RESEARCH ARTICLE

Influencing factors of consumers' buying intention of solar energy: a structural equation modeling approach

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Abstract

Due to China's massive usage of fossil fuels, climate change concerns have become serious challenges to the country's sustainable development. Despite the fact that China has effectively employed solar technology to address these problems, there is a paucity of research examining consumers' intention to adopt solar energy in the rural region of China. This study intends to fill this gap in the literature by studying consumers' buying intentions for solar energy in rural China for household purposes. Additionally, the study added to the theory of planned behavior by adding three new variables, namely, environmental knowledge, environmental concern, and beliefs about the benefits of solar energy. Primary data were collected from 847 respondents in Hebei Province using a comprehensive questionnaire survey. Structural equation modeling was employed to examine the data. Empirical results revealed that attitude, environmental knowledge, subjective norm, perceived behavioral control, and beliefs about the benefits of solar energy positively influence buying intention of solar energy. On the contrary, environmental concern had no significant effect on buying intention for solar energy. Study outcomes emphasize the critical significance of changing societal norms, boosting consumer awareness, redesigning regulatory mechanisms, and stressing the benefits provided by solar power through coherent and persistent efforts while simultaneously enhancing environmental sustainability practices.

Keywords Buying intention · Solar energy · Theory of planned behavior · Structural equation modeling · Green energy technologies

Introduction

Massive dependence on thermal energy sources imposes a strain on the national economy and contributes to a variety of environmental issues, including climate change, greenhouse gas emissions, and unusual weather patterns (Hao et al. 2020; Wu et al. 2021). Natural resources are being depleted due to the overuse of conventional fuels (Liu et al. 2022). Therefore, it is necessary to build a new energy framework (Wang et al. 2022; Yang et al. 2022). Renewables will be employed in this modern energy system, which may

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bring down the price of imported oil and ameliorate climate issues (Tanveer et al. 2021). In this regard, solar power is viewed as a viable means to combat environmental change and address climate problems (Liang et al. 2022). Numerous economies have made measures to increase solar energy's part in their energy portfolios. Residents' quality of life may be improved in several ways through solar power initiatives. For instance, solar energy may reduce emissions, creates new employment possibilities for inhabitants that promote economic development, provides inexpensive energy, and is anticipated to stabilize future power costs (Irfan et al. 2020).

The deployment of solar energy in China is critical for three fundamental reasons, as shown by past research. *Firstly*, the conventional fossil-fuel reliance strategy for electricity production failed to provide the desired results for addressing climate change issues in the country and was a failure (Luo et al. 2022). *Secondly*, China has been acknowledged as an economy having climate vulnerability challenges. Nonetheless, reliance on traditional thermal power might bring the country to an unfavorable climate change position (Bai et al. 2022). Lastly, China has massive solar power potential that, if adequately used, might mitigate the current climate and energy challenges (Sun 2020).

Prior research was conducted mostly in nations with well-defined carbon emission reduction policies. For example, Heiskanen and Matschoss (2017) conducted a research in Europe and found that age, education, and income had a substantial impact on the likelihood of families adopting renewable energy. Li et al. (2020) analyzed Australia's transition to renewable energy sources. Results revealed that the country is aggressively adopting renewables, positively impacting the climate. Likewise, Jamil et al. (2015) analyzed the deployment of renewables in the United Arab Emirates. The analysis revealed that despite its abundant oil sources, the country is growing the renewable industry to combat carbon footprints in the future.

However, social acceptability and buying intentions of renewable energy, particularly solar energy, in developing nations have been examined by few researchers. In this context, Yazdanpanah and Forouzani (2015) surveyed to investigate students' buying intention towards renewable energy. According to the survey findings, attitude, moral norms, and perceived behavioral control substantially impact respondents' buying intention of renewable energy. Mosly and Makki (2018) investigated the societal propensity to adopt renewables. Researchers concluded that as educational attainment rises, so does knowledge of renewable. Similarly, age and economic circumstances are key factors of renewables' acceptance. Yuan et al. (2015) performed a study in the Chinese province of Shandong to determine the societal acceptability of wind power. Residents have a good opinion of wind energy, according to the survey findings. Nonetheless, their willingness for measures such as installing wind

turbines in their backyards or accepting increased power bills lowers. Low consumers' readiness impedes solar energy penetration and prevents the achievement of national goals, indicating that consumers' buying intention plays a crucial role in the deployment of solar energy (Hai 2019).

Until now, the majority of studies has focused on examining these relationships within the following dimensions: (i) different power sources, rivalry, and power generation potential (Ren et al. 2021); (ii) the effect on economic development, environmental pollution reduction, and economic expansion; and (iii) the barriers to the adoption of solar energy. Some scholars have seen the impact of intent aspects such as knowledge, attitude, social norms, perceived behavioral control, and solar energy costs (Alsabbagh 2019; Jabeen et al. 2021). Though the new factors (proposed in this study), such as environmental concern, environmental knowledge, and beliefs about the benefits of solar energy, which could influence consumers' buying intention of solar energy are discussed to some extent in previous literature with the integration of TPB, researchers used these factors in different time and regions with different findings. Furthermore, in the case of China, these novel factors were never taken into account in any setting before, which warrants a comprehensive analysis. This study gap motivated us to contribute to the available body of knowledge by understanding consumers' buying intention of solar energy in China.

In this regard, three main contributions are drawn by this study. *Firstly*, in contrast to earlier research, this study addresses a gap in the literature by examining all of the elements that may influence solar energy buying intention. According to the best of the authors' knowledge, this is the first study undertaken in China's Hebei Province to determine consumers' buying intention of solar energy. Due to recent economic development and massive population growth, the province is facing severe energy-related challenges, necessitating the urgency to perform comprehensive research to determine the social acceptance of solar energy technologies. *Secondly*, the theory of planned behavior (TPB) is expanded by integrating 3 unique dimensions, which may impact consumers' buying intention. Incorporating these factors for the first time in the Chinese context is a further contribution made by this work that other scholars have not done. *Finally*, the current study extends the research results in a manner distinct from earlier studies. For example, environmental knowledge proved to be a critical dimension in solar energy adoption. In the same vein, beliefs about the benefits of solar energy remain a crucial component of TPB's theoretical framework. In contrast, environmental concern has little impact on solar energy acceptability.

This research comprehensively investigates the propensity of Chinese customers to adopt solar energy by combining current and proposed novel factors. Concerning the significance of the study results, although the research was conducted in

a specific region (China), the implications of the study findings indicate households' intention characteristics to use solar energy. China can meet all of its existing and future energy needs if its rich solar energy resources are used effectively (Chen et al. 2017). Nonetheless, China is an emerging economy, confronting numerous challenges to the growth of solar power, such as technological limitations, the reluctance of inventors to participate in solar energy schemes, and governmental, and financial impediments (Liu 2018). The variables mentioned above and the continuing energy issues are also prevalent in other emerging economies. Along these lines, the findings of this study are not region-specific but are transferable to other emerging economies and specify the influence of intention factors on solar power utilization. The example of China can be used as a typical illustration to govern this phenomenon. Consequently, the experiences obtained from this study will provide important lessons for other countries during the formulation of solar energy-related strategies.

The rest of the study is divided into different sections: theoretical framework and hypotheses development are provided in the "Research framework and formulation of hypotheses" section. Research methods are elaborated in the "Methods" section. Data analysis is given in the "Data analysis" section. Discussion and implications are provided in the "Discussion" section. Finally, a conclusion is provided in the "Conclusions and policy recommendations" section, along with valuable and essential policy proposals.

Research framework and formulation of hypotheses

Consumers' decision-making is a complicated process; several factors influence the purchase decision, including social, psychological, and economic factors. Many researchers proposed different frameworks to know consumers' buying intention (Shakeel et al. 2018), for instance, self-efficacy theory, the theory of reasoned action, social cognitive theory, and the TPB. However, TPB was adopted and constantly remained notable among all research frameworks (Madden et al. 1992). This theory predicts individuals' intention to perform such behavior. Based on this theory, we establish the theoretical framework (see Fig. 1).

With TPB's model, consumers' behavior can be identified and forecasted. Many scholars expanded the theoretical model to better understand why some people cannot keep good intentions (Abreu et al. 2019; Bashiri & Alizadeh 2018; Walters et al. 2018). In addition to the fundamental components of the TPB model, the model can integrate other essential factors that influence consumers' behavior specifically. We thoroughly studied previous literature and incorporated three additional variables, i.e., environmental knowledge, environmental concern, and beliefs about the benefits of solar energy, with other variables with the TPB model to inquire about the buying intention of solar energy technologies. Environmental concern had an insignificant effect on buying intention of solar energy technologies as people do not care about saving the environment through sustainable consumption. While the other factors, i.e., environmental knowledge, beliefs about the benefits of solar energy, and other TPB variables, significantly affected buying intention of solar energy technologies.

Attitude

Attitude has been recognized as a predictor of behavior (Casaló & Escario 2018). Ajzen (1985) opined that people with a positive attitude towards action should perform the

Fig. 1 Theoretical framework
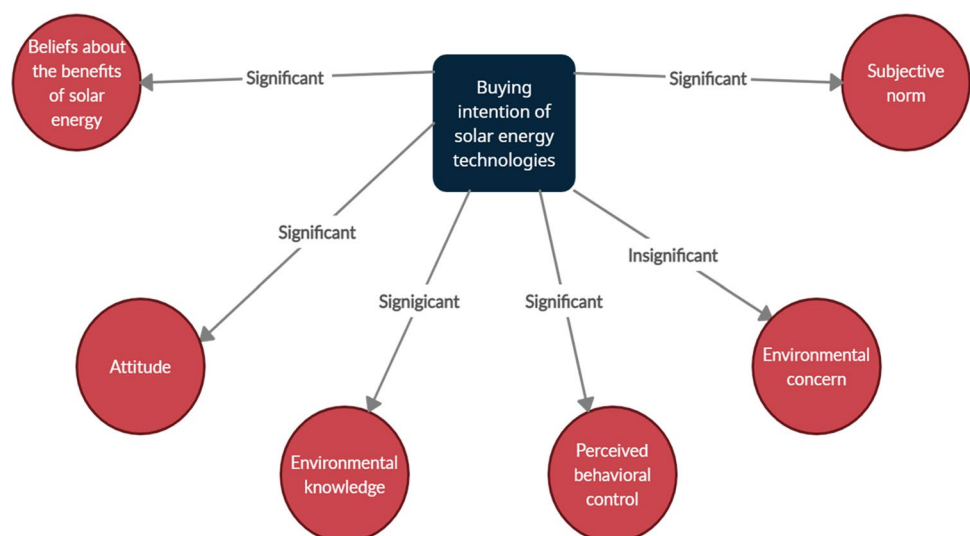
desired action. In addition to other independent variables of TPB, the relation between attitude and behavior specifying the degree to one's advantageous or non-advantageous assessment of the behavior remains a query (Ajzen 1991). Wang et al. (2011) explain attitudes as people's understanding of power-saving behavior mainly leaning on evaluating power-saving partiality and the information individuals hold for such behavior. Greaves et al. (2013) concluded that attitude towards behavior represents a person's total behavior assessment, based on the belief that the behavior will produce the desired results. Several studies show that green attitudes are essential predictors of pro-environmental behavior (Yadav & Pathak 2016). Greaves et al. (2013) researched a sample of 2000 staff of a specific company in the UK through TPB. The study shows that attitudes and extended TPB variables consist of significant divergence in staff ambitions to engross environmental behaviors, including energy preserving by switching computers off. Based on this debate, the following hypothesis was formulated:

H1: Attitude is positively related to buying intention behavior of solar energy technologies

Environmental knowledge

According to Zsóka et al. (2013), ENK means "knowledge and awareness about environmental problems and possible solutions to those problems." People tend to avoid situations where uncertainty and knowledge are insufficient to guide behavior. Therefore, people with high ENK are impatient to carry out eco-friendly behavior (Frick et al. 2004). Individuals with positive ENK recognize their activity's outcomes on the environment; this realization establishes action-based knowledge in their cognitive psychology. Pothitou et al. (2016) conducted a household survey evaluating the influence of ENK and knowledge on energy issues on potential pro-environmental behavior. A study confirms that people with more knowledge (about energy) are more likely to buy renewable energy (Zografakis et al., 2010). Thus, it shows a strong association with ENK and BISETs and is formulated as follows:

H2: ENK is positively related to buying intention behavior of solar energy technologies

Environmental concern

Environmental concern (ENC) is defined as people's understanding of environmental problems and their eagerness to fix these complications (Hoang et al. 2019). Consumers with more ENC tend to react positively regarding attitudes,

which positively impacts behavioral intentions. From a policy point of view, environmental issues may be an incentive because environmental issues seem to be liberated from the attractiveness and worthwhile of energy-efficient behavior (Urban & Ščasný, 2012). ENC is an important variable in studying environmental behavior (Albayrak et al., 2013). ENC is mainly said to be the environmental attitude in different studies, which means one's opinions affect the motive regarding environmental behavior (Chan et al. 2014). Some empirical studies positively relate the overall importance of the environment associated with a product and consumer satisfaction (Y.-S. Chen et al. 2015). On the other hand, Zhang et al. (2015) determined ENC as the acknowledger self-observed liability for energy conservation. Thus, environmental concern has a relationship with buying intention of consumers and is formulated as follows:

H3: ENC is positively related to buying intention behavior of solar energy technologies

Subjective norm

A perceived social provocation of performing or not performing a certain behavior is labeled as subjective norm (SBN) (Ajzen, 1991). Gadenne et al. (2011) detect a strong linkage between subjective norms and consumers' intentions regarding the environment and energy-saving behavior. SBN also means an individual's feelings of social pressure faced by other individuals or groups of people (Chen & Tung 2014). In Korea, SBN directly affects consumers' buying intention for energy-efficient appliances (Ha & Janda 2012). López-Mosquera et al. (2014) concluded that SBN would either motivate or obstruct an individual's act if there is social pressure. SBN is a significant role player in energy saving or buying intentions of green energy (Zhang et al. 2015). The above statements show a positive relationship between subjective norm and buying intention of green energy technologies, so we put forward the following hypothesis:

H4: SBN is positively related to buying intention behavior of solar energy technologies

Perceived behavioral control

Perceived behavioral control (PBC) refers to an individual's comprehended mitigate or struggles in carrying out precise behavior (Ajzen 1991). Wang et al. (2014) revealed that PBC significantly affects behavioral aims among Chinese inhabitants in the viewpoint of energy-saving behavior. PBC significantly affects small-scale households' sustainable energy utilization intention (Alam et al. 2014). Klöckner (2013) elaborated that it estimates an individual's degree of

possessing chance and capacity to bring off a behavior. PBC is part of the most popular TPB theory and is elaborated in many research fields, including purchasing behavior and intentions. Different authors refer to it in recent studies in different fields, and it is verified as a substantial factor of behavioral intention (López-Mosquera et al., 2014). PBC is stalwartly related to one's beliefs concerning the influence of situational and internal factors to facilitate the behavior. If there is a check over the energy-saving of such a product, it will most probably be used by that individual (Alam et al. 2014). The above discussion shows that there is a positive relationship between perceived behavioral control and buying intention of green energy technologies. Along these lines, we put forward the following hypothesis:

H5: PBC is positively related to buying intention behavior of solar energy technologies

Beliefs about the benefits of solar energy

Devine-Wright (2005) elaborated that many households in the UK support renewable energy development. The research results depicted that local consumers' interest in using renewable energy products was high while the number of locals was low. Diakoulaki et al. (2001) described that installing and operating renewable energy systems can benefit three categories: decrease in environmental pollution, energy-saving, and generation of new working posts. One of the authors believes that social acceptance of renewable energy technologies is not yet on the shelf other than the actual deployment of renewable energy technologies and policies (Sposato & Hampl 2018). The most significant benefit of solar energy sources is a decrease in pollution of the environment. It is only possible by reducing other fuel-based energy production systems (Kalogirou 2004). It shows a positive outcome upon the usage of S sources and its benefits on RE technologies so that the hypothesis will be as follows:

H6: BSE is positively related to buying intention behavior of solar energy technologies

Buying intention of solar energy technologies

A previous study confirmed that Canadian peoples' intention to purchase solar energy technologies is influenced by visual publicity of these technologies, engagement of the public, and perceived knowledge (Parkins et al. 2018). Their results depict the vital significance of solar technology to people who intend to purchase it. Yuan et al. (2011) assessed social acceptance from an end-user perspective in Shandong province. The results showed significant high-level acceptance of solar water heaters. Hsu (2018) conducted research on local

consumer solar installations in California and revealed that cities with high proportions of pro-environment, larger population size, and municipal utilities are more interested in solar energy technologies and processes. Aklin et al. (2018) examined the social acceptance of solar power in rural areas of northern India. The findings show a manipulation from private businesses in which the cost of solar energy with conventional grid energy limits locals from accepting solar energy technology. Although many studies are conducted on the acceptance or adoption of SE technologies, a standard TPB was used to get results (Perri et al. 2020).

Methods

Target population

Our study specifically targeted the rural areas of Hebei province of China, including Anxin, Boye, Dingxing, Fuping, and Gaoyang. China is focusing on developing underdeveloped regions. It is being noticed that many rural dwellers are slowly shifting towards populated and developed cities, searching for good opportunities, education, and businesses. China is the main hub of green energy production, while some rural regions still deploy green energy solutions to prevent further environmental damage. Demographically rural inhabitants are unaware of purchasing green energy technologies, as they are less aware of new technology. Hence, we selected these cities to determine our research outcomes. We selected these regions depending on their population size. Anxin has a population of 513,000, while Boye has 272,000, Dingxing 610,000 M, Fuping 230,000, and Gaoyang 325,000, respectively (National Bureau of Statistics of China 2021). These areas are less populated, and the growth ratio regarding development is slightly low, due to which these regions got mere attention for analysis purposes.

Due to the recent pandemic, some hurdles were faced with collecting the data. Due to language barrier to collecting data accurately from respondents, we performed an online questionnaire survey. The area was far from the current residence city, with COVID-19 waves and restrictions on moving to other cities, which led us to opt for an online survey strategy. All the items were analyzed using a 5-point Likert scale from 5 "strongly agree" to 1 "strongly disagree." Considering the scale, we had a sample size of 1000 respondents, of which 847 valid responses were collected for analysis purposes.

Developing questionnaire

Table 1 reports data sources and questionnaire development. The questionnaire consists of two sections. "Introduction" section has five questions, related to demographics,

Table 1 Sources of measurement

Variables	No. of items	Source
ATD	7	(Chou et al. 2015; Yazdanpanah & Forouzani 2015)
ENC	5	(Bang et al. 2000; Hartmann & Apaolaza-Ibáñez 2012)
SBN	7	(Chen and Tung 2014)
PBC	4	(Alam et al. 2014)
ENK	5	(Kaiser et al. 1999)
BSE	7	(Hartmann & Apaolaza-Ibáñez 2012; Liu et al. 2013)
BISETs	4	(Chou et al. 2015; Yazdanpanah & Forouzani 2015)

including gender, age, education, income, and occupation. "Research framework and formulation of hypotheses" section consists of 39 questions based on each construct to assess the findings of our proposed research. In these parts, we had seven questions for subjective norms, seven for beliefs about the benefits of solar energy, seven for attitude, five for environmental concern and environmental knowledge, and four for PBC and BISETs. Questionnaire details are provided in the Appendix.

Data analysis

We used AMOS (26.0) for structural equation modeling and the statistical program for social sciences (SPSS 26.0) to conduct our research analysis. To check the relationship between each variable, SEM is used to get meaningful and valid results (Steenkamp & Baumgartner 2000). Keeping account of measurement errors, SEM measured all the dependent and independent variables, while most other methods cannot estimate measurement error (Sardeshmukh & Vandenberg 2017). We opted for this technique due to its robustness and reliability in results (Belaïd 2017). Based on these arguments, it is evident that SEM is the best and most efficient method to evaluate relationships among all the variables. Table 2 presents the descriptive statistics.

Table 2 Descriptive statistics

Variable	Observations	Items	Mean	Std. dev	Coefficient of variation (CV)
ATD	847	7	3.631	0.590	0.162
ENK	847	5	2.812	1.509	0.537
ENC	847	5	3.324	0.354	0.106
SBN	847	7	3.919	0.576	0.147
PBC	847	4	2.603	0.661	0.254
BSE	847	7	2.906	1.763	0.607
BISETs	847	4	3.936	0.564	0.143

Dependent variable: BISETs

Participants' profile

Most respondents fall in the male category with a total of 493 (58.2%), while females were around 354 (41.8%). In addition, the young respondents aged 19–28 were 132 (15.58%), respondents aged 29–38 were 253 (29.87%), and 39–48-year-old respondents were 259 (30.57%) in majority from all age ranges, followed by respondents aged 49–58 years who were 157 (18.54%) and respondents aged above 58 who were in low quantity (46, 5.44%). On the other hand, 87 (10.27%) respondents belong to low education below the secondary level, which is the lowest. We also go through their income; respondents with income below 1500 RMB[1] were 259 (30.58%), while a majority of them (316 (37.31%)) have income ranging from 1501 to 3000 RMB, followed by 3001–5000 RMB in 125 (14.76%) respondents, and 147 (17.35%) respondents fall above 5001 RMB income. For occupation, there were 259 (30.58%) respondents with their own business, 213 (25.15%) employed as government person, 325 (38.37%) having a private job, and 50 (5.9%) being freelancers. Statistics are shown in Table 3.

Discriminant validity and convergent validity tests

We used correlation analysis to check the interrelationship between variables, and after analyzing the test, the results showed a significant correlation between variables. Applying the square root of the average variance extracted, we investigated discriminant validity. The results generated support for discriminant validity, as the square root of AVE is greater than its correlation with other variables (Ahmad et al. 2020). An alternate method to discover discriminant validity is by comparing AVE by MSV value with all variables. If AVE is greater than MSV, discriminant validity is achieved (Fornell & Larcker 1981). The results support AVE values of variables greater than MSV values. After that, we conducted convergent validity analysis using AVE and item loadings to check the potential association between these items (Wong 2013).

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[1] 1RMB is Chinese currency.

Table 3 Participants' profiles (N = 847)

Item	Description	Frequency	Percentage (%)
Gender	Male	493	58.2
	Female	354	41.8
Age	19–28	132	15.58
	29–38	253	29.87
	39–48	259	30.57
	49–58	157	18.54
	Above 58	46	5.44
Education	Below secondary	87	10.27
	Secondary school	181	21.37
	Bachelor's degree	339	40.02
	Master's degree	147	17.36
	Doctoral degree	93	10.98
Income	Below 1500 RMB	259	30.58
	1501–3000 RMB	316	37.31
	3001–5000 RMB	125	14.76
	Above 5001 RMB	147	17.35
Occupation	Own business	259	30.58
	Govt employee	213	25.15
	Private job	325	38.37
	Freelancer	50	5.9

Results confirm that the AVE values for every variable are greater than 0.5, which clears that these variables hit the benchmark and have 50% more variance. The test is shown in Table 4.

Reliability analysis

To validate regarding reliability of each item, we employed Cronbach-α. The minimum acceptable value of Cronbach-α is 0.70, and the results indicate that all variables crossed the benchmark (Anderson & Gerbing 1988). To investigate the consistency of all variables items, we endorse composite reliability (CR) analysis. The results depict higher values of CR than the suggested value of 0.70 (Hair et al. 2017). Table 5 provides the results.

Multicollinearity

A regression test is executed to check the multicollinearity issues to find tolerance and variance inflation factor (VIF) values. The value of VIF should not be greater than 0.1 (Field 2013). According to the results, this model does not have any multicollinearity issues because values of VIF and tolerance are within the suggested range of each variable and are in line (Strupeit & Palm 2016). The results are shown in Table 6.

Factor analysis

EFA has opted to obtain contributing design structure as it investigates factor structure in which relation of variables and grouping between them depending upon inter-variable correlations is to be found (Mahmood et al. 2019). We used the maximum likelihood method to extract the variables and analyzed them with promax Kaiser normalization to gain valid outcomes. The number of variables was determined with the help of eigenvalues. We performed different tests and methods to examine whether EFA is fit to be applied to data (Deng et al. 2013). To check the fitness of the data, we performed the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity (BTS). The outcomes indicate the value of 0.979 for KMO and prove to continue factor analysis further (Kaiser 1974), while on the other side, BTS reveals a value of 9945.37. Analogously, communality result values indicate that all variables have a higher number than the minimum benchmark value of 0.4 (Table 7) (Osborne et al. 2011).

The data was further scrutinized by utilizing confirmatory factor analysis (CFA) to identify the model. It approves the structure of the factors gained in EFA. For identification, we evaluated the uni-dimensionality of the model. Items consisting of robust loadings are sustained (more than 0.7) (Truong et al. 2020). Finding reveals that all item loadings were above the benchmark of 0.7 (see Fig. 2). All the data

Table 4 Correlation, discriminant validity analysis, and convergent validity analysis

Variables	ATD	ENK	ENC	SBN	PBC	BSE	BISETs	AVE	MSV
ATD	**(0.714)**							0.510	0.125
ENK	0.331	**(0.827)**						0.684	0.320
ENC	0.276	0.483	**(0.821)**					0.675	0.275
SBN	0.353	0.375	0.524	**(0.755)**				0.570	0.275
PBC	0.172	0.542	0.413	0.303	**(0.783)**			0.614	0.524
BSE	0.348	0.245	0.166	0.329	0.219	**(0.838)**		0.703	0.121
BISETs	0.298	0.566	0.503	0.419	0.724	0.229	**(0.743)**	0.552	0.524

Values in bracket are root square of AVE

Table 5 Factor loadings and reliability analysis

Variables	Items	Standard loadings	Cronbach-α	CR
Attitude			0.813	0.806
	ATD 1	0.552		
	ATD 2	0.827		
	ATD 3	0.720		
	ATD 4	0.654		
	ATD 5	0.908		
	ATD 6	0.931		
	ATD 7	0.616		
Environmental knowledge			0.916	0.938
	ENK 1	0.731		
	ENK 2	0.816		
	ENK 3	0.905		
	ENK 4	0.858		
	ENK 5	0.866		
Environmental concern			0.910	0.935
	ENC 1	0.868		
	ENC 2	0.949		
	ENC 3	0.751		
	ENC 4	0.720		
	ENC 5	0.515		
Subjective norms			0.903	0.902
	SBN 1	0.782		
	SBN 2	0.810		
	SBN 3	0.939		
	SBN 4	0.968		
	SBN 5	0.839		
	SBN 6	0.713		
	SBN 7	0.648		
Perceived behavioral control			0.832	0.839
	PBC 1	0.723		
	PBC 2	0.737		
	PBC 3	0.701		
	PBC 4	0.686		
Beliefs about the benefits of solar energy			0.809	0.922
	BSE 1	0.652		
	BSE 2	0.842		
	BSE 3	0.813		
	BSE 4	0.867		
	BSE 5	0.842		
	BSE 6	0.808		
	BSE 7	0.891		
Buying intention of solar energy technologies			0.874	0.831
	BISETs 1	0.687		
	BISETs 2	0.766		
	BISETs 3	0.635		
	BISETs 4	0.571		

Extraction method: maximum likelihood; rotation method: promax with Kaiser normalization

Table 6 Collinearity analysis

Variables	Collineraity statistics	
	Tolerance	VIF
ATD	0.921	1.149
ENK	0.804	1.734
ENC	0.978	1.915
SBN	0.803	1.863
PBC	0.813	1.724
BSE	0.965	1.593

Dependent variable: BISETs

and finding clearly show that our data is a good fit for the measurement model.

Structural model and hypothesis outcomes

After the results and reliable measures, we tested our hypothesis link with each other and the presented model. The value of R^2 was determined to be 0.74, indicating a significant clarification as it exceeded the advisable value of 0.35 (Cohen 2013). The results depict a high *f*-value which shows linearity between all linkages. We also performed various fitness tests to make sure our data is perfect for the presented structural model (i.e., $CFI = 0.996$, $NFI = 0.971$, $IFI = 0.994$, $TLI = 0.991$, $GFI = 0.984$, $RMSEA = 0.023$, $X^2/df = 1.156$, and $SRMR = 0.020$) falling into the suggested criteria that reveal the structural model and fit to our data (Lucianetti et al. 2018) (see Table 8).

The graphical illustration and structural paths are in Fig. 3. The path coefficients of the variables "attitude," "environmental knowledge," "subjective norms," "perceived behavioral control," and "beliefs about the benefits of solar energy" *H1* ($\beta = 0.09$, $p < 0.01$), *H2* ($\beta = 0.01$, $p < 0.05$), *H4* ($\beta = 0.10$, $p < 0.001$), *H5* ($\beta = 0.19$, $p < 0.05$), and *H6* ($\beta = 0.06$, $p < 0.001$) indicate that the variables ATD, ENK,

Table 7 Communality values

Variable	Communalities	
	Initial	Extraction
ATD	1.000	0.612
ENK	1.000	0.746
ENC	1.000	0.885
SBN	1.000	0.642
PBC	1.000	0.507
BSE	1.000	0.835
BISETs	1.000	0.741

Extraction method: maximum likelihood

SBN, PBC, and BSE have significant effects on BISETs. Consequently, we accepted hypotheses 1, 2, 4, 5, and 6, while on the opposing side, hypothesis *H3* was not validated ($\beta = 0.68$); hence, it was refused (see Table 9 for hypothesis validity and hypothesized paths).

Discussion

Consumers' attitude towards buying intention of solar energy technologies was found to have a positive relationship. The outcomes reveal that consumers' attitude towards adopting energy-efficient technologies is high, and they intend to buy such technologies. Similar findings were reported by Greaves et al. (2013) and López-Mosquera et al. (2014). They conclude a high correlation between consumer buying intention and adoption of RE technologies which declares that the relation between these variables is positive. Thus, in the early stages, the Chinese government should revert people's minds to specific technologies so that potential customers can opt for future solar energy technologies.

Environmental knowledge is the key to triggering or boosting consumers' purchase intention. The results of our study depict a significant positive effect of ENK on BISETs. Although in previous studies, it has less weight on consumers to convert into RE technologies (Chan et al. 2014). The past discovery shows that consumers do not react to the preconditions of environmental behavior until they are educated about the actual circumstances. Hence, it is clear that ENK is crucial in increasing awareness about solar energy technologies to develop buying intention. Also, the government must create a public awareness campaign to make people's minds towards these technologies and convert them from traditional energy systems to conventional solar energy technologies by showing the pros and cons.

The results confirmed that environmental concern has no significant relation to buying intention of solar energy technologies, as previous studies showed similar results to our findings in Chinese rural areas (Shakeel et al. 2018). There might be no such urge to opt for these new renewable energy technologies or have buying intentions. Contrary to previous studies, consumers' intentions to purchase solar energy technologies are triggered by environmental concerns (Liu et al. 2013). Possible outcomes might be linked with government policies that never direct consumers towards purchasing energy-efficient technologies that preserve the environment and create less pollution than traditional technologies that are harmful. Another factor can be a mindset to buy cheap products rather than useful and future-proof solar energy technologies. The government should imply such policies or environmental awareness campaigns to decide better to purchase these RE technologies.
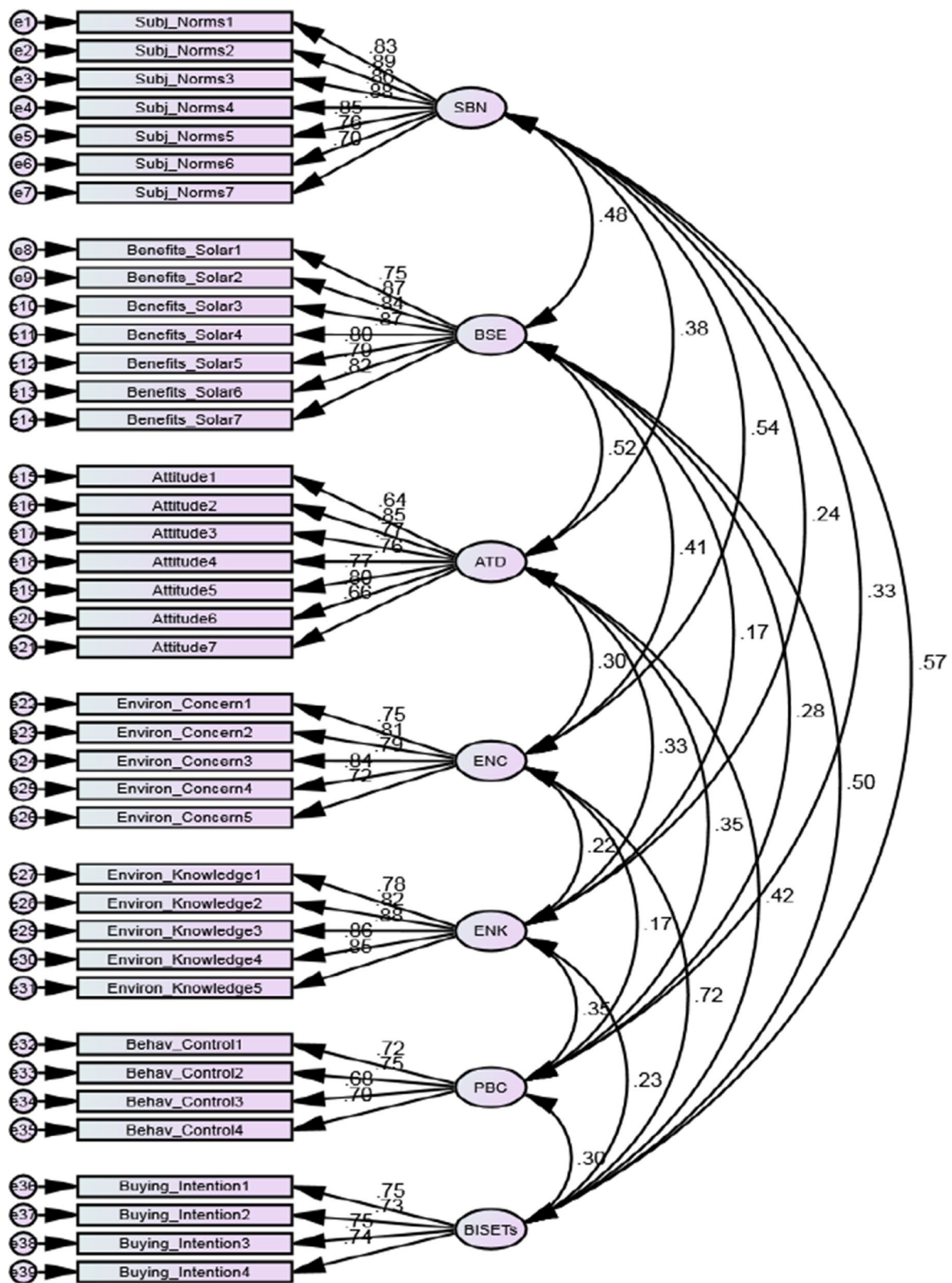
Fig. 2 Confirmatory factor analysis, showing the measurement model

Table 8 Goodness-of-fit index criteria

Fit indices	Definition	Criteria	Results
CFI	Comparative fit index	>0.9 good fit	0.996
NFI	Normed fit index	>0.9 good fit	0.971
IFI	Incremental fit index	>0.9 good fit	0.994
TLI	Tucker–Lewis index	>0.9 good fit	0.991
GFI	Goodness of fit	>0.9 good fit	0.984
RMSEA	Root mean squared error of approximation	<0.08 good fit	0.023
X^2/df	Chi-square	<3 good fit	1.156
SRMR	Standardized root mean squared residual	<0.09 good fit	0.02

The findings specify that consumers' buying intention of solar energy technologies is affected by subjective norms. These results are consistent with former studies of Chen (2016) and Jayaraman et al. (2017). Word of mouth is a powerful tool to spread awareness about something. A circle with friends, family, or office colleagues can spread something positive or negative about anything beneficial or not useful for them, leading to decision-making in moment minutes, hours, or days. The excellent experience of one consumer of specific solar energy technology can lead to positive results in adopting such technologies, while terrible experiences have a reciprocal effect (Ali et al. 2019). As mobile phones and social media applications are commonly used in China, the positive image of such technologies can be easily spread to urge consumers further to purchase such technology.

Since the development of TPB, previous researchers confirmed PBC as a significant factor of pro-environmental behavioral intention (Chen & Tung 2014), while there exist some studies which did not find any significant effect in their outcomes (Greaves et al. 2013; López-Mosquera et al. 2014). Current outcomes depict a positive association between PBC and BISETs. While results indicate that consumers have proper control, resources, and ability to adopt these RE technologies under consideration, they are likely to do so.

The results show a positive relationship between BSE and BISETs, while BSE strongly influences BISETs. Outcomes are consistent with former scholars' analysis, which depict consumers' buying intention to the specific technology they believe in its benefits. The citizens incorporate solar energy technologies by distinguishing the differences or actual benefits between ordinary energy origins (Colmenares-quintero et al. 2020). There must be a possibility as the Chinese government is briefly advertising the benefits of solar energy technologies and people prefer them. While a strong awareness is rapidly increasing among China's people towards adopting such technologies, their belief about it is boosting.

Conclusions and policy recommendations

This study examined the solar energy technology buying intention in rural regions of China by incorporating novel factors (i.e., beliefs about the benefits of solar energy, environmental concern, and environmental knowledge) in our conceptualized framework of TPB. We fetched the data by generating a questionnaire and getting responses from the rural area of China and analyzed it using SEM. Outcomes revealed that ATD, ENK, SBN, PBC, and BSE positively affect buying intention of solar energy technologies. In contrast, environmental concern has an insignificant effect on consumers' buying intentions.

China is a developing country with rapid growth in the vast type of technologies. The country contributes to renewable energy and has deployed such technologies in different regions. Although the world is shifting towards sustainable energy technologies, solar energy technologies are the priority for energy generation purposes. Our study conclusion suggests that the government should rapidly deploy these technologies to rural regions, provide a sense of knowledge about these technologies, and inform people about such technologies that consume low energy. Along these lines, it is proposed that the government create a massive promotional program in rural regions to educate people about these new technologies and their benefits to the environment and society for a better future.

The results of our study can help policymakers and developers pursue these regions and gather more information to implement such technologies for their people. The government of China should give more subsidies to the renewable energy sector to develop sustainable energy. People's intention towards purchasing these solar energy technologies will increase if they are cheap and eco-friendly to the environment. The government can also provide an opportunity for such developers with excellent knowledge to produce such technologies and provide tax relief to decrease pressure from one side and produce

Fig. 3 SEM path diagram.
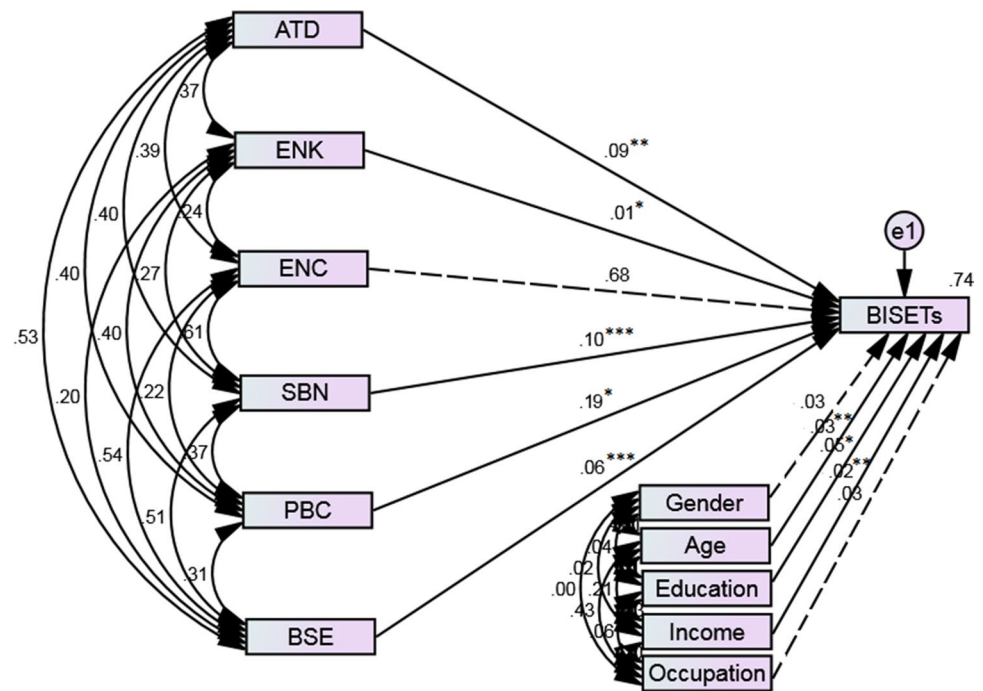Notes: ***$p < 0.01$, **$p < 0.05$,
*$p < 0.1$

Table 9 Hypothesis results

Hypotheses	Path directions	β-value	f-value	Result	R^2
H1	ATD→BISETs	0.09**	160.1***	Accepted	0.74
H2	ENK→BISETs	0.01*	112.8**	Accepted	
H3	ENC→BISETs	0.68	175.9*	Rejected	
H4	SBN→BISETs	0.10***	279.5***	Accepted	
H5	PBC→BISETs	0.19*	264.9*	Accepted	
H6	BSE→BISETs	0.06***	139.72	Accepted	

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

quality products. Such benefits should be provided to all companies with such talent to produce reasonable solar energy technologies in the market, transforming people's intention to purchase them.

The study also has some limitations. First, we use TPB as the theoretical framework. However, basic or original TPB is now not considered for theoretical underpinning because its parsimony and validity have been questioned (Sniehotta et al. 2014). Subsequent researchers should develop their theoretical frameworks using other relevant theories. Secondly, due to COVID-19 and travel restrictions, only rural regions of Hebei Province were selected for data analysis, which might raise the generalizability concern about the study results. Future studies can tackle this issue by including rural regions of other provinces to enrich the data sample. Finally, performing the levelized cost of electricity and cost–benefit analysis would be interesting in future studies to strengthen the existing knowledge pool.

Appendix 1

Questionnaire

Items	Strongly Disagree	2	3	4	Strongly Agree
Attitude					
I have a favorable attitude towards BISETs					
I think that solar energy electricity is better than conventional electricity					
I am ready to utilize green energy to save nature					
I am ready to purchase solar power technologies at home					
My attitude towards BISETs is positive as it is a clean source of energy					
I have a favorable attitude towards BISETs as it keeps the environment clean					
I think using solar energy technologies is energy-efficient					
Environmental Knowledge					
I know how solar energy technologies can be beneficial					
Consuming fossil fuels pollutes the environment					
I think the Greenhouse effect is not suitable for the atmosphere					
I think putting more seeds for planting can refresh the atmosphere in future					
The reason for massive floods on islands and shores is due to ice melting in the polar region					
Environmental Concern					
Air pollution is the biggest problem of environment					
I am concerned about climate changes					
I am worried about the waste generated					
If we adopt solar energy technologies, environmental issues can be reduced					
Subjective Norms					
People close to me think that I should buy energy-efficient technologies					
I will start using solar energy technologies if my family members advise					
I will take my neighbor's suggestion if they tell me to use energy-efficient technology					
Friends using solar energy technology motivates me to utilize it too					
I will use solar energy technology if my relatives are using it					
My peers motivate me to adopt energy-efficient technology at home					
People I have in my circle prefer me to adopt solar energy technologies					
Perceived Behavioral Control					
If energy-efficient technologies are a bit expensive, I will buy it					
I will use solar energy technologies in future					
I have knowledge, resources and the ability to adopt solar energy technologies at my home					
I am confident that using solar energy technologies can contribute to the environment					
Beliefs about the benefits of solar energy					
Using solar energy sources will decrease carbon emissions					
By utilizing solar energy, the public environment will be enhanced					
Solar energy usage can improve the energy infrastructure					
Energy supply can be improved if we adopt renewable energy sources					
There will be more employability by installing solar energy technologies					
using solar power will enhance energy safety					
Adopting solar power will save electricity cost					
Buying intention of solar energy technologies					
I have buying intention of solar energy technologies					
Energy-saving behavior motivates me to adopt solar energy technology					
I will advise my colleagues to buy solar energy technology for a better future					
I would like to spend more on solar energy technology rather than other sources of energy					

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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