

An Empirical Study on Factors Shaping Sustainable Energy Use Behavior: Analysis of social influence and environmental awareness threshold

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Abstract : *Understanding the determinants of household adoption of new energy sources is crucial for developing effective energy transition policies. This study explores how environmental awareness and social influence affect the adoption of new energy sources among residents of Ningxia, China. SEM analysis based on questionnaire data from Ningxia residents shows that environmental awareness significantly increases the likelihood of adopting new energy technologies. Social influence, manifested by social norms and peer demonstration, also plays a decisive role in residents' adoption decisions. The findings emphasize that in underdeveloped regions, combining environmental education with community-based policy tools is of great significance for accelerating energy transition at the household level.*

Keywords: Sustainable energy ; TPB; solar photovoltaic ; SPV; VBN

1. INTRODUCTION

Residents' adoption of new energy technologies is crucial for the transformation of energy systems. Existing research on sustainable energy adoption has predominantly focused on economic factors such as income levels, subsidies, and pricing mechanisms. However, as energy transitions accelerate, psychological and social factors have become increasingly important in shaping household energy behavior. Despite prior studies examining the effects of environmental awareness or social influence individually, several gaps remain. First, most research treats these factors in isolation, lacking a unified analytical framework to systematically examine their combined effects. Second, empirical evidence on the micro-level mechanisms through which psychological and social factors translate into actual energy behavior remains limited. Third, existing studies largely focus on economically developed regions, with insufficient attention to less developed areas. Ningxia presents distinctive ecological pressures, policy contexts, and social interaction patterns, making it an ideal setting for investigating these dynamics. To address the above gaps, this study develops an integrated framework that combines environmental awareness and social influence, and empirically tests the proposed hypotheses using Structural Equation Modeling (SEM). This study contributes to the literature in three main ways. First, it highlights the combined effects of environmental awareness and social influence on sustainable energy adoption within a unified framework. Second, it examines the mediating role of behavioral intention, revealing the micro-level mechanisms through which psychological and

social factors affect energy adoption. Third, by focusing on Ningxia, it provides empirical evidence and policy-relevant insights to support household-level energy transition in less developed regions.

2. THE THEORETICAL BASIS OF STUDY MODELS

This study is based on the Theory of Planned Behavior (TPB) and the Value-Belief-Normative Theory (VBN). TPB points that an individual's actual behavior is primarily determined by their behavioral intention, which is influenced by factors such as attitudes, subjective norms, and perceived behavioral control. In the energy field, TPB is widely used to explain residents' decision-making processes regarding energy conservation, low-carbon technology adoption. In the context of new energy adoption, behavioral intention is considered a key mediating variable in the shift from "cognition and attitude" to "actual use." Therefore, using behavioral intention as an important variable connecting influencing factors with new energy use behavior has a solid theoretical foundation. Social influence is one of the core variables of TPB. Environmental awareness originates from VBN, which explains deep-seated motivations and can answer the question, "Why are some residents willing to install photovoltaic systems even if the economic benefits are not high?" The conceptual framework is constructed as follows :

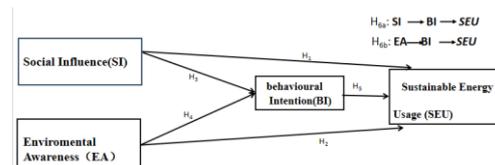


Figure 1: Conceptual Framework

3 HYPOTHESIS

3.1 The Relationship Between Social influence and Sustainable Energy Usage

Social influence also plays a decisive role in consumer willingness and behavior (Bollinger & Gillingham, 2012; Gardan et al., 2023; Irfan et al., 2021; Kulviwat et al., 2009; Li et al., 2022; Muhammad Irfan., 2021; Roy et al., 2021). Consumers have a clear cognitive understanding of the factors influencing their willingness to use energy. Group psychology suggests that people often exhibit herd mentality, stemming from their desire for acceptance and recognition from the group. Muhammad Irfan (2021) found that consumers' perceptions of peers, relatives, neighbors, and society profoundly influence the thoughts of local residents, thereby significantly increasing their willingness to adopt renewable energy. Particularly noteworthy is the positive impact of perceived neighborly involvement on the willingness to adopt renewable energy. Gardan et al. (2023) pointed out that consumers recognize that their attitudes toward renewable energy consumption are strongly influenced by a variety of underlying structures, with social influence being one of the most critical determinants. Furthermore, the relationship between social influence and individual adoption intentions becomes even stronger when innovative products are publicly consumed. Kulviwat et al. (2009) showed that consumers' willingness to adopt solar energy first increases and then decreases as village community awareness increases. Regarding energy use behavior, consumer behavior is driven by multiple factors. Roy and Mohapatra (2022) pointed out that consumers recognize the significant impact of social influence on their behavioral intentions, and that there are several social factors that favor the use of solar generators. Li et al. (2023) also support this view. Their (2022) study found that while consumers have a strong sense of independence and are unwilling to blindly follow government policies, they actively respond to the promotion of solar energy by respected leaders in their communities. Roy et al. (2021) pointed out that consumers can perceive the positive social impact of solar energy adoption in their communities. Shaw and Sergueeva (2019) found that consumers give positive feedback to community leaders' initiatives to promote solar energy, and this feedback is ultimately reflected in the actual adoption of solar energy. As Iuliana Petronela Gardan and Gardan (2023) pointed out, policymakers can exert social influence when developing national energy and climate plans.

Marketers and policymakers are interested in causal peer effects because they can leverage social spillover effects to accelerate the adoption of environmentally friendly products or technologies (Bollinger & Gillingham, 2012). Based on previous definitions of social influence, this paper argues that social influence refers to the influence of neighbors on the willingness and behavior of community residents to adopt new sustainable energy technologies. Western China has unique characteristics that are significantly different from first- and second-tier cities, forming groups based on kinship. Some studies have shown that in "familiar societies," leveraging interpersonal networks to promote agricultural technologies is the most effective method. "Opinion leaders" play a crucial role here; their views and behaviors have a significant impact on other community members. Based on previous surveys on the social impact of sustainable energy use (Goldsmith & Goldsmith, 2011; Kulviwat et al., 2009; Muhammad Irfan, 2021; Shaw & Sergueeva, 2019; Wolske et al., 2020).

Therefore, this paper makes the following assumptions:

H₁: There is a relationship between social influence and Sustainable Energy Usage.

H₃: There is a relationship between social influence and behavioral intention.

3.2 The Relationship Between environmental awareness and Sustainable Energy Usage

The impact of environmental awareness on consumer behavior has long been a focus of scholarly attention. Numerous studies have shown that environmental awareness plays a decisive role in consumer attitudes and behaviors (Austmann & Vigne, 2021; Gârdan et al., 2023; Iuliana Petronela Gârdan & Gârdan, 2023; Muhammad Irfan, 2021; Shaw & Sergueeva, 2019). Furthermore, many studies have explored the impact of environmental awareness on sustainable energy use (Iuliana Petronela Gârdan & Gârdan, 2023; Khan, 2024; Muhammad Irfan, 2021; Li Yuhong & Li Xudong, 2017). Extensive research indicates that environmental awareness is a core factor driving consumers' willingness to use sustainable energy. Muhammad Irfan (2021) points out that environmental awareness has a significant positive impact on consumers' willingness to adopt renewable energy. William Philip Wall (2021) further refined this association, finding that environmental concern, self-efficacy, awareness of renewable energy, and belief in its benefits all had a significant positive impact on consumers' willingness to adopt it. Shaw and Sergueeva (2019) supplemented this mechanism at the

social and national levels, arguing that public concern about environmental issues and the desire to improve the national image are the most powerful predictors of renewable energy adoption behavior, both of which are essentially derived from the explicit expression of individual environmental awareness. Gardan et al.(2023) revealed the crucial role of environmental awareness in attitude formation, pointing out that environmental concerns are one of the decisive potential factors influencing consumers' attitudes towards renewable energy consumption. This attitude is further translated into behavioral intentions through technology selection preferences (e.g., consumers' decisions regarding specific renewable energy technologies). Furthermore,Austmann and Vigne (2021), using electric vehicle purchase decisions as an example, confirmed that environmental awareness (i.e., concerns about climate change and sustainability) directly impacts consumer behavior. The underlying logic is that increased environmental awareness will boost market demand for green products (e.g., increased sales and registrations of electric vehicles).

Based on empirical evidence across regions and multiple scenarios (Hu et al., 2021; Khan, 2024; Chen Gezhi et al., 2023), the academic community has reached a broad consensus on the impact of environmental awareness on sustainable energy use. Masson-Delmotte, Zhai et al.(2022) further emphasized that environmental awareness not only indirectly influences the adoption of renewable energy through the “attitude-intention-behavior” chain, but also has a significant positive impact on consumers’ willingness in different cultural and social contexts. Overall, although the research perspectives encompass multiple dimensions, including individual psychology (such as self-efficacy), social norms (such as national image), and technology choices, its core conclusion points to the fundamental role of environmental awareness: it is not only a key psychological motivation driving the willingness to use sustainable energy, but also a bridge connecting cognition (such as environmental concern) and behavior (such as technology adoption decisions). Existing evidence strongly suggests that consumers' acceptance and actual use of renewable energy are largely influenced by their level of environmental awareness—the stronger their environmental awareness, the more likely they are to translate their willingness to protect the environment into concrete actions, such as choosing renewable energy technologies and purchasing green products.

Therefore, this paper makes the following hypothesis:

H2: There is a relationship between environmental awareness and Sustainable Energy Usage .

H4: There is a relationship between environmental awareness and behavioral intentions .

3.3 The Relationship Between behavioral intentions and Sustainable Energy Usage

The concept of intention falls under the realm of psychology. Fishbein and Eisen's theory of rational action defines behavioral intention as the subjective probability that an individual will take a specific action. From this perspective, purchase intention is the subjective probability that a consumer is willing to buy a certain product. To predict consumer behavior, we must first understand consumers' purchase intentions. Although having a purchase intention does not necessarily mean that a consumer will actually make a purchase, the occurrence of a purchase is necessarily based on the existence of that intention. Purchase is an action, intention is a psychological activity, and purchase intention refers to the thought process surrounding the purchase. A positive purchase intention will lead to the occurrence of a purchase.

Furthermore, the impact of community residents' attitudes and perceptions on the development of renewable energy has been discussed for many years abroad. Colenbrander, Gouldson, Roy et al. (2017) used a low-carbon community in Kolkata, India as an example to explore the degree of coordination between social, economic, and climate goals. Their findings indicated that if implemented as planned, Kolkata's energy bill could be reduced by 8.5% and greenhouse gas emissions by 20.7% by 2025; however, the development of low-carbon communities would increase social operating costs and bring significant economic costs. But if residents cooperate with the government, these social costs could be reduced to some extent. Chen (2020), building on the original impact of government and businesses on residents' low-carbon behavior, further pointed out that residents themselves are the main actors in the transformation of low-carbon communities, and focused more on how residents' own behavior affects the construction of low-carbon communities. Other studies have also found a correlation between public energy projects and positive attitudes towards related energy technologies, highlighting the importance of trust between communities and project developers.

An encouraging finding by Roy and Mohapatra (2022) is the relationship between behavioral intentions and switching behavior.

The results indicate that if consumers are persuaded to adopt an SPV, they are more likely to switch from their existing household power source to an alternative. The stronger the perceived convenience and practicality of electric vehicles, the more positive their purchasing attitude towards them (Chen,2020). The findings of Iuliana Petronela Gărdan and Gărdan (2023) suggest that consumer attitudes toward renewable energy consumption are strongly influenced by other underlying factors, with perceived utility, social impact, and environmental concerns being the most decisive. Consumers' behavioral intentions and actual consumption behaviors toward renewable energy are increasingly reflected in their preferences for different types of renewable energy technologies. In the process of adopting renewable energy technologies, people gradually become aware of the negative environmental impacts of using traditional "brown" energy sources, such as noise and air pollution, climate change and biodiversity loss in some areas, declining living standards and safety due to rising energy prices and insufficient energy supply, and the emergence of other traditional energy sources. Therefore, people's acceptance of new technologies in the energy sector, as well as the risks and benefits these technologies bring, influence the expression and updating of personal norms, thereby affecting consumption and acceptance behavior. Roy et al (2021) found that the willingness to use solar energy has a positive impact on energy conversion behavior.

Based on the above evidence, this paper proposes a hypothesis based on the role of mediating variables. Therefore, this paper makes the following assumptions:

H₅: There is a relationship between behavioral intentions and Sustainable Energy Usage

3.4 The mediating role of behavioral intentions

In this paper, behavioral intention is not only an important variable in the relationship between independent variables and behavior, but also a mediating variable. Based on existing research, the evidence for behavioral intention as a mediating variable is mainly reflected in the following aspects. The core logic is that "antecedent variables (such as environmental awareness, social impact, etc.) influence sustainable energy use behavior by affecting behavioral intention."

Gărdan et al. (2023) clearly pointed out that "environmental concern" (antecedent variable) shapes "attitudes towards

renewable energy consumption," thereby strengthening "behavioral intentions," which ultimately manifest as consumers' preferences for specific technologies (such as solar and wind power equipment). Here, behavioral intentions are the mediating variable connecting "environmental concern" and "actual consumption behavior," meaning that environmental awareness can only be transformed into concrete actions through behavioral intentions.

Wall et al. (2021) found in a study of Thai consumers that the influence of antecedent variables such as renewable energy perception and benefit beliefs on adoption behavior is entirely mediated by behavioral intention (i.e., the "perception → intention → behavior" chain). Without the mediating role of behavioral intention, the direct association between antecedent variables and behavior would be significantly weakened. Shaw and Sergueeva (2019) pointed out that public concerns about environmental issues and the desire to improve national image (antecedent variables) need to be transformed into actual technology adoption behavior through "behavioral intention to adopt renewable energy" (mediating variable). This study explicitly positioned behavioral intention as a key mediating variable, whose role is to "connect external motivations (such as national image) with actual actions." Austmann and Vigne (2021) confirmed in electric vehicle purchase decisions that "environmental awareness" (antecedent variable) first enhances "behavioral intention to purchase electric vehicles" (mediating variable), thereby promoting "vehicle registration" (actual behavior). Through structural equation modeling (SEM), they verified that behavioral intention plays a mediating role in this process, meaning that the influence of environmental awareness on purchasing behavior is entirely mediated by behavioral intention.

According to the 2021 Global Climate Status Report, climate change caused by human activities poses a severe challenge to the sustainable development of the global economy. How to reduce carbon dioxide emissions and improve carbon emission efficiency has become an important issue of common concern to countries around the world. The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C points out that the impacts of climate change are more severe than expected, and the pace of climate action should not be slowed down (Leiman, A; Ma, H, 2021).

This paper argues that behavioral intention is not only an important variable in the relationship between individual variables and behavior, but also a mediating variable. Existing research shows

that the evidence for behavioral intention as a mediating variable is mainly reflected in the following aspects: its core logic is that "antecedent variables (such as environmental awareness, social influence, etc.) affect behavioral intention, and thus affect sustainable energy use behavior."

Gardan et al. (2023) explicitly point out that "environmental concern" (an antecedent variable) influences "attitudes towards renewable energy consumption," which in turn reinforces "behavioral intentions." Ultimately, this manifests as consumer preferences for specific technologies (such as solar or wind power equipment). Here, behavioral intentions act as a mediating variable, connecting "environmental concern" and "actual consumption behavior," meaning that environmental awareness must be translated into concrete actions through behavioral intentions.

A study by Wall et al.(2021) on Thai consumers showed that antecedent variables such as perceptions of renewable energy and beliefs about its benefits influence adoption behavior entirely through the mediating variable of behavioral intention (i.e., the "perception → intention → behavior" chain). Without the mediating role of behavioral intention, the direct association between antecedent variables and behavior would be significantly weakened.

Shaw and Sergueeva (2019) found that public concern about "environmental issues" and their desire to "improve the national image" (antecedent) need to be moderated by "willingness to adopt renewable energy" (mediating variable) before translating into actual technology adoption. This study clearly indicates that behavioral intention is a key mediating variable connecting external motivations (such as national image) with concrete actions. Austmann and Vigne (2021) demonstrated in electric vehicle purchase decisions that "environmental awareness" (antecedent variable) first enhances "willingness to purchase electric vehicles" (mediating variable), which in turn drives "vehicle registrations" (actual behavior). In this process, the mediating role of behavioral intention was verified by SEM , meaning that the impact of environmental awareness on purchasing behavior is entirely mediated by behavioral intention. Based on the above evidence, this paper proposes a hypothesis based on the role of mediating variables.

H_{6a}: Behavioral Intention mediates the relationship between Social Influence and Sustainable Energy Usage ;

H_{6b}: Behavioral Intention mediates the relationship between Environmental Awareness and Sustainable Energy Usage .

4. DESCRIPTIVE ANALYSIS

In this analysis, a total of 410 questionnaires were collected, with 403 valid questionnaires, resulting in a validity rate of 98.29 % . In terms of gender distribution, the number of females were accounting for 36.48 % . Regarding age, there was little difference in the number of respondents across different age groups. Regarding education, From a level perspective, most are High school and below, there are a total of 236, accounting for 58.56 %; Monthly In terms of income, RM4001-RM6000 is the most common, totaling 184, accounting for 45.66 % .In terms of profession , the majority are farmers , accounting for 48.14 % .

The mean values of Social Influence, Environment Awareness, Behavioral Intention, Sustainable Energy Usage were 3.467, 3.177,3.448,and3.632, slightly higher than the median of 3 , indicating that users generally rated the scale items positively, without extreme overestimation or underestimation. To further test whether the data conformed to a normal distribution, this paper referred to the criteria proposed by Kline (1998), namely, the absolute value of skewness should be less than 3 , and the absolute value of kurtosis should be less than 10. According to the calculation results, the skewness and kurtosis of each item of the scale in this study met the above criteria, indicating that the data distribution did not show significant skewness or abnormal kurtosis. This result shows that the distribution of the scale data can be considered statistically basically normal.

Table 1. Descriptive analysis of different dimensions (N = 403)

Items	M	SD	Skewness	Kudo
SI	3.467	0.816	-0.388	0.02
EA	3.177	0.779	0.074	-0.359
BI	3.448	0.816	-0.334	0.182
SEU	3.632	0.685	-0.646	0.405

5.THE EXPLORATORY FACTOR ANALYSIS

The exploratory factor analysis (EFA) results provided in the table2 represent the factors identified in relation to four key constructs: Social Influence (SI), Environmental Awareness (EA), Behavioral Intention (BI), and Sustainable Energy Usage (SEU).

The factor loadings indicate the strength of the relationship between each item and the corresponding factor. the items related to

Social Influence (SI1 to SI6) exhibit high factor loadings on Factor 1, with values ranging from 0.791 to 0.829. This suggests a strong correlation between Social Influence items and Factor 1, which could reflect the collective impact of social pressures and peer influences on an individual's perception of sustainable energy. Similarly, the Environmental Awareness (EA1 to EA6) items load highly on Factor 2, with loadings between 0.708 and 0.812. These values indicate that environmental awareness is a distinct but related factor, demonstrating a clear association with the awareness of environmental issues and their potential impacts on behavior.

Items associated with Behavioral Intention (BI1 to BI6) load significantly on Factor 3, with loadings ranging from 0.806 to 0.835. This suggests that an individual's intention to engage in behavior related to sustainable energy is strongly influenced by their personal predisposition, likely reflecting the theory of planned behavior, where behavioral intention is a precursor to actual behavior. Finally, the Sustainable Energy Usage (SEU1 to SEU6) of items mainly load on Factor 4, with factor loadings between 0.526 and 0.762. While this factor exhibits a wider range of loadings, it still represents an important construct related to individuals' intentions to use sustainable energy, emphasizing practical aspects such as accessibility and ease of use.

The eigenvalues for the rotated factors are 7.546, 3.538, 2.587, and 1.894, respectively, all of which are above the commonly accepted threshold of 1, indicating that the factors extracted are meaningful and represent distinct dimensions of the data. The variance explained by each factor after rotation is 17.848%, 17.444%, 15.957%, and 13.607%, respectively. This suggests that each factor explains a significant portion of the variance in the data. The cumulative variance explained by the four factors is 64.856%, which is substantial and suggests that the model captures the majority of the underlying patterns in the data, consistent with the recommended threshold of explaining at least 60% of the variance in exploratory analyses.

The Kaiser-Meyer-Olkin (KMO) value of 0.92 indicates an excellent level of sampling adequacy for conducting factor analysis. A KMO value above 0.9 is considered excellent, suggesting that the data is highly suitable for factor analysis. Additionally, the Bartlett's test of sphericity yields a chi-square value of 5273.599 with 276 degrees of freedom and a p-value of 0, which is highly significant. This indicates that the correlation

matrix is not an identity matrix, and there are significant correlations among the variables, justifying the use of factor analysis.

Table2 The exploratory factor analysis (EFA)

Items	Factor Loading Coefficients			
	Factor 1	Factor 2	Factor 3	Factor 4
SI1		0.82		
SI2		0.829		
SI3		0.818		
SI4		0.811		
SI5		0.81		
SI6		0.791		
EA1			0.749	
EA2			0.751	
EA3			0.776	
EA4			0.812	
EA5			0.708	
EA6			0.779	
BI1	0.806			
BI2	0.821			
BI3	0.835			
BI4	0.808			
BI5	0.818			
BI6	0.816			
SEU1				0.76
SEU2				0.699
SEU3				0.715
SEU4				0.762
SEU5				0.674
SEU6				0.526
Eigenvalues (before rotation)	7.546	3.538	2.587	1.894
Variance explained % (after rotation)	17.848%	17.444%	15.957%	13.607%
Cumulative variance explained (% after rotation)	17.848%	35.292%	51.249%	64.856%
KMO value	0.92			
Barth sphericity	5273.599			
df	276			
p-value	0			

6.RELIABILITY, FACTOR LOADINGS, AND CONVERGENT VALIDITY

Reliability verification is crucial in statistical analysis, and its core lies in examining the internal consistency of the measurement tool. Cronbach's Alpha, as a typical tool, aims to quantify the relevance and consistency among items within a questionnaire. Specifically, this coefficient assesses the degree of correlation between item scores to demonstrate whether they collectively and

consistently reflect the same concept or trait. Cronbach's Alpha, values typically range from 0 to 1. The closer value is to 1, the stronger the internal consistency, meaning the scores across items are more synchronized. Industry experts generally consider a value above 0.7 to indicate good reliability, and above 0.8 to be extremely high reliability. According to data in Table 3, Social Influence, Environmental Awareness, Behavioral Intention, Cronbach's alpha coefficients of Sustainable Energy Usage were 0.910, 0.88, 0.919, and 0.831, all of which were higher than the 0.7 threshold, thus confirming the high reliability of the study.

The standardized loading coefficients of the measurement model were verified to generally exceed the 0.6 threshold, while the observed standard relative error showed a small magnitude, indicating good model accuracy. Furthermore, the critical ratios of all factors exceeded 3.29, and the parameter estimates were significant at the 0.001 significance level, further confirming the strong contribution of each factor to the model's explanatory power and thus demonstrating the model's high fitness.

AVE (mean variance extraction rate), as a method for assessing scale validity, aims to quantify the proportion of variance captured by the measurement items within the construct, which includes the portion related to observation error. Its numerical range is typically between 0 and 1. A larger AVE value indicates a stronger explanatory power of the measurement items for the construct's variance, meaning they more effectively map the nature of the construct. Generally, an AVE value exceeding 0.5 is considered to meet the standard of good validity. Influence, Environmental Awareness, Behavioral Intention, The AVE values for Sustainable Energy Usage were 0.629, 0.552, 0.654, and 0.506, respectively. On the other hand, CR (combined reliability), as a measure of model reliability, calculates the proportion of non-error components in the total variance of the measurement items. Similarly, CR values range from 0 to 1; a high CR value indicates strong internal consistency among the measurement items. Generally, a CR value exceeding 0.7 is considered an acceptable level of consistency. Influence, Environmental Awareness, Behavioral Intention, The CR values for Sustainable Energy Usage were 0.91, 0.88, 0.919, and 0.831, respectively. In this study, since the AVE values were all above 0.5 and the CR values were all above 0.7, this fully demonstrates that the scale has good convergent validity.

Table 3 Reliability, Factor Loadings, and Convergent Validity

Latent variables	Visible variables	Std. Error	Std. Estimate	AVE	CR	Cronbach α
SI	SI1	-	0.799			
SI	SI2	0.057	0.808			
SI	SI3	0.058	0.809	0.6	0.9	0.91
SI	SI4	0.057	0.79	29	11	
SI	SI5	0.058	0.785			
SI	SI6	0.058	0.768			
EA	EA1	-	0.726			
EA	EA2	0.074	0.745			
EA	EA3	0.073	0.735	0.5	0.8	0.88
EA	EA4	0.08	0.797	52	81	
EA	EA5	0.08	0.699			
EA	EA6	0.081	0.752			
BI	BI1	-	0.812			
BI	BI2	0.056	0.789			
BI	BI3	0.052	0.817	0.6	0.9	0.919
BI	BI4	0.055	0.82	54	19	
BI	BI5	0.053	0.808			
BI	BI6	0.053	0.805			
SEU	SEU1	-	0.782			
SEU	SEU2	0.067	0.651			
SEU	SEU3	0.066	0.692	0.5	0.8	0.831
SEU	SEU4	0.066	0.694	06	33	
SEU	SEU5	0.067	0.623			
SEU	SEU6	0.055	0.593			

7. DISCRIMINANT VALIDITY

Discriminant validity measures the effectiveness of a measurement tool in distinguishing different concepts or constructs; that is, whether it can effectively differentiate them from other similar but different constructs. According to the criteria proposed by Fornell and Larcker (1981), discriminant validity can be measured by comparing the average variance of the constructs. Variance Discriminant validity is determined by the AVE (Extracted Value) and the squared correlation coefficient between the construct and other constructs. Specifically, the AVE of each construct should be greater than the squared correlation coefficient between it and other constructs. This means that a construct should have a higher correlation than other constructs, thus demonstrating sufficient discriminant validity. Awareness, Behavioral Intention, Usage Intention Sustainable The energy values were 0.793, 0.743, 0.808, and 0.711, respectively, indicating that the discrimination validity met the standard.

Table 4 Discriminant validity

	SI	EA	BI	SEU
SI	0.793			
EA	0.202	0.743		
BI	0.198	0.361	0.808	
SEU	0.378	0.41	0.373	0.711

8. STRUCTURAL EQUATION MODEL

The model fit indices presented in Table 5 demonstrate that the proposed model exhibits excellent fit to the data. The chi-square statistic of 355.472 with 246 degrees of freedom results in a chi-square/degree of freedom ratio of 1.445, which is well below the critical value of 3, indicating a good fit according to the standard criteria. The RMSEA value of 0.033 is also below the threshold of 0.10, suggesting that the model fits the data well and has a low level of approximation error. Additionally, the Goodness-of-Fit Index (GFI) of 0.933 and Adjusted Goodness-of-Fit Index (AGFI) of 0.917 both exceed the recommended value of 0.8, confirming that the model explains a substantial amount of the variance in the data. Other indices, such as the Relative Fit Index (RFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI), all surpass the threshold of 0.9, further supporting the model's adequacy. These results collectively indicate that the model is well-specified and fits the observed data well, providing strong support for the validity of the underlying theoretical framework.

Table 5 Model Fit Test

Fit index	critical value	Current value	result
Card		355.472	
Degrees of freedom		246	
Chi-square/degrees of freedom	< 3	1.445	Meets standards
RMSEA	< 0.10	0.033	Meets standards
GFI	> 0.8	0.933	Meets standards
AGFI	> 0.8	0.917	Meets standards
RFI	> 0.9	0.926	Meets standards
NFI	> 0.9	0.934	Meets standards
IFI	> 0.9	0.979	Meets standards
TLI	> 0.9	0.976	Meets standards
CFI	> 0.9	0.979	Meets standards

The results from the structural equation model presented in Table 6 provide significant insights into the relationships between

Social Influence, Environmental Awareness, Behavioral Intention, and Sustainable Energy Usage. The model reveals that both SI and EA have direct, significant effects on BI and SEU. Specifically, SI significantly influences BI with a path estimate of 0.136 (SE = 0.055, CR = 2.591, P = 0.01), indicating that higher social influence is associated with a stronger behavioral intention toward sustainable energy use. EA, on the other hand, has a stronger impact on BI, with a path estimate of 0.368 (SE = 0.057, CR = 6.481, P < 0.001), suggesting that greater environmental awareness leads to more pronounced behavioral intentions to engage in sustainable practices.

Furthermore, BI significantly predicts SEU, with a path estimate of 0.231 (SE = 0.052, CR = 4.211, P < 0.001), indicating that individuals with stronger behavioral intentions are more likely to adopt sustainable energy use. Both SI and EA also directly influence SEU, with path estimates of 0.316 (SE = 0.052, CR = 5.96, P < 0.001) and 0.301 (SE = 0.055, CR = 5.233, P < 0.001), respectively. These results suggest that both social influence and environmental awareness play pivotal roles in shaping individuals' usage intentions towards sustainable energy, emphasizing the importance of external influences and personal environmental consciousness in driving the adoption of sustainable energy practices. Overall, the model underscores the interconnectedness of these factors, highlighting the direct and significant effects of social and environmental factors on both behavioral intention and Sustainable Energy Usage.

Table 6 Results of Structural Equation Modeling

			SE	CR	P	Estimate
BI	<---	SI	0.055	2.591	0.01	0.136
BI	<---	EA	0.057	6.481	***	0.368
SEU	<---	BI	0.052	4.211	***	0.231
SEU	<---	SI	0.052	5.96	***	0.316
SEU	<---	EA	0.055	5.233	***	0.301

9. MEDIATION EFFECT TEST

The bootstrap method for testing mediation effects is a nonparametric method based on repeated sampling, which effectively overcomes the strict requirements of traditional methods on sample size and normality (Preacher & Hayes, 2008). The core idea of this method is to repeatedly and randomly draw samples from the original dataset (usually 5000 or 10000 times), calculate the mediation effect of each sample (ie, the indirect effect of the independent variable X on the dependent variable Y through the mediator M), and finally construct confidence intervals (usually 95 %

or 90 %) to determine whether the mediation effect is significant. If the confidence interval for the indirect effect does not contain zero, it indicates that the mediation effect is significant; otherwise, it indicates that the mediation effect is not significant (MacKinnon et al., 2004).

Table 7 presents the results of the mediation effect test, revealing partial mediation for both Social Influence and Environmental Awareness on the relationship between Behavioral Intention and Sustainable Energy Usage. For the SI → BI → SEU pathway, the total effect is 0.258 ($p < 0.001$), with a direct effect of 0.234 ($p < 0.001$). The mediation effect is 0.024, with a 95% bootstrap confidence interval (CI) ranging from 0.008 to 0.052, indicating a

statistically significant partial mediation. This suggests that while SI directly influences SEU through BI, it also exerts an indirect effect on SEU through BI. Similarly, for the EA → BI → SEU pathway, the total effect is 0.306 ($p < 0.001$), with a direct effect of 0.242 ($p < 0.001$). The mediation effect is 0.064, with a 95% bootstrap CI of 0.040 to 0.111, again confirming partial mediation. This implies that EA influences SEU both directly and indirectly, with BI acting as a mediator. These results indicate that both SI and EA contribute to the formation of usage intentions for sustainable energy, but BI partially mediates the effects of these factors, highlighting the complex interplay between these variables in promoting sustainable energy behaviors. The final assumptions are as follows Table 8:

Table7 Mediation Effect Test (Note : * $p < 0.05$ ** $p < 0.01$ * $p < 0.001$ Bootstrap type = percentile bootstrap method)**

item	Total effect	Mediation effect value	95% BootCI	direct effects	Test conclusions
SI=>BI=>SEU	0.258***	0.024	0.008 ~ 0.052	0.234***	Partial Mediation
EA=>BI=>SEU	0.306***	0.064	0.040 ~ 0.111	0.242***	Partial Mediation

Table8 Summary of Assumptions and Results

symbol	Assumption	result
H ₁	Social influence has a positive and significant effect on Usage Intention Sustainable Energy .	Supported
H ₂	Environmental Awareness has a positive and significant effect on Usage Intention Sustainable Energy.	Supported
H ₃	Social influence has a positive and significant effect on Behavioral Intention.	Supported
H ₄	Environmental Awareness has a positive and significant effect on Behavioral Intention..	Supported
H ₅	Behavioral intention has a positive and significant effect on Usage Intention Sustainable Energy .	Supported
H _{6a}	Behavioral intention mediates the relationship between social influence and Usage Intention Sustainable Energy .	Supported
H _{6b}	Behavioral intention mediates the relationship between Environmental Awareness and Usage Intention Sustainable Energy .	Supported

9. Conclusion

This study examined the relationships among Social Influence, Environmental Awareness, Behavioral Intention, and Sustainable Energy Usage, as well as the mediating role of Behavioral Intention. The empirical results provide strong support for all proposed hypotheses. First, both social influence and environmental awareness were found to have significant positive effects on Sustainable Energy Usage (H₁ and H₂ supported). This indicates that individuals are more likely to adopt sustainable energy when they perceive social pressure or encouragement from important others and when they possess higher levels of environmental awareness. Second, social influence and environmental awareness were also shown to significantly enhance behavioral intention (H₃ and H₄ supported). These findings suggest that both

external social factors and internal cognitive factors contribute to strengthening individuals' intention to engage in sustainable energy usage. Third, behavioral intention significantly and positively affected Sustainable Energy Usage (H₅ supported), confirming its central role within the structural framework. Most importantly, the mediation analysis revealed that behavioral intention partially mediates the relationships between (a) social influence and Sustainable Energy Usage (H_{6a} supported), and (b) environmental awareness and Sustainable Energy Usage (H_{6b} supported). This finding demonstrates that social influence and environmental awareness not only exert direct effects on Sustainable Energy Usage but also indirectly influence it through behavioral intention. Overall, the results highlight the dual importance of social context and environmental cognition in shaping

sustainable energy adoption. The study provides empirical evidence that strengthening environmental awareness and leveraging social influence mechanisms can effectively enhance individuals' behavioral intentions and ultimately promote sustainable energy usage.

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