Energy Policy 63 (2013) 882–886

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Communication

Farmers' willingness to convert traditional houses to solar houses in rural areas: A survey of 465 households in Chongqing, China

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HIGHLIGHTS

- We study farmers' willingness to convert traditional houses to solar houses.
- We have nine hypotheses and test nine associated factors.
- Three factors positively and significantly impact farmers' willingness.
- Other two factors negatively and significantly impact farmers' willingness.
- Remaining four factors do not significantly impact farmers' willingness.

ARTICLE INFO

Article history:
Received 27 June 2013
Accepted 3 September 2013
Available online 24 September 2013

Keywords:
Traditional houses
Solar houses
Farmers' willingness

ABSTRACT

In rural China, reducing low-quality fuel consumption and adopting solar technologies can mitigate pollution problems and improve farmers' living conditions. Before advising farmers to convert traditional houses to solar houses, it is necessary to understand their willingness to do so. Based on the theory of planned behaviour (TPB), this study examined nine factors related to farmers' willingness (FW). A survey was conducted in Chongqing with 465 participants. Nine hypotheses were proposed based on literature studies. A binary logistic regression model was constructed to test the data with the SPSS software package. Three of the nine factors had positive and significant impacts on FW, which were quality of life, government commitments and neighbours'/friends' assessments; two factors had negative and significant impacts, which were additional monthly out-of-pocket expenses and switching cost; and the remaining four factors had no significant impacts, which were durability, popularity, timing and local solar market maturity. Based on the findings, suggestions are made to properly introduce solar houses to Chinese farmers and to quickly stimulate market activities.

1. Introduction

Currently, more than seven hundred million Chinese farmers rely on low-quality fuels to cook food and warm their dwellings (Zhang et al., 2009). Such practices reduce quality of life and degrade the environment (Liu et al., 2013; Gosens et al., 2013). To solve these problems, renewable energy sources such as solar can be adopted as substitutes (Kruzner et al., 2013). In rural China, off-grid solar photovoltaic (PV) power consumption increased from 8.8 MW in 2004 to 20 MW in 2011 (Zhang and He, 2013). As illustrated below, there are research papers that report on solar house markets in other parts of the world; however, there is no study on the Chinese market (Zhong et al., 2011), and there are no papers discussing the conversion of traditional houses to solar houses worldwide. To date, the existing literature covers two main areas: (1) comparisons between traditional and solar houses and (2) factors affecting decision-making processes.

In the first area, three observations can be made. (1) Even though solar house costs are higher than those of traditional houses with identical building structures and materials, the monthly utility cost of the former is substantially lower than that of the latter (Schnieders and Hermelink, 2006; Zhu et al., 2009). After eliminating kerosene consumption and reducing battery usage, monthly savings reach up to 20–30% (Komatsu et al., 2011a). (2) Regarding quality of life, solar technologies provide

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0301-4215
http://dx.doi.org/10.1016/j.enpol.2013.09.004

more convenience and living comfort. Residents have more quality time to study, entertain and conduct family business. (Gustavsson and Ellegard, 2004; Wijayatunga and Attalage, 2005; Dahlstrom et al., 2012). Climate-changing greenhouse gas emissions are reduced, fire hazard is avoided and population health is improved (Mondal and Klein 2011; Komatsu et al., 2011b; Dahlstrom et al., 2012). (3) There are many potential customers who are willing to purchase solar houses. Besides farmers, customers include environmentalists, college-educated baby-boomers and later generations (Dastrup et al., 2012).

Regarding the second area, there are many factors affecting decision-making processes, such as aesthetics, knowledge, cost, facility ownership, psychology, geographical locations, sociocultural traditions, demographic distributions, economic status and policies (Schnieders and Hermelink, 2006; Morante and Zilles, 2007; Komatsu et al., 2011b). For example, buyers desire solar thermal comfort at a low cost, building aesthetics and sustainable operations (Yakubu, 1996; Schnieders and Hermelink, 2006). Moreover, consumers like to purchase traditional houses incorporated with solar technologies and want easy access to incentives and information (Garrett et al., 2008). Robust technologies and adequate maintenance are essential (Laufer and Schafer, 2011) and broad monetary policies are extremely crucial (Ketlogestwe and Mothudi, 2009; Mondal 2010; Sovacool et al., 2011).

Based on the literature, solar houses are suitable for rural areas. The following characteristics are unique to Chinese farmers: (1) Each family lives in one house and does not have an extra lot for another new house; and (2) it is realistic and practical to convert traditional houses to solar houses. The aim of this study is to understand the key factors currently affecting FW. The results of the study can be used by other scholars in future conversion studies, as well as policy makers and market managers in their effort to populate solar houses in rural areas.

2. Hypotheses

In this paper, solar houses refer to traditional houses furnished with solar-powered equipment, including photovoltaic (PV), solar water heater and/or solar thermal systems. FW represents planned behaviour whose mechanism and influencing factors can be analysed by the theory of planned behaviour (TPB). According to TPB, behavioural intention is determined by three factors: attitude towards the behaviour (AB), subjective norms (SN) and perceived behavioural control (PBC). Each factor is in turn generated by a number of beliefs and evaluations. In the case of FW, intention denotes the subjective probability of a farmer to build a solar house: the greater the probability, the stronger the intention. This intention can be affected by AB, SN and/or PBC factors. Based on TPB, this paper considers these factors, with each factor composed of three sub-factors.

2.1. Farmers' attitude towards behaviour

Attitude towards behaviour (AB) is a function of beliefs and evaluations. An individual's assessment of an action is affected by his or her behavioural beliefs. With positive assessments of solar houses, farmers will be more likely to build such houses. Farmers' attitude refers to the general feelings towards solar houses, either favourable or unfavourable.

Farmers have choices to remodel their existing traditional houses by conventional means or to convert traditional houses to solar houses. To examine their attitude towards solar houses, the following three sub-factors are considered: (1) quality of life, (2) monthly out-of-pocket expenses and (3) durability. According to the literature (Gustavsson and Ellegard, 2004; Wijayatunga and Attalage, 2005; Mondal and Klein 2011; Komatsu et al., 2011b; Dahlstrom et al., 2012), pollution is reduced and life becomes more enjoyable when living in a solar house. Thus, solar houses connote a higher quality of life. Although using solar products can save money on fuel resources (Schnieders and Hermelink, 2006; Zhu et al., 2009; Komatsu et al., 2011a), installation and maintenance may lead to extra expenses. If monthly expenses exceed previous expenses incurred while living in a traditional house, residents will not be satisfied (Zhang et al., 2012). If durability is enhanced relative to that of traditional houses, farmers should be satisfied. Correspondingly, the three following hypotheses are proposed.

H1: The increased quality of life compared to traditional houses would have a positive impact on FW.

H2: Additional monthly out-of-pocket expenses after converting to solar houses would have a negative impact on FW.

H3: The increased durability of solar products compared to traditional products in a traditional house would have a positive impact on FW.

2.2. Farmers' subjective norms

Subjective norms (SN) is a function of an individual's beliefs regarding whether he or she should perform a particular act based on the opinions of other people or groups. In the process of converting traditional houses to solar houses, SN particularly refers to possible pressures from farmers' family members, neighbours, local governments, the collective organisations of a village, the economic organisations of a village and zoning regulations for new solar house construction. The pressures can be either positive or negative and may certainly have impacts on FW. With respect to the influence of SN on FW, this paper examines three sub-factors: government commitment, the opinions of family members, friends and neighbours and the maturity of the local solar market. (1) Monetary policies are extremely crucial for solar houses (Ketlogestwe and Mothudi, 2009; Mondal, 2010; Sovacool et al., 2011). In China, farmers show more willingness when the government makes strong commitments. (2) Due to Chinese culture and traditions, farmers tend to listen to the opinions of their relatives, friends and neighbours. (3) Based on previous experience regarding the adoption of new farming equipment, such as tractors, FW is affected by the maturity of the solar market. Thus, the following three hypotheses are proposed.

H_4: Government commitments would have a positive impact on FW.

H_5: Neighbours'/friends' opinions would have a positive impact on FW.

H_6: Local solar market maturity would have a positive impact on FW.

2.3. Farmers' perceived behavioural control

Perceived behavioural control (PBC) reflects an individual's ability to control behaviour and is affected by control beliefs. In this paper, PBC describes farmers' perceptions of available knowledge, resources and opportunities for making the transition to solar housing.

Individuals with more resources and opportunities will have stronger control beliefs and perceived power. The most important factors relating farmers' beliefs with behaviour include available funding, possible subsidy, quality and reliability of solar houses and family finances. Historically, a farmer would gather all available resources and information before making any major purchase. For solar houses, such PCB will lead to FW when resources and other necessary conditions are met. Thus, this paper examines three sub-factors influencing PBC: switching cost associated with converting a traditional house to a solar house, popularity and time to construct solar houses. (1) Even though different families have different financial status, many of them are poor. Due to limited financial resources, the higher the switching cost is, the lower FW becomes. (2) Due to bandwagon effects, an increase in the popularity of solar houses would lead to higher FW. (3) Chinese farmers are very conservative and often wait for opportunities. They behave as "rational economic men" who minimise risks and maximise benefits. Traditionally, timing is important for Chinese farmers. If farmers can determine and control the appropriate time frame for solar house construction, they will show more willingness. Thus, the following three hypotheses are proposed.

H7: A high switching cost of converting from a traditional house to a solar house would have a negative impact on FW.

H8: The popularity of solar houses would have a positive impact on FW.

H9: How much control farmers have over construction timing would be positively correlated with FW.

3. Research design

3.1. The structure of the model

FW is the explained variable, with either a "yes" or "no" answer gathered from each participant. Because there are only two levels, a binary logistic model is applied. There are nine independent variables corresponding to nine hypotheses. The probability of a "yes" answer is P, as expressed in Equation (1).

$$P = 1/\{1+\exp[-(B+B_1X_1+B_2X_2+\ldots+B_9X_9)]\} \quad (1)$$

where B is the regression constant term and B_j is the regression coefficient for X_j, which is an independent variable with $j=1, 2, \ldots, 9$. In Table 1, the explained variable and the independent variables are tabulated.

3.2. Measurement instrument

The items on attitude, subjective norm and perceived behavioural control were based on existing validated measures obtained from the literature (Ajzen, 1991). According to the realistic situation of rural China, the measures were properly modified. As illustrated in Table 1, there are nine independent variables (items), each with a five-point Likert scale. Both mean and standard deviation values are also tabulated.

3.3. The survey

Heads of households in Chongqing who are married and do not have any or reliable electrical power supplies for their homes were surveyed. In rural China, the head of each household is usually the spokesman for the entire family.

Chongqing possesses characteristics considered essential for Chinese solar house planning. Known as one of the four "ovens" in China, its annual solar energy radiation is 3400–4180 MJ/m^2, with an annual direct solar exposure time of 1000–1400 h. Chongqing is one of the first areas to demonstrate new solar energy construction in China.

To generate a representative sample, the respondents were selected from three different areas in Chongqing by combining convenience sampling and judgment sampling methods. Five counties were selected, with two towns in each county and two random villages in each town. There were 30 households in each village. During March–May 2013, 465 valid questionnaires were collected from 600 distributed. This relatively high response rate of 77.5% was achieved because the survey was carried out by face-to-face interviews. Before each interview, a brief introduction to solar houses was given, and the cost of each solar system installation was explained.

3.4. Descriptive analysis

Among the 465 households, 292 answered "yes" or expressed the willingness to convert their traditional houses to solar houses. The answers from the remaining 173 households were "no," "not sure" or "wait and see", which were all classified as "no" answers. In Table 2, the demographic characteristics of the participants are tabulated: gender, age, education level, family size, having any children in college, having relatives in cities and having any family members who are migrant workers in cities.

Table 1
Descriptions of variables.

Description	Variable/ hypothesis	Meaning and evaluation of variables	Mean	Standard deviation
Quality of Life	X_1/H_1	"In comparison with traditional houses, solar houses can improve quality of life." No=1, Somewhat=2, Likely=3, Most likely=4, Definitely=5	2.067	.767
Monthly Expenses	X_2/H_2	"In comparison with traditional houses, solar houses require additional monthly out-of-pocket expenses" Much less=1, Less=2, Same=3, More=4, Much more=5	2.856	1.286
Durability	X_3/H_3	"In comparison with traditional products in a traditional house, how important is the additional durability of solar products?" Not important at all=1, Slightly important=2, Important=3, Fairly important=4, Very important=5	3.127	1.342
Government commitments	X_4/H_4	"The government's commitments to solar housing are important." Strongly disagree=1, Disagree=2, Neither agree nor disagree=3, Agree=4, Strongly agree=5	1.501	.692
Neighbours'/friends' assessments	X_5/H_5	"Neighbours'/friends' (including relatives) assessments affect farmers' willingness." Strongly disagree=1, Disagree=2, Neither agree nor disagree=3, Agree=4, Strongly agree=5	2.815	1.253
Local Solar Market Maturity	X_6/H_6	"How mature is your local solar market?" Unsatisfactory =1, Fair=2, Good =3, Very Good=4, Excellent=5	2.019	.743
Switching cost	X_7/H_7	"How much would you be able to pay for the switching cost of converting from a traditional house to a solar house?" Very little =1, Small part=2, Half=3, Most =4, All=5	2.052	.744
Popularity	X_8/H_8	"It is popular to build a solar house. Would you follow the trend?" Definitely Not=1, No=2, Neutral=3, Yes=4, Definitely Yes=5	3.232	1.403
Timing	X_9/H_9	"I should be able to decide when the best time for solar house construction is." Definitely Disagree=1, Disagree=2, Neutral=3, Agree=4, Definitely Agree=5	3.656	1.100
FW	Y	"Are you willing to consider solar housing?" Yes=1, No=0	–	–

Table 2
Demographic characteristics of participants.

Type	Selection	Number	Percent	Type	Selection	Number	Percent
Gender	Male	266	57.2	Relatives in cities	Yes	80	17.2
	Female	199	42.8		No	385	82.8
Age	35 and younger	155	33.33	Family size	3 or less	190	40.86
	36–54	213	45.81		4–6	263	56.56
	55 and older	97	20.86		7 or more	12	2.58
Education level	Senior high school	84	18.06	Location relative to Chongqing city centre	Within 1 hour driving	158	33.98
	Junior high school	156	33.55		Southeast	146	31.4
	Some elementary school	225	48.39		Northeast	161	34.62
Having children in colleges	Yes	153	32.9	Being migrant worker in cities	Yes	175	37.63

Table 3
Model summary.

Step	Cox and Snell R^2	Nagelkerke R^2	χ^2	Hosmer and Lemeshow
1	.364	.489	30.082***	7.761 n.s.

*** $p<.001$, n.s.$p>.1$

Table 4
Variables in equation (1).

		B_i	S.E.	Wald	*df*	Sig.	Exp(B_i)	95% C.I. for EXP(B_i)	
								Lower	Upper
Step 1[a]	X1	.344	.134	6.609	1	.010	1.410	1.085	1.833
	X2	−.446	.227	3.848	1	.050	.640	.410	1.000
	X3	.026	.093	.075	1	.784	1.026	.855	1.231
	X4	.542	.160	11.450	1	.001	1.720	1.256	2.355
	X5	.489	.230	4.518	1	.034	1.631	1.039	2.560
	X6	.354	.232	2.318	1	.128	1.424	.903	2.246
	X7	−.465	.232	4.040	1	.044	.628	.399	.988
	X8	.046	.087	.284	1	.594	1.047	.883	1.242
	X9	−.027	.113	.059	1	.808	.973	.780	1.214
	Constant	−.959	.610	2.472	1	.116	.383		

[a] Variables entered on step 1: X1, X2, X3, X4, X5, X6, X7, X8, X9.

As shown in Table 2, most of the heads of the households are 54 or younger (79.14%) and possess a junior high school education or lower (81.94%). Some families have connections to cities: 32.90% have children in colleges, 37.63% have members who are migrant workers and 17.20% have city relatives. Because three generations typically reside in one house, the majority of the families (59.14%) have four or more members. The demographic characteristics listed in Table 2 are representative of the rural areas.

3.5. Reliability and validity

The internal consistency of the data was tested by the Cronbach's alpha, .60. Because the questionnaire was the first one designed for FW in China, belonging to the exploratory study, such a Cronbach's alpha value is acceptable (Hair et al., 2005). Regarding content validity, a draft questionnaire was initially provided to three different experts in psychology, marketing and energy economics, who provided expertise in AB, SN and PBC and graded the draft questions on scales ranging from 1 to 4. Higher scores indicated greater relevance and required fewer changes. Based on the experts' opinions, the draft questionnaire was modified and resent to them for the next round of corrections. After two iterations, the final scores for the AB, SN and PBC contents were 3.96, 3.93 and 3.97, with indices of content validity of .99, .93 and .95, respectively. Some of the previous questions were deleted based on the experts' assessments. For example, an initial question asked the farmers “how much money do you have?” This question was deleted due to its low index of content validity.

4. Results of hypothesis testing and discussion

Using SPSS 19.0, nine hypotheses were tested. As illustrated in Table 3, the values of Cox and Snell R^2 and Nagelkerke R^2 were 36.4% and 48.9%, respectively. These values provided some evidence for the closeness between the model and the data, indicating that there were relationships between the explained variables and the independent variables. The χ^2 value was 30.082, and $P<.001$, reaching the significance level. Thus, the goodness of fit is satisfactory. However, the Hosmer and Lemeshow value was 7.761, and $p>.1$, which failed to reach the significance level.

Based on the values listed in the sixth column of Table 4, five out of nine factors had significant impacts on FW, with “sig” values equal to or less than .05. Hypothesis H1 was supported, with $B_1=.344$ and $EXP(B_1)>1$. Compared with remodelling traditional houses, a stronger desire to improve quality of life with solar houses can lead to more FW, which is consistent with findings reported for other countries and regions (Gustavsson and Ellegard, 2004; Wijayatunga and Attalage 2005; Mondal and Klein 2011; Komatsu et al., 2011b). Hypothesis H2 was supported, with $B_2=-.446$, and $EXP(B_2)<1$. Compared with the monthly out-of pocket expenses associated with a traditional house, the additional monthly expenses associated with a solar house would lead to less FW, which is consistent with results reported in the literature (Li et al., 2009; Zhu et al., 2009; Mondal, 2010). Hypothesis H4 was supported, with $B_4=.542$ and $EXP(B_4)>1$. Strong government commitments would lead to more FW. Similar conclusions were reached in other studies (Zhong et al., 2011; Mondal, 2010; Garrett et al., 2008). It is clear that government roles are crucial in three respects: (1) making funding available to farmers via subsidies and/or loans, (2) formulating new policies to encourage solar house construction and (3) enforcing regulations. Hypothesis H5 was supported, with $B_5=.489$ and $EXP(B_5)>1$. Positive assessments from neighbours and friends (including relatives) would lead to more FW, as farmers seriously consider the opinions of their neighbours and friends. Indeed, farmers tend to get on the same bandwagons as people close to them. Hypothesis H7 was supported, with $B_7=-.465$ and $EXP(B_7)<1$. Higher switching costs would lead to less FW, as most farmers do not have enough financial resources for the conversion.

Hypotheses H3, H6, H8 and H9 were not supported. The durability of solar houses, the maturity of the local solar market, the popularity and timing of solar house construction did not have significant impacts on FW, with “sig” values greater than .05. Although these hypotheses were not supported statistically, the directions of hypotheses H3, H6 and H8 are consistent with the assumed directions, which may suggest that the sample size should be enlarged to obtain stronger supporting evidence. Thus, the durability of solar houses, solar market maturity and the popularity of solar housing should be considered as influential factors on FW, though perhaps not as important as hypotheses H1, H2, H4, H5 and H7 suggest. Other reasons for the lack of support for hypotheses H3, H6 and H8 may be as follows. (1) Even though most solar products could last 30 years or longer, farmers may use the houses for only 20–30 years for various reasons, including government planning, family structure changes and natural disasters. Thus, farmers do not consider durability under their current circumstances. (2) Although Zhong et al. (2011) stated that the regulations for the market can promote the development of the solar industry in China, local solar markets depend on villages and towns to a certain extent. If local solar markets are not mature, farmers could purchase solar equipment in large cities. (3) The trend may be guided by villages' solar house construction plan. Farmers in one village usually build houses with similar architectural and functional features. When solar houses become popular, some farmers may follow the trend. However, different farmer families face different economic conditions and have different preferences regarding solar-harvesting mechanisms. Therefore, for some farmers, popularity does not motivate them to build solar houses.

Hypothesis H9 and the survey results were inconsistent. One possible explanation is that Chinese farmers usually do not make quick decisions. Their hesitation may reflect their concerns over huge financial expenses. In the past, some farmers regretted financial decisions made many years ago. Thus, during the conversion process, farmers should be the decision makers.

5. Conclusions

Among nine factors, five had significant impacts on FW, with three being positive and two being negative. The positive factors were the desire to improve quality of life, strong government commitment and the good assessments of others, and the negative factors were large monthly expenditures and high switching costs. The four insignificant factors were durability, market maturity, popularity and timing. More empirical studies will be required to further verify the impacts of these factors on FW.

6. Policy implications and limitations

The determinants of FW have important theoretical and practical implications. First, based on TPB and using a binary logistic regression model, this study predicts several key influencing factors and provides a basis for future scholarly research. Second, to convert traditional houses to solar houses, the following three aspects should be considered. First, governments should facilitate solar house planning while not directly interfering with the market. Most importantly, governments should focus on quality-assurance schemes for solar house products, the dissemination of reliable information about product performance, guidance for cost structures and financial assistance and guarantees. Furthermore, governments should provide research grants to encourage innovations in solar housing and ensure a healthy environment for solar enterprises to flourish. Second, marketing managers should focus on communities where solar houses are initially being built. To initiate a new market, a local champion who can promote the construction of solar houses among his or her neighbours should be identified and trained at the beginning. Ideally, this person should be a well-respected village leader. Furthermore, it will be important to expand local capacities once a sample house is built. Third, farmers should be active players in the conversion process to improve their living standards.

There are three limitations to this study: (1) The research only focussed on FW; (2) only nine factors were considered; and (3) the model was simple. Currently, we are developing a new research project to overcome these limitations: (1) to study the relationships between FW and farmers' actions; (2) to incorporate factors that can provide a better understanding of the problems related to attitude, behaviour and barriers; and (3) to develop a complete model to explore the connections between intention and behaviour.

Acknowledgements

Currently, Xuesong Li is sponsored by the China Scholarship Council as a visiting professor at Alfred University. This research was inspired by an international collaboration project called Solar Decathlon 2013 China.

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