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Factors Affecting the Willingness to Pay for Solar Home Systems: An Empirical Study in Bangkok, Nonthaburi, Pathum Thani, and Samut Prakan Provinces, Thailand

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Abstract
Natural sources of energy such as sunlight, wind, rain, and tides are more environmentally safe than traditional carbon-based energy resources. Recently, many households in Thailand have taken advantage of renewable energy to power electronic devices and appliances in their homes. The solar home energy system (SHS) provides clean, efficient energy for residential applications including home appliances, lighting, electronics and the household's water pump. Critical to the success of encouraging consumers to use SHS for household consumption is to know whether they are willing to pay for one. In this study, the main purpose is to provide a framework to determine the willingness to pay (WTP) for SHS. This paper reviews several literatures regarding the use of mathematical model to determine WTP and factors affecting the WTP. A survey was developed and contains questions about demographics information, environmental awareness toward the use of renewable energy, and SHS. The survey also provides hypnotically situations based on the idea of conserving and using renewable energy at home. Surveys were distributed to residents in Bangkok, Nonthaburi, Pathum Thani, and Samut Prakan. The Contingency Valuation (CV) method was applied to determine the WTP. Binary logistic regression was employed to identify significant factors affecting the WTP for SHS. The results showed that factors that influence willingness to pay are income, energy consumption behavior, prior experience with renewable energy, environmental awareness, and trust.

Keywords: Contingent valuation method, Solar home system, Willingness to pay, Bidding game question, Adoption process, Binary logistic regression, Environmental awareness, Green product.

1. Introduction

In the 21st Century, electric power becomes majority energy that necessary for daily life. According to the growth of the world's electricity consumption, the per-capita electricity consumption in non-Organization for Economic Co-operation and Development (non-OECD) countries doubles by 2030, rising to almost 2400 kWh per person, but in OECD Europe per capita electricity consumption rises by 24% and OECD North America by 7% (European Environment Agency, 2015). Since the electric power is non-renewable energy, it will eventually become insufficient. According to the REN21 (2016), non-renewable energy; for instance, electric power, fuel, and oil are likely to be replaced by renewable energy. There is significant evidence that, in the future, renewable energy consumption will be increased.

In Thailand, there is a trend of increasing energy consumption. The electricity consumption per capita in Thailand has increased by 20% from 2009 to 2015, from 2,100 kW to 2595 kW per person (World Bank, 2018; Ministry of Energy, 2015). The increasing of electricity consumption in Thailand is a significant indication that leads Thailand toward to utilizing renewable or green energy. Moreover, geographic is favorable as Thailand is located close to the equator. Thailand contains the potential area that receives sufficient amount of sunlight when compared to other countries around Southeast Asia (SEA). The average solar radiation in Thailand is around 18-20 MJ/m2/day or 5.278-5.556 kW/hour/m2/day (Solaris, 2018). By the characteristic of solar energy, wavelengths of 380 nm to 750 nm (violet to red) are enough to dislodge the electrons and create electric current (Solar power is the future, 2018).

Most of the areas in Thailand get the solar energy on an average of 4.7-5.5 kW/hour/m2. This amount is higher than the average amount received in European countries, which get around 3-4 kW/hour/m2 (Bangchak, 2012). In the next few years, Thailand should have more solar power capacity than others in SEA (Jittapong, 2015). According to the policy 2015 to 2036 of the Alternative Energy Development Plan (AEDP), the electricity generation by solar power was 1,298.51 MW in 2015; however, the AEDP has planned to promote the electricity generation by solar power to 6,000 MW by 2036 in order to achieve 20 percent of the net electrical energy demand (Ministry of Energy, 2015). Since 2007, Thai citizens are interesting in the renewable energy because of an incentive policy of buying back of electricity from Thai's government under a special price as Adder (feed-in premium); especially, solar energy entrepreneur gets the lower price of solar panels. This has led to a rapid growth of many new suppliers in Thailand.

In 2013, the buying back promotion of solar rooftop was initiated with special price and is referred to as Feed-in Tariff (FiT) (Ministry of Energy, 2014). Consequently, this has attracted many households to consider an installation of SHS. SHS can be used in both urban and rural areas (Abdullah et al., 2017). The demand of SHS in cities are limited by consumers' awareness, lack of sufficient income to support and maintain an SHS unit at home, lack of technical knowledge and uncertainty in after-sales service. It is important to examine the public acceptance of SHS technology as, inevitably, the SHS will dominate in future electricity generation as indicated by the promotion policy of the Alternative Energy Development Plan (Ministry of Energy, 2015). However, the assessment of the willingness to pay for SHS in Thailand and the factors affecting its willingness has rarely been done in Thailand. More specifically the purpose of this study is to determine the SHS technology acceptance level in Thailand. The willingness to pay for SHS will be examined and recommendations are discussed and can be served as a guideline for policymakers.

The Area with Solar Power Potential in Thailand

Solar power is known as a clean source for producing electricity. The temperature of the solar panel affects directly to the efficiency of electricity production. If the temperature of the panel rises, the performance will decrease (Bangchak, 2012). Thailand is located in a tropical area which is suitable for using solar power. The northeastern region (southern and northern parts) and the central region of Thailand are the potential area for implementing solar power. Those areas have a potential to be a solar power source since the higher level of solar heat. According to the Ministry of Energy (2018), these combined solar potential areas (around 14.3% of the country) can generate solar power around 19 – 20 MJ/m2/day, and 18 – 19 MJ/m2/day for other 50% of the country.

The Northeastern region is more suitable in the solar farm not for the solar home system. On the other hand, the central region has more number of households than in the northeastern region. In addition, the households' incomes, which is a considered as a factor affecting the willingness to pay for the solar home system, are higher in the central region of Thailand when compared to other regions (Tourism Authority of Thailand, 2018). The number of registered households, density, population, average energy consumption, and average income of the central area is greater than those in the northeastern region. Thereby, this study is focused on the solar potential area in Bangkok, Nonthaburi, Pathum Thani, and Samut Prakan.

2. Literature Review

Willingness to Pay

Willingness to pay (WTP) refers to the amount of money that a person willing to pay for any specific product or service. WTP is known as a tool for measuring the monetary value of any product or service that a certain group of people willing to pay. Values of WTP provide precise information for measuring tangible and intangible values. This technique originally employed with environmental economics area to estimate the monetary value of environmental issues, healthcare service, quantifying public preferences, and it also support the decision□making process (Pattanayak, Van den Berg, Yang, and Van Houtven, 2006; Piran, Alison, and Emma, 2001). Then, it was applied in many fields including the viability of projects, setting the tariffs, providing policy alternatives, beneficial cost-benefit analysis and examining the effects of socio-economic factors (Gunatilake, Yang, Pattanayak, and Choe, 2007). The measurement of WTP leads to a better price set up for offering the best possible margin for any product or service. Therefore, it leads to the optimization in term of both volumes and margins. Moreover, the understanding of influential factors on WTP can support the rising in sales volume, and adapting to the right price (Gall-Ely, 2009).

The Contingent Valuation Method (CVM)

The Contingent Valuation Method (CVM) is the most widely used method for evaluating WTP for an environmental good or service, public goods, and there are many researchers that use CVM in their study (Xie and Zhao, 2018). The CVM is usually applied in recent years, and it has been developed mainly in the context of environmental valuation (Asian Development Bank, 2013). However, using CVM may lead to exceeding true feelings that resulting in over value of WTP. In addition, respondents may not familiar with the context for articulating the true value that they willing to pay, this problem can be solved by asking them with role play question (Khalid, 2008).

The popular techniques used in this survey are open-ended (OE), close-ended (CE), and bidding game questions. An OE question allows respondents to answer the maximum value of willingness to pay. An CE and bidding game questions are employed to obtain the willingness to pay for SHS at each specific price. If respondents are willing to pay for a given

price, the next question will ask if they are willing to pay for at a higher price. The series of questions are continued and stopped when the maximum amount of money respondents are willing is reached (Lopez, 2004). The highest or the lowest price indicates the maximum willingness to pay.

Five Stages of Consumer Adoption Process

The consumer adoption process occurs when customers go through learning about a product and whether becoming a loyal customer by purchasing a product or rejecting all customers interested (Jadoon, 2016). The five steps of the consumer adoption process are a marketing tool. These stages are discussed as:

1. Awareness: it is the stage that a consumer knows about a product but does not have enough information (Wisdom, Horwitz, and Hoagwood, 2014). The producers try to inform and provide knowledge. Customer awareness is important to generate an intention to buy intangible products; for instance, renewable energy. Without customer awareness, it might be more difficult for the customer to understand the relevance of intangible forms of renewable electricity. Awareness also encourages customers to interest and find more information about the product or service (Thiele, Paladino, and Apostol, 2008).

2. Interest/Search for information: it is the phase that a consumer becomes more aware and informed about a product (Jadoon, 2016). A consumer tends to search for more information and examine the substitutes in the market (Wisdom, Horwitz, and Hoagwood, 2014). A consumer will identify the product characteristics, the value that a product delivery to the consumer, and also find about manufacturer (Jadoon, 2016).

3. Evaluation: in this stage, a consumer is looking to evaluate and compare whether a product will deliver any value to him or her (Wisdom, Horwitz, and Hoagwood, 2014). However, a consumer's evaluation criteria depend on the differences in consumer behavior (Jadoon, 2016). The differences vary from consumer's need, price sensitivity of consumer, features of the product and the value that a product could deliver (Jadoon, 2016).

4. Trial: a consumer at this stage would experience the product on a trial basis. A consumer determines that a product provides actual benefits that he or she needs (Jadoon, 2016). The trial and the experience of using a product is an important step that affects an adoption or a rejection of a product (Jadoon, 2016).

5. Adoption/Rejection: after a consumer decided to adopt a product or select for an alternative, a product must be accepted and satisfied for consumer's need (Wisdom, Horwitz, and Hoagwood, 2014; Jadoon, 2016). When adoption exists, a consumer needs for availability, quality, ease, and accessibility of the product (Jadoon, 2016).

Factors Associated with WTP

The investigated factors are divided into two groups which are independent variables and a dependent variable. The independent variables include several factors which are gender, age, education, income, trust, environmental awareness, knowledge, and benefit. The dependent variable includes WTP. The explanation of each variable is summarized in table 1.

3. Methodology

Data Collection and Questionnaire Design

Two research methods are employed to cover both primary and secondary data source. The first method is documentary research from research published in credential sources such as "National Statistical Office Thailand", "Electricity Generating Authority of Thailand" and "Ministry of Energy" in from journals, articles, previous research works and case-studies

related to renewable energy and solar power. The second method is empirical research. It is done by means of a questionnaire survey to people who are able to make a decision in each household. The questionnaire surveys are conducted by households in Bangkok, Nonthaburi, Pathum Thani, and Samut Prakan.

Table 1: The explanation of each variable

Variables	**Definition**	**Source**
Gender	The roles and responsibilities of men and women.	UNESCO, 2003
Age	Date of birth relates to a past even.	Settersten and Mayer, 1997
Education Level	Grouping of education programs relates to gradations of learning experiences, as well as the knowledge, skills, and competencies which each program is designed to impart.	UNESCO-UIS, OECD, and EUROSTAT, 2017
Income	All distributive transactions received by a household.	Reich, 1991
Trust	A key to positive interpersonal relationships in various settings.	Mcknight and CHERVANY 1996
Environmental awareness	It is how much customer concern on the environmental issue, and how they can perceive that value from the environment. It also related with knowledge about the environment, attitude, and the willingness to solve environment-related problems.	Sengupta, Das, and Maji, 2010
Benefits	Benefits cover both non-monetary and monetary terms. Therefore, allowances, salaries, social security medical care, housing, cars, etc. are accounted as benefits.	Mirea, Naftanalia, and Mirea, 2012
WTP	WTP is the capacity of the customer to pay for a product or service in monetary term.	Gall-Ely, 2009

Data Collection

According to the official statistics registration systems (2017), the total number of population is 4,796,258. Thus, the population is 2,887,274 in Bangkok, 667,539 in Nonthaburi, 585,814 in Pathum Thani, and 655,631 in Samut Prakan. Taro Yamane formula is employed in this study to calculate the sample size with 95% confidence level. The number of sample sizes from each location depends on the proportion of the population of the sampling area. The questionnaire is divided into five parts. The first part contains the questions about the demographic information. The second part concerns about electricity consumption behavior of each respondent. The third part is based on five-point Likert scale asking about items affecting on SHS; for instance, trust, environmental awareness, benefit, and knowledge. The fourth part focuses on the willingness to pay on SHS.

The last part contains questions about the respondent experiences and government policy on renewable energy and alternative energy. The summary and definitions of variables are shown in table 2.

Model Specification

Reliability Test

Reliability is one of a significant concern of a test, survey, observation, or another measuring tool (Heffner, 2018). In the social sciences, the behavior is not easy to predict because people's beliefs or intentions will hinder to understand (Ellen, 2011). In this research, Cronbach's alpha is applied. It is used to measure an internal consistency and how closely related a set of items are grouped (Joseph and Rosemary, 2003). The value of Cronbach's alpha is ranging from 0 and 1 (Tavakol and Dennick, 2011). It can be used to interpret for dichotomous questions or Likert scale questions (Glen, 2017). If all items are perfectly reliable, then the coefficient alpha is close to 1 (Joseph and Rosemary, 2003). If the coefficient alpha is below 0.5, it is not acceptable. In contrast, if the result is higher than 0.7 means it is acceptable and if it is beyond 0.9 means excellent (Glen, 2017).

Table 2: Summary of variables and their definitions

Variables	**Item(s)**
Demographic Information	
Ownership	The owner of respondent house.
Decision Maker	Ability of a respondent to make a decision within the house.
Dwelling Type	Type of a respondent house.
Gender	Gender of a respondent.
Education Level	The highest education level of respondent.
Income	The average of family income of a respondent.
Behavior	
Electric Consumption Behavior	The behavior of respondent on electricity consumption and using of electronic devices.
Factors affecting willingness to pay	
Trust	▪ Trust on performance of SHS. ▪ Trust on SHS manufacturer. ▪ Trust on lifetime of SHS. ▪ Trust on government policy.
Environmental Awareness	▪ Awareness on environmental issue. ▪ Awareness on pollution of coal power plant. ▪ Awareness on renewable energy and alternative energy. ▪ Awareness on long term environmental issue problem solving.

Variables	Item(s)
Benefits	▪ Benefit from government policy. ▪ Benefit of earning revenue from selling energy. ▪ Benefit of monthly power bill deduction.
Knowledge	▪ Knowledge about advantages of SHS. ▪ Knowledge about SHS working processes. ▪ Knowledge about basic equipment of SHS. ▪ Knowledge about government buyback policy.
Willingness to Pay (WTP)	
WTP	Whether a consumer is willing to pay for a standard SHS.
Bidding Game	The actual WTP on the standard SHS size.
Maximum WTP	The maximum WTP on the standard SHS size.
Experiences	
Past Experience	Past experience about the renewable and alternative energy.

Binary Logistic Regression Analysis

Binary logistic regression is a statistical method that mostly employs to analyze the relationship of one or more independent variables that determine an outcome. Since the outcome of binary logistic regression consists of two possible outcomes (dichotomous variable), the outcomes are measured as 0 and 1. The meaning of 0 is "not buy, not approve, and failure". While the meaning of 1 is "buy, approve, and success". The ultimate goal of binary logistic regression is to identify the best fit model for describing the relationships between a set of independent variables and dichotomous variables (Schoonjans, 2017; Statistics laerd, 2018). The main objective is to measure if independent variables have any impacts on a dependent variable. In this case, whether a consumer is willing to pay for SHS or not is a dependent variable, and independent variables are gender, age, education, income, trust, environmental awareness, knowledge, and benefit.

In order to compare the fit of one model to one another, likelihood ratio test is employed as a tool for estimating the models. It is necessary to identify the statistically significant difference in the observed variable in the model by removing predictor variables. The formula for the likelihood ratio test statistic is shown in equation (1):

$$lr = -2\log^*[L(m_1)/L(m_2)] = 2ll(m_2) - ll(m_1) \quad (1)$$

The resulting test statistic is distributed chi-squared, with a degree of freedom with degrees of freedom equal to the number of parameters that are constrained (Institute for Digital Research and Education, 2018). Wald test is employed to measure the significant level of explanatory variables in the model. If the null hypothesis is rejected, it means that the variables in question can be removed without any effect on the model fit.

In contrast, if the test shows the parameters are not zero, the variables should be included in the model (Glen, 2017). Then odds ratio is used to measure the correlation of particular exposure and determine a risk for a particular outcome. The odds ratio indicates that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. In addition, the odds ratio also represent the magnitude of various risk factors. If the value of odd ration is 1, exposure does not affect the probability of an outcome. If the ratio is greater than 1, exposure associated with a higher probability of an outcome. When the Odd ratio is less than 1, exposure associated with lower probability of outcome (Szumilas, 2010).

4. Analysis and Results

Descriptive Statistics

Samples are randomly selected and distributed a questionnaire by mean of both online and paper-based questionnaires. Data from a total of 411 respondents are collected and summarized in table 3. Moreover, table 4 describes general statistical information of the sample group. The majority of respondents are female, and their education level is mainly at a bachelor degree. Furthermore, when asked whether they are willing to pay for a standard SHS, 59.1% of them are not willing to pay more than 80,000 baht (243 out of 411 respondents).

Table 3: General Information

Information		Frequency (n=411)	%
Ownership	House-owner	24	58.4
	Live with parent	17	41.6
Dwelling type	Detached house	21	52.1
	Townhouse	14	35.8
	Commercial building	4	11.9
	Other		0.2
Gender	Male	13	32.4
	Female	27	67.6
Education level	<=High school	6	14.8
	Diploma	5	13.9
	Bachelor degree	25	62

Average family income	< 30,000 baht (INCOME 1)	7	18.7
	30,000-40,000 baht (INCOME 2)	8	20.7
	40,001-50,000 baht (INCOME 3)	5	13.9
	50,001-60,000 baht (INCOME 4)	7	17.8
	> 60,000 baht (INCOME)	11	29
Willingness to pay	Yes	16	40.9
	No	24	59.1

Factor analysis

Before the binary regression analysis, those 11 questionnaire items are analyzed to validate the compatibility of a questionnaire to WTP of SHS by using the principal component analysis with orthogonal varimax rotation.

Table 4*:* Result of factor analysis

Factor[a]	**Mean**	**Standard deviation**	**Factor loading**	**Variance Explained %**
Factor 1: Environmental Awareness (0.821)[b]				24.955
Awareness on environmental issue.	4.20	0.920	0.812	
Awareness on pollution of coal power plant.	3.82	1.015	0.548	
Awareness on renewable energy and alternative energy.	4.09	1.001	0.817	
Awareness on long term environmental issue problem solving.	4.03	1.017	0.756	
Knowledge about SHS working processes.	3.95	0.972	0.732	
Factor 2: Trust (0.662)[b]				17.478
Trust on performance of SHS.	3.61	0.781	0.671	
Trust on SHS manufacturer.	3.50	0.813	0.737	

Trust on lifetime of SHS.	3.44	0.888	0.691	
Trust on government policy.	3.12	1.018	0.606	
Factor 3: Benefits (0.771)[b]				17.464
Benefit from government policy	3.59	0.923	0.797	
Benefit of earning revenue from selling energy.	3.58	0.997	0.816	
Knowledge about government buyback policy.	3.66	0.960	0.686	
TOTAL VARIANCE EXPLAIN				59.897

[a] Principal component factors with iteration: Varimax rotation.
[b] Reliability score (Cronbach's α) for each factor grouping is shown in parentheses.

To perform factor analysis, the statistical tests needed to be performed to identify the suitability of questionnaire data for the further factor analysis. Kaiser-Meyer-Olkin (KMO) test is used to measure sampling adequacy and Bartlett's test of sphericity. KMO is used to indicate the proportion of variance that might be caused by underlying factors, and the outcome of KMO is between 0 and 1, the value at least 0.50 presents the suitable data for factor analysis (Willians, Onsman and Brown, 2012). In this research, KMO is 0.857 which is close to one. Table 4 present the results of factor analysis and their Cronbach's coefficients.

Determinants of WTP

This section presents an econometric model for the dependent variable WTP which run against five independent variables. The independent variables are shown in table 5. The procedure measures the willingness to pay of an individual for Solar Home System by asking respondents whether are they willing to pay or not. The variable WTP is a dichotomous variable which represents the choice made; "1" represent YES (willing to pay) and "0" represent NO (not willing to pay). Logistic regression is selected to test the hypothesis because the dependent variable is dichotomous variable and our independent variables are continuous scale.

The overall result indicates that some of the variables tend to be an important determinant to WTP. The variable INCOME is highly statistically significant at one percent level. By setting INCOME as the Last reference categorical, INCOME (1) and INCOME (2) have a significant difference in the willingness to pay, but INCOME (3) and INCOME (4) are not statistically significant. The turning point is at the edge of INCOME (2). The point shows that families with income at or below INCOME (2) level or at most 39,999 are likely to pay about 22.2% less than the reference income group (60,000 Baht or more). On the other hands, families with their monthly income above INCOME (2) level or more than 40,000 Baht do not have statistically significant difference than the reference income group (60,000 Baht or more). The variable TRUST is highly statistically significant at one percent level. This result shows that each point increase in trust score will increase the odds of paying for a solar home system by almost double.

Table 5: Parameter Estimate for Willingness to Pay Equation

Independent Variables	B	Wald	Exp(B)
INCOME		39.468***	
INCOME (1)	-1.466	16.503***	0.231
INCOME (2)	-1.503	17.998***	0.222
INCOME (3)	-0.006	0.000	0.994
INCOME (4)	0.307	0.881	1.360
ENERGY CONSUMPTION BEHAVIOR	-1.136	19.908 ***	0.321
ENVIRONMENTAL AWARENESS	0.331	7.004***	1.393
TRUST	0.622	20.832***	1.863
BENEFITS	0.201	2.768**	1.223
Constant	3.155	19.724	23.460

Note: *, **, *** indicate statistical significant at the ten, five, and one percent level, respectively.

In addition, the variable ENERGY CONSUMPTION BEHAVIOR is highly statistically significant in a negative direction. A person who has a habit of consuming much energy tends to have a higher chance of paying for SHS about 30 percent higher than a person who trends to consume energy conservatively. Since they consume energy much more than usually household consumption; for instance, they turn on an air condition system at home at all time, they are likely to seek for the alternative way such as installing SHS, to generate electricity at home.

The variable ENVIRONMENTAL AWARENESS is highly statistically significant at below one percent level. This result indicates that ENVIRONMENTAL AWARENESS has a highly significant relationship with willingness to pay. Every changing of one point of ENVIRONMENTAL AWARENESS score affects by one and a half of a chance in increasing the willingness to pay. The variable BENEFITS is statistically significant at 5 percent level which indicates that increase the BENEFITS of government policy will increase the willingness to pay for SHS.

5. Conclusion

This paper examines determinants influencing the willingness to pay for the solar home system in Bangkok, Nonthaburi, Pathum Thani, and Samut Prakan. The results with 70.1% confident prediction rate show that income, energy consumption behavior, environmental awareness, and trust are significantly affecting on the probability of a person's willingness to pay for a solar home system. The results indicate that a person with the entire family income of higher than 40,000 Baht per month is a targeted market group.

An increase in family income leads to a higher chance of willingness to pay. Likewise, a person with environmental awareness and trust in a solar home system is likely to pay for a solar home system than those who are not aware of environmental issues and lack of trust in the solar home system; meanwhile people with who have a habit of consuming a high amount of electricity is likely to pay for it.

The results also indicate that approximately 40.9% of respondents are willing to pay for the solar home system and their average of willingness to pay is about 90,000 Baht. We recommend for an increase in trust about the solar home system by creating a reliability of performance, solar home system manufacturer, lifetime, and government policy. Besides, income is also another important factor influenced the willingness to pay. The results show that respondents with higher income are likely to pay for the solar home system. The manufacturer should consider to discount or cutting the cost for lower-income people.

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