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How Does Social Capital Promote Willingness to Pay for Green Energy? A Social Cognitive Perspective

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Abstract

Individual willingness to pay (WTP) for green energy plays a vital role in mitigating climate change. Based on social cognitive theory (SCT), which emphasizes the dynamic interaction among individual cognition, behavior and the environment, this study develops a theoretical model to identify factors influencing green energy WTP. The study is based on 585 valid questionnaire responses from urban areas in China and uses Structural Equation Modeling (SEM) to reveal the linear causal path. Meanwhile, fuzzy-set Qualitative Comparative Analysis (fsQCA) is utilized to identify the combined paths of multiple conditions leading to a high WTP, making up for the limitations of SEM in explaining complex mechanisms. The SEM analysis shows that social trust, social networks, and social norms have a significant positive impact on individual green energy WTP. And this influence is further transmitted through the mediating role of environmental self-efficacy and expectations of environmental outcomes. The FsQCA results identified three combined paths of social capital and environmental cognitive conditions, including the Network–Norm path, the Network–efficacy path and the Network–Outcome path, all of which can achieve a high level of green energy WTP. Among them, the social networks are a core condition in every path and a key element for enhancing the high green energy WTP. This study promotes the expansion of SCT, from emphasizing the linear role of individual cognition to focusing on the configuration interaction between social structure and psychological cognition, provides empirical evidence for formulating differentiated social intervention strategies and environmental education policies, and contributes to sustainable development and the green energy transition.

Keywords: green energy; willingness to pay; social capital; structural equation model; environmental self-efficacy; expected environmental outcomes

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1. Introduction

Sustainable development has emerged as a central concern for the global community in the 21st century [1], with the energy transition identified as a key pathway to addressing climate change and advancing green development. The United Nations Sustainable Development Goals emphasize that establishing a new energy system dominated by green energy is essential for ensuring food security, fostering economic growth, and maintaining social stability [2]. As a major alternative to fossil fuels, green energy (such as solar and wind power) plays a crucial role in reducing carbon emissions, mitigating environmental pollution, and supporting sustainable economic development [3]. As the world's largest energy consumer, China faces mounting environmental pressures due to rapid industrialization [4],

which has also become an important part of the global green transformation. To meet its carbon peaking and carbon neutrality targets, the Chinese government is actively pursuing sustainable development strategies [5]. However, the traditionally government-led model of atmospheric environmental governance has often neglected the role of individual participation, resulting in issues such as high costs and inefficiencies. With the popularization of green energy technologies, individuals are increasingly transitioning from passive energy consumers to active prosumers, directly participating in the investment and use of green energy [6,7]. In this context, individual willingness to pay (WTP) has attracted considerable attention in environmental economics and energy policy research [8–10]. Therefore, enhancing individual green energy WTP represents an essential step toward accelerating the energy transition. To better understand the psychological and social mechanisms underlying green energy WTP, this study integrates social cognitive theory (SCT) and social capital theory, providing a comprehensive framework to analyze both individual cognition and external social structures in shaping pro-environmental behavior.

Green energy WTP serves as a key indicator of individual commitment to the energy transition and is shaped by a range of influencing factors. Numerous studies have examined the determinants of WTP, highlighting the complex interplay between macro- and micro-level factors. Macro-level drivers include social capital [11,12], economic conditions [13], population density [14], and policy design [15], as well as government size and per capita GDP [16]. Sangroya and Kumar [17] emphasize that consumers' decisions to adopt green energy are shaped not only by external factors, such as financial considerations, but also by emotional and social influences. Micro-level drivers encompass demographic characteristics (e.g., income, education, age, gender) [5,14–16], personal attitudes [18,19], environmental values [20], environmental concerns [13,19], emotions [19], moral norms [21], and risk perceptions [22]. This diversity of influencing factors underscores that WTP is not determined by a simple cause-and-effect relationship but rather emerges from complex interactions among environmental, cognitive, and behavioral dimensions. Most of these studies have focused on the identification of the variable "net effect", ignoring the possible complex combination of relationships among various influencing factors. Especially within developing economies, there is significant heterogeneity among different regions in terms of green energy accessibility, environmental awareness and payment capacity [23], and the systematic examination of regional WTP differences is still insufficient.

In recent years, social capital has received increasing attention in research on sustainable consumption behavior, as it represents a vital social resource that shapes individual actions [19,24,25]. The concept of social capital was first introduced by Bourdieu [26] and later incorporated into public policy by Putnam et al. [27] in 1993, who defined it as encompassing trust, norms, networks, and social participation. This definition has provided the conceptual foundation for a wide range of subsequent studies. Scholars have demonstrated that social trust facilitates collective environmental actions by lowering perceived risks of cooperation [24]; social networks strengthen environmental norms through information diffusion [25]; and social norms influence individual behavioral choices via mechanisms of group pressure [19]. While these studies emphasize the direct effects of social capital on WTP, few have systematically examined the internal transmission mechanisms—particularly how social capital influences behavioral intentions through individual psychological and cognitive variables. This gap constitutes a core concern of social cognitive theory (SCT).

SCT provides a systematic psychological framework for understanding individual behavioral decision-making, emphasizing that behavior results from the dynamic interaction between the environment, cognition, and personal factors [28,29]. Self-efficacy and outcome expectations are considered key mediators that drive behavioral intentions [5,30].

However, the potential pathways through which social capital influences individuals' green energy WTP—particularly via self-efficacy and outcome expectations—remain underexplored. Similarly, how social environmental variables affect individual behavior through cognitive mechanisms is not yet fully understood. To address these theoretical gaps, this study investigates the following question: how does social capital affect consumers' WTP through the lens of social cognitive mechanisms? Explaining complex social phenomena generally requires a holistic perspective [5,31]. Traditional regression models are limited in capturing causal complexity, as they typically emphasize net or moderating effects among variables [31,32]. Qualitative Comparative Analysis (QCA) offers a configurational approach to social explanation, recognizing that multiple causal conditions can jointly lead to the same outcome through different combinations [5,31–34]. Compared with the linear relationship between variables tested by SEM, fuzzy-set Qualitative Comparative Analysis (fsQCA) can identify multiple causal paths, condition combinations and causal asymmetries, thereby revealing the complex behavioral mechanisms that are difficult to capture by SEM [34]. Therefore, this study integrates social capital theory and SCT to construct a unified theoretical framework. The model incorporates social trust, social networks, and social norms as independent variables, with environmental self-efficacy and outcome expectations serving as mediators. SEM is used to validate the model based on 585 valid survey responses. Given that WTP may arise through multiple pathways and conditional combinations, the study further applies fsQCA to identify various causal configurations under which high WTP is achieved. This approach reveals more complex and diverse mechanisms of influence.

To this end, this paper aims to answer the following three specific research questions: (1) How does social capital (social trust, social networks and social norms) affect individuals' WTP for green energy? (2) Do environmental self-efficacy and environmental outcome expectations play a mediating role in the path by which social capital influences green energy WTP? (3) Under the combination of different social capital and environmental cognitive conditions, are there multiple equivalent paths to achieve high WTP? The findings of this study will benefit green energy suppliers, governments, and stakeholders by revealing the determinants of green energy WTP. First, the study systematically elucidates how social capital influences WTP through social cognitive variables, thereby expanding the theoretical foundation of environmental behavior research. Previous studies have highlighted the positive impact of social capital on individual environmentally friendly behaviors [11,12,24], but the underlying mechanisms remain under-explored. Based on SCT, this study further explores the mediating role of environmental self-efficacy and environmental outcome expectations between environmental factors and behavioral intentions. Another value of this study is its use of regression analysis and fsQCA, a hybrid method that combines inductive and deductive thinking [35], offering a dynamic and complex perspective on sustainable consumption. Finally, the SCT framework emphasizes the interplay between individual, environmental, and behavioral factors, providing a dynamic and complex perspective on sustainable consumption [34]. This study combines the configuration perspective with fsQCA to explore the pathways leading to high and low green energy WTP. Previous research has already validated the net effect of various factors influencing green energy WTP [3,7,8,22,35], which limits the explanatory power of these factors. The configuration perspective offers a novel approach to sustainability research and clarifies why certain factors to support clean energy WTP may be effective or ineffective. In conclusion, this study will help policymakers design more targeted incentives to combat environmental degradation and promote the deeper implementation of green transformation strategies.

2. Literature Review and Research Hypothesis

SCT is a psychological theory that explains the formation of individual behavior, emphasizing that behavior is the result of the interaction among environmental factors, cognitive processes, and individual factors [28,29]. In environmental behavior research, SCT not only focuses on the influence of the external social environment on behavior, but also emphasizes the mediating role of individual cognitive factors in behavior formation [5,30]. As an important social environmental factor, social capital refers to the state of trust and cooperation among social entities such as individuals, groups, society and even the state, which can prompt individuals to undertake environmental protection responsibilities and enhance their efficiency in solving environmental problems [36,37]. This study is based on the SCT framework and aims to reveal how social capital influences green energy WTP by stimulating individuals' environmental self-efficacy and expectations of environmental outcomes. Social capital, as a coordinating and organizational mechanism, plays a crucial role in shaping individuals' attitudes towards environmental protection and enhancing their tendency to improve environmental quality [37]. Referring to previous studies [27], this study divides social capital into three dimensions, social trust, social networks and social norms, and explores their specific influence paths on WTP, respectively. The existing literature indicates that individuals and communities with abundant social capital are more inclined to work together for environmental benefits through cooperation [37,38].

2.1. Analysis of the Influence of Social Trust on WTP

Social trust is the subjective expectation that others will act in a way beneficial to collective welfare [5]. Luhmann categorizes social trust into institutional trust (such as trust in government, businesses, or institutions) and interpersonal trust (such as trust in neighbors, friends, or ordinary citizens) [39]. Research has shown that social trust significantly influences individual green consumption behavior [5,40] and waste-sorting behavior [41]. Individuals who trust others in their community are more likely to engage in environmental problem-solving [5,24]. Higher levels of social trust help reduce communication costs and cooperation barriers, deepen individuals' understanding and consensus on environmental issues, and thus increase their willingness to participate in pro-environmental behaviors [41]. This is especially relevant in the green energy sector, where collective action is essential, and individuals often face uncertainties related to energy technologies, policies, and shared costs [42]. Social trust can mitigate information asymmetries and alleviate policy concerns, enhancing individuals' confidence in green energy products and promotion systems [11,24]. Moreover, trust in others fosters the belief that others will also support green energy, which reduces free-rider behavior and increases individuals' WTP higher prices to achieve collective environmental outcomes [36]. However, some studies have pointed out that social trust does not always bring about positive environmental behavioral consequences. For instance, Frémeaux et al. [43] discovered that in situations where the system is not sound or the cost of environmental behavior is high, high social trust may instead induce blind trust or "free-riding" behavior. In a high-trust situation, an individual may assume that others will fulfill their environmental protection responsibilities, thereby reducing their efforts. This indicates that the relationship between social trust and WTP is not always positive or stable, and its effect is regulated by the external institutional environment and individual cognitive mechanisms. As Polyzou et al. suggest, social trust shapes expectations that others will also comply with environmental regulations and contribute to the public good [24,44]. Therefore, based on the above analysis, this study proposes the following hypothesis:

Hypothesis 1 (H1). *Social trust has a positive impact on green energy WTP.*

2.2. Analysis of the Influence of Social Network on WTP

Social networks refer to the social connections and interactions formed by individuals in their daily social lives, including formal and informal relationships with family, friends, neighbors, and colleagues. Social networks focus on the interactions, connections, and communications between people, which influence social behaviors [45]. The extent and frequency of an individual's interactions with relatives, neighbors, and colleagues can determine the environmental benefits of their efforts, affecting the spread of environmental knowledge and participation in environmental protection [46,47]. These social networks and civic engagement promote individual participation in environmental protection and green consumption [25]. Both individual- and group-level participation in social networks can enhance the likelihood of engaging in collective environmental actions, thereby increasing green energy WTP [48]. In the context of China's acquaintance society, social networks rooted in interpersonal trust often act as conduits for policy signals and behavioral modeling [49,50]. Kim's study found that when family members, friends, or neighbors demonstrate positive attitudes and purchasing behavior toward green energy products, others are more inclined to adopt similar behaviors due to trust, conformity, or reciprocity [50]. This socially embedded behavior pattern lowers psychological barriers to green energy adoption and fosters collective environmental action. Byrne further revealed that individuals with more frequent social contact are more likely to participate in green power programs [51]. In China, the embeddedness of consumer behavior within interpersonal interactions makes the role of social networks particularly salient. Based on the above discussion, the following hypothesis is proposed:

Hypothesis 2 (H2). *Social network has a positive impact on green energy WTP.*

2.3. Analysis of the Influence of Social Norms on WTP

In behavioral psychology, the thoughts and actions of others serve as a standard for observers to evaluate whether an action is beneficial or unproductive, socially acceptable or unacceptable in specific situations [52]. Thus, the term social norms implies the influence of others on individuals [53]. In other words, social norms are the behavioral standards and expectations that are widely accepted and influence individual behavior within a particular society or group [19]. Social norms can be categorized into descriptive norms and injunctive norms. The former reflects the consensus on how things are generally performed, while the latter embodies the moral or social expectations on how things should be performed [54]. It has been reported that injunctive norms are key determinants of various green consumption behaviors, including consumers' WTP for green products [55,56] and young vacationers' willingness to reduce waste and recycle [57]. Similarly, studies have found that descriptive social norms positively impact the willingness or actual behavior of green consumption, such as reducing waste and recycling willingness [57] and green behavior among teenagers [58].

For the altruistic and public act of paying for the additional cost of green energy, social norms play a significant role in guiding behavior and imposing psychological constraints. According to the value–belief–norm theory, social norms drive environmental behaviors by encouraging us to protect valuable objects, organisms, or nations, thus playing a crucial role in promoting environmentally friendly actions [59]. Lin and Syrgabayeva's research indicates that consumers who feel confident in their environmental responsibilities tend to have a positive attitude toward eco-friendly products and are willing to pay more for them. This suggests that consumers' sense of responsibility for social and community welfare is crucial in accepting environmental behaviors, meaning that those who consider themselves environmentalists and feel responsible for protecting the environment show a positive

attitude toward the use of renewable energy [19]. Furthermore, Yang et al. found that green consumers feel a moral obligation to contribute to the expansion of renewable energy and practice environmental behaviors in their daily lives [19]. Based on samples from the United States, Arpan et al. discovered that personal moral norms are positively correlated with WTP, and this relationship is very strong [60]. Based on the above, we hypothesize the following:

Hypothesis 3 (H3). *Social norms have a positive impact on green energy WTP.*

2.4. Mediation Effect Analysis of Environmental Self-Efficacy and Environmental Outcome Expectations

Under the framework of SCT, an individual's behavioral intention is jointly influenced by the interaction among the environment, self-awareness and behavioral outcomes. Among them, self-efficacy and outcome expectation are regarded as two key psychological mechanisms of behavioral intention [28,30]. Self-efficacy refers to an individual's confidence in their ability to complete a specific behavior [5,61]. In other words, it is people's belief in their ability to complete a certain task [62]. In this study, environmental self-efficacy is defined as an individual's belief that they can take behaviors that contribute to environmental improvement (such as choosing green energy). This sense of self-efficacy is usually manifested in the following aspects: actively choosing green energy in daily consumption, promoting sustainable lifestyles at the family and community levels, influencing others to practice environmental protection concepts through one's own actions, etc. Existing studies have shown that self-efficacy can significantly positively predict green purchasing behavior, as consumers with a sense of high performance are more likely to believe that they can identify and choose environmentally friendly products [63]. Furthermore, in the research on energy behavior, it has also been found that when individuals believe they can adopt energy-saving behaviors, their willingness to make green payments is stronger [64]. Therefore, self-efficacy helps enhance green energy WTP.

Under the framework of Social Cognitive Theory (SCT), self-efficacy is regarded as the key cognitive antecedent that determines whether an individual adopts a certain behavior. Environmental self-efficacy reflects an individual's confidence in their ability to take environmental protection actions and achieve results. In the context of green energy consumption, this is manifested as an individual's subjective judgment that they can give priority to green energy in their consumption decisions. When individuals believe that their actions can bring positive changes to the environment, their willingness to act increases significantly. An empirical study shows that self-efficacy can significantly positively predict green purchasing behavior, as consumers with a sense of high performance are more likely to believe that they can identify and choose environmentally friendly products [63]. Furthermore, in the research on energy behavior, it has also been found that when individuals believe they can adopt energy-saving behaviors, their willingness to make green payments is stronger [64]. Therefore, self-efficacy helps enhance the WTP of green energy and constitutes a key mediating mechanism for social capital to influence the process of the formation of willingness.

Result expectation is an individual's judgment on whether their behavior can bring about the expected result, constituting another core psychological mechanism for the formation of behavioral motivation in SCT. Result expectation refers to a person's belief in the successful performance result, which is an important driving factor of behavior [30]. The environmental outcome expectations mentioned in this study refer to individuals' beliefs that their environmental protection behaviors can bring positive environmental benefits and social returns, such as enhanced reputation, expanded interpersonal relationships, and the

acquisition of potential gains. Empirical research shows that positive outcome expectations can significantly enhance the possibility of energy-saving behaviors and environmentally friendly consumption [64]. Ballew et al. further pointed out that when individuals can foresee the effectiveness of their actions, their willingness and consistency in implementing environmental protection behaviors are significantly enhanced [64]. Furthermore, Steg and Vlek emphasized that the perceived outcome visibility of perceived behavioral effects is a key psychological variable in behavioral decision-making, especially in green energy usage scenarios with a strong group and collaborative nature, where collective identity and social influence are particularly crucial [65]. Therefore, the expected environmental outcome not only directly affects WTP as an independent variable but also may constitute an important mediating path for social capital to influence the WTP.

Social capital has a significant influence on these two psychological variables. Firstly, a high level of social trust helps enhance individuals' confidence and sense of control over green energy projects [5,66], which is manifested in the field of environmental protection as trust in others' environmental protection behaviors and positive expectations for institutional arrangements [67]. Social trust enhances individuals' self-efficacy and outcome confidence in participating in green energy payments by strengthening their belief in the consistency of others' behaviors and reducing the "free-rider" mentality [41,67].

Secondly, an active social network provides rich positive experiences and social support, which can enhance individuals' confidence in their own environmental protection capabilities through imitation mechanisms and emotional incentives, and amplify their visibility of the achievements of environmental protection behaviors [68,69]. In frequent interactions, individuals observe the environmental benefits brought by others' successful use of green energy and internalize them as potential outcomes of their own behaviors, enhancing behavioral expectations [70].

Finally, social norms shape behavioral standards through group pressure and value orientation mechanisms. When mainstream norms reinforce the concept of environmental protection, individuals are more likely to internalize the behavioral belief of a "green lifestyle", thereby enhancing their sense of self-efficacy [52,71]. Meanwhile, the social comparison process under normative guidance will also magnify individuals' cognition of the positive consequences of environmental protection behaviors, thereby enhancing their expected results [72].

Therefore, based on SCT, this paper further proposes the following hypotheses:

Hypothesis 4 (H4). *Environmental self-efficacy has a positive impact on green energy WTP.*

Hypothesis 4a (H4a). *Environmental self-efficacy plays a mediating role between social trust and green energy WTP.*

Hypothesis 4b (H4b). *Environmental self-efficacy plays a mediating role between social networks and green energy WTP.*

Hypothesis 4c (H4c). *Environmental self-efficacy plays a mediating role between social norms and green energy WTP.*

Hypothesis 5 (H5). *Environmental outcomes are expected to have a positive impact on green energy WTP.*

Hypothesis 5a (H5a). *Environmental outcome expectations play a mediating role between social trust and green energy WTP.*

Hypothesis 5b (H5b). *Environmental outcomes are expected to play a mediating role between social networks and green energy WTP.*

Hypothesis 5c (H5c). *Environmental outcomes are expected to play a mediating role between social norms and green energy WTP.*

Based on the above assumptions, this study proposes a model of factors influencing green energy WTP based on SCT, as shown in Figure 1.

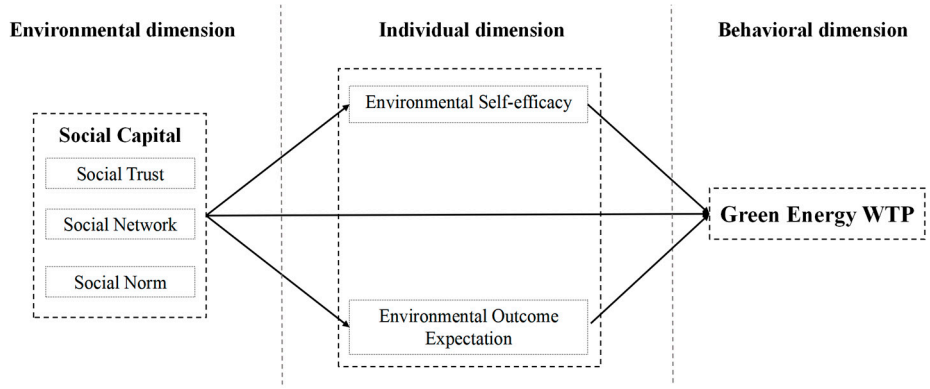


Figure 1. Model of influencing factors of green energy WTP based on SCT.

3. Research Design

Shanxi Province has long been a key supplier of coal energy to China, producing over 10 billion tons of coal from 2011 to 2024, accounting for about one-quarter of the national total. To meet the national coal security requirements, Shanxi is expected to continue increasing its coal production in the future. For a long time, Shanxi's industrial structure has been heavily reliant on coal mining, which has contributed significantly to the country, but also led to severe air pollution. In 2019, the Ministry of Ecology and Environments monitoring rankings showed that several cities in Shanxi had the worst air quality, with Taiyuan ranking seventh from the bottom, severely impacting its socio-economic development. Considering the geographical distribution and socio-economic development level, this study selected Wanbailin District, Xiaodian District and Xinghualing District of Taiyuan as research areas. In each district, 3 to 4 communities were randomly selected for one-on-one resident surveys. The survey was conducted from June to August in 2024. A total of 656 questionnaires were collected, and researchers removed those with identical or abnormal answers. The final recovery rate was 89.18% (585/656), with 585 valid questionnaires available for further analysis.

Regarding the demographic characteristics of the sample, the sample consists of 299 males (51.1%) and 286 females (48.9%). In terms of age, 70 respondents (12.0%) are aged between 18 and 34, 96 (16.4%) are aged between 35 and 44, 204 (34.9%) are aged between 45 and 54, 61 (10.4%) are aged between 55 and 64, and 54 (9.2%) are aged 65 or older. Regarding education level, 35 respondents have no formal education, 85 have completed primary school, 165 have completed junior high school, 127 have completed senior high school, 97 have a bachelors degree, and 76 have a masters degree or higher. With respect to monthly income, 70 respondents earn less than 3000, 163 earn between 3000 and 5000, 137 earn between 5000 and 10000, and 215 earn more than 10000. Regarding house-ownership, 437 respondents (74.7%) own a house, while 148 (25.3%) are renters. Additionally, marital status is also reported, with 181 respondents (30.9%) unmarried, 210 (35.9%) married, and 194 (33.2%) divorced.

This study employed a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The latent variables used in the model are presented in the research framework (Figure 1). All measurement items were adapted from prior research and revised to suit the context of this study, ensuring both reliability and validity. Table 1 provides the measurement details and corresponding items for all variables used in this study. In this study, we measured six variables: green energy WTP, social trust, social networks, social norms, environmental self-efficacy, and environmental outcome expectations. The items measuring green energy WTP were adapted from three items by Hojnik et al. [35]. The three items measuring social trust were adapted from [35,73]. The items measuring social networks were adapted from [11,12,74]. The items measuring social norms were adapted from [21,35,73]. The items measuring environmental self-efficacy were adapted from [75,76]. The items measuring environmental outcome expectations were adapted from [77,78].

Structural Equation Modeling (SEM) can handle latent variables and their indicators [79]. In SEM, the Maximum Likelihood Estimation (MLE) method is most commonly used. This study utilized AMOS 22.0 software for data analysis to verify that the data aligns with the conceptual model and research hypotheses. Confirmatory Factor Analysis (CFA) was used to test the measurement model's validity and reliability. Additionally, SEM analysis was used to conduct hypothesis testing on the model.

Table 1. Measurement and sources of items for the variables in the green energy WTP framework.

Variable Type	Construct	Measurement Items	Items	References
Explained Variable	Green energy WTP	It is acceptable to pay a higher price for green energy.	WTP1	[35]
		Even though green energy is more expensive than conventional energy, I am proud to use it in my home.	WTP2	
		If I had a choice, I would pay more for green energy products.	WTP3	
Explanatory Variable	Social trust	Most strangers are trustworthy.	ST1	[35,73]
		My friends and colleagues are trustworthy.	ST2	
		The government can seriously implement policies related to the energy transition.	ST3	
	Social network	I know more people than anyone else in the community.	SW1	[11,12,74]
		I have more close friends in the community than I do anywhere else.	SW2	
		In my community, most people are willing to help each other.	SW3	
	Social norm	Most of my friends and acquaintances think its a good idea to use green energy.	SN1	[21,35,75]
		It is important to me that people I care about want me to be part of the action to support green energy.	SN2	
		I personally hope to contribute my own strength to the development of green energy.	SN3	

Table 1. *Cont.*

Variable Type	Construct	Measurement Items	Items	References
Mediating Variable	Self-efficacy	I am confident in my ability to practice and promote environmental protection.	SE1	[75,76]
		As a consumer, I believe that we can reduce environmental pollution by choosing green energy.	SE2	
		I believe that by acting environmentally, I can encourage others to adopt a sustainable lifestyle.	SE3	
	Outcome expectation	Participating in green energy initiatives helps to enhance my reputation in the community.	OE1	[77,78]
		Participating in green energy related activities helps me expand my interpersonal relationships.	OE2	
		Supporting green energy will eventually bring me real economic or social benefits.	OE3	

However, SEM assumes that the relationships among variables are generally consistent and uniform, which has certain limitations when explaining the complex mechanism of behavioral intention formation in reality. Existing studies have pointed out that the determination mechanism of green energy WTP is not driven by a single variable alone but is caused by the interaction of multiple factors and the combination of conditions [5]. It is difficult to use traditional linear analysis methods to reveal such causal complexity and path heterogeneity, and there may even be situations where different studies reach opposite conclusions. To make up for the above deficiencies, this study introduces the fsQCA method to identify the multiple configuration paths that lead to high green energy WTP. FsQCA is a subset of QCA and is applicable to studies involving continuous condition variables, just as in the case of this study. It is particularly suitable for exploring the asymmetric relationships and equivalent paths among condition variables. It emphasizes the interaction and sufficiency conditions of variable combinations in specific situations [5,32]. The combination of SEM and fsQCA provides methodological complementarity: SEM estimates the net effects of individual variables and validates the overall structure of the theoretical model, while fsQCA reveals the configurational pathways that different groups may follow to arrive at the same behavioral outcome. This hybrid approach enhances the robustness of the findings and offers a more comprehensive understanding of both average tendencies and alternative patterns of causality. Specifically, SEM was used to test the proposed hypotheses and confirm key antecedent variables, which then informed the selection of conditions included in the fsQCA. FsQCA was subsequently applied to identify multiple equivalent configurations of social capital and cognitive factors that lead to high green energy WTP.

4. Empirical Results and Analysis

4.1. SEM Result Analysis

4.1.1. Measurement Model and Analysis

As shown in Table 2, the Cronbach's Alpha value for each variable ranges from 0.815 to 0.854, all exceeding 0.7, indicating a high level of reliability. Furthermore, the composite

reliability (CR) for each variable is greater than 0.7, and the average variance extraction (AVE) is greater than 0.5, suggesting that the convergent validity of each variable is ideal.

Table 2. Item loadings and reliabilities.

Constructs	Item	Factor Loading	CR	AVE	Cronbach's Alpha
Social trust	ST 1	0.769	0.817	0.599	0.815
	ST 2	0.789			
	ST 3	0.763			
Social network	SW 1	0.837	0.832	0.623	0.831
	SW 2	0.745			
	SW 3	0.784			
Social norm	SN 1	0.799	0.837	0.631	0.835
	SN 2	0.824			
	SN 3	0.758			
Outcome expectation	OE 1	0.867	0.837	0.633	0.832
	OE 2	0.788			
	OE 3	0.725			
Self-efficacy	SE 1	0.776	0.855	0.663	0.854
	SE 2	0.824			
	SE 3	0.841			
Green energy WTP	WTP 1	0.815	0.817	0.598	0.815
	WTP 2	0.778			
	WTP 3	0.725			

As shown in Table 3, there is a significant correlation between social trust, social network, social norms, outcome expectation, self-efficacy and green energy WTP ($p < 0.01$). In addition, the correlation coefficient of each latent variable is less than 0.6. The correlation coefficient between latent variables is less than the square root of AVE, indicating that there is a certain correlation between each latent variable and a certain degree of differentiation among them, indicating that the latent variables have good discriminant validity.

Table 3. Correlation coefficient matrix and roots of the AVE.

	1	2	3	4	5	6
1. Social trust	0.774					
2. Social networks	0.460 **	0.789				
3. Social norms	0.330 **	0.327 **	0.794			
4. Outcome expectation	0.416 **	0.438 **	0.371 **	0.796		
5. Self-efficacy	0.404 **	0.436 **	0.404 **	0.492 **	0.814	
6. Green energy WTP	0.451 **	0.478 **	0.394 **	0.454 **	0.457 **	0.773

Note: Numbers in the diagonal present the square root of AVE. **, $p < 0.05$.

4.1.2. Hypothesis Test

The structural model, as illustrated in Figure 2, was created using AMOS 22.0 software. Initially, the overall fit of the structural equation model was assessed. If the model fitting results do not meet the standards, it indicates that the sample data and the theoretical model do not have an ideal fit. The model fitting results are presented in Table 4. Table 4 shows that the overall goodness of fit index for the structural model is $\chi^2/df = 2.647$, GFI = 0.942, CFI = 0.961, NFI = 0.940. The estimated results are very consistent with the structural model.

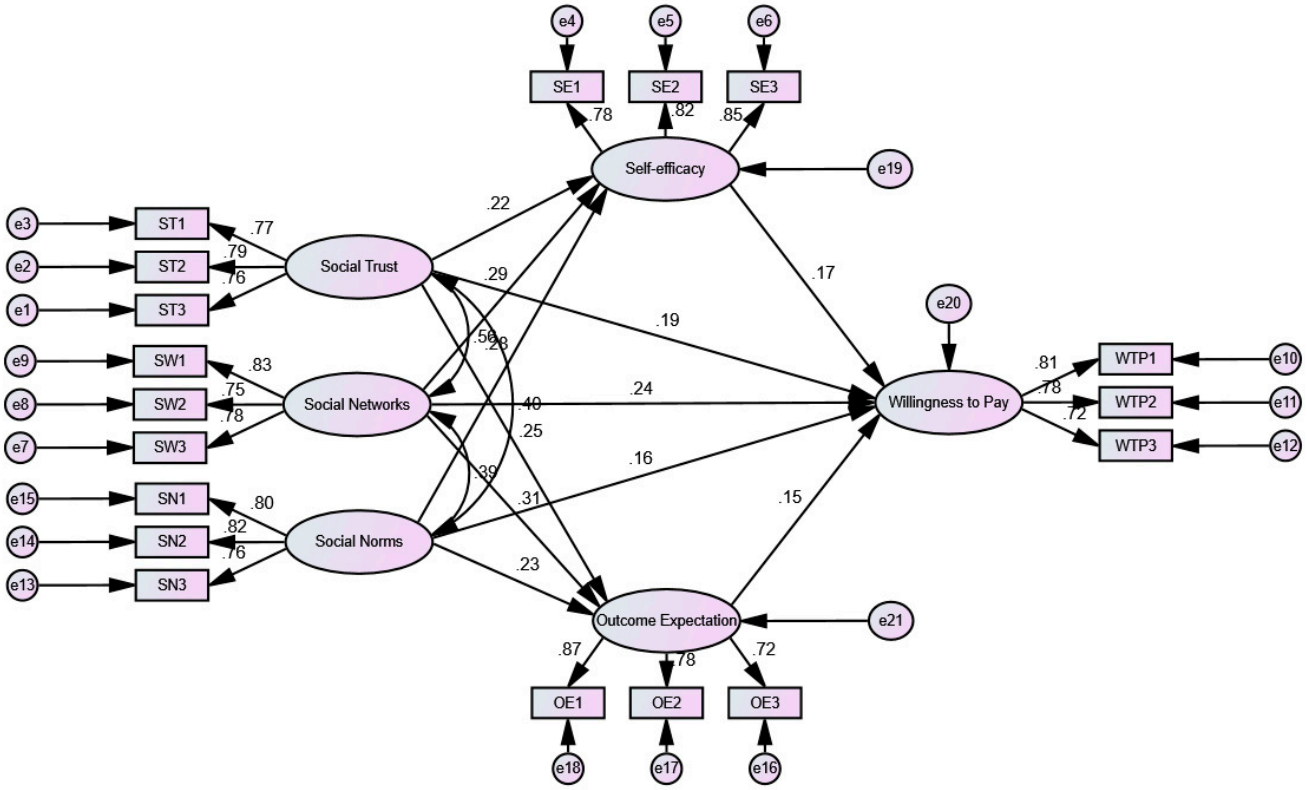


Figure 2. Structural model for green energy WTP.

Table 4. Summary of fit indices.

Fit Indices	χ^2/df	GFI	NFI	CFI	RMSEA
Recommended value	<3	>0.90	>0.90	>0.90	<0.08
Value in this study	2.647	0.942	0.940	0.961	0.053

As shown in Table 5, social trust (β = 0.195, $p < 0.001$), social network (β = 0.238, $p < 0.001$), social norms (β = 0.157, $p = 0.002$), self-efficacy (β = 0.170, $p = 0.002$) and outcome expectation (β = 0.155, $p = 0.004$) positively influence green energy WTP, supporting H1–H5. In addition, environmental self-efficacy (β = 0.170, $p = 0.002$) and environmental outcome expectation (β = 0.155, $p = 0.004$) also significantly affect individual green energy WTP.

4.1.3. Mediation Testing

To assess the mediating roles of environmental self-efficacy and outcome expectations between social capital and green energy WTP, this study conducted bootstrap analyses with 5000 resamples at a 95% confidence level. If the confidence interval does not include the value 0, it can be concluded that the mediating effect is significant. Table 6 indicates that the indirect effect is significant, and the confidence intervals for social capital influencing green energy WTP through environmental self-efficacy and environmental outcome expectations do not include 0, thus supporting H4a–H4c. H5a, H5b and H5c are further confirmed, consistent with the SCT model.

Table 5. Results of hypotheses test.

Path	Std. Estimate	*p*-Value	t-Value	Result
Social trust → Self-efficacy	0.224	***	3.960	Supported
Social networks → Self-efficacy	0.290	***	5.168	Supported
Social norms → Self-efficacy	0.283	***	5.785	Supported
Social trust → Outcome expectation	0.247	***	4.312	Supported
Social network → Outcome expectation	0.308	***	5.392	Supported
Social norms → Outcome expectation	0.231	***	4.744	Supported
Self-efficacy → Green energy WTP	0.170	0.002	3.114	Supported
Outcome expectation → Green energy WTP	0.155	0.004	2.848	Supported
Social trust → Green energy WTP	0.195	***	3.371	Supported
Social network → Green energy WTP	0.238	***	4.008	Supported
Social norms → Green energy WTP	0.157	0.002	3.097	Supported

Note: ***, $p < 0.001$.

Table 6. Mediation effect test.

Path	Point Estimate	Bias-Corrected 95% CI		Percentile 95% CI	
		Lower	Upper	Lower	Upper
Social trust → Self-efficacy → Green energy WTP	0.038	0.004	0.112	0.002	0.104
Social network → Self-efficacy → Green energy WTP	0.049	0.014	0.114	0.011	0.104
Social norms → Self-efficacy → Green energy WTP	0.048	0.013	0.114	0.011	0.109
Social trust → Outcome expectation → Green energy WTP	0.038	0.006	0.097	0.002	0.085
Social network → Outcome expectation → Green energy WTP	0.048	0.01	0.111	0.005	0.102
Social norms → Outcome expectation → Green energy WTP	0.036	0.006	0.089	0.003	0.083

4.2. Fuzzy-Set Qualitative Comparative Analysis

4.2.1. Selection and Calibration of Variables

This study examined five antecedents of green energy WTP: social trust, social networks, social norms, environmental self-efficacy, and environmental outcome expectations. Both theoretical frameworks and empirical evidence support the relationships between these variables and green energy WTP. As the foundational step in the QCA methodology [80], variable calibration was performed. Three qualitative anchor points were established: full non-membership (25th percentile), crossover point (50th percentile), and full membership (75th percentile) for variable calibration. Values of exactly 0.5 were adjusted by adding 0.001 [32] to prevent ambiguous calibration results. Table 7 presents descriptive statistics and calibration details for both conditional and antecedent variables.

4.2.2. Necessity Analysis

Prior to sufficiency analysis, necessary condition analysis was performed to evaluate whether individual antecedent variables constituted necessary conditions for green energy WTP. Analysis of 585 survey responses using fsQCA 4.0 software revealed low necessity consistency scores for individual conditions (all < 0.9) [34], as documented in Table 8. These results demonstrate the multifaceted nature of green energy WTP, where no single

condition proves sufficient, instead requiring synergistic interactions among antecedent conditions to predict high WTP.

Table 7. Descriptive statistics and calibrations.

Variable	Statistical Distributions			Calibration		
	Max	Mean	Min	Full-Membership	Cross-Over	Non-Membership
Social trust	5	3.981	1	4.667	4.333	3.667
Social network	5	3.750	1	4.333	4.000	3.333
Social norm	5	3.932	1	4.667	4.000	3.667
Self-efficacy	5	3.854	1	4.333	4.000	3.333
Outcome expectation	5	3.855	1	4.667	4.000	3.333
WTP	5	3.954	1	4.667	4.000	3.333

Table 8. Necessity analysis of conditions affecting green energy WTP.

Antecedent Conditions	High Green Energy WTP	
	Consistency	Coverage
Social trust	0.605	0.756
~Social trust	0.537	0.487
Social network	0.706	0.754
~Social network	0.423	0.438
Social norm	0.691	0.726
~Social norm	0.454	0.471
Environmental self-efficacy	0.730	0.736
~Environmental self-efficacy	0.397	0.436
Environmental outcome expectation	0.702	0.748
~Environmental outcome expectation	0.442	0.458

4.2.3. Sufficiency Analysis

Configuration analysis represents the core analytical procedure in the QCA methodology [81–84]. This study utilized the fsQCA 4.0 software for sufficiency analysis, setting the consistency threshold at 0.80, the frequency threshold at 1, and the PRI consistency at 0.7 [5], to further validate the sufficient condition combinations of the factors influencing green energy WTP. The truth table algorithm can generate three types of solutions including parsimonious, intermediate, and complex. This study, following the research in [81], selected the parsimonious and intermediate solutions as the judgment criteria, defining the common antecedents in both solutions as core conditions and those that only appeared in the intermediate solution as edge conditions, with necessary degrees distinguished by differential symbols. The frequency threshold was established at 10, retaining 87% of cases and exceeding the recommended 75% minimum sample retention [82]. Solution consistency and coverage metrics in fsQCA indicate the sufficiency of configurations and their explanatory power, respectively. Typically, a consistency greater than or equal to 0.8 and a coverage greater than or equal to 0.5 are considered acceptable [32]. In Table 9, forming high green energy WTP involves three configuration pathways, with the consistency levels of both individual and overall solutions exceeding the 0.8 threshold, indicating strong overall explanatory power of the analysis results.

Table 9. Configuration that results in high green energy WTP.

Configurations	High Green Energy WTP		
	C1	C2	C3
Social trust			•
Social network	●	●	●
Social norm	●		•
Environmental self-efficacy	•	●	
Environmental outcome expectations		•	●
Raw coverage	0.465	0.471	0.332
Unique coverage	0.092	0.099	0.045
Consistency	0.862	0.846	0.884
Solution coverage		0.608	
Solution consistency		0.832	

Note: ● indicates the presence of core conditions, • indicates the presence of edge conditions, and blank indicates that either exists or is missing. The same symbols apply to all later tables.

Configuration C1 demonstrates that the combination of extensive social networks and robust social norms (core conditions), complemented by environmental self-efficacy (edge condition), constitutes a sufficient pathway to increased green energy WTP. This configuration suggests that individuals with extensive social networks, whose behavior is influenced by clear and strong social norms, as well as their perceived greater ability to influence environmental behavior, are likely to exhibit a higher green energy WTP. This configuration emphasizes that environmental cues and social expectations compensate for the insufficiency of individual self-efficacy through normative activation and group affiliation mechanisms, which is in line with the external motivation-driven path in SCT. Configuration C2 represents a causal pathway in which two core conditions—social network centrality and environmental self-efficacy—interact with peripheral outcome expectations to generate high green energy WTP. This suggests that individuals can have higher green energy WTP when they have extensive social connections and a strong sense of environmental self-efficacy and when they have expected confidence in the outcome of their environmental behavior. This reflects that imitation, encouragement and resource support in social networks strengthen an individual's perception of inner ability, thereby offsetting concerns about the uncertainty of the outcome. That is to say, behavior is driven by a sense of efficacy. Configuration C3 indicates that a high social network and strong environmental outcome expectations, with high social trust and high social norms as edge conditions, can also enhance the WTP for green energy. When individuals are in an environment with active social relationships and firmly believe that their environmental protection behaviors will bring positive environmental outcomes, and at the same time have a certain degree of social trust and social norm support, they can demonstrate a relatively high green energy WTP. It is worth noting that the social network is the core condition in all three paths, which indicates that in the current research context, it is a powerful driving force influencing the WTP of green energy. Social networks possess dual attributes of connectivity and flow and are capable of synchronously transmitting environmental information, imitative behaviors and social identities at the cognitive, emotional and normative levels [45,68]. It not only supports individuals in acquiring environmental protection knowledge and experience but also enhances their self-efficacy and outcome expectations through social feedback and the successful behaviors of others, thereby catalyzing the occurrence of green energy WTP.

4.2.4. Robustness Analysis

To avoid the randomness of the fsQCA research results, this study will test the robustness of the results by adjusting the frequency threshold. The frequency threshold in the truth table is increased from 10 to 15 [5], and the truth table is reconstructed and standardized again. The resulting conditional configuration for high green energy WTP is a subset of the original results, with only minor differences in consistency and coverage indicators, without introducing new interpretations. The robustness test results (Appendix A) indicate that the conditional configuration of individual green energy WTP has good robustness.

5. Discussion

This study aims to find the relationship between individual WTP for green energy and social capital in the context of dual carbon, with environmental self-efficacy and environmental outcome expectations as mediators. Phipps et al. recommended applying SCT to sustainable consumption [36]. And this study responds to their call. The study collected data from 585 residents through a questionnaire survey and used the SCT system to explore how social capital influences individuals' green energy WTP through environmental cognitive factors. Based on this, the study identified the pathways leading to green energy WTP, which have been validated in research on individual green consumption behavior [5,35]. The findings provide a more explanatory theoretical framework for understanding the socio-psychological basis behind individual green energy WTP and have significant implications for the green energy transition and individual green consumption.

5.1. Social Capital, Environmental Self-Efficacy, Environmental Outcome Expectations and Green Energy WTP

The three dimensions of social capital, social trust, social networks and social norms, are positively correlated with individual green energy WTP. This finding indicates that strong social capital is a crucial external factor in motivating individuals to engage in green energy consumption, consistent with previous research [11,12,24]. Higher levels of social trust help reduce communication costs and cooperation barriers among individuals, deepen their understanding and consensus on environmental issues, and thus increase their willingness to participate in pro-environmental behaviors [42]. Social networks also positively influence individual green energy WTP. In terms of social networks, the extent and frequency of an individual's interactions with relatives, neighbors and colleagues can determine the environmental benefits of their efforts [46,47], influencing the spread of environmental knowledge and participation in environmental protection. Social norms also positively affect green energy WTP. Within the SCT framework, social norms are seen as a key mechanism for coordinating individual behavior, encouraging cooperation, and reducing the difficulty of collective action [19]. For altruistic and public behaviors such as paying additional costs for green energy, social norms play a significant role in guiding behavior and imposing psychological constraints. According to the value–belief–norm theory, social norms drive environmental behavior by motivating us to protect valuable objects, creatures, or countries. Therefore, it played an important role in building on individuals' inclination towards pro-environmental actions [59].

The results further reveal that environmental self-efficacy and environmental outcome expectations act as mediators between social capital and green energy WTP. This finding supports the cognitive mediation pathway hypothesis in social cognitive theory, which suggests that the influence of external social structures on individual environmental behavior is not direct but is achieved by altering their perceptions of their own behavioral capabilities and outcomes [28,61]. Specifically, individuals in environments characterized by high social trust, strong interaction networks, and robust norms are more likely to

develop the psychological beliefs that "I can impact the environment" and "My actions will have consequences," thereby increasing their green energy WTP.

5.2. Configuration Pathway of Green Energy WTP

Traditional regression models can only examine unidirectional linear relationships and causal symmetry between variables, but they fail to explain multiple concurrent causal relationships, causal asymmetry, and the complex causal dynamics between prior conditions and green energy WTP [32]. The formation of individual green energy WTP is a complex psychological process and social phenomenon, influenced by the intricate interactions of personal, group, and societal factors [5,35]. Therefore, an asymmetric perspective is needed for a deeper discussion. SCT posits that there is a dynamic interaction between individual cognition, behavior, and environment [28,36]. This study employs fsQCA to bridge the gap between qualitative and quantitative analysis, offering new insights into the diverse pathways leading to green energy WTP. Necessary condition analysis indicates that no single factor can fully account for green energy WTP. Sufficiency analysis shows that three configurations effectively lead to high green energy WTP, highlighting the complementary effects of different social capital variables and the configurational effect, reflecting the nonlinear and complex nature of the social cognitive decision-making process in forming individual green energy WTP.

This study employed SEM to verify the significant positive and direct impact of social capital on green energy WTP and simultaneously revealed the mediating role between environmental self-efficacy and expectations of environmental outcomes. In contrast, fsQCA further reveals three configuration paths, with the social network as the core condition, highlighting the diversity and synergy mechanism between the social network and other variables, and breaking through the limitations of SEM that can only reveal the linear effect between variables, ignoring multiple causal paths and asymmetric causal relationships. Therefore, SEM provides an overall verification of the theoretical model and a framework for direct relationships among variables, while fsQCA deepens the understanding of the behavior formation mechanism, emphasizing condition configuration and causal asymmetry. The two complement each other and jointly enrich the systematic understanding of the social cognitive impact mechanism of green energy WTP.

Specifically, the three high green energy WTP pathways all center on a strong social network. This highlights the crucial role of social networks in stimulating individual acceptance and green energy WTP through mechanisms such as resource sharing, group identity, and information dissemination. This aligns with Ratinen's perspective that green energy is a socially embedded commodity [85]. Existing studies have pointed out that extensive social networks can enhance individuals' acceptance and participation in green behaviors through information sharing, behavioral demonstration and group identity mechanisms [86,87], reduce uncertainty, enhance trust, and thereby trigger a higher WTP [81,88]. Even if individuals lack a strong sense of efficacy or have insufficient confidence in the results, they may still exhibit a relatively high WTP driven by social network pressure and group norms.

These results not only validate the applicability of SCT and social capital theory in the context of green energy WTP but also extend their explanatory scope by revealing how different combinations of social and cognitive factors can lead to the same behavioral outcome. Specifically, this study advances SCT by showing that self-efficacy and outcome expectations can function as complementary or substitutable mechanisms under different social capital contexts. It also refines social capital theory by uncovering that its impact is conditional, with social networks consistently emerging as the dominant driver when configured with appropriate cognitive support.

Moreover, compared with the SEM results, the configurational analysis using fsQCA reveals additional nuances that are not evident in traditional linear modeling. While SEM confirms the positive influence of all three social capital dimensions and the mediating role of cognitive factors, fsQCA demonstrates that strong WTP for green energy can still emerge even when some factors—such as environmental outcome expectations or social norms—are only peripheral rather than core conditions. This implies that under certain conditions, high levels of social networks and self-efficacy alone may be sufficient to drive behavior, underscoring the existence of conditional substitution and configurational compensation mechanisms. These asymmetric, path-dependent relationships highlight the strength of fsQCA in capturing causal complexity and heterogeneity, thereby complementing and deepening the linear insights derived from SEM.

6. Conclusions

In the context of achieving the dual carbon goals and the green transformation of the energy structure, individual green energy WTP is becoming a key driver of green and low-carbon development. Based on social cognition theory, this study aims to uncover the complex social psychological mechanisms behind individual green energy WTP, with a particular focus on how social capital and environmental perception interact. These findings go beyond the linear explanation of green energy WTP, offering a comprehensive perspective that encompasses the interactions between social capital and social cognition.

SEM indicates that social capital has a significant and positive impact on green energy WTP. Environmental self-efficacy and environmental outcome expectations mediate the effect of social capital on green energy WTP. Furthermore, this study uses fsQCA to uncover three pathways leading to high green energy WTP. This finding suggests that high green energy WTP is the result of the synergy between social capital and social cognition. Social networks are central in all these pathways, highlighting their crucial role in driving green energy WTP. Environmental cognitive variables form complementary combinations in different pathways, reflecting the diversity and substitutability of psychological mechanisms. This discovery challenges the traditional linear models of single causal perception, revealing the complex interaction between social structure and individual psychology in generating green behavior.

This study makes a significant contribution to the field of sustainable development research and offers multidimensional practical insights for promoting green energy transformation and public green consumption policy design in our country. Firstly, the critical role of social networks indicates that enhancing community recognition of green energy and fostering a positive green public opinion environment can boost green energy WTP through acquaintance influence and group behavior demonstration. Therefore, the government and power companies can promote the widespread dissemination of green energy concepts within social networks by establishing green community advocate systems, organizing green family selections, and promoting online green community development. Secondly, the study finds that environmental self-efficacy and environmental outcome expectations play a crucial psychological mediating role in influencing WTP, indicating that people are more likely to experience WTP when they believe their actions are effective and expect them to benefit the environment. Therefore, policymakers should enhance the dissemination of green energy knowledge and public participation education through environmental campaigns and participatory projects to improve individuals' understanding of the effectiveness of green actions. Thirdly, the combination of social capital and social cognition factors suggests that different groups may generate green WTP through different mechanisms, and policy tools should have contextual adaptability and pathway diversity. For example, for the middle-aged and young group, policymakers can focus on

the guidance of social norms and the shaping of green consumption identity, while for the elderly group, community trust and practical operation training are necessary. For the group with a higher knowledge level, policymakers should focus more on stimulating their environmental outcome expectation, while for the group with weaker cognition, they need more popular science knowledge of green energy.

This study has several limitations. The cross-sectional design makes it challenging to fully capture dynamic changes and causal evolution processes. Green energy WTP may be influenced by the long-term accumulation of social interactions and cognitive construction. Future research could adopt a longitudinal design or tracking surveys to better identify the long-term effects of social capital accumulation and cognitive changes on green behavior. Moreover, the coefficients of social capital, environmental self-efficacy, and environmental outcome expectations on individual green energy WTP may be biased by unobserved variables. Finally, the samples of this study mainly come from Shanxi Province, China. Due to its abundant coal resources, this region has long been dominated by high-carbon industries and is facing relatively prominent environmental governance pressure and demand for energy structure transformation. This special background may affect the formation mechanism of respondents' cognitive structure towards green energy, policy sensitivity and WTP. For instance, compared with the southeast coastal areas or regions with more complete green energy infrastructure, residents in Shanxi may rely more on government leadership and community promotion and thus have a stronger dependence on the "network" and "regulation" dimensions in social capital. Therefore, the applicability of the research conclusions in other regions may be somewhat limited. In the future, comparative studies in a multi-regional context can be considered to test the universality and boundary conditions of the conclusions.

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Appendix A. Robustness Test for High Green Energy WTP

Table A1. Robustness test results for high green energy WTP.

Configurations	High Green Energy WTP		
	H1	**H2**	**H3**
Social trust		•	•
Social network	●	●	●
Social norm	•		•
Environmental self-efficacy	•	•	
Environmental outcome expectations		•	•
Raw coverage	0.465	0.332	0.352
Unique coverage	0.178	0.045	0.065
Consistency	0.862	0.884	0.887
Solution coverage		0.575	
Solution consistency		0.842	

Note: ● indicates the presence of core conditions, • indicates the presence of edge conditions, and blank indicates that either exists or is missing.

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