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The influence of environmental protection attitudes on people's intention to install rooftop solar power: A study in the south of Vietnam

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Abstract
Using renewable energy to replace fossil energy sources is a sustainable development trend of each country. Vietnam is a country that is very active in implementing the commitments signed at COP26, so the Government of Vietnam is mobilizing all resources, in which resources from the people are a very important resource. In order to have a basis for making recommendations to develop green energy sources, we carried out this study with the aim of determining the relationship between environmental protection attitude and intention to install rooftop solar power, while also considering its regulatory role in the relationship between installation costs and installation intentions. Using linear regression with the participation of the moderator variable for a dataset of 628 people in the southern region of Vietnam. Research results show that environmental protection attitude is an important factor that increases the intention to install rooftop solar power of people in Vietnam. Although the high cost of installation is a barrier to people's intentions, if people have a good attitude, they will overcome the price barrier and move towards the goal of protecting the environment by rooftop solar installation. To be able to take advantage of the great resources of the people in the use of renewable energy, in addition to raising awareness about environmental protection, local authorities need to pay attention to a number of policies on supporting finance to reduce the burden of rooftop solar installation costs.

Keywords: green energy, rooftop solar power, environmental protection attitude, intention to use renewable energy

Introduction

Renewable energy represents the foundation for developing our energy system towards sustainability and supply security (Resch *et al*., 2008) [25]. In recent years, environmental problems have increased, such as atmospheric pollution and the greenhouse effect caused by direct burning of fossil fuels (Olhoff, 2021) [19]. Therefore, renewable energy has become the focus of current research to mitigate these problems. Among the different types of renewable energy, solar energy is widely available, widely distributed and has high potential for application in power generation (Ram 2020) [24]. Its development and use can effectively solve the global energy crisis and climate problems (Ram 2020) [24]. Economists, governments, policymakers and researchers are now searching for methods to ensure a sustainable healthy living environment (Chaabouni & Saidi, 2017; Akbar *et al*., 2020; Liu *et al*., 2020) [8, 4, 17]. Environmental protection agencies around the world also propose a more substantial use of renewable energy sources to offset the rate of climate change (Apergis & Payne, 2010; Jebli *et al*., 2016) [5, 13].

The development of renewable energy sources is gradually taking an important position in sustainable economic development in Vietnam due to its great benefits in making the most of inexhaustible natural resources (Vietnam Ministry of Industry and Trade, 2019) [32]. According to the Ministry of Industry and Trade of Vietnam (2022) [33], rooftop solar power has been noticed to be developed in order to make the most of the "idle" roof area to bring efficiency to people while reducing the burden on the system. However, to promote the potential of the people, especially the investment of households in general, has not yet brought about high efficiency. According to Vietnamsolar (2023) [34], the cost of installing rooftop solar power for a household is 100,000,000 VND to 200,000,000 VND, the cost is equivalent to 1.5 times the average income of people by year. We believe that the low environmental protection attitude plus high installation costs may hinder people's participation in installing rooftop solar power. In order to have a scientific and experimental basis for the policy proposals and recommendations, we carried out the study with the aim of determining the influence of installation costs and environmental protection attitudes on the intention to install, at the same time, it examines the moderating role of environmental protection attitudes on the relationship between people's perceived cost and intention to install rooftop solar power in the southern region of Vietnam.

Research question

How do perceptions of installation costs and environmental protection attitudes affect people's intention to install rooftop solar power?
How does environmental attitudes affect the relationship between perceived installation costs and intention to install rooftop solar?
What recommendations are given for rooftop solar development in Vietnam?

Literature overview

1. Recycled energy

According to the United Nations (Accessed in 2023) [31], renewable energy is energy derived from natural sources such as sunlight, wind, etc. converting these energy sources produces much lower emissions than fossil fuel burning. Zarnikau (2003) [37] defines green energy as electricity

generated using renewable energy sources and includes technologies such as photovoltaic panels, biomass projects, geothermal projects and wind farms. Renewable electricity is also known as green electricity, mainly refers to electricity generated by renewable energy, such as hydroelectricity, photovoltaic, wind power and biomass electricity (Lin & Qiao, 2022) [15]. Meanwhile, Kostakis & Sardianou (2012) [14] said that green energy sources for electricity generation will not emit greenhouse gases. Similarly, Zheng *et al*. (2021) [38] argue that renewable electricity has a significant effect on limiting carbon emissions. Based on the above statements, we realize that renewable energy is a broad, scientific concept that can be understood as non-fossil energy sources, which are more renewable than consumed, including small hydropower, marine energy, wind energy, solar energy, geothermal energy, biomass energy and biofuels.

2. Building research models and hypotheses

Model building

Regarding the behavioral intention of consumers, there have been many theoretical models related to this issue such as: Theory of rational action (TRA); Theory of planned behavior (TPB); Decomposition theory of planned behavior (DTPB).

The theory of rational action proposed by Fishbein & Ajzen (1975) [10], is considered one of the pioneering theories, the most important foundation in consumer behavior research (Puschel *et al*, 2010). According to this theory, behavioral intention is the determinant of customer behavior. Therefore, instead of focusing on consumer behavior, TRA focuses on behavioral intention.

The theory of planned behavior, developed by Ajzen (1985) [2] based on the theory of rational action by Fishbein and Ajzen (1975) [10]. The theory of planned behavior was built by Ajzen by adding cognitive factors controlling behavior to the TRA model. TPB believes that customers' actual behavior is influenced by both behavioral intentions and perceived behavioral control.

Decomposition theory of planned behavior (DTPB) was developed by Taylor & Todd (1995) based on TPB of Ajzen (1985) [2] by separating three factors: attitude, subjective norm and perceived behavioral control into more specific variables.

Based on the above research objectives and theoretical models, we apply the TRA of Fishbein and Ajzen (1975) [10] for this study. TRA suggests that consumers may consider the consequences of alternative behaviors before engaging in them and tend to exhibit behaviors that they associate with desired outcomes (Fishbein and Ajzen, 1975), Ajzen and Fishbein, 2005) [10, 3]. Some previous studies have shown that TRA is a well-organized and successful research model in predicting and explaining behaviors, including those related to environmental protection such as: Bang *et al*.(2000) [6] study of willingness to pay high prices for renewable energy in the US; Pagiaslis and Kronalis (2014) [20] study on consumer behavior towards biofuels in Greece; Lin & Syrgabayeva (2016) [16] researched on consumers' intention to pay more for renewable energy in developing countries. In addition, there are a number of other studies that also use TRA in analyzing people's environmental protection behavior such as: Fitzmaurice *et al*. (2014); Saphores *et al*. (2012); Hu *et al*. (2019) [11].

Based on the above arguments, we propose the following model for the study:

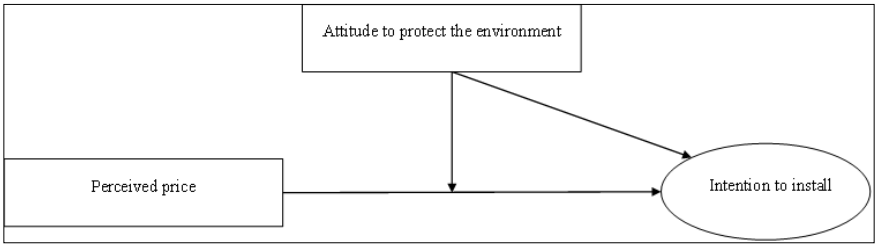


Fig 1: Proposed model

Research hypothesis

Attitude to protect the environment (ATT): Attitude is the positive or negative attitude of an individual in performing a particular behavior (McEachan *et al*., 2011) [18]. Attitude is a relatively stable psychological construct, and many studies have confirmed and predicted the influence of attitude on behavior (Yazdanpanah *et al*., 2015) [36]. Pagiaslis & Krontalis (2014) [20] and Tilikidou (2007) [30] suggest that consumers' interest in environmental protection is a precursor to their willingness to pay for shopping activities. At the same time Lin & Syrgabayeva (2016) [16] said that consumer environmental concerns can be positively linked with renewable energy attitudes and purchases, the authors also explain that consumers who consider themselves environmentalists and are responsible for protecting the environment are those who show favorable attitudes towards the use of renewable energy. Tan (2011) [28] proposed that consumers will have a favorable attitude towards green purchases if an individual is concerned about the environment. Besides, previous studies have reported a positive relationship between environmental protection attitude and environmentally friendly purchasing behavior (Egea & Frutos, 2013; Polonsky *et al*., 2012) [9, 22].

Some studies have also found that consumers' good attitude towards environmental protection also makes consumers willing to pay more for green products (Pagiaslis and Krontalis, 2014; Lin & Syrgabayeva, 2016) [20, 16]. This means that environmental attitudes will influence the relationship of product price with purchase intention. Based on the above arguments, we hypothesize the following research:

H1: Environmental protection attitudes have a positive impact on the intention to install rooftop solar power of people in the southern region of Vietnam.

H2: Environmental protection attitude has a moderating effect on the relationship between perceived installation cost and intention to install rooftop solar PV of people in the southern region of Vietnam.

Perceived price (PP), is the cost that people perceive when using solar power technology at home. Perceived price refers to a subjective form of the monetary value of a product, such as how cheap or expensive the product is, and an assessment of the consumer's purchasing power (Calvo & Mangin, 2017) [7]. In addition, price fairness can be defined as the consumer's judgment and feelings regarding whether the difference (or lack of difference) between the seller's price and the comparable price is reasonable (Xia & Cox, 2004) [35]. The presence of a price reference increases consumer interest and purchase intention and influences consumers (Ahmetoglu *et al*., 2014) [1]. In this case, the perceived price of rooftop solar PV installations can influence consumer behavior when compared to the electricity price that the government sells to the people.

Therefore, the study hypothesizes the relationship between perceived price and intention to install rooftop solar as follows:

H3: Perceived price has a negative effect on people's intention to install rooftop solar power.

Data and methods

Data

This study used survey data from residents, collected between January 2023 and March 2023. The questionnaire was completed using a method that was randomly sent to households in the southern region of Vietnam. Stratified random sampling method was applied in the survey to meet the population characteristics. A total of 650 questionnaires were distributed to households. Results obtained A total of 645 tables after removing a number of tables with insufficient information, the number of satisfactory tables is 628. In which, the characteristics are described in detail in Table 1.

Table 1: Characteristics of survey subjects (N=628)

Characteristics		n	%
Gender	Female	180	28.7%
	Male	448	71.3%
Income/month	≤ Medium	323	51.4%
	Hight	305	48.6%
Power Consumption	≤ Medium	400	63.7%
	Hight	228	36.3%
Age (mean/SD)		35.06(±9)	

Measure

The survey questionnaire of the people is designed in 2 parts. (1) are questions related to demographic characteristics of the people such as: gender, age, income and size of household electricity consumption; (2) questions related to the content of the study, including the intention to install solar PV, environmental protection attitudes, and the price of gas sensing for installing solar power. The questions are designed on a 5-point Likert scale from 1 to 5, corresponding to strongly disagree to strongly agree.

Methods of data analysis

To meet the research objectives, we use the following data analysis methods: First, descriptive statistics are used to examine the socio-demographic characteristics of the interviewees; Second, testing the reliability and validity of the scale; Third, linear regression analysis with moderator variable to determine the relationship of perceived price, environmental protection attitude with intention to install rooftop solar power. Simultaneously measure the moderating effect of attitudes on the relationship between perceived price and intention to install rooftop solar; Fourth, the tests evaluate the fit of the model. The analytical support tool is IBM's SPSS 25 software.

Research results

Check the reliability and validity of the scales

Testing the reliability of the scale to measure the relationship of observed variables in the same scale, whether there is a consistent intrinsic relationship and the same explanation for the same problem? The results of the reliability analysis of the scales (Table 2) show that, all values: Cronbach's Alpha total >0.8; the correlation coefficient of the total variable > 0.5 and the coefficient of Cronbach's Alpha components are >0.7. This means that the reliability of the scales included in the study is guaranteed.

Table 2: Reliability of the scale

Var	Variable definition	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
I	Attitude to protect the environment (ATT), measured by 5 observed variables, Cronbach's Alpha total = 0.853		
ATT1	Using renewable electricity is environmental protection	0.626	0.833
ATT2	Energy from fossil fuels is increasingly depleted	0.615	0.836
ATT3	Protecting the environment is everyone's responsibility	0.699	0.814
ATT4	The environment around you is becoming more and more polluted	0.682	0.819
ATT5	I can set an example for children by using renewable energy	0.708	0.812
II	*Price perception (PP), measured by 4 observed variables, Cronbach's Alpha total =0.894*		
PP1	The cost of installing rooftop solar power is high	0.781	0.858
PP2	Cost burden is a barrier to solar installation	0.804	0.850
PP3	I need time to get enough money for solar installation	0.792	0.854
PP4	The cost of using solar energy is higher than electricity purchased from the government	0.690	0.891
III	*Intent to install (BI), measured by 3 observed variables, Cronbach's Alpha total = 0.848*		
BI1	Installing solar power is my plan in the near future	0.715	0.789
BI2	I will install rooftop solar power for the family	0.713	0.791
BI3	I am considering to install rooftop solar power	0.720	0.785

To measure the validity of the research scales, the main factor analysis method is used to determine the newly formed factors through the convergence and the discriminant. The exploratory factor analysis results in Table 3 show that: KMO coefficient = 0.844 (range from 0.5 to 1); Barlett test has p.value <0.001; Eigenvalue = 1.59 > 1; Total variance extracted = 71.13% > 50%; Load factor of factors >0.5. From this result, we conclude that the factor analysis method of the study is appropriate, with 12 observed variables included in the EFA analysis, 3 main factors have been extracted which are environmental protection attitude, perceived price and installation intention. These three main factors represent 71.13% of the variance of 12 observed variables.

Table 3: Results of Analysis EFA

STT	Measure		Value
1	***KMO***		0.848
2	***Bartlett's test***	Chi-Square Value	3799.266
		Degree of Freedom	66
		Level of significance	0.000
3	*Total Variance Explained*	Eigenvalue	1.59
		Total % of variance extracted	71.13
4	*Rotation matrix*	Number of factors that make up	3
		Factor loading factor	>0.5

Regression analysis results

To measure the impact of environmental protection attitudes, perceived prices on people's intention to install rooftop solar power, at the same time, it also measures the moderating role of environmental protection attitudes on the relationship between perceived price and intention to install, using linear regression combined with the moderating variable (ATT). The regression results shown in Table 4 show that:

Environmental protection attitude has a positive impact with people's intention of rooftop solar power (β1=0.349; P < 0.001);

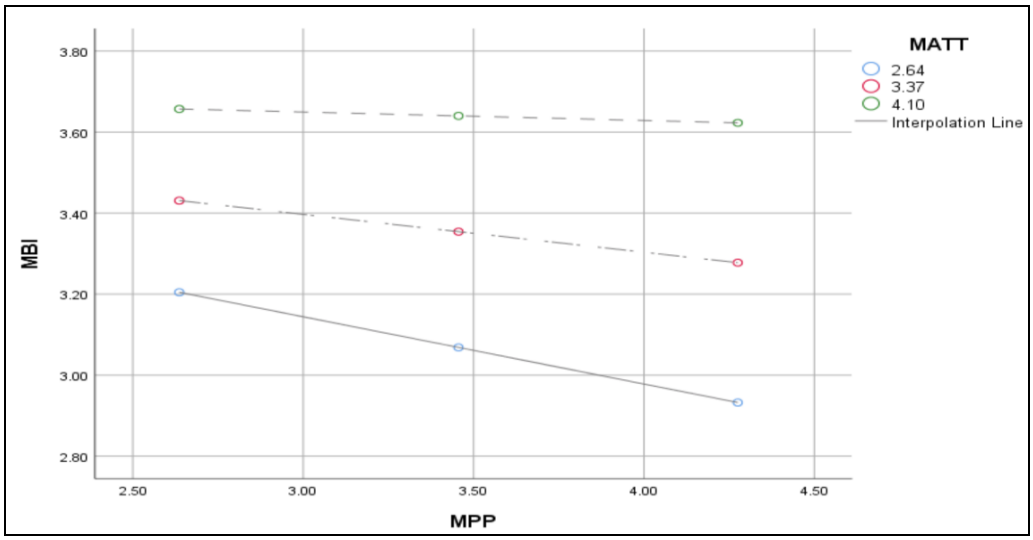
Perceived high installation cost has a negative effect on people's intention to install rooftop solar power (β2=-0.098; p=0.009);

Environmental protection attitude has a regulatory role in increasing the intention to install solar power (β3=0.072; p=0.025), this means that if the environmental protection attitude is good, they can accept the high price to install rooftop solar power. In addition, the regulatory role of environmental protection attitude is also visually described in Figure 2.

Table 4: Regression results

	Iv	β	t	P. value	Tolerance	VIF
1	B_0	0.014	0.370	0.712		
2	ATT	0.349***	9.092	0.000	0.903	1.108
3	PP	-0.098**	-2.639	0.009	0.963	1.038
4	Int (ATT*PP)	0.072*	2.247	0.025	0.931	1.074
R2				0.169		
F				42.19		
P (F)				<0.001		
Durbin-Watson				1.908		

Note: ATT is attitude, PP is perceived price, Int (ATT*PP) is the interaction variable of attitude to price perception, * significance level less than 5%, ** significance level less than 1%, *** significance level less than 0.1%.



Note: *MBI is mean of behavioral intention; MPP is mean of perceived price; MATT is mean of attitude to protect the environment*

Fig 2: Moderating effect of attitude

Check the model's suitability

The analysis results show that the test value is F=42.19 and the significance level <0.001, so the above model is suitable; The variance inflation factor (VIF) of all variables included in the model is < 2, so there is no multicollinearity; Durbin-Watson value = 1,908, based on the value of Durbin-Watson lookup table, 1,908 is in the range (du; 4-du), so no autocorrelation occurs; Besides, the results of the distribution of residuals shown in Figure 3 show that the residuals of the regression results have a normal distribution (the mean value of the residuals = 3.59x10-17 is close to 0 and standard deviation = 0.996 is close to 1), so the model does not occur variance of error changes.

From the above results, we find that the model that the study implements is completely suitable, the estimated results are reliable.

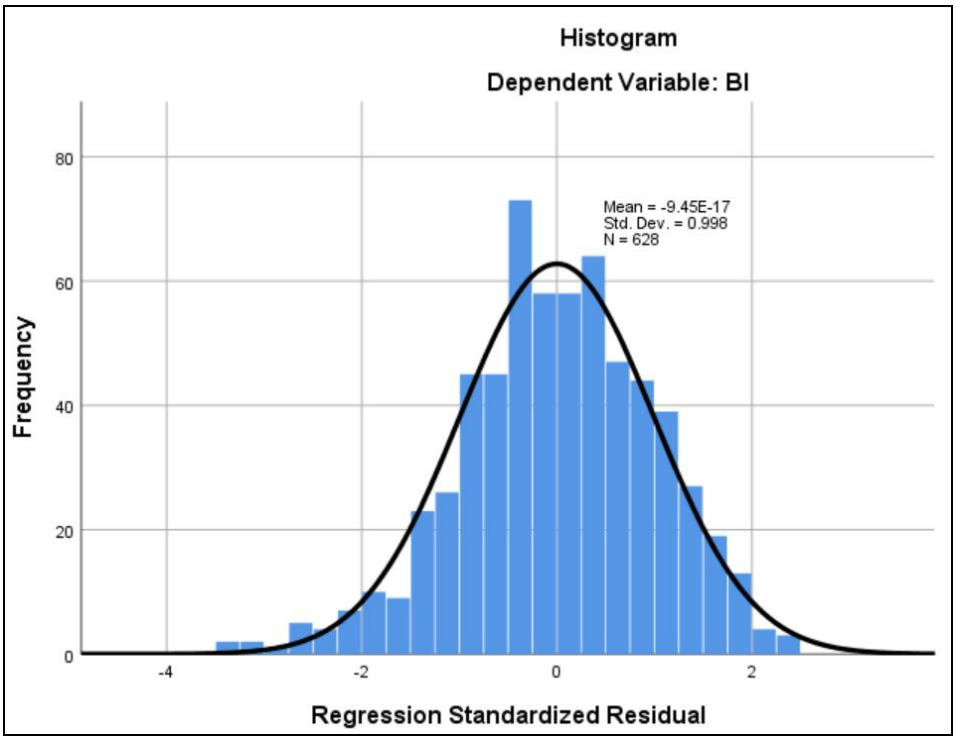


Fig 3: Distribution of the residuals

Discussion

Environmental protection attitude

It can be seen that the attitude of protecting the environment is an important motivation for people to install rooftop solar power. In this study, when people's environmental protection attitude increased by 1 unit, their intention to install rooftop solar power increased by 0.349 units. The positive relationship between environmental protection attitude and intention to use renewable energy has been mentioned by some previous studies such as: Pagiaslis and Krantalis (2014); Lin & Syrgabayeva (2016); Lin & Qiao (2022); Sangroya & Nayak (2017) [15, 20, 16]. In it, Lin & Syrgabayeva (2016) [16] explain that when consumers consider themselves as environmentalists and are responsible for protecting the environment, they show favorable attitudes in using renewable energy.

Perceived price

Perceived high price is a barrier to the intention to install rooftop solar power in this study. Consumer purchase intention is negatively affected by high price mentioned in the study of (Calvo & Mangin, 2017; Xia & Cox, 2004) [7, 35]. In a recent study by Lin & Qiao (2022) [15], the government's financial support policy will help people increase their intention to use renewable energy. To explain this problem, we think: To install a rooftop solar power system in Vietnam with a capacity of about 10KW-15kw/day (equivalent to the consumption of an average family), the cost is about 100-140 (million VND), not including maintenance costs. In fact, this is a relatively high amount of money compared to people (the average income of people in 2022 is about 80 million VND/year), so installing a rooftop solar power system can be a big difficulty for people**.**

Regulatory role of environmental protection attitude

In this study, we also found the moderating role of environmental protection attitude on the perceived influence of installation cost, Specifically, if people have a good attitude in environmental protection, they are willing to overcome the barrier of high installation cost to increase their intention to install rooftop solar power. In the study of Pagiaslis and Krantalis (2014); Lin & Syrgabayeva (2016) [20, 16], their research results also show that the good attitude of consumers in environmental protection also makes consumers willing to pay more for products. We believe that if people feel that they have an important responsibility in environmental protection, the high installation cost will not stop them from intending to install but become a goal for them to look forward to in the future.

Conclusion, recommendation

Environmental protection attitude is an important factor that increases the intention to install rooftop solar power of people in Vietnam. Although the high cost of installation is a barrier to people's intentions, if people have a good attitude, the problem can overcome the price barrier and move towards the goal of protecting the environment by installing solar power.

To be able to take advantage of the great resources of the people in the use of renewable energy to reduce pressure on environmental pollution as well as pressure on fossil energy sources, in addition to raising awareness of environmental protection, the government needs to pay attention to a number of policies to support the cost of installing rooftop solar power such as: Support a part of the initial investment cost for people when installing ; implementing the policy of deferred payment for purchases of rooftop solar power equipment; Allowing many organizations to participate in providing rooftop solar power equipment to create price competition or credit support policies from banks.

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