

Does Beneficiaries' Satisfaction Enhance Their Trust in State Grid for Solar PV Adoption? – An Evidence From PAPs in Rural China

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Abstract

Background: Photovoltaic Poverty Alleviation Projects (PPAPs) have been implemented in Chinese rural areas since 2014. As a new energy policy, PPAPs have played an important role in alleviating rural poverty. However, the adoption of solar PV faces multiple barriers from the perspective of beneficiaries. Therefore, this study basically aims to discuss and analyze factors affecting beneficiaries' satisfaction and their trust in State Grid, promoting the adoption of solar PV.

Methods: Based on the integrated American Customer Satisfaction Index (ACSI) and Unified Theory of Acceptance and Use of Technology (UTAUT) model, this study uses the Structural Equation Model (SEM) to reveal how the beneficiaries' satisfaction enhance their trust in State Grid. The data were obtained from a survey of 928 PPAPs' beneficiaries by stratified and random sampling in Chinese rural areas.

Results: The results confirm that environmental perception in this study positively impacts on beneficiaries' satisfaction. And perceived quality also has a positive effect on beneficiaries' satisfaction and trust in State Grid, however, social influence has a negative impact on beneficiaries' satisfaction; behavior expectation can directly promote beneficiaries' satisfaction, while indirectly propel their trust in State Grid.

Conclusions: This study constructs an integrated customer satisfaction model from the perspective of beneficiaries and proposes relevant measures to promote the adoption of solar PV that can be applied to poverty reduction of other developing countries worldwide.

Background

Nowadays, the global energy system has accelerated the transition to being low-carbon. It has become an inevitable requirement to build a green-cycle and low-carbon energy system for social development, while the solar and other renewable energies have showed huge potential and great prospect. Since 2014, the Chinese government has been implementing the construction of Photovoltaic Poverty Alleviation Projects (PPAPs) which is in conformity to the concept of green development, making great efforts to accelerate the speed of rural poverty alleviation [27]. From 2015 to 2017, National Energy Administration has issued the special construction scales of PPAPs for 1.5 million kilowatts, 5.16 million kilowatts and 4.19 million kilowatts respectively for three consecutive years. As of 2019, the National Energy Administration has issued a total of 17.12 million kilowatts of PV poverty alleviation, which can help 2.88 million poverty-stricken households in China [66].

China's PPAPs mainly include four types: household PV power station, village-level PV power station, greenhouse PV power station, and commercial PV power station for poverty alleviation. The beneficiaries in this research mainly benefit from three types, i.e., household, village-level, and commercial PV power stations for poverty alleviation.

However, as an innovative and targeted poverty reduction initiative, PPAPs must overcome current difficulties in order to achieve the expected results in a large scope. In previous researches, scholars mostly study the internalities obstacles (quality of PV equipment, profit allocation mechanism, institutional framework of energy policy management, etc.) and externalities obstacles (subsidy delays, environmental licensing challenges, etc.) to discuss the sustainable development of PPAPs [26, 37, 52]. With the rapid development of PPAPs, more and more rural residents who are the main stakeholders of PPAPs participate in PPAPs. Therefore, their satisfaction should not be ignored for solar PV adoption. The State Grid is a monopolistic power supply corporation in China, whose technicians also play a major role in the progress of PPAPs. They need to proactively offer tracking services and develop a particular plan according to each customer to ensure the safe and stable operation of PV equipment. In the case of solar projects in Ghana, the continued growth of the solar market has been hampered by financing difficulties and the lack of local technicians and credit lines [61]. Only individuals who trust the installer and believe the solar is beneficial are more likely to contact the installer and adopt it [67].

Therefore, it is essential to reveal how the beneficiaries' satisfaction enhance their trust in State Grid for PPAPs. It might promote the adoption of solar PV and contribute to poverty alleviation. To this end, this study constructs an integrated model adding the features of PPAPs and uses the AMOS software to explore the factors affecting beneficiaries' satisfaction. Also, it proposes relevant measures to promote the beneficiaries' satisfaction with PPAPs, which may be useful for other developing countries' poverty alleviation.

The rest of this paper is arranged as follows: the existing literature is reviewed and discussed in Sect. 2. Section 3 will explain the conceptual model and propose the research hypotheses. The methodology and the results will be introduced respectively in Sect. 4 and Sect. 5, followed by Sect. 6, with the details of impact of the results, theoretical contributions and limitations. Finally, in Sect. 7 it will conclude this paper with policy implications.

Satisfaction theory and method

With a rapid development of satisfactory theories, scholars have adopted different theories and methods to study the satisfaction of their respective fields. In terms of the adopted theories, grounded theory [5], three-factor theory of customer satisfaction [4] and satisfaction spillover theory [65] are widely applied to explore the satisfaction in various fields. The most common theory is the Customer Satisfaction Index (CSI). In 1989, CSI was originally established by Sweden [42], namely the Swedish Customer Satisfaction Barometer Index (SCSBI). Based on this, a new factor "perceived quality" was added into establish an American Customer Satisfaction Index (ACSI) model [20]. At present, scholars also begin to adopt the extended Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) to study customer satisfaction of mobile food ordering or mobile commerce [3]. In terms of the adopted methods, qualitative methods such as fuzzy analytic hierarchy process [69] and evaluation method based on rough set conditional information entropy [79] are adopted to establish the attribute weight of satisfaction. Furthermore, some scholars adopted quantitative method such as cross-domain hybrid method [36] and partial least squares method based on SEM technology [17, 51] to evaluate satisfaction.

Factors affecting satisfaction

SEM or path analysis is mostly used in satisfaction studies to explore the causal relationship among variables [11, 77]. In the field of renewable energy, the important factors determining consumers' satisfaction included the image of service provider, consumer expectation, and perceived quality, etc. [51]. Specifically, in the solar PV research, the benefits of the solar household system (SHS) lifestyle and the quality of its equipment played a key role in improving users' satisfaction with SHS in rural Bangladesh from a quantitative perspective [34, 46]. At the same time, public's satisfaction played a positive role in using solar technology [33]. Information and educational campaigns about clean energy technologies might have a positive impact on home owners' satisfaction, leading to positive word-of-mouth recommendation and other impact [46]. In a survey of distributed solar technology adoption in rural India, it was found that the use of home solar technology is closely related to the subjective satisfaction of home lighting [2]. In addition, scholars also analyzed other factors affecting satisfaction, such as public trust [29], purchase intention [23], and government image [10].

Satisfaction and trust

Trust is regarded as a critical feature and a central mechanism in business transactions [64]. In the expansion of modern coal-fired power plant projects and power grid projects, trust exerted a significant influence on public support attitudes [41, 48]. For the environmental sustainable development, companies need to invest resources to increase customers' green perceived value, thereby enhancing green trust and customers' green loyalty [12]. Previous literatures have shown there is a direct and indirect correlation between satisfaction and trust. For the former, some scholars found that the satisfaction of neighborhood facilities was an important predictor of social trust [39]. Otherwise, the trust in local government also had a significant positive impact on urban residents' environmental public service satisfaction, while the trust in central government had no significant impact [70]. Thus, it was necessary to improve residents' trust in local governments with communication and cooperation. For the latter, trust played a certain intermediary or mediation role when scholars discussed the relationship among satisfaction of service quality [8], organizational culture and leadership performance [44] and manufacturer-supplier [50]. Accordingly, some scholars also used satisfaction as an intermediary variable to discuss the influence between trust with green perceived quality, green perceived risk [13] and relationship benefits [19].

Overall, current researches mainly use ACSI model to explore the factors that affect the satisfaction. A few researches have begun to use UTAUT to explore it, but few studies integrate the two models to explore the impact of users' satisfaction and their behaviors. Therefore, this study will consider integrating ACSI and UTAUT model adding "environmental perception" variable. In addition, most scholars investigated the relationships between satisfaction and loyalty or complaint; few scholars explored the relationship between satisfaction and trust. Even though some scholars have explored the relationship between satisfaction and trust, most of them discussed satisfaction and trust as an intermediary role. This study will add "trust in State Grid" as a behavioral outcome variable for beneficiaries' satisfaction to explore the relationship between beneficiaries' satisfaction and their trust in State Grid.

The conceptual model

Based on the ACSI model, this study builds beneficiaries' satisfaction index of PPAPs. Among them, perceived value is a subjective feeling of customers on their benefits after integrating quality and price [68], while PPAPs generally involve State Grid, government, and enterprises' behavior. Thus, the beneficiaries do not need to afford "high investment" The total incomes of the PPAPs are directly shared by the beneficiaries or together with the State Grid and village collectives. Therefore, we will not consider the influencing factors of perceived value in this paper. The complaint and loyalty respectively represented the degree of users' dissatisfaction and lack of trust in the service provided by the product [31]. This study will combine these two consequence variables into one to explore the beneficiaries' trust in State Grid, which includes both the beneficiaries' judgment on the PPAPs' services provided by the State Grid, and the beneficiaries' credibility on it. At the same time, "social influence" and "environmental perception" will be added to the original model in order to further explore the factors influencing satisfaction of PPAPs. Figure 1 shows the proposed research framework of this study.

Social influence

Social influence means that the extent to which an individual perceives it significant, while others believe they should apply the new system [63]. Since solar PV is an emerging renewable energy, the beneficiaries are not fully familiar with it. Their satisfaction with PPAPs is primarily influenced by the views, ideas, and attitudes of others. Thus, this study defines social influence as the extent to which the beneficiaries perceive the government officials and village leaders who persuade them to adopt solar PV. The influence of government officials or village leaders is also an external environmental impact. It was found that there were indirect effects of environment and outcome expectation through constructing a theoretical framework of the factors influencing farmers' participation in the joint-stock cooperative system from self-efficiency, outcome expectation, and external environment [74]. Therefore, this study proposes the following hypothetical path:

H1. Social influence will have a positive impact on the behavioral expectation with PPAPs.

In terms of perceived quality, social interaction was divided into "social interaction with employees" and "social interaction with peers", simultaneously, they all had an impact on perceived service quality [16]. Government officials and village leaders should promote residents' awareness to understand PPAPs or the program itself in their daily interactions. Therefore, this study proposes the following hypothetical path:

H2. Social influence will have a positive impact on the perceived quality with PPAPs.

Environmental perception is an element of judging the government's environmental governance. The more serious the public perceive environmental pollution, the lower the local government's evaluation will be. Consumers' cognition and preference for ecological technology were affected by society. Thus, it would underestimate the potential of consumers' choice for the emerging environmental technologies when neglecting the process of social influence [6]. Therefore, this study proposes the following hypothetical path:

H3. Social influence will have a negative impact on environmental perception with PPAPs.

It was confirmed that social influence affected citizen satisfaction through developing a model for compelling citizens to adopt e-government technology [9]. Customers could gain social acceptance from others when using a product, which would simultaneously increase social value and satisfaction [22]. Therefore, this study proposes the following hypothetical path:

H4. Social influence will have a negative impact on beneficiaries' satisfaction with PPAPs.

Trust was an essential driving force for consumers' shopping decisions in social commerce [40]. Consumers developed familiarity and trust in the products when engaging in social interactions [72]. Personal factors, community factors, and social factors all significantly affected residents' social trust, which demonstrated that the improving of society trust not only need individual efforts but also need intermediary organizations' progress [73]. Therefore, this study proposes the following hypothetical path:

H5. Social influence will have a positive impact on trust in State Grid with PPAPs.

Behavioral expectation

Expectation represents both prior consumption experience with its offering and a forecast of the company's ability to provide quality in the future [20]. The government is involved to ensure the quality of designing and implementing PPAPs. Therefore, this study defines the behavior expectation as the degree to which the beneficiaries expected the government's behavior with PPAPs. In the energy sector, it was found that consumer expectation has a positive relationship with perceived quality [51]. Otherwise, combined with the need to build a service-oriented government, public expectation was found to have a positive impact on perceived quality [71]. Therefore, this study proposes the following hypothetical path:

H6. Behavioral expectation will have a positive impact on perceived quality with PPAPs.

A lot of researches showed that user expectation and environmental perception have direct or indirect effects on users' satisfaction and loyalty [75], but the relationship between them still has not been discussed. At present, PPAPs are still in a period of continuous development, and they still require subsidies and support from the government. Only when government attaches great importance can farmers better understand the significance. Therefore, this study proposes the following hypothetical path:

H7. Behavioral expectation will have a positive impact on environmental perception with PPAPs.

Public's satisfaction could be jointly influenced by three variables: public expectation, perception of public service quality, and perceived difference in service effectiveness [38]. Otherwise, passengers expectation was positively correlated with passengers' perceived quality and their satisfaction through the analysis of passengers' satisfaction [59, 71]. Therefore, this study proposes the following hypothetical path:

H8. Behavioral expectations will have a positive impact on beneficiaries' satisfaction with PPAPs.

At present, some scholars have explored the indirect effects between customer expectation and perceived trust of customer satisfaction based on ACSI model. Customer expectation (antecedent variable) and perceived trust (result variable) is used to explore the impact on satisfaction, accordingly, customer expectation also have an indirect effect on perceived trust through satisfaction. Some scholars found that effort expectation had a significant impact on perceived trust as an internal belief factor for the public to use E-government [78]. Therefore, this paper proposes the following hypothetical path:

H9. Behavior expectation will have a positive impact on trust in State Grid with PPAPs.

Perceived quality

Perceived quality is the service quality that customers perceived, while the concept of service quality is defined as a comparison between expectation and actual service performance [56]. In this paper, perceived quality is defined as the beneficiaries' perceive quality changes in family energy use and environment problems after the adoption of PPAPs. Scholars found that there is often a positive relationship between perceived quality and consumers' awareness in environmental protection [14]. Consumers will feel a high quality about the product if it has an environmental label on the package, which will also encourage them to pay attention to environmental awareness [18]. Therefore, this study proposes the following hypothetical path:

H10. Perceived quality will have a positive impact on environmental perception with PPAPs.

Some researchers simplified the perceived service quality into three dimensions, including platform perceived service quality, bicycle entity perceived quality, and value perceived quality. The platform and bicycle entity perceived service quality were found to significantly affect users' satisfaction [77]. In addition, the equipment quality of solar home systems (SHS) played an essential role in improving users' satisfaction in rural areas [34]. Therefore, this study proposes the following hypothetical path:

H11. Perceived quality will have a positive impact on beneficiaries' satisfaction with PPAPs.

An indirect relationship between e-service quality and green trust was found to explore the factors influencing green purchase intention [1]. Other researchers found that perceived quality also had a direct and positive effect on trust. Green perceived quality positively affected green trust and the relationship between them was partially moderated by green satisfaction [12]. Therefore, this study proposes the following hypothetical path:

H12. Perceived quality will have a positive impact on trust in State Grid with PPAPs.

Environmental perception

Environmental perception can be divided into two aspects. One refers to the image formed by the environment in an individual's mind. The other refers to the feeling that the quality of the environment brings to the individual [55]. The environmental perception in this paper refers to the beneficiaries' perception of environmental quality due to excessive use of non-renewable energy. Environmental perception and farmers' satisfaction with desertification control are also highly correlated [34]. Therefore, this study proposes the following hypothetical path:

H13. Environmental perception will have a positive impact on beneficiaries' satisfaction with PPAPs.

It was found that the perception of environmental problems was an essential factor in low-carbon behavior [1], while social trust had a moderating effect between environmental fairness perception and farmers' low carbon production behavior [49]. It was also found that the trust in government had a significant moderating effect on the relationship between public risk perception (public environmental risk perception, public health risk perception, public economic risk perception) and neighborhood conflict intentions [12]. Therefore, this study proposes the following hypothetical path:

H14. Environmental perception will have a positive impact on trust in State Grid with PPAPs.

Beneficiaries' satisfaction

Satisfaction is an overall affective response to a perceived discrepancy between prior expectation and perceived performance after consumption [54]. This study defines satisfaction as the sense of happiness formed by the beneficiaries through the previous expectation and actual perception. Some scholars confirmed a close connection between trust and users' satisfaction in mobile commerce [32, 58]. In addition, scholars found that consumers' green satisfaction has a significant effect on green trust in the research on users' word-of-mouth intentions of the green hotel industry [43]. Therefore, this study proposes the following hypothetical path:

H15. Beneficiaries' satisfaction will have a positive impact on trust in State Grid with PPAPs.

Methods

Data collection and participants

The empirical part of this study was an extensive sample questionnaire conducted in 8 provinces of China, including Changyang County, Hubei Province; Shangcai County, Henan Province; Republican County, Qinghai Province; Haiyuan County, Ningxia Province; Tongwei County, Gansu Province; Tianzhen County, Shanxi Province; Chayouzhong Banner, Inner Mongolia Autonomous Region; and Jinzhai County, Anhui Province. The surveyed areas involve eight provinces in China considering different sunlight levels. From June 2018 to September 2018, the research group selected survey samples based on the principles of stratified sampling and random sampling, and conducted a one-to-one interview with beneficiaries in the field survey. The actual number of questionnaires issued was 940, of which 928 are valid, with an efficiency of 98.70%.

Questionnaire

The main contents of the questionnaire include the basic characteristics of the household population, such as gender, age, household register, education background, whether they are village leaders or not. Otherwise, it also includes what kind of PPAPs they have benefited from, the satisfaction degree with the implementation of PPAPs, the perception of environmental condition, energy use situation, etc. The alpha value of Cronbach was also tested. According to the recommendations of [53], all construction values should be higher than 0.70.

As shown in Table 1, the actual number of distributed questionnaires was 940, and 928 (98.7%) valid questionnaires were obtained after deleting incomplete and inconsistent questionnaires. The object of this study is rural residents who benefited from PPAP. The majority (76.9%) of beneficiaries interviewed were male. The beneficiaries within the age group of 50–59 years old were about 27.6%, while beneficiaries of 40–49 years old and 60–69 years old respectively accounted for 23.5% and 23.2%, and the age group less than 20 years old (0.6%) was the smallest proportion. In terms of education level, the largest group was primary school degrees (50.4%), followed by high school degrees (26.4%). Regarding household registration, most of the current samples (98.6%) were those who have rural household registration, about 1.4% were non-farm household registration. Among the beneficiaries interviewed, most (98.3%) belongs to ordinary villagers, while only 1.7% belongs to village leaders.

Table 1
Demographic Characteristics of Beneficiaries.

Demographic Profile	Number of Beneficiaries (N = 928)	Percentage (%)
Gender		
Male	714	76.9
Female	214	23.1
Total	928	100
Age		
< 20	6	0.6
20 ~ 29	24	2.6
30 ~ 39	62	6.7
40 ~ 49	218	23.5
50 ~ 59	256	27.6
60 ~ 69	215	23.2
> 69	147	15.8
Total	928	100.0
Education Level		
Illiteracy	165	17.8
Primary school	468	50.4
Junior high school	245	26.4
High school	45	4.8
Specialist	2	0.2
University	3	0.3
Total	928	100.0
Household Registration		
Rural area	915	98.6
Town	13	1.4
Total	928	100.0
Whether a Village Leader		
Yes	912	98.3
No	16	1.7
Total	928	100.0

Results

Preliminary data analysis and test of statistics will be first provided in Sect. 5.1. Then the two-stage SEM will be introduced, which was used to verify the conceptual model and test its associated hypotheses. The results of confirmatory factor analysis (CFA) in the first phase are provided in Sect. 5.2, and the structural model of the SEM in the second stage is presented in Sect. 5.3.

Descriptive statistics

As shown in Table 2, beneficiaries seem to have a relatively satisfactory view of PPAP for all the aspects considered in the current study. For example, the average mean of behavioral expectation items was 4.578, while the average standard deviation was 0.672, which indicated that the beneficiaries were positive about the government's behavior in PPAPs. The quality improvement brought by PPAPs was relatively obvious for the beneficiaries, as the average mean of perceived quality items was 3.469 (0.933). Likewise, the implementation of PPAPs was considered satisfactory for the beneficiaries, since the average mean of beneficiaries' satisfaction items was 3.920 (0.643). The majority of participants believed that the State Grid was trustworthy in PPAPs, as the average mean of trust in State Grid items was 3.997 (0.786). In addition, the average mean of these two factors was as follows: social influence (3.506; 1.168) and environmental perception (3.504; 0.870), which means that the beneficiaries also gave positive evaluations for the two innovative factors added to the PPAPs.

This study designed the Likert five-point scale, as shown in Table 3. There are 6 latent variables and 21 items in the questionnaire. SI represents social influence, BE refers to behavioral expectation, PQ is perceived quality, and EP denotes environmental perception, BS represents beneficiaries' satisfaction, TSG stands for trust in State Grid. In all measured variables, the kurtosis coefficient (kurtosis) is less than 8, and the skew coefficient (skew) is less than 3. It can be considered that the data are basically in conformity with the normal distribution

Table 2
Descriptive Statistics of the Scale Items (Mean and Standard Deviation).

Constructs	Item	Mean	Standard Deviation
Social Influence	SI 1	3.412	1.2008
	SI 2	3.533	1.1505
	SI 3	3.574	1.1532
	Average	3.506	1.1682
Behavioral Expectation	BE 1	4.558	0.6690
	BE 2	4.568	0.7483
	BE 3	4.489	0.6935
	BE 4	4.697	0.5782
	Average	4.578	0.6724
Perceived Quality	PQ 1	3.319	0.8069
	PQ 2	3.366	0.9413
	PQ 3	3.723	1.0515
	Average	3.469	0.9332
Environmental Perception	EP 1	3.575	0.8340
	EP 2	3.422	0.8779
	EP 3	3.515	0.8982
	Average	3.504	0.8700
Beneficiaries' Satisfaction	BS1	3.860	0.6649
	BS 2	3.871	0.6606
	BS 3	3.843	0.6428
	BS 4	3.955	0.6454
	BS 5	4.072	0.5968
	Average	3.920	0.6432
Trust in State Grid	TSG 1	4.000	0.7461
	TSG 2	4.011	0.7532
	TSG3	3.920	0.8591
	Average	3.9770	0.7861

Table 3
Topic Design of Latent Variables.

Latent variable	Item	Kurtosis	Skew
Social Influence (SI)	SI1 Government officials want me to use solar PV power generation	-0.622	-0.502
	SI 2 The poverty alleviation leader in the village hope that I will use solar PV power generation	-0.248	-0.66
	SI 3 Village leader want me to use solar PV power generation	-0.315	-0.61
Behavioral Expectation (BE)	BE 1 I hope the government will honor its promise and give us the subsidies we deserve	2.656	-1.587
	BE 2 I hope the government will strengthen the maintenance of solar PV power generation facilities	1.984	-1.435
	BE 3 I hope that the solar PV policy will remain stable and not become too fast	1.256	-1.272
	BE 4 I hope the government can provide us with all the support needed for solar PV power generation projects	4.738	-2.064
Perceived Quality (PQ)	PQ 1 I will be able to better manage household energy use	-0.108	0.136
	PQ 2 I will be able to better control household energy expenditure	-0.258	-0.104
	PQ 3 Our community / village will be able to better protect the environment	-0.252	-0.562
Environmental Perception (EP)	EC 1 I am concerned about environmental problems such as air and water pollution caused by excessive use of energy	-0.348	-0.067
	EC 2 I'm worried that excessive use of energy will increase carbon emissions	-0.133	0.065
	EC 3 I worry that excessive use of energy will cause the natural environment to be unable to recover	-0.243	-0.054
Beneficiaries' Satisfaction (BS)	BS 1 How do you think the rationality of collective income distribution of PPAPs	0.895	-0.541
	BS 2 How satisfied are you with the subsidy for PPAPs	0.274	-0.304
	BS 3 How satisfied are you with the follow-up management and protection of PPAPs	1.426	-0.6
	BS 4 How satisfied are you with the implementation of PPAPs	1.463	-0.584
	BS 5 How do you think the sustainability of PPAPs	-0.224	-0.025
Trust in State Grid (TSG)	TSG 1 I believe that State Grid is credible in PPAPs	0.346	-0.483
	TSG 2 I believe that State Grid provides good service in PPAPs	0.609	-0.578
	TSG 3 I believe that State Grid has relations with their customers	1.055	-0.827

Notes: Compiled by the authors according to the questionnaire for this research

Confirmatory factor analysis

From the KMO and the Bartlett sphericity test, the KMO value was 0.800, indicating that the sample data had high validity. The significance level of the Bartlett sphericity test was 0.000 less than 0.005. Therefore, the null hypothesis of the Bartlett sphericity test was rejected and the data was considered suitable for factor analysis. The principal component analysis method was adopted to perform exploratory analysis with the data, and five common factors were set to be extracted, and then the maximum variance method was used to rotate the factor. The factor load matrix after the rotation is shown in Table 4, the factor load values of each measurement item on its associated variable were all greater than 0.50, and the factor load of the cross-measure item did not exceed 0.50, indicating that the scale had good convergence and discriminant validity.

The reliability and validity of the measurement model were further analyzed by using multiple criteria. Firstly, Cronbach's alpha and composite reliability (CR) were adopted to test the internal consistency of the variables. CR values for all latent variables were calculated and found to be not less than 0.70 [21, 24]. As shown in Table 5, the largest value of CR was for SI (0.9438), whereas the smallest value of CR was recorded for TSG (0.8118). Likewise, the Cronbach's alpha values of all latent variables were higher than their critical values of 0.70. SI had the largest Cronbach's alpha value (0.944), while the lowest value of Cronbach's alpha was for TSG (0.805), indicating that the model had a high reliability.

The factor loading value (Estimate) of each latent variable corresponding to the observed variable was considered to test the convergence validity [24]. It was generally required that factor loading value and average variance extracted (AVE) were greater than 0.50. The factor loading values in Table 6 were all greater than 0.5, which were in line with the recommendations of [24]. The model is a very ideal state when the factor loading value was greater than 0.71 and the AVE value was 0.50. Accordingly, it is good when the factor loading value was greater than 0.63, and the AVE value was 0.40 [62]. AVE values corresponding to each latent variable in Table 5 were greater than 0.5, indicating that these variables were in a very ideal state. Though the AVE value of beneficiaries' satisfaction was 0.480, it still indicated that the variable was in a good condition. Therefore, the above shows that the model had good convergence validity. The discriminant validity of latent variables was also tested. If the correlation coefficients were less than the square roots of their corresponding AVE values,

then it can be considered that different variables have obvious discriminant validity [21]. As shown in Table 7, the correlation coefficient of each variable was less than the square root of its corresponding AVE value, so the model is considered to have good discriminant validity.

Furthermore, CFA was involved to test the applicability of the model at first phase. The models' overall fit evaluation indexes were considered, such as absolute adaptation indexes (χ^2/df , RMR, SRMR, RMSEA, GFI, AGFI), value-added adaptation indexes (NFI, RFI, IFI, TLI, CFI), simple adaptation indexes (PGFI, PNFI, CN, PCFI). As shown in Table 8, one index of absolute adaptation indexes (SRMR) was not within the standard level, and SRMR was close to the adaptation standard. To sum up, the theoretical model constructed in this study has a good fit for the sample data.

Finally, a common method deviation test was conducted by considering Harman's single factor [25, 56]. Harman's single factor test for EFA was conducted on 21 observed variables, and was checked with a non-rotation factor solution. It was clearly found that there were no newly recorded factors, and the variation rate of the first factor was recorded as 21.401%. Thus, there was no need to worry about the deviation of the general method of the current research data. According to the suggestion of [56], this value was not higher than 50%.

Table 4
Factor Loading Matrix By Orthogonal Method.

Variable	SI	BE	PQ	EP	BS	TSG
SI 1	0.915					
SI 2	0.916					
SI 3	0.917					
BE 1		0.783				
BE 2		0.821				
BE 3		0.792				
BE 4		0.757				
PQ 1			0.863			
PQ 2			0.879			
PQ 3			0.734			
EP 1				0.844		
EP 2				0.830		
EP 3				0.868		
BS 1					0.805	
BS 2					0.841	
BS 3					0.729	
BS 4					0.797	
BS 5					0.684	
TSG 1						0.775
TSG 2						0.860
TSG 3						0.844

Table 5
Construct Validity and Reliability.

Variable	Cronbach's alpha	CR	AVE
SI	0.944	0.9438	0.8484
BE	0.814	0.8167	0.5277
PQ	0.821	0.8440	0.6484
EP	0.845	0.8239	0.6171
BS	0.840	0.8201	0.4800
TSG	0.805	0.8118	0.5913

Table 6
Standardized Regression Weights
(Factor Loading).

Items	Latent construct	Estimate
SI 1 < - SI		0.907
SI 2 < - SI		0.938
SI 3 < - SI		0.918
BE 1 < - BE		0.764
BE 2 < - BE		0.751
BE 3 < - BE		0.730
BE 4 < - BE		0.656
PQ 1 < - PQ		0.867
PQ 2 < - PQ		0.894
PQ 3 < - PQ		0.628
EP 1 < - EP		0.666
EP 2 < - EP		0.973
EP 3 < - EP		0.679
BS 1 < - BS		0.598
BS 2 < - BS		0.654
BS 3 < - BS		0.687
BS 4 < - BS		0.828
BS 5 < - BS		0.676
TSG 1 < - TSG		0.686
TSG 2 < - TSG		0.828
TSG 3 < - TSG		0.786

Table 7
Discriminant Validity.

Variable	SI	BE	PQ	EP	BS	TSG
SI	0.921					
BE	0.264	0.726				
PQ	0.308	0.143	0.805			
EP	-0.34	0.245	0.28	0.786		
BS	-0.17	0.108	0.085	0.225	0.693	
TSG	0.08	0.029	0.182	0.205	0.182	0.769

Table 8
Fit Indices.

Fit Indices.	Recommended Value	Measurement Model
Absolute Fit Indices		
χ^2/df	≤ 5	4.156
RMR	≤ 0.05	0.046
SRMR	≤ 0.05	0.0545
RMSEA	≤ 0.08	0.058
GFI	≥ 0.9	0.928
AGFI	≥ 0.9	0.903
Value-added Fitness Indices		
NFI	≥ 0.9	0.931
RFI	≥ 0.9	0.916
IFI	≥ 0.9	0.947
TLI	≥ 0.9	0.935
CFI	≥ 0.9	0.947
Minimal Fit Indices		
PGFI	≥ 0.5	0.691
PNFI	≥ 0.5	0.763
CN	≥ 200	283
PCFI	≥ 0.5	0.775

Structural model

In the second phase, AMOS 23.0 was used to test the research hypotheses of the conceptual model. The conceptual model also supported prediction validity. As for the test of the research hypotheses (Table 9), the results of the path coefficient analysis showed that beneficiaries' satisfaction was significantly affected by the role of SI ($\gamma = -0.170, p < 0.001$); BE ($\gamma = 0.108, p < 0.05$); PQ ($\gamma = 0.085, p < 0.05$); EP ($\gamma = 0.225, p < 0.001$). As for the main causal path leading to grid corporation trust, the results supported the significant effect of SI ($\gamma = 0.088, p < 0.05$); PQ ($\gamma = 0.248, p < 0.001$); EP ($\gamma = 0.205, p < 0.001$); BS ($\gamma = 0.182, p < 0.001$). Although BE ($\gamma = 0.029, p > 0.05$) didn't directly affect the beneficiaries' trust in State Grid, it can be indirectly affected by perceived quality. In addition, the results also confirmed that there was an interaction among these factors. For example, BE ($\gamma = 0.264, p < 0.001$); PQ ($\gamma = 0.308, p < 0.001$); EP ($\gamma = -0.0340, p < 0.001$) will be affected by social influence, while PQ ($\gamma = 0.143, p < 0.001$); EP ($\gamma = 0.245, p < 0.001$) will be affected by behavioral expectation, and perceived quality will also affect EP ($\gamma = 0.245, p < 0.001$), as shown in Fig. 2.

Table 9
Results of Hypotheses Testing.

Research Hypotheses	Hypothesized Path	Unstandardized Path Coefficient Estimation	S.E.	C.R.	P	Standardized Path Coefficient Estimation	Accept / Reject	VIF
H1	BE< – SI	0.124	0.017	7.093	***	0.264	Accept	1.000
H2	PQ< – SI	0.198	0.023	8.508	***	0.308	Accept	1.056
H3	EP< – SI	-0.173	0.022	-8.047	***	-0.340	Accept	1.196
H4	BS< – SI	-0.062	0.016	-3.944	***	-0.170	Accept	1.256
H5	TSG< – SI	0.041	0.020	2.116	0.034	0.088	Accept	1.288
H6	PQ< – BE	0.195	0.052	3.722	***	0.143	Accept	1.056
H7	EP< – BE	0.267	0.044	6.038	***	0.245	Accept	1.086
H8	BS< – BE	0.084	0.033	2.545	0.011	0.108	Accept	1.131
H9	TSG< – BE	0.029	0.041	0.703	0.482	0.029	Reject	1.136
H10	EP< – PQ	0.223	0.033	6.823	***	0.280	Accept	1.200
H11	BS< –PQ	0.048	0.024	1.998	0.046	0.085	Accept	1.269
H12	TSG< –PQ	0.182	0.031	5.893	***	0.248	Accept	1.277
H13	BS< – EP	0.161	0.030	5.344	***	0.225	Accept	1.128
H14	TSG< –EP	0.189	0.038	5.020	***	0.205	Accept	1.157
H15	TSG< – BS	0.234	0.053	4.427	***	0.182	Accept	1.075

The variance inflation factors (VIF) were tested to ensure that there was no multicollinearity between independent factors and dependent factors. Table 9 indicated that VIF values of all causal associations were not higher than 10, meaning that there was no problem of multicollinearity [7, 15]. The direct, indirect and total effect values of each research path were further explored. As shown in Table 10, the largest impact on beneficiaries' satisfaction was for EP (0.225), followed by SI (0.170), then BE (0.108) and PQ (0.085). Whereas the greatest impact on grid corporation trust, was recorded for PQ (0.333), followed by EP (0.246), then BS (0.182), BE (0.156), and SI (0.117). The indirect effect (0.128) of behavioral expectation on trust in State Grid was greater than its direct effect (0.029). The total effect value of behavioral expectation on environmental perception was 0.285, which was greater than the total effect value on BS (0.185), TSG (0.156), and PQ (0.143). It shows that behavior expectation affects the trust in State Grid more through environment perception and beneficiaries' satisfaction, and the influence of environment perception on the trust in State Grid is greater.

Table 10
Direct Effect, Indirect Effect and Total Effect Value of Each Path.

Hypothesized Path	Direct Effect value	Indirect Effect value	Total Effect Value
BE< – SI	0.264	-	0.264
PQ< – SI	0.308	0.038	0.346
EP< – SI	-0.340	0.162	-0.178
BS< – SI	-0.170	0.018	-0.153
TSG< – SI	0.088	0.029	0.117
PQ< – BE	0.143	-	0.143
EP< – BE	0.245	0.040	0.285
BS< –BE	0.108	0.076	0.185
TSG< – BE	0.029	0.128	0.156
EP< – PQ	0.280	-	0.280
BS< – PQ	0.085	0.063	0.148
TSG< – PQ	0.248	0.084	0.333
BS< – EP	0.225	-	0.225
TSG< – EP	0.205	0.041	0.246
TSG< – BS	0.182	-	0.182

Discussion

The results of the path coefficient analysis confirmed most of the proposed hypotheses. As shown in Table 9, environmental perception was the most influential factor predicting beneficiaries' satisfaction. This proves the importance of environmental perception in the residents' satisfaction of PPAPs. Rural residents mostly rely on planting crops as their main source of income, while their incomes are affected by the air or water pollution and extreme weather. Compared with traditional energy sources, the use of solar PV can greatly improve the current environmental situation. Therefore, rural residents are satisfied with PPAPs as they believed that PPAPs can alleviate the current environmental problems. There was a significant positive effect between passengers' environmental perception and satisfaction [76]. The State Grid is involved in dealing with PV power generation and grid connection issues. Power supply stability can promote the extensive use of clean energy and reduce the use of traditional fossil fuels [30]. Therefore, as residents have stronger perception of the environment, they can understand better that the efforts made by the State Grid will effectively solve environmental problems. Then, they are more likely to trust the State Grid. Some researches indicated that with higher individuals' understanding of information literacy, more people will trust the website [35].

Social influence had a negative effect on beneficiaries' satisfaction, while it had a positive effect on the trust in State Grid. The result is different from the previous researches [3, 9, 28]. Their research found that social influence had a greatly positive impact on users' satisfaction. Users can understand the products' quality and situation through multiple channels of the network, so their satisfaction about the product was higher after adoption. In this study, most beneficiaries are poverty-stricken households, whose understandings of the projects are mainly through the recommendation and publicity of village leaders, etc. There are multiple gaps between the high expectation and the actual benefits of the projects, resulting in the lower satisfaction of residents with PPAPs. It is reasonable for the residents to have a lower satisfaction with PPAPs in a short term, but this cannot prove that the residents won't be perceived positive satisfaction from the long run.

According to the results, perceived quality was confirmed to have the strongest positive effect on the trust in State Grid and have a positive effect on beneficiaries' satisfaction. As for the State Grid, its main responsibility is to ensure the efficient generation of PV panels. This will not only bring efficient use of household energy and cost savings to beneficiaries, but also further improve the environmental quality. Therefore, the residents only perceive the reduction in household energy consumption and the improvement in environmental quality, and they will believe that the State Grid has fulfilled their responsibilities. This is similar to the results by Sarkar and Chen [12, 58]. Furthermore, the residents were satisfied with PPAPs when they realized that a more energy-efficient method can bring benefits for their families and communities. In previous researches, the users' perception of solar home systems' benefits and the reduction in their energy costs had a critical impact on their satisfaction [34].

Behavior expectation can directly facilitate beneficiaries' satisfaction, but indirectly encourage their trust in State Grid. At present, PPAPs still rely on government publicity and support. Therefore, if the government can promulgate policies, subsidies and other support for solar PV in time, the residents' satisfaction with PPAPs will be enhanced, which was similar to the results found by Zhang and Shen [59, 71]. In this paper, behavior expectation refers to the residents' expectation on the government's support on PPAPs, so it may not have a direct significant impact on their trust in State Grid. But when the residents actually realize the benefits of PPAPs in their lives, such as reduction in household energy expenditure, they may believe that the State Grid plays a vital role in PPAPs. In this way, their trust in State Grid can be enhanced. Therefore, even though behavior expectation had no direct effect on the trust in State Grid, it can be an essential factor for the trust in State Grid through perceived quality. Likewise, customer expectation was confirmed to have an indirect role in promoting social trust [47].

The results of this study supported the hypothesis that beneficiaries' satisfaction had a positive impact on the trust in State Grid. This indicates that the more satisfied the residents are with PPAPs, the more they will trust in State Grid. China State Grid implement "one-stop service" to ensure safe and stable operations of PV equipment, whether it is in the early stage, mid-stream maintenance, or later tracking services, etc. However, these all involve the relationship between beneficiaries and the State Grid. When the residents are satisfied with PPAPs, meaning that they are satisfied with the services provided by the State Grid, then they will rely on State Grid and continue to participate in PPAPs. The predecessors also found a significant role between trust and customers' satisfaction [32, 57]. Inadequate power supply and unreliable power service will lead to end-users' dissatisfaction with power service [60].

Theoretical implications

As discussed in the literature review, few scholars have studied the direct relationship between satisfaction and trust from the perspective of beneficiaries. In addition, most satisfaction models were based on ACSI [20] to test customers' satisfaction or explore the relationship between satisfaction and users' complaints [29], loyalty [45] or adoption willingness [3].

This study, hence, establishes an integrated model based on ACSI and UTAUT with the dimension of "environmental perception" to examine the beneficiary perception about the environmental benefits of PPAPs, and provides a new dimension and theoretical models for critical aspects that beneficiaries should consider in the process of building PPAPs' satisfaction.

Limitations And Future Research Directions

Although this study has enriched our understandings of the current implementation of PPAPs in China, some limitations still exist. Firstly, the data used in this paper are cross-sectional due to the fact that the implementation period of PPAP in China is not long. The data can reflect the current views of the beneficiaries on the projects, but it cannot show the changed satisfaction of the beneficiaries in the process of PPAPs. Therefore, in the future researches, longitudinal research is needed to find out the factors that affect the PPAPs' beneficiaries' satisfaction over time. Secondly, although the current research model covers many factors, other factors involving household energy usage, rural residents' cognition, and power supply stability before and after project implementation, etc. can also be considered in the future researches to fully explain the reasons for affecting the sustainable development of PPAPs. In

addition, this study has not considered the impact of family cultural factors (such as energy saving habits, family size and lifestyle). Future studies will ponder over these cultural aspects to enrich current understandings of the main factors that hinder or support the success of PPAPs.

Conclusions

This study attempts to provide more understandings about what may affect beneficiaries' satisfaction with PPAPs and their trust in State Grid. Behavioral expectation (BE) and perceived quality (PQ) were used to predict beneficiaries' satisfaction in this paper. Environmental Perception (EP) was also considered as the unique features of PPAPs. Thus, this further provides a more practical and empirical understanding of the main factors that should be considered in the sustainable development of solar PV. Finally, this study intends to propose the following policy recommendations from the behavior of the government, village leaders, and State Grid.

1. Environmental perception was the most influential factor predicting beneficiaries' satisfaction. It means that only when residents' environmental perception is enhanced, they will be more satisfied with PPAPs and adopt solar PV. The Chinese government and village leaders, therefore, should explain the current environment problems to residents for boosting the use of daily energy, and make concerted effort to help residents better understand that solar PV can bring more environmental benefits comparing with traditional energy (including coal, fuel wood, straw, etc.). Furthermore, environmental perception also has a crucial impact on the trust in State Grid. The State Grid also should promptly explain the current implementation of renewable energy projects to residents. By doing this, they can understand the improvement of environmental problems caused by these projects. Only by enhancing the environmental perception of the residents, can their satisfaction and trust in State Grid be increased.

2. Social influence had a negative impact on beneficiaries' satisfaction and a positive impact on the trust in State Grid. In fact, if the government or village leaders excessively force the residents to participate in the PPAPs, it may not bring good results, making the residents feel resistant instead. Therefore, the government or village leaders should enhance residents' understanding of PPAPs by conducting appropriate publicity and education. Otherwise, through sharing their personal experience of using PPAPs and recommending suitable PPAPs' type to residents. When promoting PPAPs with residents, the government or village leaders should also first let the residents fully understand the credibility of the State Grid in solar energy projects, so as to increase trust in State Grid.

3. Perceived quality had the most important impact on trust in State Grid. In order to enhance the residents' quality perception of household energy usage and expenditure, the government and village leaders should first explain the operation, maintenance, service and quality assurance of PPAPs' throughout the process to residents. At the same time, in order to ensure the reliability of the data obtained by the beneficiaries and the professional quality of the equipment, the State Grid's technicians should implement full-tracking services and regularly maintain the equipment in PPAPs, thus the residents may learn more about the transformation of the quality of household energy. The low quality of equipment and high energy costs both have a negative impact on the satisfaction of households using solar PV [34]. Therefore, learning about the integration of the PPAPs' implementation process can improve residents' perceived quality.

4. Behavioral expectation had a direct impact on beneficiaries' satisfaction and an indirect impact on the trust in State Grid. The residents expect the government's subsidies, policies and maintenance of facilities. Affected by the epidemic, the country has made appropriate adjustments to the distribution of PV poverty alleviation benefits and electricity prices. These policy changes should be greatly publicized by the local government and village leaders. And then residents can perceive the government's full support for PPAPs. Accordingly, the State Grid should also adjust electricity prices in a timely manner so that residents can perceive improvements in household energy quality, promoting their trust in grid corporations in an underlying manner.

Declarations

- **Ethics approval and consent to participate**

Not applicable

- **Consent for publication**

Not applicable

- **Availability of data and materials**

Not applicable

- **Competing interests**

The authors declare that they have no competing interests

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- **Authors' contributions**

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Figures

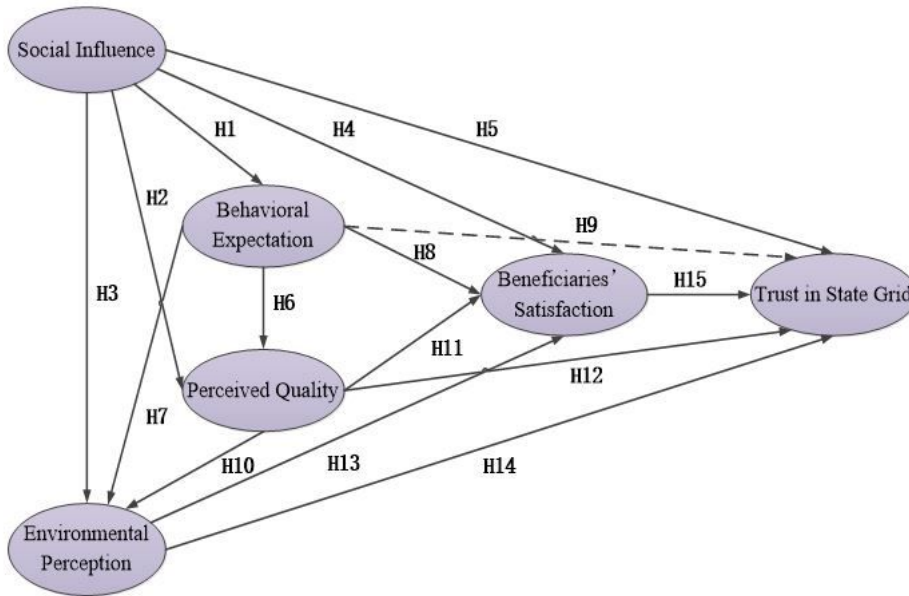


Figure 1

Conceptual Model of Beneficiaries' Satisfaction Index

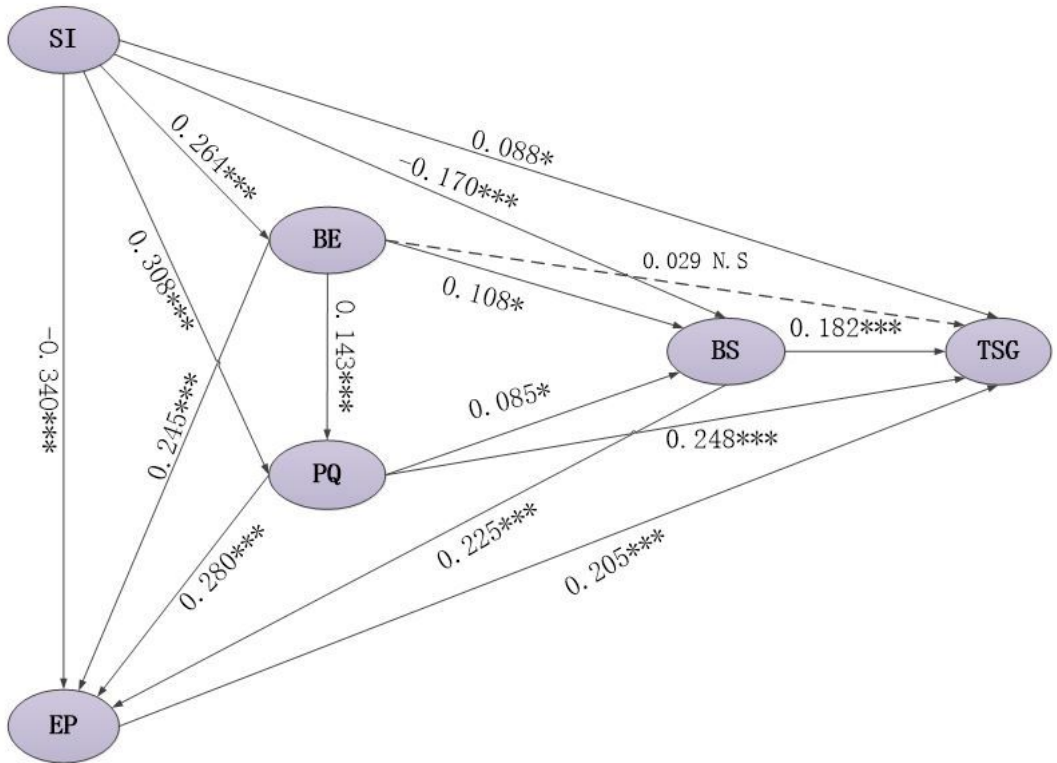


Figure 2

Validation of the Conceptual Model. Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.