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Internal and External Factors Influencing Rural Households' Investment Intentions in Building Photovoltaic Integration Projects

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Abstract: Building integrated photovoltaics (BIPV) contributes to promoting green and low-carbon transformation in rural areas. In order to better guide rural households to invest in BIPV projects and promote the goal of "carbon neutrality" in China's building sector, this study integrates the theory of planned behavior (TPB), the social cognitive theory (SCT), and the PEST analysis framework. It constructs a theoretical model from the perspective of "External Factors-Internal Psychology-Investment Intention" to investigate rural households' investment intentions toward BIPV projects and their influencing factors. Basic data were collected from 488 valid questionnaires from rural households in Henan Province, and the theoretical model was empirically tested using structural equation modeling. The results show that the model constructed from both internal and external factors effectively explains rural households' investment intentions (II) toward BIPV projects (R^2 = 0.89), with investment attitude (IA) being the strongest psychological motivation leading to their II. All four external factors—policy, economic, social, and technological—positively influence II with diminishing effects. Additionally, the policy factor has the most significant effect on IA, while the economic factor has a more prominent effect on perceived behavioral control (PBC), and the technological factor has a relatively weaker effect on the two psychological factors. Furthermore, the four external factors indirectly influence investment intentions through the two psychological factors of IA and PBC, with the mediating effect of IA being higher than PBC. Based on the findings, this study proposes effective suggestions to enhance rural households' investment intentions toward BIPV projects.

Keywords: investment intention; rural household; structural equation model; mediating effect analysis

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1. Introduction

Solar energy is seen as a clean, safe solution to pressing issues such as climate change and fossil fuel depletion [1]. Solar power is projected to account for 20–25% of China's total electricity demand by 2050, which is broadly in line with the country's long-term climate goal of achieving net-zero emissions by 2060 [2]. Compared to centralized PV power plants that occupy large areas of land, building integrated photovoltaic (BIPV) systems mainly use the building envelope to collect solar energy [3], which has become an important solution for energy saving and carbon reduction in the building sector [4].

The concept of BIPV was first proposed by the World Energy Organization in 1986 and it is also known as "Zero-energy Building". It involves the direct replacement of photovoltaic modules and is an integral part of the building materials, aiming for the design, construction, and installation to meet the building's power needs, integrating with the building [5]. BIPV is primarily implemented in new construction but can also be retrofitted to existing buildings. With the latest advances in photovoltaic technology, BIPV

is being designed to completely replace architectural components, such as windows, roofs, and façades, as well as structural components, such as railings, porches, and balconies [6].

BIPV is in a promising early stage of development [7]. Currently, the global BIPV market capacity can only reach 1 GW per year, and the usage of BIPV is still low [8]. The distribution of BIPV in the Chinese market exhibits the same characteristics, with only 709 MW of new BIPV-installed capacity in 2020, accounting for only 4.6% of newly distributed PV-installed capacity that year [9]. Increased investment in BIPV projects is imminent, so it is important to identify the main constraints to accelerate solutions for their deployment.

Households are key players in the decarbonization of our economy, especially in the solar PV sector, where investments are decentralized [10]. BIPV houses are suitable for rural areas, and the following characteristics are unique to rural households in China: (1) each family lives in one house; (2) it is realistic and practical to convert a traditional house into a BIPV [11]. For example, conventional roofs can be retrofitted with solar photovoltaic (PV) tiles through BIPV technology [12]. With the advancement in technology, retrofitting rural roofs with BIPV through solar photovoltaic (PV) tiles represents an important breakthrough in promoting the development of the BIPV industry [12].

In October 2021, in order to promote the development of the PV industry in rural areas, China's National Energy Administration (NEA) published the "Notice on the Announcement of the Pilot List of Distributed Rooftop Photovoltaic Development in Whole Counties (Cities and Districts) " in the country's 676 counties (cities and districts). The initiative aims to transform the construction of roof-distributed photovoltaic systems, and for all types of buildings, set the minimum photovoltaic installation rate, of which, the total area of rural residential roofs installed should have a photovoltaic power generation ratio of no less than 20% [13]. However, the implementation of this policy still faces major challenges [12]. Currently, there are few studies on the intention of rural households to invest in BIPV construction, limiting the diffusion of BIPV technology in rural areas. Promoting better participation of rural households in investing in BIPV projects has become a pressing issue for policymakers; however, to date, no studies have been conducted on this topic.

The goal of investment decision-making is to identify the most relevant factors for decision-making from the perspective of the decision-maker and to develop an investment strategy based on these findings [14]. Due to the limitations of observing actual investment behavior, we focus on behavioral intention, i.e., investment intention. However, there is still a gap between intention and behavior [15]. But intention is valuable because the stronger the intention, the more enforceable the behavior will be [16].

Internal psychology plays a pivotal role in investment decision-making. Ajzen's exploration of the complex psychological processes behind behavior led to the development of the theory of planned behavior (TPB), widely used for behavior prediction [17]. Studies have indicated that farmers' investment intentions in PV projects are shaped by various internal psychological factors [18,19]. Furthermore, external conditions also play a role in the decision-making process [14]. Social cognitive theory (SCT) emphasizes the significance of both individual and environmental factors in driving actual behavior [20]. These external influences affect individuals' thoughts, thereby contributing to their behavior. Rural households' investment intentions are not solely determined by internal attitudes and opinions, they are also impacted by external factors such as policies and costs [12,16].

The PEST analysis framework offers a structured approach to examining the external environment, categorizing factors into political, economic, social, and technological dimensions [21]. Political factors primarily encompass social institutions, policies, and laws, while economic factors involve macro- and microeconomic considerations. Social factors pertain to demographics, cultures, and values, while technological factors encompass the application and trends of various technologies [22]. This systematic framework facilitates a comprehensive evaluation of external factors influencing rural households' investments in BIPV programs.

While the interaction between external scenarios and internal psychology impacts investment intentions, the specific pathways and magnitudes of this influence remain unclear. Further exploration is necessary to understand the internal mechanisms driving rural households' investment intentions toward BIPV projects. Based on the above analysis, this study integrates the TPB, SCT, and PEST models to study the investment intentions of rural households on BIPV projects from the perspective of "external factors—internal psychology—investment intention", which further reveals the interactions between the external and internal factors, thus promoting the rapid development of BIPV, promoting the transformation of rural clean energy, and contributing to the realization of the national dual-carbon goal.

The contributions of this study are as follows: (1) Establishing a model of rural household intentions to invest in BIPV projects, exploring the main influencing factors, and providing a basis for the formulation of strategies to guide investment intentions (II). (2) Henan Province is a large province with a large rural population and a wide distribution of villages in China, and the study of rural households in Henan can provide a reference for other provinces to guide rural households to invest in BIPV programs. (3) On the basis of the TPB–SCT–PEST analysis framework, the four external factors of "perceived ease of use (PEU)", "perceived financial benefit (PFB)", "perceived policy effectiveness (PPE)", and "subjective norm (SN)" and the two internal factors "investment attitude (IA)" and "perceived behavioral control (PBC)" are introduced to explore the intentions of rural households to invest in the BIPV program under the interaction between external and internal factors.

The remainder of this study is organized as follows: In Section 2, a theoretical framework based on the TPB–SCT–PEST model is developed, followed by a list of the research hypotheses for this paper. In Section 3, a variety of research methods used for the data collection and analysis are explained, including questionnaires and the structural equation model. The results of the empirical study are reported in Section 4, while Section 5 discusses the main findings of the study. Section 6 concludes the research and addresses its limitations.

2. Theoretical Basis and Research Hypothesis

2.1. Literature Review

2.1.1. Advantages and Disadvantages of BIPV

The BIPV system presents several advantages: (1) It embodies green energy production processes that are environmentally friendly, purely green, and devoid of pollution [8]. (2) It boasts high spatial utilization by effectively utilizing the external surface area of buildings without necessitating additional land occupation [23]. (3) Its proximity to load centers minimizes transmission line losses, thereby enhancing electricity output efficiency [24]. (4) It seamlessly integrates with buildings, offering notable aesthetic advantages [7,23].

However, the BIPV system also entails certain drawbacks: (1) The involvement of multiple stakeholders in the investment and construction phases results in development and operational maintenance complexities, alongside relatively low efficiency in electricity billing [25]. (2) It incurs high construction costs and protracted investment payback periods [8]. (3) Supply–demand mismatches arise, with BIPV capacity peaking at noon, while the highest daily electricity demand for domestic use typically occurs in the evening. This leads to situations where reliance solely on solar energy proves insufficient to meet production and domestic requirements during periods of high electricity demand, with surplus electricity being fed back into the grid during periods of low demand [26]. (4) Its installation on roofs and facades can compromise building fire resistance due to the highly flammable nature of arcs in junction boxes and combiners. This poses significant risks in the event of exposure to external building fires [26–28]. Despite these inherent limitations, both domestic and international prospects for BIPV projects remain optimistic [8,29].

2.1.2. Factors Influencing the Development of BIPV

The influencing factors of BIPV development include barriers and driving factors. Barriers and driving factors are intricately intertwined. To realize the implementation of BIPV applications, it is imperative to address the consistencies between barriers and critical issues [30]. Agathokleous and Kalogirou [31] assert that the foremost obstacles to implementing BIPV systems lie in the implementation of grid electricity tariffs, public acceptance, government subsidies, and economic support in terms of technology. Lu, et al. [32] indicate that economic factors not only serve as significant drivers for the implementation of BIPV projects in Singapore but also represent the most crucial hindering factors. Cost savings or achieving higher economic returns are primary motivators for BIPV implementation. However, the two most critical obstacles are the long payback period and high initial costs. Chen, et al. [33] argue that the lack of cost-effective BIPV products, shortage of professionals, and absence of design tools are pivotal factors influencing BIPV implementation in Singapore. Wu, et al. [34] suggest that imperfect policies and regulations, reduced subsidies, high initial investment, equipment aging, and poor quality are key obstacles affecting the investment in distributed photovoltaics by rural households in China. Reddy, et al. [35] study the Indian BIPV market and find that the lack of experts and industry professionals lead to slow market development. Ding, Zhu, Zheng, Dai, and Zhang [8] find that the media influence the public and societal acceptance of renewable energy, emphasizing the need to enhance investors' understanding of BIPV projects and alleviate their concerns about project uncertainties. Taşer, Koyunbaba, and Kazanasmaz [29] posit that the promotion and implementation of BIPV depend on four factors: national population, government policies, geographical location, and climatic characteristics. The barriers and driving factors of BIPV development are precisely the aspects that rural households focus on when investing in BIPV projects. Previous studies have shown that these factors involve various aspects such as government incentive policies, investment economic benefits, public acceptance, and equipment quality. This study utilizes the PEST analysis framework to analyze the external factors influencing rural household investments in BIPV projects.

2.2. Theoretical Basis

Ajzen [36] proposed TPB based on the theory of reasoned action (TRA), aiming to explore and predict human social behavior [37]. The core element of TPB involves an individual's intention to perform a specific behavior, and the theory suggests that behavior is directly influenced by behavior intentions [37]. Behavior intentions are the result of a combination of attitudes, SNs, and PBC [37].

TPB stands out as one of the most extensively utilized frameworks for behavior analysis [38,39]. It is increasingly being applied to understand green and pro-environmental behaviors [39,40], including household energy conservation, low-carbon consumption, segregation of urban residential waste, and the adoption of low-carbon agricultural technologies by farmers, among others [41–44].

SCT was created by Bandura based on the social learning theory and is a fundamental theory for the study of individual behavior [20]. SCT emphasizes that human behavior is controlled and shaped by individual perceptions in the social environment [45]. Individuals adjust their self-perception by observing and interpreting their external environments, ultimately committing the corresponding act [46]. The essence of SCT is that it provides a comprehensive framework for examining individual behaviors and their outcomes by integrating personal, behavioral, and environmental perspectives [47].

TPB primarily focuses on the influence of psychological factors on behavior while ignoring the role of external factors [48]. SCT suggests that behavioral decisions are caused by the interaction between individual cognition and the social environment [49]. In this interaction, cognitive processes/events mediate the change in behavior [20]. Investment decisions are made under limited rationality, which means that households only consider those aspects of the investment decisions that they find the most relevant [50]. There are a number of external factors that may influence the decision-making and behavior of rural

households investing in BIPV projects, so a proven analytical framework will facilitate the identification and selection of potential factors [21]. The PEST analysis framework is a valuable method for investigating external factors [21]. Its advantage is to select potentially important environmental factors without causing serious omissions, and the PEST analytical framework is appropriate in this study as it considers BIPV to be a mature technology, and investing in BIPV projects as a rural household's strategy-making behavior.

Khatiwada, et al. [51] used the PEST methodology to identify constraints and barriers to decarbonization in the natural gas sector. Li, Cao, and Ou [21] used the PEST framework to select some key factors for the diffusion of clean energy alternatives in businesses. In this study, the PEST framework will be used to select the external factors that influence rural households to invest in BIPV programs.

Therefore, based on the above-mentioned TPB–SCT–PEST analysis framework, this paper focuses on the process of a rural household's investment in BIPV as an "external environment-internal psychology-investment intention", and further reveals the interactions between the external factors (social, technological, economic, and policy) and the internal psychological factors.

2.3. Research Hypothesis

This study is based on the TPB model used to construct the IIs of rural households toward BIPV projects, identifying attitudes and PBC as important factors affecting investment decisions [52]. In this study, IA refers to the positive or negative evaluation of rural households toward investing in BIPV projects; PBC encompasses rural households' perceptions on issues such as available knowledge, available capital, possible subsidies, quality and reliability of the solar house, and the financial status of the household in investing in BIPV projects. The application of the TPB model to new energy investment decisions has shown [53,54] that attitudinal and PBC positively and significantly influence investment intentions in new energy projects, and based on previous research, the current research hypotheses are as follows:

H1. *Investment attitude positively affects rural households' investment intentions toward BIPV projects.*

H2. *Perceived behavioral control positively affects rural households' investment intentions toward BIPV projects.*

The influence paths of external factors refer to the TPB model and the SCT model. This study discusses the influence of external factors on rural household investments in BIPV projects from four perspectives: policy, economic, social, and technological, based on the PEST analytical framework.

Policy incentives are a key factor and an important driver for the popularization of solar energy systems [55,56]. Policy incentives have a direct impact on perceived behavioral control by enhancing people's beliefs about investing in BIPV projects [57]. Government policy subsidies also influence people's attitudes toward investing in BIPV projects [57]. Additionally, Li, Fan, and Liu [48] demonstrated that non-compulsory policy instruments significantly impact residents' willingness to use green power. Based on previous studies, the current research hypotheses are as follows:

H3a. *Perceived policy effectiveness positively affects rural households' investment intentions toward BIPV projects.*

H3b. *Perceived policy effectiveness positively affects rural households' investment attitudes toward BIPV projects.*

H3c. *Perceived policy effectiveness positively affects rural households' perceived behavioral control toward BIPV investment.*

Economic feasibility is the determining factor in whether a project can be invested in or not, with profit maximization being the most important factor for investment [54]. When assessing solar PV adoption intentions, more than 72% of the studies examined economic-related factors [58]. Meanwhile, due to the generally low incomes of Chinese farmers, economic goals are the focus of our attention when it comes to farmers' behavioral goals [59].

In the pro-environmental domain, perceived economic gains play an important role in predicting purchase intentions for energy-efficient products [60]. Wang, et al. [61] explored Chinese perceptions and the acceptance of nuclear energy based on perceived benefits and showed that perceived benefits have a positive impact on public attitudes toward nuclear energy. Nketiah, et al. [62] studied whether the awareness of economic benefits has a positive effect on PBC. Based on the above discussion and previous research, the current research hypothesis is as follows:

H4a. *Perceived financial benefit positively affects rural households' investment intentions toward BIPV projects*.

H4b. *Perceived financial benefit positively affects rural households' investment attitudes toward BIPV projects.*

H4c. *Perceived financial benefit positively affects rural households' perceived behavioral control toward BIPV investment.*

SN refers to rural households' perceptions of possible social pressures from their neighbors, the local government, the village/collective organization, etc. According to the TPB, SNs can positively influence attitudes and behavioral intentions [17]. Gamel, et al. [63] showed that subjective norms influence wind energy investment intentions. Yee, Al-Mulali, and Ling [53] concluded that SNs influence investment intentions in renewable energy projects, and Van Tonder, et al. [64] concluded that subjective norms have a significant positive green attitude influence. Adu-Gyamfi, et al. [65] concluded that subjective norms positively influence the perceived behavioral control of battery replacement in electric vehicles. Based on previous studies, the current research hypotheses are as follows:

H5a. *Subjective norms positively affect rural households' investment intentions toward BIPV projects.*

H5b. *Subjective norms positively affect rural households' investment attitudes toward BIPV projects.*

H5c. *Subjective norms positively affect rural households' perceived behavioral control toward BIPV investment.*

The implementation of new technology decisions is based on its perceived ease of use (PEU) [66]. In this study, PEU refers to the extent to which the BIPV program is easy for farmers to understand, operate, and maintain. From the TAM model, it can be seen that PEU is a prior variable for investment attitudes and investment intentions [67]. Gârdan, et al. [68] conducted a study on consumer attitudes toward renewable energy in the context of the energy crisis and concluded that PEU influences consumer attitudes toward renewable energy. Zhang, et al. [69] conducted a study on the purchase intentions of new energy vehicle consumers, showing that PEU influences investment attitudes and investment intentions. Regarding the interaction between PBC and PEU [70], PEU has a positive impact on PBC from a technical perspective [71]. Based on these insights, we propose the following hypothesis:

H6a. *Perceived ease of use positively affects rural households' investment intentions toward BIPV projects.*

H6b. *Perceived ease of use positively affects rural households' investment attitudes toward BIPV projects.*

H6c. *Perceived ease of use positively affects rural households' perceived behavioral control toward BIPV investment.*

While perceived external factors significantly influence the behavior of investors in BIPV projects, Ajzen argues that all other factors, through attitudes and PBC, indirectly influence behavioral intentions [72]. Engelken, et al. [73] found that perceived financial benefit and technology affinity influence the family investment PV system through attitudes. Munir, et al. [74] concluded that personality variables can explain entrepreneurial intentions through PBC. Villanueva-Flores, et al. [75] concluded that PBC mediates the relationship between psychological capital and entrepreneurial intentions. Sun, et al. [76] found that attitude and PBC mediate the relationship between mobile functionality and customer satisfaction. Nketiah, Song, Adu-Gyamfi, Obuobi, Adjei, and Cudjoe [62] concluded that the awareness of economic benefits through subjective norms and PBC influences Ghanaians' willingness to pay for renewable green electricity.

Based on the above analysis, this study makes the following hypotheses:

H3d. *Investment attitude mediates the relationship between perceived policy effectiveness and investment intention.*

H3e. *Perceived behavioral control mediates the relationship between perceived policy effectiveness and investment intention.*

H4d. *Investment attitude mediates the relationship between perceived financial benefit and investment intention.*

H4e. *Perceived behavioral control mediates the relationship between perceived financial benefit and investment intention.*

H5d. *Investment attitude mediates the relationship between subjective norms and investment intention.*

H5e. *Perceived behavioral control mediates the relationship between subjective norms and investment intention.*

H6d. *Investment attitude mediates the relationship between perceived ease of use and investment intention.*

H6e. *Perceived behavioral control mediates the relationship between perceived ease of use and investment intention.*

The full study framework is presented in Figure 1.

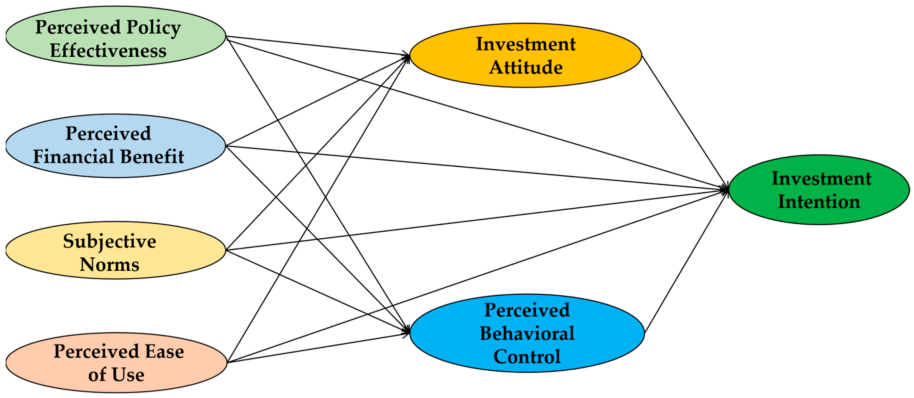


Figure 1. Study framework depicting the investment intentions of BIPV.

3. Research Methodology

3.1. Questionnaire Design

We administered a questionnaire on these concepts using valid and reliable scales available in the literature but adapted to the context of this study. All constructs were measured using a 5-point Likert scale, where "1" means strongly disagree and "5" means strongly agree.

3.2. Survey Site

Henan Province serves as a representative region for the development of BIPV projects. Villages in Henan Province are widely distributed, with a permanent rural population of 42.39 million by the end of 2022, accounting for 44.94% of the population [77]. The annual average total solar radiation is between 1050 and 1400 kWh/m^2, which is in the richer solar resource belt of China [78]. Solar energy is currently the second-largest power source in Henan Province. In recent years, Henan Province has promoted the development of BIPV projects through the release of various policies. The 2023 Work Points for Promoting Carbon Peak and Carbon Neutral and Green Low Carbon Transformation Strategy of Henan Province points out the importance of optimizing the structure of energy use in buildings and promoting the integration of solar energy systems and buildings [79]. Therefore, exploring the investment intentions of rural households in Henan Province toward BIPV projects is of great significance in promoting the energy transition in Henan Province; at the same time, the study of rural households in Henan Province can provide a reference for other provinces in guiding rural households to invest in BIPV projects, which will help to realize the dual-carbon goal at the national level.

This study utilized online and face-to-face survey techniques, employing snowball and quota sampling methods to conduct a cross-sectional survey of rural households in Henan Province. The target group for the research was limited to household heads, as they are responsible for making decisions on behalf of their households. In Henan Province, there are 18 cities, and rural households are classified based on the city they reside in. The proportion of the sample in each city is based on the rural population of each city divided by the rural population of Henan Province. Official rural population data from the National Bureau of Statistics of China were used in this study to calculate the proportions of collected samples. A total of 550 questionnaires were distributed, with details of the sample sizes for each city in Henan Province provided in Table 1. Eventually, 488 valid questionnaires were returned.

Table 1. Distribution of sample location.

Location	Number of Rural People (Millions)	The Proportion of the Population Distribution (Official Statistics)	Number of Questionnaires Issued
Zhengzhou	2.64	6.23%	34
Nanyang	4.59	10.83%	60
Zhoukou	4.91	11.59%	64
Shangqiu	4.03	9.51%	52
Luoyang	2.37	5.59%	31
Zhumadian	3.74	8.83%	49
Xinyang	2.98	7.03%	39
Xinxiang	2.53	5.97%	33
Anyang	2.45	5.78%	32
Pingdingshan	2.23	5.26%	29
Kaifeng	2.18	5.15%	28
Xuchang	1.96	4.63%	25
Puyang	1.81	4.27%	23
jiaozuo	1.26	2.97%	16
Luohe	1.03	2.43%	13
Sanmenxia	0.84	1.98%	11
Hebi	0.59	1.39%	8
Jiyuan	0.23	0.54%	3
Total	42.37	100%	550

The descriptive analysis of the sample showed (Table 2) that the gender distribution of the respondents was reasonable, with 55% males and 45% females. Since the respondents were farmers who worked at home all year round, and more young people went out to work, the respondents were mainly aged 46–55 (62%). The respondents' education level was generally low, with 88% of them having a high school education or below. Monthly household income was mainly below CNY 6000 (53%), with a smaller proportion of households having a monthly income of CNY 12,000. The main household size was more evenly distributed, with 68% of households having four or fewer members.

Table 2. Demographic characteristics of survey participants.

Features	Options	Frequencies	%
Gender	Male	267	55%
	Female	221	45%
Age	18–25	22	5%
	26–35	95	19%
	36–45	56	11%
	46–55	302	62%
	56–65	13	3%
Family size	2	29	6%
	3	126	26%
	4	178	36%
	5	84	17%
	6 or more	71	15%
Education	Primary school or below	22	5%
	Middle school level	89	18%
	High school level	315	65%
	University or college degree	56	11%
	Post-graduate or higher level of education	6	1%

Table 2. *Cont.*

Features	Options	Frequencies	%
Monthly family Income (CNY, yuan)	Less than 6000	257	53%
	6000 to less than 12,000	142	29%
	12,000 to less than 18,000	48	10%
	18,000 to less than 24,000	24	5%
	24,000 or more	17	3%

4. Results

4.1. Reliability and Validity Test

Construct validity and reliability were assessed prior to hypothesis testing (Table 3). First, reliability tests were conducted using SPSS 27 software, which showed that Cronbach's alpha values for each variable ranged from 0.9 to 1, which was greater than the minimum value of 0.7, indicating that the scale had high reliability [80]. Secondly, AMOSv.24.0 was used to conduct confirmatory factor analysis (CFA) to test the structural validity of the measured variables. The results showed that the factor loads of all items were higher than the critical value of 0.7, indicating that the questionnaire had good structural validity [81]. The composite reliability (CR) and average variance extracted (AVE) of the variables were calculated by CFA; the results showed that the CR value was greater than 0.8 and the AVE was greater than 0.6, indicating that the questionnaire showed good convergent validity [82]. The model-fitting indexes were CMIN/DF 2.607 (3), RMSEA 0.057 (0.08), IFI 0.974 (0.9), CFI 0.974 (0.90), and TLI 0.969 (0.90), all of which met the requirements.

Table 3. Analysis results of convergent validity and reliability.

Latent Variable	Observation Variable	Based on	Cronbach's α	Loading	AVE	CR
Investment intentions (II)	I intend to encourage others to invest in BIPV projects.	Rahmani, et al. [54]	0.936	0.910	0.785	0.936
	I intend to invest in BIPV projects.			0.885		
	The attitude of consuming fewer fossil fuels makes me invest in BIPV projects.			0.888		
	I intend to invest in green projects soon.			0.860		
Investment Attitude (IA)	In my opinion, investing in BIPV projects is valuable.	Rahmani, Mashayekh, Aboojafari, and Bonyadi Naeini [54]	0.967	0.937	0.878	0.967
	I think that investing in BIPV projects is an intelligent choice.			0.929		
	I think that investing in BIPV projects is a good idea.			0.945		
	I think that investing in BIPV projects is enjoyable.			0.938		
Subjective norm (SN)	The people I think are important to me will invest in BIPV.	Tan, Ying, Gao, Wang, and Liu [12]	0.946	0.918	0.855	0.947
	The people I think are important to me will support me in investing in BIPV.			0.927		
	The people I consider important to me want me to invest in BIPV.			0.929		
Perceived Behavioral Control (PBC)	I have sufficient resources, knowledge, and ability to use BIPV.	Liu, Qi, and Xu [56]	0.927	0.922	0.815	0.930
	Using BIPV power generation systems is within my control.			0.926		
	It is easy for me to become a solar prosumer in the coming years.			0.859		
Perceived Financial Benefit (PFB)	I find that a BIPV system for my household serves as a financial provision for old age.	Engelken, Römer, Drescher, and Welpe [73]	0.948	0.926	0.859	0.948
	I find that BIPV systems for my household is a secure financial investment.			0.937		
	I find that installing a BIPV system for my household is a profitable investment in the long run.			0.918		
Perceived Policy Effectiveness (PPE)	Government incentive policies on BIPV attract me.	Vu, Nguyen, and Nguyen [18]	0.936	0.915	0.785	0.936
	I think the government's promotional policies will continue for a long time.			0.888		
	The policies to buy back electricity from solar energy are very meaningful to households in terms of benefits.			0.899		
	I believe government policies will create an incentive for many people to invest in BIPV.			0.841		
Perceived Ease of Use (PEU)	I believe the BIPV system will be easy for me to use.	Wang, Chu, Deng, Lam, and Tang [59]	0.940	0.911	0.797	0.940
	I believe learning to operate a BIPV system will be easy for me.			0.898		
	I believe the operation of a BIPV system will be clear and understandable for me.			0.882		
	I believe a BIPV system will be well-suited for me to carry out my daily energy needs.			0.879		

Note: AVE = average variance extracted, CR = composite reliability, α = Cronbach's alpha (N = 488).

The square root of the AVE must be greater than the correlation coefficient for each construct to show discriminant validity. In Table 4, the numbers on the diagonal are the square root of the AVE, and the numbers below the diagonal are the correlation coefficients between variables. From the figure, we can see that the standardized correlation coefficients between each dimension are less than the square root of the AVE value corresponding to the dimension, thus indicating that each dimension has good discriminant validity [82]. Therefore, we infer that the discriminant validity, reliability, and convergence of the model are adequate and that the acquired data are consistent with the measured model.

Table 4. Analysis results of discriminant validity.

Latent Variables	Mean	S.D.	II	IA	SN	PBC	PFB	PPE	PEU
II	3.39	0.795	**0.886**						
IA	3.51	0.866	0.849 **	**0.937**					
SN	3.38	0.846	0.804 **	0.772 **	**0.925**				
PBC	3.40	0.788	0.812 **	0.772 **	0.791 **	**0.903**			
PFB	3.50	0.817	0.819 **	0.796 **	0.748 **	0.813**	**0.926**		
PPE	3.50	0.775	0.829 **	0.809 **	0.756 **	0.779 **	0.797 **	**0.886**	
PEU	3.47	0.728	0.799 **	0.775 **	0.751 **	0.769 **	0.777 **	0.787 **	**0.893**

Note: ** $p < 0.010$. The bold in the table represents the square root of the AVE of the variables.

4.2. Hypothesis Testing

Prior to hypothesis testing, we assessed the degree of the model fit using AMOSv.24.0. The results were as follows: $\chi 2/df = 2.607$ (<3), RMSEA = 0.057 (<0.08), $p < 0.001$, IFI = 0.974 (>0.9), TLI = 0.969 (>0.9), and CFI = 0.974 (>0.9). Therefore, synthesizing the results of this analysis can show that the model is a good fit. Figure 2 presents the results of the BIPV project investment intention model.

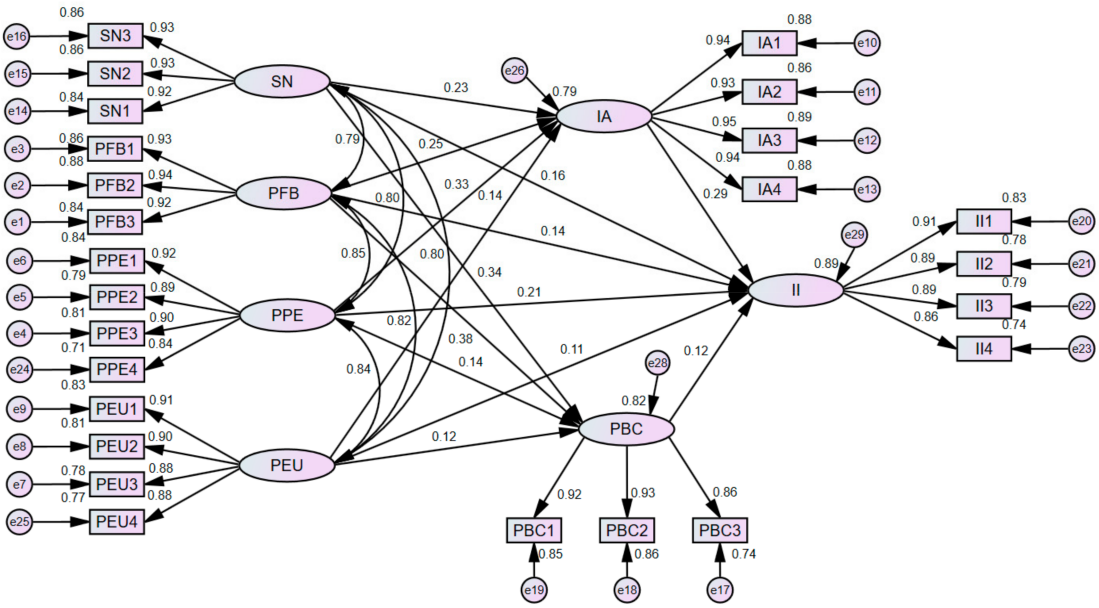


Figure 2. Results of the investment intentions for the BIPV project model.

To assess the explanatory power of the model developed in this study on rural households' intentions to invest in BIPV projects, the coefficient of determination (R^2) is considered. R^2 ranges between 0 and 1, and its adequacy depends on the particular research question. As Chin suggests, R^2 values of 0.19, 0.33, or 0.67 can be categorized as "weak", "moderate", or "substantial", respectively [83]. As presented in Figure 2, the R^2 for II in this

study is 0.89, while the R^2 for IA is 0.79, and the R^2 for PBC is 0.82, significantly exceeding 0.67, indicating a substantial level of explanatory power.

Table 5 lists all the results of hypothesis testing in the path hypothesis relationship test of this study. The internal psychological factors, IA and PBC, have a positive influence on investment intentions, assuming that H1 and H2 are confirmed, the regression coefficients are 0.285 ($p < 0.001$) and $\beta = 0.122$ ($p < 0.05$), respectively, and IA has a stronger effect on II. All four external factors, PPE, PFB, SN, and PEU, have a positive influence on II, and the effects were gradually weakened, with regression coefficients of $\beta = 0.206$ ($p < 0.001$), $\beta = 0.145$ ($p < 0.05$), $\beta = 0.156$ ($p < 0.001$), and $\beta = 0.106$ ($p < 0.05$), respectively, assuming that H3a–H6a are confirmed. Meanwhile, PPE, PFB, SN, and PEU all have positive influences on IA, with regression coefficients of $\beta = 0.329$ ($p < 0.001$), $\beta = 0.250$ ($p < 0.001$), $\beta = 0.231$ ($p < 0.001$), and $\beta = 0.145$ ($p < 0.05$), respectively; PPE has the greatest influence on IA, and hypotheses H3b–H6b are confirmed. PPE, PFB, SN, and PEU all positively affect PBC with regression coefficients of $\beta = 0.138$ ($p < 0.05$), $\beta = 0.376$ ($p < 0.001$), $\beta = 0.338$ ($p < 0.001$), and $\beta = 0.119$ ($p < 0.05$), respectively, and PFB has the strongest influence on PBC, assuming that H3c–H6c are confirmed.

To test for mediating effects in the regression model, we conducted a bootstrap analysis with 5000 resamples and 95% bias-corrected confidence intervals using the PROCESS V4.2 macro. The results are shown in Table 6. The results show that the indirect effects of PPE (95% CI: 0.3502–0.5133), PFB (95% CI: 0.3424–0.4896), SN (95% CI: 0.3493–0.4746), and PEU (95% CI: 0.3493–0.4746) on investment intentions through IA are 0.4301, respectively, 0.4168, 0.411, and 0.488, and the indirect effects of PPE (95% CI: 0.2724–0.4118), PFB (95% CI: 0.3424–0.4896), SN (95% CI: 0.2813–0.4229), and PEU (95% CI: 0.3215–0.4913) on investment intentions through PBC are 0.3381, 0.3381, 0.411, 0.488, and 0.488 respectively. The effects are 0.3381, 0.3403, 0.3496, and 0.4055 respectively. The confidence intervals exclude zero, supporting the relationships proposed in H3d–H6e.

Table 5. Path relationships among the constructs.

Hypothesis	Path			UnStd. Coefficient	Std. Coefficient	S.E.	C.R.	*p*	Results
H1	IA	→	II	0.273	0.285	0.046	5.96	***	Supported
H2	PBC	→	II	0.133	0.122	0.061	2.191	0.028	Supported
H3a	PPE	→	II	0.223	0.206	0.060	3.729	***	Supported
H3b	PPE	→	IA	0.373	0.329	0.070	5.354	***	Supported
H3c	PPE	→	PBC	0.137	0.138	0.062	2.225	0.026	Supported
H4a	PFB	→	II	0.150	0.145	0.056	2.687	0.007	Supported
H4b	PFB	→	IA	0.271	0.250	0.060	4.483	***	Supported
H4c	PFB	→	PBC	0.357	0.376	0.055	6.504	***	Supported
H5a	SN	→	II	0.155	0.156	0.047	3.317	***	Supported
H5b	SN	→	IA	0.239	0.231	0.050	4.777	***	Supported
H5c	SN	→	PBC	0.307	0.338	0.046	6.739	***	Supported
H6a	PEU	→	II	0.124	0.106	0.056	2.209	0.027	Supported
H6b	PEU	→	IA	0.177	0.145	0.068	2.588	0.010	Supported
H6c	PEU	→	PBC	0.128	0.119	0.061	2.090	0.037	Supported

Note: *** $p < 0.001$.

Table 6. Intermediary effect test results.

Hypothesis	Relationship	Indirect Effect	BootSE	Bootstrap 95% CI		Results
				LLCI	ULCI	
H3d	PPE → IA → II	0.4301 ***	0.0421	0.3502	0.5133	Supported
H3e	PPE → PBC → II	0.3381 ***	0.0359	0.2724	0.4118	Supported
H4d	PFB → IA → II	0.4168 ***	0.0372	0.3424	0.4896	Supported
H4e	PFB → PBC → II	0.3403 ***	0.0425	0.2603	0.4261	Supported

Table 6. *Cont.*

Hypothesis	Relationship	Indirect Effect	BootSE	Bootstrap 95% CI		Results
				LLCI	ULCI	
H5d	SN → IA → II	0.411 ***	0.032	0.3493	0.4746	Supported
H5e	SN → PBC → II	0.3496 ***	0.0357	0.2813	0.4229	Supported
H6d	PEU → IA → II	0.488 ***	0.0405	0.4088	0.5700	Supported
H6e	PEU → PBC → II	0.4055 ***	0.0431	0.3215	0.4913	Supported

Note: *** $p < 0.001$.

5. Discussion of the Main Findings

In the research on factors influencing investment intentions in BIPV programs, many scholars have explored the influence of behavior from the perspectives of psychosocial attitudes, cognition, and environmental concerns, with most of them focusing on the influence of sociodemographic factors [19,60], ignoring external contextual factors. Based on this, this study explores the investment intentions of rural households toward investing in BIPV, based on the TPB model, from the perspectives of internal psychological and external contextual factors, in order to develop more targeted policy measures.

In terms of explaining investment intentions, the research findings indicate that IA, PBC, PPE, PFB, SN, and PEU, six latent variables, explained 89% of the variance in II. In similar studies, an extended TPB included six latent variables that explained 61.2% of the variance in investment intentions in new energy projects [54]. Additionally, another study constructed a model that explained 50% of the variance in individual investment behavior intentions for wind energy projects [63]. Therefore, compared to previous research, this study added three variables, PPE, PFB, and PEU, to the TPB model, resulting in a model that effectively explains the intentions of rural households toward investing in BIPV projects from both internal and external perspectives.

The research findings indicate that IA is a key factor that influences the IIs of BIPV projects. When households have a more positive attitude towards investing in BIPV projects, they are more likely to invest in them. This study's results are consistent with previous research [52–54]. In contrast, another study found that attitude had no significant effect on II for wind energy projects [63]. Regarding direct effects, IA has the strongest impact on increasing the IIs of rural households toward BIPV projects. The four external factors explain 79% of the variance in attitude, whereas one study found that perceived risk and subjective norms explained 32% of the variance in attitude [54]. Another study used social awareness and perceived risk to predict 18% of the variance in attitude [84]. This indicates that the choice of the PEST analysis method is appropriate, as these four factors comprehensively cover external factors and significantly enhance the explanatory power of IA. In terms of indirect effects, IA mediates among PPE, PFB, SN, PEU, and II, with the mediation effect of IA being higher than that of PBC. Our research results support previous studies that indicate that a supportive attitude toward pro-environmental behavior is an important predictor of pro-environmental behavioral intentions [85,86].

PBC is also a significant psychological factor influencing II, albeit with a lesser impact compared to investment attitude. This finding aligns with research that underscores the pivotal role of PBC in shaping households' intentions toward investing in renewable energy projects [54]. In contrast, another study found that II in renewable energy was unaffected by PBC, presenting a stark contrast to these findings [87]. Moreover, four external factors accounted for 82% of the variance in PBC, surpassing the explanatory power of II. This suggests that these external factors also play a crucial role in shaping PBC. In terms of indirect effects, PBC mediates the relationship among PPE, PFB, SN, PEU, and II. This observation aligns with the conclusions that propose that PBC serves as a mediator in the relationship between psychological capital and entrepreneurial intentions [75]. However, this finding contradicts the conclusions of researchers who argue that government involvement cannot influence investment intentions through PBC [62]. This discrepancy may be attributed to the focus of Henan Province as a key area for the promotion of PV policies. In this study,

the majority of rural households in Henan Province are well-informed about the availability of BIPV projects, and possess the requisite knowledge to make informed decisions.

Government policy guidance plays a significant role in household investments in BIPV projects. Research indicates that PPE has a positive impact on II, confirming the findings of Li, Fan, and Liu [48]. Moreover, PPE also exerts significant positive effects on IA and PBC, with its influence on IA being the strongest. This aligns with the conclusions of previous studies by Lin and Qiao [57]. However, inconsistent with the findings of Vu, Nguyen, and Nguyen [18], due to the suspension of Vietnam's solar purchase support policy during the study period, it was found that government incentive policies enhanced residents' attitudes toward solar investment but did not positively influence II. In 2018, the Chinese government announced a reduction in household PV subsidies, with subsidies decreasing to RMB 0.18/kWh, RMB 0.08/kWh, and RMB 0.03/kWh in 2019, 2020, and 2021, respectively, marking the solar PV industry's transition into the post-subsidy era [56]. However, since BIPV represents a new form of photovoltaics, the government has taken various measures to promote BIPV projects. Currently, policies primarily focus on promoting BIPV technology in commercial and industrial buildings. The Chinese government should prioritize the promotion of BIPV technology in rural areas and implement policy incentives to support rural households in investing in BIPV projects.

The research findings indicate that PFB has a positive impact on the II of BIPV projects, confirming previous research conclusions [60]. Additionally, PFB also has a positive influence on the II toward BIPV projects. In the pro-environmental domain, previous studies have similarly concluded that PFB has a significant positive effect on IA [16,88]. Moreover, PFB positively influences the PBC of rural households investing in BIPV projects, with its impact being the greatest among the four external factors. Prior studies have similarly concluded that PFB has a significant positive effect on PBC [62,89]. The evidence indicates that financial factors are important considerations in investment decisions for rural households in China. The Chinese government should provide tax exemptions and subsidies for investors interested in BIPV projects, while financial institutions should offer convenient loans for BIPV projects, thereby increasing the II of rural household investors.

The research findings demonstrate that SNs significantly influence the IIs of BIPV projects, suggesting that factors outside the household, including social influences from family, friends, and the community, positively affect rural household investments in BIPV projects. This conclusion is consistent with previous research in the field of renewable energy investment [53,54,63]. Furthermore, the results indicate that an improvement in SN investments leads to a corresponding improvement in IA within households. This finding aligns with previous research conclusions, which revealed the positive and significant impact of SNs on IA [64]. Additionally, SNs significantly influence PBC, confirming previous research findings [65]. In rural areas, individuals often rely on other evaluations to gather more information about products, thereby altering their perceptions of the products and driving decision-making [48]. Based on this, public communication and word-of-mouth are potentially effective means of encouraing rural households to make investment decisions, and stakeholders can promote BIPV projects through group or community channels.

PEU has a positive impact on the IIs and IAs toward BIPV projects, consistent with Davis' [67] findings in the TAM model, and this result also corroborates previous research in the proximal environment domain [68,69]. Additionally, PEU significantly influences PBC. Ease of use represents a psychological barrier toward understanding and maintaining the technology before purchase, particularly for individuals with limited familiarity or skills [90]. When household investors perceive the technology as easy to use, they are more likely to adopt BIPV technology. Among the four external factors, PEU has a positive influence on II, IA, and PBC, although not as strong as the other three factors. This suggests that, relative to the other three factors, BIPV technology is not a primary barrier for rural households in Henan. As the promotion of photovoltaic projects progresses, the application of photovoltaic technology in the rural areas of Henan is becoming increasingly widespread.

Rural household investors are more concerned about policies, as well as economic and social factors.

Many studies focus on the influence of psychological factors on pro-environmental behaviors, while the ways in which external situational factors act on behaviors are not clear [91]. It can be seen through the results of the study that the four external factors are direct, positive, and significant regarding rural households' intentions to invest in BIPV projects, and that all four factors are able to trigger rural households' intentions to invest in BIPV. Meanwhile, the four external factors effectively explain the two psychological factors, IA and PBC, respectively. In addition, the findings support the mediating role of psychological factors; external factors influence rural households' investment intentions on investing in BIPV through psychological factors, and psychological factors play a decisive role in their investment decision-making process; our findings support the previous studies on external factors influencing pro-environmental behavioral intentions through psychological factors [48,85].

6. Conclusions and Policy Implications

6.1. Conclusions

Building upon the research background and existing influencing factors of BIPV development, this study integrates the TPB–SCT–PEST analysis framework to examine the II of rural households toward BIPV projects from the perspective of an "external environmental factors-subjective psychological characteristics-investment intention" and constructs a conceptual model. With rural households in Henan Province as the research subjects, valid cross-sectional data were obtained through a questionnaire survey, totaling 488 responses, which were then empirically validated against relevant hypotheses.

The results indicate that the R^2 values for II, IA, and PBC are 0.89, 0.79, and 0.82, respectively, suggesting that the model possesses a high explanatory power, effectively explaining the intention of rural households to invest in BIPV projects from both internal and external perspectives. The selection of the PEST analysis framework is appropriate, as these four factors comprehensively cover external factors and significantly enhance the explanatory power of IA and PBC.

II emerges as the most crucial psychological determinant of rural households' willingness to invest in BIPV projects, exhibiting strong relationships with other variables. Rural investors' perceptions of PPE, PFB, SN, and PEU indirectly influence II by affecting IA. Therefore, stimulating their IA is key to enhancing rural households' IIs.

Among the four external factors, PPE and PFB exert the strongest influences on IA and PBC, while the impact of PEU is relatively weaker, indicating that rural households prioritize policy and economic factors in their investment decisions regarding BIPV projects. As photovoltaic technology becomes increasingly widespread, technological barriers are diminishing.

6.2. Policy Implications

Under the dual-carbon target, China's energy transition is under great pressure, and the promotion of renewable energy is imperative; BIPV projects are important to realize zero energy consumption in buildings. Rural areas in Henan Province are rich in solar energy resources, but the promotion and application of BIPV projects are still in their initial stage. Independent property rights and vast roof areas in rural areas will be the focus in promoting BIPV projects in the next stage.

Government policy is an important driving force for the development of BIPV projects and it has a significant impact on the investment intentions of rural households to invest in BIVP projects. The Henan government should develop plans for promoting BIPV projects in rural areas according to local conditions, without copying the experiences of other provinces, and without directly interfering in the market. Most importantly, the government should focus on the development and implementation of technical standards for BIPV applications, the dissemination of reliable information about product performance, and the composition of product prices. In addition. The government should pay full attention

to farmers' attitudes and acceptance of the policy and introduce appropriate policies to promote the gradual increase of investment in BIPV systems, taking into account the actual situation of each city and different social groups.

Because of the capital-intensive nature of BIPV projects, they require a large initial investment, and the results of the study prove that economic benefits can increase rural households' investment intentions toward BIPV projects. As the cost of PV projects decreases, the government is currently phasing out subsidies for household PV, and fewer subsidy policies are being implemented for BIPV projects. In order to encourage investors to enter the market, the government should develop specific incentive policies for rural areas, such as subsidies for installed system capacity and power generation, tax rebates, and financing incentives.

Subjective norms have a significant impact on rural investors; therefore, the government should further strengthen the publicity and dissemination of knowledge about BIPV systems and encourage rural households to invest in BIPV technology by disseminating knowledge about BIPV systems to farmers through various means, such as billboards in villages, publicity banners, and regular radio training for village cadres. As subjective norms are based on perception, it is possible to regularly publish the national increase in the BIPV system adoption rate, even if it is not common in some areas. The national adoption of BIPV technology can help increase rural households' investment intentions. At the same time, the construction of demonstration bases for BIPV projects should be further accelerated. Some villages should be selected as pilot bases through field research, combined with farmers' willingness, to guide farmers in pilot areas to invest in BIPV projects by granting subsidies. Utilizing the herd mentality of farmers will gradually guide other farmers to accept and use BIPV technology.

The acceptance of technology by rural investors affects investment intentions. The government should regularly implement family training programs to lower the psychological acceptance barriers of rural investors toward BIPV technology. At the same time, the government should provide more R&D subsidies to encourage the innovation of BIPV technology. In addition, the government should effectively guide the industrial synergy between PV companies and construction companies, promote the rapid integration of advanced technologies between industries, reduce R&D barriers, and ensure a healthy environment for the BIPV market to flourish.

6.3. Limitations and Future Research

The current study has certain limitations that can be further discussed and addressed in future research. Firstly, despite the rigorous design process of the questionnaire, there was inevitably some disagreement in understanding farmers' internal mental activities, and EEG and eye-tracking experiments may be introduced in future studies to address the difficulty in accurately quantifying internal psychology [48]. Second, this study focused only on rural areas and did not include urban areas. Socioeconomic characteristics, i.e., knowledge, education, and income, may differ significantly between urban and rural areas. This limitation can be addressed by incorporating the views of urban residents in future studies. Third, this study only focuses on the impact of various factors on investment intentions of BIPV projects and does not address the investment behavior of BIPV projects; however, there may be a bias between intention and actual behavior [15]. Therefore, the relationship between investment intentions and the actual consumption behavior of BIPV systems can be further explored in the future. Finally, given that this study was conducted in China, a global leader in photovoltaic development, conclusive determinations regarding the influencing factors of rural households outside of China on their intentions to invest in BIPV projects cannot be drawn from this research. However, this study has established an effective model for exploring the willingness of rural households to invest in BIPV projects, which can be applied to research conducted in other countries.

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Abbreviations

BIPV	building-integrated photovoltaic
TPB	theory of planned behavioral
SCT	social cognitive theory
PEST	political, economic, social, and technological factors
II	investment intentions
PEU	perceived ease of use
PFB	perceived financial benefit
PPE	perceived policy effectiveness
SN	subjective norm
IA	investment attitude
PBC	perceived behavioral control

References

1. Rababah, H.E.; Ghazali, A.; Mohd Isa, M.H. Building Integrated Photovoltaic (BIPV) in Southeast Asian Countries: Review of Effects and Challenges. *Sustainability* **2021**, *13*, 12952. [CrossRef]
2. Chen, H.; Chen, W. Status, trend, economic and environmental impacts of household solar photovoltaic development in China: Modelling from subnational perspective. *Appl. Energy* **2021**, *303*, 117616. [CrossRef]
3. Wang, W.; Yang, H.; Xiang, C. Green roofs and facades with integrated photovoltaic system for zero energy eco-friendly building—A review. *Sustain. Energy Technol. Assess.* **2023**, *60*, 103426. [CrossRef]
4. Zhang, Y.; Zuo, Z. Development trend forecast and investment prospect analysis of BIPV: Analysis of stock data based on 36 BIPV Companies in Shanghai and Shenzhen stock markets. In Proceedings of the 2021 2nd International Conference on Big Data Economy and Information Management (BDEIM), Sanya, China, 3–5 December 2021; pp. 298–302.
5. Martín-Chivelet, N.; Kapsis, K.; Wilson, H.R.; Delisle, V.; Yang, R.; Olivieri, L.; Polo, J.; Eisenlohr, J.; Roy, B.; Maturi, L.; et al. Building-Integrated Photovoltaic (BIPV) products and systems: A review of energy-related behavior. *Energy Build.* **2022**, *262*, 111998. [CrossRef]
6. Yang, R.; Zang, Y.; Yang, J.; Wakefield, R.; Nguyen, K.; Shi, L.; Trigunarsyah, B.; Parolini, F.; Bonomo, P.; Frontini, F.; et al. Fire safety requirements for building integrated photovoltaics (BIPV): A cross-country comparison. *Renew. Sustain. Energy Rev.* **2023**, *173*, 113112. [CrossRef]
7. Curtius, H.C. The adoption of building-integrated photovoltaics: Barriers and facilitators. *Renew. Energy* **2018**, *126*, 783–790. [CrossRef]
8. Ding, L.; Zhu, Y.; Zheng, L.; Dai, Q.; Zhang, Z. What is the path of photovoltaic building (BIPV or BAPV) promotion?—The perspective of evolutionary games. *Appl. Energy* **2023**, *340*, 121033. [CrossRef]
9. Zhu, J.; Mei, Z. Photovoltaic building integration industry development trend analysis and forecast. *Highlights Sci. Eng. Technol.* **2023**, *40*, 383–387. [CrossRef]
10. Petrovich, B.; Carattini, S.; Wüstenhagen, R. The price of risk in residential solar investments. *Ecol. Econ.* **2021**, *180*, 106856. [CrossRef]
11. Li, X.; Li, H.; Wang, X. Farmers' willingness to convert traditional houses to solar houses in rural areas: A survey of 465 households in Chongqing, China. *Energy Policy* **2013**, *63*, 882–886. [CrossRef]
12. Tan, Y.; Ying, X.; Gao, W.; Wang, S.; Liu, Z. Applying an extended theory of planned behavior to predict willingness to pay for green and low-carbon energy transition. *J. Clean. Prod.* **2023**, *387*, 135893. [CrossRef]
13. NEA. *Notice on the Announcement of the Pilot List of Distributed Rooftop Photovoltaic Development in Whole Counties (Cities and Districts)*; NEA: Beijing, China, 2021.
14. Mankiw, N.G. *Principles of Microeconomics*, 9th ed.; Cengage Learning Asia Pte Limited: Singapore, 2021.
15. Zhang, Y.; Bai, X.; Mills, F.P.; Pezzey, J.C.V. Examining the attitude-behavior gap in residential energy use: Empirical evidence from a large-scale survey in Beijing, China. *J. Clean. Prod.* **2021**, *295*, 126510. [CrossRef]
16. Korcaj, L.; Hahnel, U.J.J.; Spada, H. Intentions to adopt photovoltaic systems depend on homeowners' expected personal gains and behavior of peers. *Renew. Energy* **2015**, *75*, 407–415. [CrossRef]

17. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [CrossRef]
18. Vu, T.D.; Nguyen, H.V.; Nguyen, T.M.N. Extend theory of planned behaviour model to explain rooftop solar energy adoption in emerging market. Moderating mechanism of personal innovativeness. *J. Open Innov. Technol. Mark. Complex.* **2023**, *9*, 100078. [CrossRef]
19. Irfan, M.; Elavarasan, R.M.; Hao, Y.; Feng, M.; Sailan, D. An assessment of consumers' willingness to utilize solar energy in China: End-users' perspective. *J. Clean. Prod.* **2021**, *292*, 126008. [CrossRef]
20. Bandura, A. Social cognitive theory: An agentic perspective. *Annu. Rev. Psychol.* **2001**, *52*, 1–26. [CrossRef]
21. Li, F.; Cao, X.; Ou, R. A network-based evolutionary analysis of the diffusion of cleaner energy substitution in enterprises: The roles of PEST factors. *Energy Policy* **2021**, *156*, 112385. [CrossRef]
22. Song, J.; Sun, Y.; Jin, L. PESTEL analysis of the development of the waste-to-energy incineration industry in China. *Renew. Sustain. Energy Rev.* **2017**, *80*, 276–289. [CrossRef]
23. Ghosh, A. Potential of building integrated and attached/applied photovoltaic (BIPV/BAPV) for adaptive less energy-hungry building's skin: A comprehensive review. *J. Clean. Prod.* **2020**, *276*, 123343. [CrossRef]
24. Yan, X. Research on Solar Photovoltaic Building Integration System Evaluation System. Master's Thesis, Beijing University of Civil Engineering and Architecture, Beijing, China, 2019.
25. Xue, J.; Ye, J.; Tao, Q.; Wang, D.; Liu, H.; Lu, D. Operating Strategy of Distributed PV System for Different Investors. *Power Syst. Technol.* **2017**, *41*, 93–98. [CrossRef]
26. Luo, X. Research on Cost Sharing of Distributed Photovoltaic Systems for Residential Buildings under the Constraints of Resource Conditions in Different Regions of China. Ph.D. Thesis, Xi'an University of Architecture and Technology, Xi'an, China, 2017.
27. Huang, X.; Chen, W. Application status and development prospect of photovoltaic building integration (BIPV). *J. Civ. Eng. Manag.* **2022**, *39*, 160–166. [CrossRef]
28. Ishii, H.; Wang, W. R&D and international standardization of BIPV. *Archit. J.* **2019**, *S02*, 29–34.
29. Taşer, A.; Koyunbaba, B.K.; Kazanasmaz, T. Thermal, daylight, and energy potential of building-integrated photovoltaic (BIPV) systems: A comprehensive review of effects and developments. *Sol. Energy* **2023**, *251*, 171–196. [CrossRef]
30. Shukla, A.K.; Sudhakar, K.; Baredar, P.; Mamat, R. BIPV in Southeast Asian countries—Opportunities and challenges. *Renew. Energy Focus* **2017**, *21*, 25–32. [CrossRef]
31. Agathokleous, R.A.; Kalogirou, S.A. Status, barriers and perspectives of building integrated photovoltaic systems. *Energy* **2020**, *191*, 116471. [CrossRef]
32. Lu, Y.; Chang, R.; Shabunko, V.; Lay Yee, A.T. The implementation of building-integrated photovoltaics in Singapore: Drivers versus barriers. *Energy* **2019**, *168*, 400–408. [CrossRef]
33. Chen, T.; Sun, H.; Tai, K.F.; Heng, C.K. Analysis of the barriers to implementing building integrated photovoltaics in Singapore using an interpretive structural modelling approach. *J. Clean. Prod.* **2022**, *365*, 132652. [CrossRef]
34. Wu, Y.; Xu, M.; Tao, Y.; He, J.; Liao, Y.; Wu, M. A critical barrier analysis framework to the development of rural distributed PV in China. *Energy* **2022**, *245*, 123277. [CrossRef]
35. Reddy, P.; Gupta, M.S.; Nundy, S.; Karthick, A.; Ghosh, A. Status of BIPV and BAPV system for less energy-hungry building in India—A review. *Appl. Sci.* **2020**, *10*, 2337. [CrossRef]
36. Ajzen, I. From intentions to actions: A theory of planned behavior. In *Action Control: From Cognition to Behavior*; Springer: Berlin/Heidelberg, Germany, 1985; pp. 11–39.
37. Zhao, S.; Duan, W.; Zhao, D.; Song, Q. Identifying the influence factors of residents' low-carbon behavior under the background of "Carbon Neutrality": An empirical study of Qingdao city, China. *Energy Rep.* **2022**, *8*, 6876–6886. [CrossRef]
38. Ulker-Demirel, E.; Ciftci, G. A systematic literature review of the theory of planned behavior in tourism, leisure and hospitality management research. *J. Hosp. Tour. Manag.* **2020**, *43*, 209–219. [CrossRef]
39. Yuriev, A.; Dahmen, M.; Paillé, P.; Boiral, O.; Guillaumie, L. Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resour. Conserv. Recycl.* **2020**, *155*, 104660. [CrossRef]
40. Agarwal, R.; Bhadauria, A.; Swami, S.; Rajwnashi, R. Factors influence or inhibit the purchase intention towards rooftop solar: Using structural equation modeling and importance performance map analysis approach. *J. Clean. Prod.* **2023**, *410*, 137109. [CrossRef]
41. Fu, W.; Zhou, Y.; Li, L.; Yang, R. Understanding household electricity-saving behavior: Exploring the effects of perception and cognition factors. *Sustain. Prod. Consum.* **2021**, *28*, 116–128. [CrossRef]
42. Jiang, X.; Ding, Z.; Liu, R. Can Chinese residential low-carbon consumption behavior intention be better explained? The role of cultural values. *Nat. Hazards* **2019**, *95*, 155–171. [CrossRef]
43. Zhang, Y.; Wang, G.Z.; Zhang, Q.; Ji, Y.J.; Xu, H. What determines urban household intention and behavior of solid waste separation? A case study in China. *Environ. Impact Assess. Rev.* **2022**, *93*, 106728. [CrossRef]
44. Yang, X.; Zhou, X.; Deng, X. Modeling farmers' adoption of low-carbon agricultural technology in Jianghan Plain, China: An examination of the theory of planned behavior. *Technol. Forecast. Soc. Change* **2022**, *180*, 121726. [CrossRef]
45. Bandura, A.; Freeman, W.H.; Lightsey, R. *Self-Efficacy: The Exercise of Control*; Springer Publishing: New York, NY, USA, 1999.
46. Jian, P.; Nan, H.; Yu, P. Employees' green behavior: Summarizing the concept and the theoretical explanation. *Adv. Psychol. Sci.* **2019**, *27*, 1297–1306.

47. Guo, N.; Hao, J.L.; Zheng, C.M.; Yu, S.W.; Wu, W.W. Applying Social Cognitive Theory to the Determinants of Employees' Pro-environmental Behaviour Towards Renovation Waste Minimization: In Pursuit of a Circular Economy. *Waste Biomass Valorization* **2022**, *13*, 3739–3752. [CrossRef]
48. Li, L.; Fan, F.; Liu, X. Determinants of rural household clean energy adoption intention: Evidence from 72 typical villages in ecologically fragile regions of western China. *J. Clean. Prod.* **2022**, *347*, 131296. [CrossRef]
49. Cai, J.; Hu, S.; Que, T.; Li, H.; Xing, H.; Li, H. Influences of social environment and psychological cognition on individuals' behavioral intentions to reduce disaster risk in geological hazard-prone areas: An application of social cognitive theory. *Int. J. Disaster Risk Reduct.* **2023**, *86*, 103546. [CrossRef]
50. Tovar Reaños, M.A.; Meier, D.; Curtis, J.; Pillai, A. The role of energy, financial attitudes and environmental concerns on perceived retrofitting benefits and barriers: Evidence from Irish home owners. *Energy Build.* **2023**, *297*, 113448. [CrossRef]
51. Khatiwada, D.; Vasudevan, R.A.; Santos, B.H. Decarbonization of natural gas systems in the EU—Costs, barriers, and constraints of hydrogen production with a case study in Portugal. *Renew. Sustain. Energy Rev.* **2022**, *168*, 112775. [CrossRef]
52. Raut, R.K. Past behaviour, financial literacy and investment decision-making process of individual investors. *Int. J. Emerg. Mark.* **2020**, *15*, 1243–1263. [CrossRef]
53. Yee, C.H.; Al-Mulali, U.; Ling, G.M. Intention towards renewable energy investments in Malaysia: Extending theory of planned behaviour. *Environ. Sci. Pollut. Res.* **2022**, *29*, 1021–1036. [CrossRef]
54. Rahmani, A.; Mashayekh, J.; Aboojafari, R.; Naeini, A.B. Determinants of households' intention for investment in renewable energy projects. *Renew. Energy* **2023**, *205*, 823–837. [CrossRef]
55. Sun, P.-C.; Wang, H.-M.; Huang, H.-L.; Ho, C.-W. Consumer attitude and purchase intention toward rooftop photovoltaic installation: The roles of personal trait, psychological benefit, and government incentives. *Energy Environ.* **2020**, *31*, 21–39. [CrossRef]
56. Liu, D.; Qi, S.; Xu, T. In the post-subsidy era: How to encourage mere consumers to become prosumers when subsidy reduced? *Energy Policy* **2023**, *174*, 113451. [CrossRef]
57. Lin, B.Q.; Qiao, Q. Exploring the acceptance of green electricity and relevant policy effect for residents of megacity in China. *J. Clean. Prod.* **2022**, *378*, 134585. [CrossRef]
58. Shakeel, S.R.; Yousaf, H.; Irfan, M.; Rajala, A. Solar PV adoption at household level: Insights based on a systematic literature review. *Energy Strategy Rev.* **2023**, *50*, 101178. [CrossRef]
59. Wang, J.H.; Chu, M.; Deng, Y.Y.; Lam, H.M.; Tang, J.J. Determinants of pesticide application: An empirical analysis with theory of planned behaviour. *China Agric. Econ. Rev.* **2018**, *10*, 608–625. [CrossRef]
60. Hasheem, M.J.; Wang, S.; Ye, N.; Farooq, M.Z.; Shahid, H.M. Factors influencing purchase intention of solar photovoltaic technology: An extended perspective of technology readiness index and theory of planned behaviour. *Clean. Responsible Consum.* **2022**, *7*, 100079. [CrossRef]
61. Wang, S.; Wang, J.; Lin, S.; Li, J. Public perceptions and acceptance of nuclear energy in China: The role of public knowledge, perceived benefit, perceived risk and public engagement. *Energy Policy* **2019**, *126*, 352–360. [CrossRef]
62. Nketiah, E.; Song, H.; Adu-Gyamfi, G.; Obuobi, B.; Adjei, M.; Cudjoe, D. Does government involvement and awareness of benefit affect Ghanaian's willingness to pay for renewable green electricity? *Renew. Energy* **2022**, *197*, 683–694. [CrossRef]
63. Gamel, J.; Bauer, A.; Decker, T.; Menrad, K. Financing wind energy projects: An extended theory of planned behavior approach to explain private households' wind energy investment intentions in Germany. *Renew. Energy* **2022**, *182*, 592–601. [CrossRef]
64. Van Tonder, E.; Fullerton, S.; De Beer, L.T.; Saunders, S.G. Social and personal factors influencing green customer citizenship behaviours: The role of subjective norm, internal values and attitudes. *J. Retail. Consum. Serv.* **2023**, *71*, 103190. [CrossRef]
65. Adu-Gyamfi, G.; Song, H.; Nketiah, E.; Obuobi, B.; Adjei, M.; Cudjoe, D. Determinants of adoption intention of battery swap technology for electric vehicles. *Energy* **2022**, *251*, 123862. [CrossRef]
66. Bandara, U.C.; Amarasena, T.S.M. Impact of Relative Advantage, Perceived Behavioural Control and Perceived Ease of Use on Intention to Adopt with Solar Energy Technology in Sri Lanka. In Proceedings of the 2018 International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE), Phuket, Thailand, 24–26 October 2018; pp. 1–9.
67. Davis, F.D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* **1989**, *13*, 319–340. [CrossRef]
68. Gârdan, I.P.; Micu, A.; Paștiu, C.A.; Micu, A.E.; Gârdan, D.A. Consumers' Attitude towards Renewable Energy in the Context of the Energy Crisis. *Energies* **2023**, *16*, 676. [CrossRef]
69. Zhang, L.; Tong, H.; Liang, Y.; Qin, Q. Consumer purchase intention of new energy vehicles with an extended technology acceptance model: The role of attitudinal ambivalence. *Transp. Res. Part A Policy Pract.* **2023**, *174*, 103742. [CrossRef]
70. Hansen, J.M.; Saridakis, G.; Benson, V. Risk, trust, and the interaction of perceived ease of use and behavioral control in predicting consumers' use of social media for transactions. *Comput. Hum. Behav.* **2018**, *80*, 197–206. [CrossRef]
71. Nasri, W.; Charfeddine, L. Factors affecting the adoption of Internet banking in Tunisia: An integration theory of acceptance model and theory of planned behavior. *J. High Technol. Manag. Res.* **2012**, *23*, 1–14. [CrossRef]
72. Ajzen, I. The theory of planned behavior: Frequently asked questions. *Hum. Behav. Emerg. Technol.* **2020**, *2*, 314–324. [CrossRef]
73. Engelken, M.; Römer, B.; Drescher, M.; Welpe, I. Why homeowners strive for energy self-supply and how policy makers can influence them. *Energy Policy* **2018**, *117*, 423–433. [CrossRef]

74. Munir, H.; Jianfeng, C.; Ramzan, S. Personality traits and theory of planned behavior comparison of entrepreneurial intentions between an emerging economy and a developing country. *Int. J. Entrep. Behav. Res.* **2019**, *25*, 554–580. [CrossRef]
75. Villanueva-Flores, M.; Hernández-Roque, D.; Díaz-Fernández, M.; Bornay-Barrachina, M. Exploring the mediation role of perceived behavioural control and subjective norms in the relationship between psychological capital and entrepreneurial intention of university students. *Int. J. Manag. Educ.* **2023**, *21*, 100865. [CrossRef]
76. Sun, S.; Law, R.; Schuckert, M. Mediating effects of attitude, subjective norms and perceived behavioural control for mobile payment-based hotel reservations. *Int. J. Hosp. Manag.* **2020**, *84*, 102331. [CrossRef]
77. Li, L. How Much Do You Know about Henan's Population in 2022_Departments_Henan People's Government Portal. Available online: https://www.henan.gov.cn/2023/02-22/2694140.html?eqid=c09285f800149fbc000000026491039e (accessed on 26 December 2023).
78. NEA. How Are Our Solar Resources Distributed? Available online: http://www.nea.gov.cn/2014-08/03/c_133617073.htm (accessed on 26 December 2023).
79. HNDRC. Highlights of Henan Province's Work to Promote Carbon Peak Carbon Neutrality and Green and Low Carbon Transition Strategy in 2023. Available online: https://fgw.henan.gov.cn/2023/07-12/2777202.html (accessed on 26 December 2023).
80. Hair, J.F.; Sarstedt, M.; Ringle, C.M. Rethinking some of the rethinking of partial least squares. *Eur. J. Mark.* **2019**, *53*, 566–584. [CrossRef]
81. Cheung, G.W.; Cooper-Thomas, H.D.; Lau, R.S.; Wang, L.C. Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations. *Asia Pac. J. Manag.* **2023**, 1–39. [CrossRef]
82. Wang, X.-W.; Cao, Y.-M.; Zhang, N. The influences of incentive policy perceptions and consumer social attributes on battery electric vehicle purchase intentions. *Energy Policy* **2021**, *151*, 112163. [CrossRef]
83. Chin, W.W. The partial least squares approach to structural equation modeling. *Mod. Methods Bus. Res.* **1998**, *295*, 295–336.
84. San Martín, H.; Hernández, B.; Herrero, Á. Social consciousness and perceived risk as drivers of crowdfunding as a socially responsible investment in tourism. *J. Travel Res.* **2021**, *60*, 16–30. [CrossRef]
85. Sun, M.; Gao, X.; Jing, X.; Cheng, F. The influence of internal and external factors on the purchase intention of carbon-labeled products. *J. Clean. Prod.* **2023**, *419*, 138272. [CrossRef]
86. Xing, Y.; Li, M.; Liao, Y. Trust, identity, and public-sphere pro-environmental behavior in China: An extended attitude-behavior-context theory. *Front. Psychol.* **2022**, *13*, 919578. [CrossRef] [PubMed]
87. Daiyabu, Y.A.; Manaf, N.A.A.; Mohamad Hsbollah, H. Extending the theory of planned behaviour with application to renewable energy investment: The moderating effect of tax incentives. *Int. J. Energy Sect. Manag.* **2023**, *17*, 333–351. [CrossRef]
88. Zhang, X.; Bai, X.; Shang, J. Is subsidized electric vehicles adoption sustainable: Consumers' perceptions and motivation toward incentive policies, environmental benefits, and risks. *J. Clean. Prod.* **2018**, *192*, 71–79. [CrossRef]
89. Luc, P.T. The Relationship between Perceived Access to Finance and Social Entrepreneurship Intentions among University Students in Vietnam. *J. Asian Financ. Econ. Bus.* **2018**, *5*, 63–72. [CrossRef]
90. Alam, S.S.; Ahmad, M.; Othman, A.S.; Shaari, Z.B.H.; Masukujjaman, M. Factors affecting photovoltaic solar technology usage intention among households in Malaysia: Model integration and empirical validation. *Sustainability* **2021**, *13*, 1773. [CrossRef]
91. Duan, J.; Zhang, M.; Cheng, B. Study on Consumers’ Purchase Intentions for Carbon-Labeled Products. *Sustainability* **2023**, *15*, 1116. [CrossRef]

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