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Investigating the Factors Impact the Decision to Invest in Rooftop Solar Power in Vietnam

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ABSTRACT

More muscular economic development leads to increasingly depleted energy resources. Renewable energy is one of the alternative solutions for today's increasingly depleted energy sources. Solar energy and rooftop solar systems are new developments in many countries, including Vietnam. However, the investment in rooftop solar systems has not yet been implemented uniformly in Vietnam. This article uses the interview survey method by questionnaire to evaluate the factors affecting the investment in rooftop solar systems in some provinces in Vietnam. The research results show that most factors positively impact the intention to invest in rooftop solar systems. The authors will make some policy suggestions from the research results to increase investment in rooftop solar systems in Vietnam and towards environmentally sustainable development.

Keywords: Rooftop Solar Power, Theory Plan Behavior, Energy, Investment
JEL Classifications: E22, F63, O44, Q01, Q43

1. INTRODUCTION

Along with economic growth, the consumption of traditional energy sources (oil, gas, coal) is increasing. Therefore, the reserves of fossil energy sources are decreasing day by day. Many countries have researched exploiting renewable energy sources, including solar energy, to solve the future energy shortage and destructive impacts on the environment. Although the application potential of solar energy is enormous, in a long time, solar power only accounts for a tiny percentage of the total energy exploited and used in many countries around the world. Vietnam also faces many challenges of fossil fuel depletion, impacts of climate change, security and safety issues in energy supply. In addition, Vietnam needs to make an energy transition towards the implementation of a circular economy (Trần et al., 2022). Moreover, to achieve the dual goal of becoming a high-income country by 2045 and reducing net emissions to zero by 2050, Vietnam needs policies and institutions to green the economy. The economy will not be able to go green if the energy sector remains "brown." Therefore, gradually diversifying energy sources, focusing more on renewable energy sources that Vietnam has potential, mainly biomass, wind, and solar energy sources, is considered one of the most important energy sources for sustainable development solutions.

An advantage of Vietnam in exploiting and using solar energy is that the potential of solar energy in Vietnam is relatively high, which is located in the relative distribution of sunshine in the year with strong on the world solar radiation map (Roy et al., 2022). Therefore, consider the planning to exploit and effectively use the renewable energy sources that Vietnam has potential with a large, significant, and appropriate amount such as solar energy. Currently, power plants in Vietnam mainly focus on investing in hydroelectricity and thermal power. These are two relatively abundant sources of energy for a long time. However, the exploitation of these energy sources has strongly affected the environment and the country's climate, thereby leading to negative impacts on production and people's lives. Recently, the transformation of the way electricity is produced has been studied and implemented more in Vietnam. Solar and wind power plants are being formed and developed, showing decisive innovation steps in electricity. These energy sources have brought positive results, indicating that the shift in investment direction is appropriate.

It is necessary to have studies on the factors affecting investment decisions in rooftop solar power in Vietnam to promote solar power development, including rooftop solar power. In which the factors of policy mechanism are critical. In addition, it is necessary to have a clearer understanding of investment behavior in this field so that appropriate policies can be made, creating the necessary investment incentives for the development of renewable energy sources.

The research behavior and investment decisions in both theory and practice to understand the factors affecting investors' behavior. This kind of research will help identify positive and potentially negative factors influencing investor behavior towards rooftop solar power projects. Thereby helping managers and policymakers make decisions to best meet investment needs in the market. With the above situation, this article will study the factors affecting investment decisions in rooftop solar power in Vietnam.

2. LITERATURE REVIEW

The investment in the rooftop solar power system can be considered in many different aspects. The term "investment in rooftop power system" is not only reserved for power generation enterprises but is also used in the consumer sector (Shirizadeh and Quirion, 2022). As rooftop solar becomes more and more personalized (unlike buying electricity on the national grid produced by many different sources), households will consider whether to invest in a roof energy system. Therefore, there are many studies on the factors affecting investment decisions in the rooftop solar energy system.

There are two different research groups on the approach's determinants of household investment in renewable energy. Some researchers have investigated the spatial and temporal spillovers of renewable energy systems using aggregated data, such as Islam et al. (2022), Sun and Sankar (2022), Eshchanov et al. (2021). Ayodele et al. (2021) and Kooij et al. (2018) have conducted household surveys that use microdata to apply renewable energy power systems. The micro-approach can reveal the driving forces behind household investment decisions in renewable energy systems. Therefore, most of the literature focuses heavily on this research direction. Poier (2021) believes that investing in rooftop energy systems will be pretty risky, so an important factor affecting the investment decision of households is financial ability. The willingness to protect the environment also plays an essential role in the sale because self-generating electricity requires less energy from waste sources, thus protecting the environment. Information searches and evaluations are determined by a person's level of engagement and cognitive ability. Mellor et al. (2018) also evaluated that setting the rooftop solar system depends on personal preferences and social influences. In addition, the intention to invest in a rooftop energy system is also strongly influenced by the expectations and behavior of surrounding relatives or consumption trends of society (Kwon et al., 2017).

Malik and Ayop (2020) stated that the investment decision for rooftop energy of low-income households indicates that the government's supportive policy is the most important influencing factor. Solar panels installed on rooftops bring electricity to low-income families and generate income. The generated electricity will be sold to licensed utility companies or sold to the grid by installing a rooftop battery. This setup can be understood to create more income for households when they have a roof space that can absorb solar energy. In particular, this simple way of generating electricity reduces climate change and is environmentally friendly. (Gorjian et al., 2021) showed that rooftop solar power systems in Indonesia double income for low-income households from 2014 to 2020. In addition to the government's supportive policy factor, the perception of the benefits gained the Knowledge of rooftop energy is also a factor included in the research model to assess the influence on investment decisions of low-income households in Malaysia.

Rai and Robinson (2015) developed an empirically based model of household rooftop energy investment decisions using a comprehensive data set that includes households living in Texas. Research shows that the investment in rooftop solar energy systems depends on system cost, electricity and water discount, tax, electricity price, and annual power output of the system. Overall, the main influencing factor identified here is financial. In addition, the model of Rai and Robinson also considers the social and demographic factors affecting the decision to invest in the rooftop solar power system of households.

Braito et al. (2017) surveyed households that accept and do not accept rooftop power system investments in an area of Italy and a place of Austria. Research results show that a higher government support policy will attract households to buy, in addition to those who accept because of economic motives (financial motives) and environmental protection attitudes.

Wasi and Carson (2013) showed that the probability of households choosing a renewable system, i.e., a rooftop solar power system, increased significantly after the program was introduced. Furthermore, the impact of the price reduction policy differs from household income, education level, gas grid demand, hot water use, and future electricity price expectations to the investment decision of rooftop solar power of households. The model of Palmer-Wilson et al. (2019) shows that the variables selected to evaluate the investment decisions for the rooftop energy system of families are financial (installation costs and project benefits and knowledge gained), an interest in the environment, technology, sociological characteristics, and housing. The study showed that the most influential factor was financial, while factors of concern for the environment, sociological aspects had no significant impact.

Crago and Chernyakhovskiy (2017) examined the effectiveness of state incentives in the United States to increase household investment in rooftop energy. Research shows that solar power demand is positively influenced by financial incentives that reduce upfront costs for installation. Although the context in developing countries is different, financial incentives to reduce the upfront costs of rooftop solar system adoption are believed to play an essential role in shaping household behavior. Likewise, a study of Pakistani households found government financial support to install small rooftop solar systems. Schelly (2014) studied the factors affecting the investment decision of households for the application of rooftop energy technology. The author emphasizes that household investment decisions are shaped by demographic and financial characteristics and by household conditions, awareness of this technology, and access to information. Another study on rooftop solar investment in the Netherlands discovered four important drivers: technology perceptions, innovation trends, and social and financial influences (Vasseur and Kemp, 2015).

Lay et al. (2013) analyzed the emerging rooftop solar market in which awareness, availability, and affordability were the main drivers of household investment in East Africa (Kenya). Ondraczek (2013) again identified three common factors contributing to accelerating investment in household rooftop solar systems in Kenya and Tanzania as (a) world market prices for reduced rooftop solar technology, (b) international donor support, and (c) government-created favorable conditions. Several models have been developed to explain behavioral science's investment-related behaviors in the energy sector. One of the best-known approaches is the theory of planned behavior (TPB) developed by Ajzen (1991). In this theory, the intention to exhibit a particular behavior is assumed to depend on three factors: attitude towards the behavior, subjective norm, and perceived behavioral control (PBC). All three factors are based on beliefs: attitudes are based on the expected consequences of the behavior; subjective norms are based on perceived social pressure to perform the behavior; perceived behavioral control is based on the estimated ability to perform the behavior. According to TPB, attitudes and subjective norms do not directly affect behavior; instead, their influence is mediated by behavioral intentions. PBC affects behavioral intention and has a direct relationship with behavior. The core of this theory is that people base their behavior on self-interest, seek positive outcomes, and avoid the dire problems of the social environment (Bamberg and Möser, 2007).

Schwartz's normative activation model offers a different perspective. In this model, pro-social behavior is assumed to be based primarily on pro-social motives (De Groot and Steg, 2009). Personal (or moral) norms are a key construct in the model. Personal norms are defined as a feeling of a moral obligation to engage in pro-social actions (e.g., save energy). Personal standards are directly related to behavior. They are formed and activated if individuals become aware of social (e.g., environmental) problems, associate them with their behavior, and realize that they can reduce these problems by changing their behavior. Suppose an individual realizes that they are acting inconsistent with their standards - despite being able to do so - possible adverse emotional reactions (e.g., guilt or shame). These feelings can lead to behavior change, denial of the problem, or the ability to do something about it. Other variables influencing emotional responses and resulting behaviors relate to social norms and unethical motives (e.g., economic aspects).

Numerous studies provide evidence that the theory of planned behavior can explain the interest in solar installations. Korcaj et al. (2015) show that the intention to install solar energy systems is significantly predicted by positive attitude, subjective norm, and perceived behavioral control. Positive attitudes are strongly influenced by the belief that solar installations lead to increased social status, energy independence, and financial returns. Claudy et al. (2015) confirmed that awareness of the pros and cons of a solar power system are essential factors in installation decision-making. The authors point out that positive reasons such as economic and environmental benefits lead to more positive attitudes towards solar installations. The disadvantages of a solar power system, such as cost and maintenance requirements, reduce installation intentions. Besides, the solar power system installation faces many other challenges such as high initial installation cost, time and effort involved in information gathering, inaccurate estimation benefits, and uncertain perceptions of the technology's performance and usefulness.

3. RESEARCH METHODS

This study uses the survey method by questionnaire to evaluate the factors affecting investment in the rooftop solar system. The questionnaire has been sent to the respondents via email and social networks.

The larger the sample size, the better, but it is time-consuming and costly. Therefore, according to the empirical formula of Hair Jr et al. (2021), the sample size is usually determined based on: (1) the minimum size and (2) the number of measurement variables included in the analysis. The sample size should be at least 50, preferably 100, and the observation/measurement ratio 5:1. This research model includes six variables (5 independent and one dependent variable) with 27 observed variables. Therefore, the required number of samples is 27*6=162 samples or more. So the number of samples in this study can be n=280, and the sample's representativeness is guaranteed for the survey. After collecting the appropriate number of samples, the author uses SPSS 20 software to analyze data with coded scales.

3.1. The Linkert Scale

The Likert scale used to measure a set of statements and a series of statements related to the attitude in the question is given, and the respondent will choose one of those answers. In this study, the author uses the Likert scale (Likert1932) to design a survey questionnaire to measure the customer's agreement with the factors affecting the investment decision to set up the solar rooftop system. The survey questionnaire ranged from 1 as "strongly disagree" to 5 as "strongly agree."

Level	Strongly disagree	Disagree	No idea	Agree	Strongly agree
	1	2	3	4	5

3.2. Research Hypothesis

Based on the research of Ajzen and Fishbein (1970), Harland et al. (1999), Rai and Beck (2015), and the theoretical framework of planned behavior, we study the behavioral, normative, and control factors affecting the intention and behavior of installing residential solar power systems. In addition, subjective norms, personal norms, and environmental concerns that serve as potential regulatory factors for adopting "green" technologies are also considered. In the early stages, we investigate the factors that influence initial interest in new technology and, simultaneously, due to limitations in the number of observations of actual solar installation behavior. We focused on predictors of intention, as measured by respondents' assessment, of solar system installation and ability to communicate with a system installer solar for quotes. The article also focuses on studying the intention to consider installing a solar power system because this is the first step in using solar energy. Although intention and behavior may differ (Gifford, 2014), the two variables are highly correlated.

Based on the theory of planned behavior (Ajzen 1991, 2002), specific research hypotheses to test the factors driving the intention to install solar energy systems are listed below.

H1: Attitude has a positive relationship (+) with installing a solar energy system.

H2: Subjective norm has a positive relationship (+) with the decision to install a solar energy system.

H3: Perceived behavioral control has a positive relationship (+) with the decision to install a solar energy system.

H4: Environmental concerns have a positive (+) relationship with the decision to install a solar energy system.

H5: Financial capacity has a positive relationship (+) with the decision to install a solar energy system.

Pearson correlation and factor analysis eliminated questions that provided little additional information. Suppose there are still many questions that evaluate the same element of the theory of planned behavior. In that case, an index variable is calculated as the mean of the responses to the questions used. The resulting variables were used to build a logit model for the dependent variables with binary responses (yes/no) and an ordered logit model for the dependent variables measured by the Likert scale.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

The survey with the number of questionnaires was 280, distributed in 3 inner districts of Hanoi City, with 47% in Long Bien district, 26% in Hoang Mai district, and 27% in Hai Ba Trung district (Table 1). The proportions of men and women are 46.1% and 53.9%, respectively. The age of the mean sample was 49.5 years old (standard deviation = 13.1 years). 56.2% of respondents have a bachelor's degree or higher. When asked about homeownership, 70% of respondents (n = 280) own a home they live in. Homeownership is often likely to influence perceived behavioral control related to solar installations, as non-homeowners are less inclined to install. However, the t-test showed no statistically significant difference in perceived behavioral control between homeowners and renters, p = 0.61. The average total residential usable area was 86.2 square meters (median = 78.3 square meters), and the house value of the respondents was 2,136 billion VND. The average household income of the respondents is between 150 and 250 million VND/year.

Table 1: Descriptive statistics of demographic variables

	n		% of response
District	280	Hai Bà Trưng	27%
		Hoàng Mai	26%
		Long Biên	47%
Sexual	280	Male	46.1%
		Female	53.9%
Age (mean, years)	280		49.5
Residential area (average, m2)	280		86.2
House value (average, billion VND)	280		2.136
Income	280	Under 50 million	22%
		50-100 million VND	15%
		100-150 million VND	27%
		150-200 million won	14%
		200-300 million won	15%
		Over 300 million VND	5%

Source: Survey results 2021

4.2. The Reliability of the Scale

The results of Cronbach's alpha of the scales on the components of the factors affecting the customer's decision to invest in a rooftop solar system are shown in Table 2. The scales are represented by 27 observed variables, and they all have satisfactory Cronbach's alpha reliability coefficients.

Specifically, Cronbach's alpha of the variable met the requirements. Moreover, the correlation coefficients of the adjusted total variable are all higher than the allowed level. These coefficients are all larger than 0.4. Cronbach's alpha coefficient is used to eliminate the garbage variable first. Variables with the item-total correlation of <0.3 will be excluded, and the scale must have alpha reliability of 0.60 or more (Nunnally and Burnstein 1994). After that, variables with weight (factor loading) <0.50 in EFA will continue to be excluded. Therefore, all scales meet the requirements of reliability (0.6 < 0.95) and are accepted included in exploratory factor analysis (EFA) to test convergent and discriminant validity.

The results of the scale reliability analysis show that the reliability coefficients of Cronbach's Alpha of the scales are all greater than 0.8. Some scales have high-reliability coefficients such as decision to invest (DT) in rooftop solar system (0.921); subjective norm (TD) (0.895); financial capacity (TC) (0.873). Besides, the total correlation coefficient of all observed variables is greater than 0.3 and Cronbach's Alpha coefficient. Suppose the variable types of all observed variables are lower than the Cronbach's Alpha coefficient of the observed variables. In that case, removing any observed variables will decrease the scale's reliability. Therefore, the scales are suitable for use in subsequent analyses.

4.3. Exploratory Factor analysis

4.3.1. Exploratory factor analysis for independent variables

After checking the reliability of the scale, exploratory factor analysis was conducted. The extraction method selected for factor analysis is the principal components method with varimax rotation.

Table 2: Cronbach's Alpha Coefficient of the Observed Variables

Variable	Scale mean if item deleted	Scale variance if item deleted	Corrected item—total correlation	Cronbach's alpha if item deleted
Attitude (TD) (Cronbach's Alpha = 0.807)				
TD1	15.1839	5.817	0.622	0.761
TD 2	15.3318	5.565	0.532	0.799
TD 3	15.1704	6.277	0.602	0.770
TD 4	15.4529	5.834	0.560	0.782
TD 5	15.4170	6.280	0.739	0.743
Subjective norm (CQ)(Cronbach's Alpha = 0.895)				
CQ1	10.6233	4.668	0.740	0.817
CQ 2	10.5830	4.686	0.743	0.816
CQ 3	10.6278	4.901	0.681	0.841
CQ 4	10.5830	5.091	0.696	0.836
Cognitive behavioral control (NT) (Cronbach's Alpha = 0.869)				
NT 1	11.7309	5.765	0.641	0.863
NT 2	11.4350	5.103	0.758	0.816
NT 3	11.5516	5.321	0.782	0.808
NT 4	11.5874	5.487	0.705	0.838
NT 5	11.645	5.476	0.715	0.835
Financial capability (TC) (Cronbach's Alpha = 0.873)				
TC 1	14.3139	10.180	0.799	0.821
TC 2	14.2825	11.564	0.728	0.842
TC 3	14.5247	11.070	0.719	0.842
TC 4	14.4978	11.639	0.649	0.859
Concern for the environment (QT) (Cronbach's Alpha = 0.872)				
QT1	15.5919	8.207	0.700	0.846
QT 2	15.7354	9.132	0.732	0.839
QT 3	15.7085	8.586	0.620	0.868
QT 4	15.8027	8.772	0.685	0.848
QT 5	15.9238	9.125	0.821	0.824
QT 6	15.8765	9.124	0.819	0.820
Investment decision (DT)(Cronbach's Alpha = 0.921)				
DT1	7.4081	3.153	0.875	0.856
DT2	7.4439	3.410	0.838	0.887
DT 3	7.3812	3.471	0.806	0.912

Source: Survey results 2021

Components of factors affecting investment decisions on rooftop solar systems are measured by 27 observed variables. According to the components, all variables meet the requirements and are included in the EFA exploratory factor analysis to determine the degree of convergence.

Conducting exploratory factor analysis, EFA gave the following results:

- KMO and sig. Coefficient.

The exploratory factor analysis for the independent variables shows that the p-value = 0.000 of Bartlett's test allows us to safely reject the null hypothesis H0 (H0: Factor analysis does not fit the data).). KMO index equal 0.847 shows that the model's relevance is high (Tables 3 and 4).

- Coefficient of Variance Extracted

Besides, the results of 5 factors extracted at Eigenvalue = 11.218 with total variance extracted is 58.999% > 50%. Therefore, factor analysis is appropriate. Thus, the exploratory factor analysis results show five groups of factors extracted from the data to ensure eligibility for factor analysis. These factors will act as independent variables in the study's research model (Table 5).

- Exploratory factor analysis for the dependent variable

The dependent variable scale of 3 observed variables with Cronbach's alpha reliability was included in the exploratory factor analysis.

The results of the exploratory factor analysis for the dependent variable are as follows: The KMO coefficient is 0.745> 0.5, and the significance level is 0.000 < 0.05; Therefore, the observed variables are correlated with each other in general (Tables 6 and 7).

Three observed variables of the dependent factor were extracted to the same factor at Eigenvalue = 2.453 > 1, and the variance extracted was 61.338% > 50%, proving that the extracted factor explained 61.338% of the variation of the data.

All observed variables have loading coefficients greater than 0.5, so all observed variables meet the requirements, and no variables are excluded.

4.4. Multiple Linear Regression Analysis

Before testing the research model by multiple linear regression analysis, we need to consider the correlation between the model's variables. Correlation matrix analysis uses the

Pearson Correlation coefficient to quantify the closeness of the relationship between each factor with the decision to invest in a rooftop solar system and between independent factors. This coefficient is always in the range (–1) to (1), taking the absolute value if <0.3, the relationship between variables is weak (Table 8).

Accordingly, the decision to invest in a rooftop solar system is correlated with five factors. The test results show that the "correlation coefficient" between the dependent variable and the factors is 0.650 (for the Subjective Standard variable (CQ)), and the lowest is 0.345 (for the variable Concern about the environment (QT)). These relationships are significant when sig < 0.05. The independent variables can be included in the model to explain the dependent variable.

In addition, the correlation coefficient between the independent variables, although it exists, is at a low level. So it can be predicted that the possibility of multicollinearity between the independent variables above is unlikely. In summary, the data are perfectly suitable for inclusion in regression analysis.

Table 3: KMO Coefficient and Bartlett's Test for Independent Factors

Inspection KMO		0.847
Inspection bartlett	Chi-square	3069.910
	Df	253
	Sig.	0.000

Source: Survey results 2021

4.5. ANOVA Analysis

ANOVA analysis showed the fit of the regression model. The hypothesis H_o posed was no relationship between the independent and dependent variables. The analytical results show that the sig value of the F test < 0.05. Thus, we reject the hypothesis H_o at the 95% significance level. In conclusion, at least one independent variable correlates with the dependent variable (Table 9).

In addition, the author conducts further analysis to detect the violation of the hypothesis in the regression model of attractiveness.

First, the author conducts a test on the normal distribution of the residuals. The following Figure 1 shows a bell-shaped (normally distributed) histogram. The mean is close to 0, and the Standard Deviation (Std.Dev) is 0.988, close to 1. Thus, the distribution of the residuals is approximately standard.

Next, the following figure also shows that the observed variables are not far from the regression line estimated by the OLS method drawn on the scatter plot of the observed variables with the mean = 0 normalized regression and the standard deviation. = 1, that is, the closer the observed variables are to the line, the more accurate the unbiased estimate for a beta. Thus, the above test results show that the built regression model does not violate the necessary assumptions in linear regression.

4.6. Multicollinearity Test

The variance exaggeration factor VIF results are less than 10, and the acceptability of the variable is greater than 0.1. So the hypothesis of multicollinearity can be rejected.

Table 4: Extracted Variance

Total variance explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	T total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	66.231	24.926	24.926	66.231	24.926	24.926	44.683	18.730	18.730
2	33.666	14.663	39.589	33.666	14.663	39.589	33.152	12.607	31.338
3	11.979	7.918	47.506	11.979	7.918	47.506	22.572	10.288	41.626
4	11.656	6.623	54.129	11.656	6.623	54.129	11.939	7.754	49.380
5	11.218	4.870	65.015	11.218	4.870	58.999	11.916	7.665	57.045
6	0.097	4.390	63.389						
7	0.986	3.943	67.332						
8	0.893	3.573	70.905						
9	0.840	3.362	74.267						
10	0.826	3.305	77.571						
11	0.735	2.940	80.512						
12	0.622	2.486	82.998						
13	0.552	2.208	85.205						
14	0.532	2.126	87.332						
15	0.476	1.904	89.236						
16	0.451	1.805	91.040						
17	0.387	1.550	92.590						
18	0.342	1.370	93.960						
19	0.303	1.210	95.170						
20	0.289	1.156	96.326						
21	0.253	1.013	97.338						
22	0.235	0.942	98.280						
23	0.188	0.751	99.031						
24	0.135	0.540	99.572						

Extraction Method: Principal Component Analysis.
Source: Survey results 2021

Table 5: Rotation Factor Matrix

Factor	Factor				
	1	2	3	4	5
QT5	0.860				
QT 2	0.858				
QT 4	0.799				
QT 1	0.776				
QT 3	0.777				
QT 6	0.868				
TC 1		0.817			
TC 3		0.788			
TC 2		0.713			
TC 4		0.691			
TD 1			0.762		
TD4			0.763		
TD 5			0.747		
TD 2			0.695		
TD 3			0.673		
CQ2				0.858	
CQ 1				0.826	
CQ 3				0.784	
CQ 4				0.775	
NT3					0.804
NT 2					0.787
NT 4					0.725
NT 1					0.675
NT5					0.755

Source: Survey results 2021

Table 6: KMO Coefficient and Bartlett's Test for the Dependent Variable

KMO		0.745
Bartlett	Chi - square	503.561
	Df	3
	Sig.	0.000

Source: Survey Results 2021

The following Table 10 shows the multivariable regression results of factors affecting the decision to invest in roof voltage. The degree of influence of the independent variables on the dependent variable is shown through the standardized regression coefficient.

Regression results show that all the independent variables included in the model are correlated with the dependent variable (sig value < 0.05). We have a normalized regression model:

DT = 0.143TD + 0.107NT + 0.325CQ + 0.301TC + 0.229QT

Based on the regression results, we see that all five factors included in the model influence the decision to invest in a rooftop solar system. The factor "Subjective Norm" has the most significant impact with a standardized regression coefficient of 0.325, followed by "Financial capacity" with a standardized regression coefficient of 0.301. The factor with the lowest impact is "Cognitive behavioral control" with a standardized regression coefficient of only 0.107. As follows:

- Attitude variable (TD): a standardized regression coefficient of 0.143 has a positive effect on Investment Decision with a statistical significance of 1% with 99% confidence. When this variable increases by 1 point, the investment decision increases to 0.143 points.

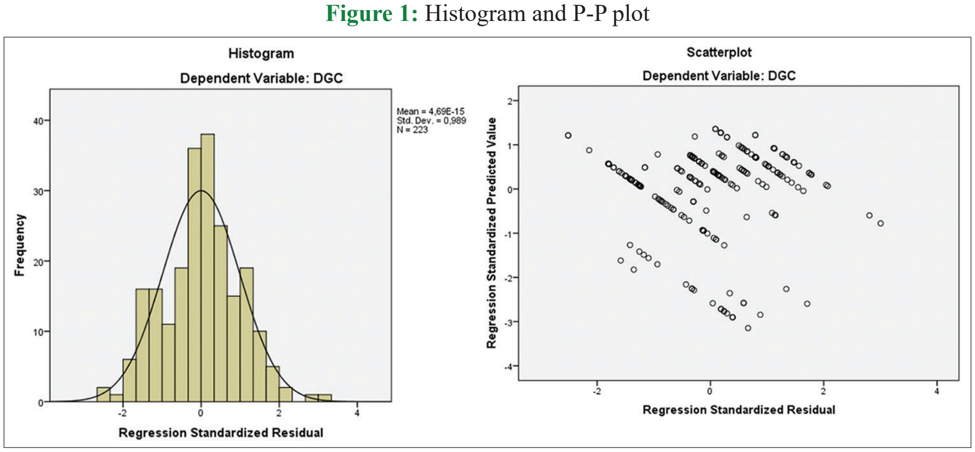
Subjective Norm variable (CQ) with a regression coefficient of 0.325 positively influences the decision to invest in the rooftop solar system with statistical significance at 1% (99% confidence level). When this variable increases by 1 unit, the decision to invest in the rooftop solar system increase by 0.325 points. Therefore, hypothesis H_2 is accepted.

Table 7: Initial Eigenvalues

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	TTotal	%of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	22.453	61.328	61.328	2.453	61.338	61.338
2	0.856	21.403	82.731			
3	0.463	11.575	94.306			
4	0.228	5.694	100.000			

Extraction method: Principal component analysis.

Figure 1: Histogram and P-P plot



Source: Survey results 2021

Table 8: Correlation analysis between variables

	DT	TD	NT	CQ	TC	QT
DT	1	0,375**	0,418**	0,650**	0,567**	0,345**
TD	0,375**	1	0,185	0,383**	0,406**	-0,146*
NT	0,418**	0,185	1	0,469**	0,267**	0,237**
CQ	0,650**	0,383**	0,469**	1	0,517**	0,294**
TC	0,567**	0,406**	0,267**	0,517**	1	0,058
QT	0,345**	-0,146*	0,237**	0,294**	0,058	1

**Correlation at 1% significance level (2-sided test). *Correlation at 5% significance level (2-sided test). Source: Survey results 2021

Table 9: ANOVA Analysis

Model	Sum of squares	df	Average squared	F	Sig.
Regression model	99.408	5	19.882	54.512	0.000b
Residual	79.144	217	0.365		
Sum	178.552	222			

Source: Survey results 2021

Table 10: Results of Regression Analysis

Model	Unnormalized Regression Coefficient		Normalized Regression Coefficient	T	Sig.
	B	Standard Dev	Beta		
(Constant)	–1.346	0.383		–3.518	0.001
TD	0.214	0.079	0.143	2.695	0.008
NT	0.132	0.065	0.107	2.050	0.042
CQ	0.382	0.073	0.325	5.243	0.000
TC	0.328	0.060	0.301	5.474	0.000
QT	0.281	0.061	0.229	4.570	0.000

Source: Survey results 2021

The perceived behavioral control (NT) variable has a regression coefficient of 0.107 and positively influences the decision to invest in rooftop voltage with statistical significance at 5% (95% confidence level). When this variable increases by 1 point, the decision to invest in the rooftop solar system increases to 0.107 points.

- The variable Financial ability (TC) has a regression coefficient of 0.301, which has the same effect as the customer's decision to invest in the rooftop solar system with statistical significance at 1% (99% confidence level). When this variable increases by 1 point, the decision to invest in the rooftop solar system increases to 0.301 point

The variable Environmental concerns (QT) has a standardized regression coefficient of 0.229 that positively influences the decision to invest in rooftop solar systems with a significance level of 1% (99% confidence level). When this variable increases by 1 point, the customer's decision to invest in rooftop solar system increases by 0.229 points.

5. CONCLUSION

The article has collected and analyzed survey data on households in three urban districts of Hanoi, finding the existing attitudes, norms, and perceptions of behavioral control and their impact on intentions and behaviors related to using a solar power system. Based on the Theory of Planned Behavior and extensive research models, the article sheds light on the nature of behavioral and informational barriers in installing residential solar power systems in Hanoi and generates insights to design potential policy interventions against obstacles.

All three factors, attitudinal, subjective norm, and perceived behavioral control of survey respondents, are significantly related to the intention to consider investing in installing and using solar power systems. Perceived behavioral control was statistically significant in both intention assessment models considering solar system installation or installation service provider communication, albeit as an evaluative lowest among the analyzed factors (mean response is 4.33). Korcaj et al. (2015) indicate that the importance of perceived behavioral control may increase when data-driven analyzes relate to actual (installation) purchasing behavior rather than the intention to purchase.

The low perceived behavioral control may explain why model norms influence solar installation and use (median respondent 5.28). Since respondents did not feel confident or knowledgeable with a new and complex technology called solar energy, they relied on the behavior of those around them to capture or confirm information and benefits. This result is consistent with findings in studies confirming the importance of the peer effect in solar energy use (Graziano and Gillingham, 2015). Solar energy incentive programs should therefore strive to take advantage of the beneficial effects of the peer-to-peer effect (reflected in the normative norm) to limit fundamental information barriers in the use of solar energy. Positive externalities related to the peer effect take many forms ranging from pure economics to information tools (for example, online peer-to-peer exchange platforms, or other institutional tools (e.g., nonprofit community organizations)

REFERENCES

Ajzen, I. (1991), The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179-211.

Ajzen, I., Fishbein, M. (1970), The prediction of behavior from attitudinal and normative variables. Journal of Experimental Social Psychology, 6(4), 466-487.

Ayodele, T.R., Ogunjuyigbe, A.S.O., Ajayi, O.D., Yusuff, A.A., Mosetlhe, T.C. (2021), Willingness to pay for green electricity derived from renewable energy sources in Nigeria. Renewable and Sustainable Energy Reviews, 148, 111279.

Bamberg, S., Möser, G. (2007), Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. Journal of Environmental Psychology, 27(1), 14-25.

Braito, M.T., Böck, K., Flint, C., Muhar, A., Muhar, S., Penker, M. (2017), Human-Nature Relationships and Linkages to Environmental Behaviour. Environmental Values, 26(3), 365-389.

Claudy, M.C., Garcia, R., O'Driscoll, A. (2015), Consumer resistance to innovation – A behavioral reasoning perspective. Journal of the Academy of Marketing Science, 43(4), 528-544.

Crago, C.L., Chernyakhovskiy, I. (2017), Are policy incentives for solar power effective? Evidence from residential installations in the Northeast. Journal of Environmental Economics and Management, 81, 132-151.

De Groot, J.I.M., Steg, L. (2009), Morality and Prosocial Behavior:

The Role of Awareness, Responsibility, and Norms in the Norm Activation Model. The Journal of Social Psychology, 149(4), 425-449.

Eshchanov, B., Abdurazzakova, D., Yuldashev, O., Salahodjaev, R., Ahrorov, F., Komilov, A., Eshchanov, R. (2021), Is there a link between cognitive abilities and renewable energy adoption: Evidence from Uzbekistan using micro data. Renewable and Sustainable Energy Reviews, 141, 110819.

Gifford, R. (2014), Environmental Psychology Matters. Annual Review of Psychology, 65(1), 541-579.

Gorjian, S., Calise, F., Kant, K., Ahamed, M.S., Copertaro, B., Najafi, G., Zhang, X., Aghaei, M., Shamshiri, R.R. (2021), A review on opportunities for implementation of solar energy technologies in agricultural greenhouses. Journal of Cleaner Production, 285, 124807.

Graziano, M., Gillingham, K. (2015), Spatial patterns of solar photovoltaic system adoption: The influence of neighbors and the built environment ‡. Journal of Economic Geography, 15(4), 815-839.

Harland, P., Staats, H., Wilke, H.A.M. (1999), Explaining proenvironmental intention and behavior by personal norms and the theory of planned behavior. Journal of Applied Social Psychology, 29(12), 2505-2528.

Islam, Md. M., Irfan, M., Shahbaz, M., Vo, X.V. (2022), Renewable and non-renewable energy consumption in Bangladesh: The relative influencing profiles of economic factors, urbanization, physical infrastructure and institutional quality. Renewable Energy, 184, 1130-1149.

Kooij, H.J., Oteman, M., Veenman, S., Sperling, K., Magnusson, D., Palm, J., Hvelplund, F. (2018), Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands. Energy Research and Social Science, 37, 52-64.

Korcaj, L., Hahnel, U.J.J., Spada, H. (2015), Intentions to adopt photovoltaic systems depend on homeowners' expected personal gains and behavior of peers. Renewable Energy, 75, 407-415.

Kwon, K.T., Lee, W.S., Kwon, L.S., Seong, S.H., Kim, Y.D., Kwon, W.T. (2017), Entry into the Southeast Asian Energy Market from the Sales Promotion Viewpoint. Journal of Distribution Science, 15(10), 29-39.

Lay, J., Ondraczek, J., Stoever, J. (2013), Renewables in the energy transition: Evidence on solar home systems and lighting fuel choice in Kenya. Energy Economics, 40, 350-359.

Malik, S.A., Ayop, A.R. (2020), Solar energy technology: Knowledge, awareness, and acceptance of B40 households in one district of Malaysia towards government initiatives. Technology in Society, 63, 101416.

Mellor, A., Alonso Alvarez, D., Guarracino, I., Ramos, A., Riverola Lacasta, A., Ferre Llin, L., Murrell, A.J., Paul, D.J., Chemisana, D., Markides, C.N., Ekins-Daukes, N.J. (2018), Roadmap for the next-generation of hybrid photovoltaic-thermal solar energy collectors. Solar Energy, 174, 386-398.

Ondraczek, J. (2013), The sun rises in the east (of Africa): A comparison of the development and status of solar energy markets in Kenya and Tanzania. Energy Policy, 56, 407-417.

Palmer-Wilson, K., Donald, J., Robertson, B., Lyseng, B., Keller, V., Fowler, M., Wade, C., Scholtysik, S., Wild, P., Rowe, A. (2019), Impact of land requirements on electricity system decarbonisation pathways. Energy Policy, 129, 193-205.

Poier, S. (2021), Towards a psychology of solar energy: Analyzing the effects of the Big Five personality traits on household solar energy adoption in Germany. Energy Research and Social Science, 77, 102087.

Rai, V., Beck, A.L. (2015), Public perceptions and information gaps in solar energy in Texas. Environmental Research Letters, 10(7), 074011.

Rai, V., Robinson, S.A. (2015), Agent-based modeling of energy technology adoption: Empirical integration of social, behavioral, economic, and environmental factors. Environmental Modelling snd Software, 70, 163-177.

Roy, S., Lam, Y.F., Hossain, M.U., Chan, J.C.L. (2022), Comprehensive evaluation of electricity generation and emission reduction potential in the power sector using renewable alternatives in Vietnam. Renewable and Sustainable Energy Reviews, 157, 112009.

Schelly, C. (2014), Residential solar electricity adoption: What motivates, and what matters? A case study of early adopters. Energy Research and Social Science, 2, 183-191.

Shirizadeh, B., Quirion, P. (2022), Do multi-sector energy system optimization models need hourly temporal resolution? A case study with an investment and dispatch model applied to France. Applied Energy, 305, 117951.

Sun, B., Sankar, A. (2022), The changing effectiveness of financial incentives: Theory and evidence from residential solar rebate programs in California. Energy Policy, 162, 112804.

Trần, T.V., Phan, T.H., Lê, A.T.T., Trần, T.M. (2022), Evaluation of factors affecting the transition to a circular economy (CE) in Vietnam by structural equation modeling (SEM). Sustainability, 14(2), 613.

Vasseur, V., Kemp, R. (2015), The adoption of PV in the Netherlands: A statistical analysis of adoption factors. Renewable and Sustainable Energy Reviews, 41, 483-494.

Wasi, N., Carson, R.T. (2013), The influence of rebate programs on the demand for water heaters: The case of New South Wales. Energy Economics, 40, 645-656.