar energy is used.

This study also found that perceived benefits have positive relationship with society's perception of solar energy. This is in line with a study that found the factor as important in determining public acceptance towards solar energy technologies [36].

6. Conclusion

Overall, the result shows that among the independent variables, knowledge, cost and perceived benefits have a high level of mean score mean. A Spearman correlation analysis shows that knowledge and perceived benefits have a significant positive relationship with society's perception towards solar energy. Cost, on the other hand, has a negative relationship with perception. Similarly, knowledge also has a negative relationship with NIMBY.

The present study was conducted in the residential area in Taiping, Perak. The different environment will lead to the different view and perception compared to other states in Malaysia. For future research, respondents from other states should also be studied to represent the whole nation. Furthermore, differences in suburban and rural areas compared to the central area may result in a variety of outcomes.

In addition, this study only involved four independent variables, which are knowledge, cost, perceived benefits and environmental impacts. Other variables such as awareness, socio-economic impacts and trust in developers should also be included in future studies. This will increase our understanding on social acceptance of solar energy technology and projects, which could eventually help in formulation of strategies that could be used to promote more sustainable energy development and use.

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