Analysis of the Factors Influencing Residents' Household Energy-Saving Behavior Based on TPB-NAM Integration

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Abstract. Domestic energy consumption is the second largest source of carbon emissions in China, and it is important for residents to implement household energy-saving behaviors to reduce their domestic carbon emissions. In this context, based on questionnaire data from 436 residents in different cities of Shandong Province, structural equation modeling was used to analyze the influencing factors of residents' household energy-saving behaviors and their mechanisms of action under the framework of TPB-NAM integration theory. The results show that: (1) Personal norms, behavioral attitudes, subjective norms, and perceptual behavioral control all influence residents' household energy-saving behavior through the mediation of residents' household energy-saving behavioral intentions, with the personal norms path coefficient of 0.762 having the most significant positive effect on household energy-saving intentions. (2) Awareness of consequences is an important factor in determining the implementation of household energy-saving behavior, which can positively influence personal norms through direct or indirect effects, and thus influence residents' behavioral intentions and household energy-saving behavior. (3) Subjective norms can both directly drive residents' intentions to save energy in their homes and act as antecedent variables for behavioral attitudes and perceptual behavioral control to drive behavioral intentions to implement home energy efficiency.

Keywords: residents, household energy-saving behavior, influencing factors, theory of planned behavior, normative activation model.

1. Introduction

In the 21st century, resource and environmental constraints, climate change, and other issues have become global challenges. The Chinese government is committed to promoting the "carbon peaking and carbon neutrality" process, which has become a significant issue for the sustainable development of the Chinese nation and the building of a community of human destiny. Studies have shown that residential energy consumption currently generates more than 40% of the total carbon emissions from primary energy use in the country[1], with domestic energy consumption having a vast driving effect on the growth of carbon emissions in China[2], and has become the second largest carbon-emitting sector after the industrial sector[3].Studies by Liu [4], Lillemo [5], and Zhang [6] have shown that Household energy saving behavior plays a vital role in the energy saving and carbon reduction of residents' domestic energy consumption. Therefore, it is crucial to investigate the factors influencing residents' Household energy saving behavior and its mechanism to guide residents better to implement Household energy saving behavior, which is essential to reduce residents' carbon emissions and quickly achieve the "carbon peaking and carbon neutrality" strategy.

Current research by scholars on residents' household energy saving behaviors has focused on two main areas. One focuses on defining the types and definitions of residents' household energy-saving behaviors [7]. For example, Scott [8] classifies residents' household energy-saving behaviors into three main categories: reduction behaviors, investment behaviors, and management behaviors. Second, it explores the influencing factors of energy saving in residential households. According to previous studies, it is known that the influencing factors of residents' household energy conservation behavior are mainly divided into three categories: psychological factors (e.g., awareness of consequences, attribution of responsibility, personal norms, perceived behavior control, etc.), situational factors (e.g., government policies, school education, social opinion propaganda, etc.), and

demographic characteristics (e.g., respondents' age, household income status, education level, etc.) [9-11]. At the same time, some other literature has explored the influencing factors of each type of energy saving behavior based on the classification of different household energy saving behaviors and found that there are differences in the influencing factors of different kinds of energy saving behaviors [12]. In addition, some scholars have started to study how to solve environmental problems from the perspective of environmental behavior theory in recent years, such as Chen [13] and Yang [14], who explained residents' energy saving behavior from the perspective of theory of planned behavior (TPB) and normative activation theory (NAM), respectively, to provide targeted suggestions for government energy saving and carbon reduction policies.

In summary, it can be found that many studies have been conducted on the influencing factors of residents' household energy saving behavior. Still, it is rare to study residents' household energy saving behavior by combining the Theory of Planned Behavior (TPB) and Normative Activation Theory (NAM). In contrast to the existing literature, this paper uses structural equation modeling to analyze the factors influencing residents' household energy saving behavior and their mechanisms of action based on questionnaire survey data from 436 residents in different cities of Shandong Province under the framework of TPB-NAM integration theory.

2. Materials and methods

2.1. Data sources

The research data in this study were obtained from random questionnaire surveys conducted by the subject group among residents of different cities in Shandong Province. The subject group adopted face-to-face interviews for school students and online questionnaires for faculty members and obtained 436 questionnaires. After eliminating questionnaires containing missing values and unmatched questionnaires, 369 valid questionnaires were finally accepted, with a correct return rate of 84.63%, whose specific characteristics are shown in Table 1.

Table.1. Distribution of sample characteristics

Project	Category	Quantity	Percentage/%
Gender	Male	219	59.35
	Female	150	40.65
Age	＜18	10	2.71
	18-35	258	69.92
	36-55	77	20.87
	＞55	24	6.80
Number of family members	≤2	11	2.98
	3	138	37.40
	4	164	44.44
	5	31	8.40
	≥6	25	6.78
Highest level of family education	Junior high school and below	18	4.88
	High School	32	8.67
	Undergraduate	279	75.61
	Master and above	40	10.84
Family Location	Urban	223	60.43
	Rural	146	39.57
Monthly household income (yuan)	＜3999	49	13.28
	4000-5999	79	21.41
	6000-7999	77	20.87
	8000-9999	68	18.43
	＞100000	96	26.01

2.2. Theoretical framework and research hypothesis

As the current mainstream model for predicting individual behavior in various fields, the theory of planned behavior (TPB) starts from the rational choice of individuals and argues that individuals' household energy-saving behavior (HESB) is influenced by a combination of behavioral intention (INT) and perceived behavioral control (PBC), which in turn is directly influenced by subjective norms (SN), perceived behavioral control, and behavioral attitudes (ATT) [15, 16]. Among these, behavioral attitudes are the positions that individuals develop after conceptualizing the evaluation of implementing a particular home energy efficiency behavior [17]. As residents place increasing importance on household energy-saving behavior, they are more likely to implement home energy efficiency behaviors. Subjective norms are the degree to which individuals are influenced by social pressures and family moral constraints when making behavioral decisions [18]. Residents are more likely to have positive attitudes toward home energy efficiency and motivate themselves to engage in home energy efficiency behaviors when they perceive that implementing household energy-saving behavior is more in line with mainstream social values. In addition, the easier it is for people around them to engage household energy-saving behavior, the more likely they are to perceive that there are fewer constraints on implementing household energy-saving behavior and that they can control and manage the difficulties and obstacles they encounter in the process of household energy-saving behavior. Perceived behavioral control is the sense of efficacy and control individuals exhibit when performing a behavior [19]. Residents are more likely to form a willingness to household energy-saving behavior when they have sufficient knowledge and skills to believe that household energy-saving behavior are easy to achieve in their daily lives. Based on the above, this paper makes the following hypotheses (H).

H1：Residents' behavioral attitudes have a significant positive effect on residents' behavioral intention to household energy-saving behavior.

H2: Residents' subjective norms have a significant positive effect on residents' behavioral intention to household energy-saving behavior.

H3: Residents' perceived behavioral control has a significant positive effect on residents' behavioral intention to household energy-saving behavior.

H4: Residents' household energy-saving behavior intention has a significant positive effect on residents' actual household energy-saving behavior.

H5: Residents' subjective norms have a significant positive effect on residents' attitudes toward household energy-saving behavior.

H6: Residents' subjective norms have a significant positive effect on the perceived behavioral control of household energy-saving behavior.

As a classical model used to explain individual pro-environmental behavior, norm activation theory (NAM) integrates the pro-social determinants of individual behavior into a behavioral model by starting from an individual's intrinsic sense of moral obligation through three components: awareness of consequences (AC), attribution of responsibility (AR), and personal norms (PN) [20]. Among these, personal norms are individuals' sense of moral obligation to implement home energy efficiency behaviors [21]. When residents' subjective norms for implementing home energy efficiency behaviors are activated, it directly promotes their willingness to implement home energy efficiency. Behavioral intentions are the sense of responsibility for the negative consequences of not implementing home energy efficiency behaviors [22]. If residents have a stronger behavioral intention to implement home energy conservation, the greater the likelihood their personal norms will be activated. Behavioral intention is an individual's perception of the negative consequences of not performing a household action [23]. The clearer a person's perception of the results of not implementing energy efficiency measures, the more likely they will be motivated to take responsibility for energy efficiency in the home and assign moral value to implement energy efficiency measures. Based on the above, this paper makes the following hypotheses (H).

H7: Residents' awareness of consequences has a significant positive effect on the attribution of responsibility for household energy-saving behavior.

H8: Residents' awareness of consequences has a significant positive effect on personal norms for household energy-saving behavior.

H9: Residents' attribution of responsibility has a significant positive effect on residents' personal norms for household energy-saving behavior.

H10: Residents' personal norms have a significant positive effect on residents' behavioral intention to household energy-saving behavior.

Although the Theory of Planned Behavior (TPB) and Normative Activation Theory (NAM) can make more accurate predictions of individual home energy-saving behaviors, it has been demonstrated that combining TPB and NAM can improve the lack of explanatory power of a single theory to make more accurate predictions of individual behaviors [24, 25]. According to the integrated model, residents' awareness of consequences for household energy-saving behavior will influence their subjective norms and behavioral attitudes. The more residents perceive that household energy-saving behavior can contribute to a low-carbon society and economic growth, the more social pressure they will perceive and the more positive their attitudes toward household energy-saving behavior will be. In addition, subjective norms can validate personal norms and attributions of responsibility. If residents perceive that household energy-saving behavior is a mainstream awareness in all corners of society, there is a high probability that they will perceive themselves as having a responsibility and obligation to implement household energy-saving behavior. Based on the above, this paper makes the following hypotheses (H).

H11: Residents' awareness of consequences has a significant positive effect on residents' behavioral attitudes toward household energy-saving behavior.

H12: Residents' awareness of consequences has a significant positive effect on residents' subjective norms of household energy-saving behavior.

H13: Residents' subjective norms have a significant positive effect on the attribution of responsibility for household energy-saving behavior.

H14: Residents' subjective norms have a significant positive effect on personal norms for household energy-saving behavior.

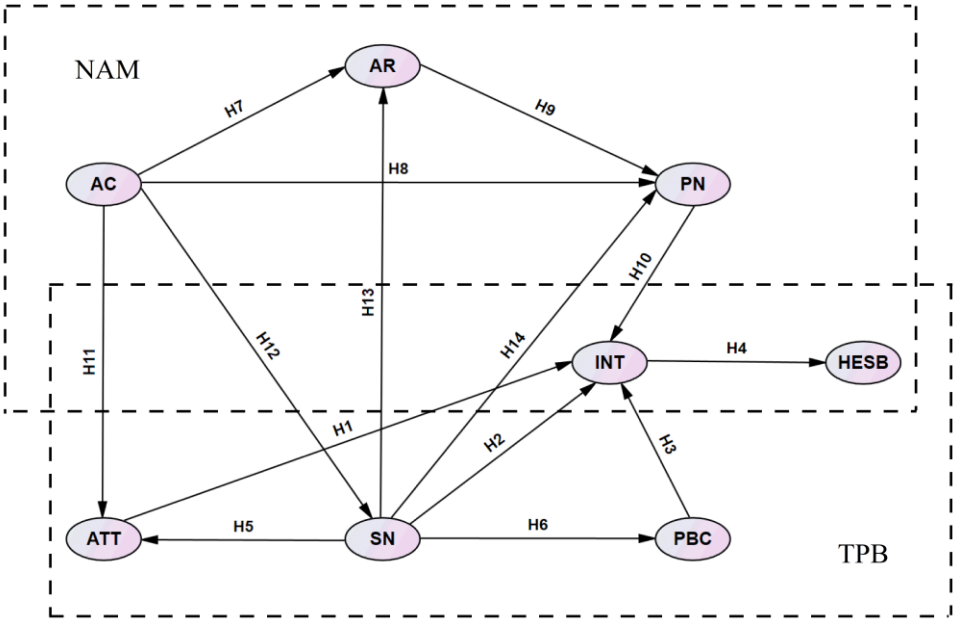

Figure 1. TPB-NAM theoretical analysis framework

2.3. Scale design

Based on the TPB-NAM theoretical framework and the nature of the information required for the research content, and taking into account the specific life reality of the residents, the article designed 26 questions with three parts: basic information of the respondents, psychological variables of household energy saving and household energy-saving behavior. Accordingly, the article collected

basic information from users and measured seven psychological variables of household energy saving behavioral intention (INT), behavioral attitude (ATT), subjective norm (SN), perceptual behavioral control (PBC), personal norm (PN), awareness of consequences (AC), and attribution of responsibility (AR) to measure household energy-saving behavior. The articles were measured using a 5-point Likert scale, except for demographic information. Among them, the psychological variables of the respondents were measured by the level of agreement: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. Home energy-saving behaviors were measured by how often they were implemented in the subjects: 1=never, 2=occasionally (1-2 days/month), 3=sometimes (1-2 days/week), 4=often (3-4 days/week), and 5=always. In addition, two trap questions (the same questions but disrupted the order of the scale) were set to reduce potential response bias. The findings of the scale are shown in Table 2.

Table.2. Scale design

Variable Dimension	Serial number	Measurement question item	Average value	Standard deviation
behavioral attitudes (ATT)	ATT1	I believe that performing household energy-saving behavior will benefit future generations	4.34	0.870
	ATT2	I think it is crucial to promote household energy-saving behavior	4.32	0.865
	ATT3	I strongly agree that we need more energy saving and emission reduction measures	4.35	0.845
personal norms (PN)	PN1	I think it is necessary to protect the environment through household energy-saving behaviors	4.27	0.881
	PN2	I think it is my responsibility to protect the environment through household energy-saving behaviors	4.32	0.871
	PN3	I believe that the present generation has a moral responsibility and obligation to the resources and environment of future generations	4.34	0.852
perceived behavior control (PBC)	PBC1	I can reduce household energy use and protect the environment	4.31	0.846
	PBC2	I have the knowledge and skills to save energy in my daily life	4.27	0.845
	PBC3	Saving energy is entirely up to me	4.27	0.834
behavioral intention （INT）	INT1	I would like to contribute to the promotion of household energy saving	4.31	0.839
	INT2	I am willing to spend time and effort to implement household energy-saving behaviors	4.23	0.885
	INT3	I practice household energy conservation every time I have the opportunity	4.20	0.872
awareness of consequences (AC)	AC1	I think the act of saving household energy can reduce environmental pollution	4.31	0.849
	AC2	My participation in household energy saving can reduce environmental pollution	4.30	0.869
	AC3	My involvement in household energy efficiency can reduce resource consumption	4.31	0.844
attribution of responsibility (AR)	AR1	I think I have a responsibility to participate in activities that promote household saving energy	4.29	0.864
	AR2	I think if we don't implement pro-environmental behaviors it will cause serious environmental problems	4.25	0.888
	AR3	I believe that all people have a shared responsibility for the environment and energy	4.31	0.849
subjective norms (SN)	SN1	The government guides and supports residents in implementing household energy-saving behaviors through publicity	4.29	0.863
	SN2	My friend thinks we have an obligation to promote household saving energy	4.36	0.919
	SN3	My family thinks we have an obligation to promote household saving energy	4.30	0.976
Household energy saving behavior (HESB)	ESB1	Cool hot food before storing in the refrigerator	4.05	1.151
	ESB2	Turn off the lights when no one is in the room	4.39	1.016
	ESB3	Turn off household appliances (e.g. TV, computer) when not in use	4.29	1.042
	ESB4	The water heater is off when not in use	4.14	1.193

3. Results and Analysis

3.1. Questionnaire reliability and validity tests

To ensure the credibility and validity of the research data, this paper examined the reliability and validity of each question item in the scale based on SPSS26.0 and AMOS26.0 software, and the results are shown in Table 3 and Table 4. It is generally accepted that data reliability is high when both Cronbach's α coefficient and combined reliability (CR) are greater than 0.7 and standardized factor loading estimates (Std.) are greater than 0.5. For good convergent validity, the KMO value should be greater than the critical value of 0.5, the probability of significance of Bartlett's spherical test is less than 0.001, and the average variance extracted (AVE) of each latent variable are greater than 0.7. The test results show that the standardized factor loading estimates (Std.) of each question item in the scale ranged from 0.705 to 0.953. The Cronbach's α coefficients of the latent variables ranged from 0.851 to 0.979, all of which were greater than the critical value of 0.7. In addition, the combined reliability (CR) and Cronbach's α coefficients of the latent variables were approximately the same, indicating that the research data had high internal consistency and stability, and the overall reliability of the scale was The overall reliability of the scale is good. It was also noted that the KMO values of each latent variable were between 0.730 and 0.772, which was greater than the critical value of 0.5, and the probability of significance of Bartlett's spherical test was less than 0.001. The interscale data were suitable for factor analysis. In terms of convergent validity, the average variance extracted (AVE) of each latent variable was more significant than 0.7, indicating that the scale had superior convergent validity. In addition, in terms of discriminant validity, comparing the square root of AVE with the correlation values, it was found that the square root of AVE for each latent variable was more significant than the correlation coefficient values, and the scale as a whole had good discriminant validity.

Table.3. Reliability, validity and factor analysis results of variables

Title item	Reliability test			Validity test		
	Std.	Cronbach's α	CR	KMO	Bartlett spherical test	AVE
ATT1	0.905	0.961	0.933	0.734	658.862	0.822
ATT2	0.953				P=(0.000)	
ATT3	0.857					
PN1	0.856	0.952	0.918	0.739	580.203	0.789
PN2	0.908				P=(0.000)	
PN3	0.903					
PBC1	0.874	0.958	0.932	0.739	660.797	0.822
PBC2	0.939				P=(0.000)	
PBC3	0.905					
INT1	0.869	0.942	0.893	0.735	471.112	0.736
INT2	0.877				P=(0.000)	
INT3	0.827					
AC1	0.937	0.979	0.958	0.772	866.324	0.884
AC2	0.943				P=(0.000)	
AC3	0.941					
AR1	0.911	0.949	0.898	0.746	513.699	0.747
AR2	0.835				P=(0.000)	
AR3	0.845					
SN1	0.869	0.851	0.849	0.730	342.021	0.752
SN2	0.790				P=(0.000)	
SN3	0.773					
HESB1	0.705	0.836	0.854	0.737	259.097	0.738
HESB2	0.720				P=(0.000)	
HESB3	0.780					
HESB4	0.754					

Table.4. Differential validity of variables Differential validity of variables

Title item	Differential validity							
	ATT	PN	PBC	INT	AC	AR	SN	ESB
ATT	0.907							
PN	0.879	0.888						
PBC	0.713	0.769	0.907					
INT	0.711	0.768	0.736	0.878				
AC	0.691	0.744	0.663	0.870	0.940			
AR	0.663	0.736	0.655	0.850	0.903	0.864		
SN	0.191	0.249	0.153	0.327	0.250	0.241	0.807	
HESB	0.241	0.253	0.282	0.331	0.340	0.356	0.215	0.662

3.2. Model Fit Test

To obtain the fit between the theoretical model and the actual research data, the fit statistics of the relevant indicators were calculated using AMOS 26.0, and the results are shown in Table 5. From the relevant results, it can be seen that all the statistical test indicators pass the corresponding threshold of the fitness test. Therefore, the structural equation model can better reflect the relationship between the latent variables, and the relevant results are excellent.

Table.5. Results of model fitness test

Types of statistical test indicators	Goodness-of-fit statistic	Value of goodness-of-fit statistics	Standard value
Absolute goodness-of-fit index	$\chi 2/df$	2.992	<3
	GFI	0.893	>0.8
	AGFI	0.881	>0.8
	RMR	0.038	<0.08
Value-added goodness-of-fit index	NFI	0.893	>0.8
	RFI	0.819	>0.8
Streamlined goodness-of-fit metrics	PGFI	0.698	>0.5
	PNFI	0.733	>0.5

3.3. Effectiveness analysis

From the estimation results, it can be concluded that the standardized path coefficient of the implementation of household energy-saving behaviors and the behavioral intention of residents is 0.351, and it passes the significance test at the 1% level, indicating that the behavioral intention of residents can directly and positively influence the implementation of household energy-saving behaviors, and when residents maintain a high level of willingness to adopt household energy-saving behavior, they will be more inclined to implement energy-saving behaviors in their lives, and hypothesis H4 is supported. This hypothesis is supported. The path coefficients of residents' intention to household energy-saving behavior and personal norms, behavioral attitudes, subjective norms, and perceived behavioral control reach 0.762, 0.396, 0.150, and 0.279, respectively, confirming that all four can positively influence residents' behavioral intention to household energy-saving behavior, and hypotheses H1, H2, H3, and H10 are valid. Notably, the standardized path coefficients for personal norms and behavioral attitudes were significantly larger than the remaining two, indicating that residents' attitudes toward implementing household energy-saving behavior and sense of moral obligation were the most significant factors influencing residents' willingness to implement household energy-saving behavior, a result confirmed by Heath [26], Fraj [27], and others. In guiding residents to implement household energy-saving behavior, the government should focus on strengthening residents' inherent sense of moral obligation to implement household energy-saving behavior and fostering positive attitudes toward household energy-saving behavior. The effects of subjective norms on behavioral attitudes and perceptual behavioral control are 0.365 and 0.212,

respectively, indicating that subjective norms can directly and positively influence residents' intention to household energy-saving behavior, but also indirectly through the behavioral attitudes and perceptual behavioral control they influence, and hypotheses H5 and H6 hold. In terms of the intrinsic relationship between residents' pro-social factors, the standardized path coefficients between residents' awareness of the consequences of household energy-saving behavior and their attribution of responsibility and personal norms are 0.780 and 0.233, respectively, and the standardized path coefficient between attribution of responsibility and personal norms reaches 0.352, indicating that positive awareness of consequences can both activate residents' personal norms for household energy-saving behavior by generating higher attribution of responsibility and directly promote the activation of personal norms. Hypotheses H7-H9 are verified. This result is generally consistent with the findings of Han [28]. It can also be seen that the effects of consequence awareness on behavioral attitudes and subjective norms amount to 0.736 and 0.331, respectively, indicating that residents' awareness of the consequences of household energy-saving behavior has a significant positive effect on residents' behavioral attitudes and subjective norms, and hypotheses H11 and H12 hold. In addition, the coefficients of subjective norms and residents' attribution of responsibility and personal norms paths are 0.247 and 0.245, respectively, which are also significant at the 1% level, and hypotheses H13 and H14 are also supported. This result indicates that residents can internalize the mainstream social values into their own sense of moral responsibility under the influence of subjective norms, and that the government's promotion of household energy-saving behavior plays an important role in the formation of residents' personal norms for energy conservation and low carbon.

Table.6. Structural equation model coefficients

Hypothetical	Standardization factor	Conclusion	Hypothetical	Standardization factor	Conclusion
H1:ATT→INT	0.396***	Support	H8:AC→PN	0.233***	Support
H2:SN→INT	0.150***	Support	H9:AR→PN	0.352***	Support
H3:PBC→INT	0.279***	Support	H10:PN→INT	0.762***	Support
H4:INT→HESB	0.351***	Support	H11:AC→ATT	0.736***	Support
H5:SN→ATT	0.365***	Support	H12:AC→SN	0.331***	Support
H6:SN→PBC	0.212***	Support	H13:SN→AR	0.247***	Support
H7:AC→AR	0.780***	Support	H14:SN→PN	0.245***	Support

Note: *** indicates significant at the 1% level

4. Conclusions

The By conducting a questionnaire survey on 436 residents in Shandong Province under the framework of TPB-NAM integration theory and using structural equation modeling to analyze the influencing factors of residents' household energy-saving behaviors and their mechanisms of action, this paper draws the following conclusions.

(1) Residents' personal norms, behavioral attitudes, subjective norms, and perceived behavioral control all influence residents' household energy-saving behaviors through the mediating role of residents' behavioral intention to household energy-saving behaviors. Among them, residents' attitudes and sense of moral obligation to implement household energy-saving behaviors are the most significant factors that drive residents' intention to implement household energy-saving behaviors. When guiding residents to implement household energy-saving behaviors, it is important to focus on the values of residents and to strengthen their intrinsic sense of moral obligation to household energy-saving behaviors and foster positive attitudes toward household energy-saving behaviors through the education system and mass media.

(2) In addition to positively driving residents' attitudes toward household energy-saving behaviors, a positive sense of consequence can also directly influence behavioral intentions and household energy-saving behaviors. At the same time, it activates residents' personal norms about household energy-saving behaviors by generating higher attributions of responsibility and subjective norms,

which in turn influence residents' behavioral intentions and household energy-saving behaviors. It can be seen that individual perceptions of the consequences of implementing household energy-saving behaviors can greatly influence the implementation of household energy efficiency behaviors. This requires the government to strengthen education and awareness of the consequences and responsibilities of household energy-saving behaviors in daily life and to promote the implementation of household energy-saving behaviors.

(3) Residents' subjective norms are one of the key variables that influence residents' household energy-saving behaviors. In addition to positively influencing residents' intentions to household energy-saving behaviors, it can also drive behavioral intentions to implement household energy-saving behaviors by increasing residents' perceived behavior control over the process of handling household energy-saving behaviors and by improving their attitudes toward household energy-saving behaviors. In addition, residents can also internalize mainstream social values directly under the influence of social pressure or indirectly by increasing their sense of responsibility, which in turn influences their own moral responsibility to household energy-saving behaviors. Therefore, the government should try to create a social atmosphere for the implementation of household energy-saving behaviors and continuously improve the subjective norms of residents by setting up advanced models to guide them to widely participate in the implementation of household energy-saving behaviors.

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