PRINT: ISSN 0972-0073 ONLINE: ISSN 2456-6802
Anthropologist, 22(1): 1-14 (2015)
DOI: 10.31901/24566802.2015/22.01.01

A Study on Willingness of Chinese Housing Residents to Adopt Solar Photovoltaic Power Generation

Qing Guo[1,2] and Hui-ling Song[1,*]

[1]School of Economics and Management, China University of Geosciences, Wuhan, Hubei 430 074 China
Telephone: (34) 675-694-084, E-mail: qingguovip@126.com
[2]Industrial Engineering Department, Technical University of Madrid, Madrid 28006 Spain

KEYWORDS Photovoltaic Power Generation. LSD Multiple Comparison Analysis. Regression Analysis. S-N-K Test. Single Factor Variance Analysis. Willingness to Adopt.

ABSTRACT The study was conducted based on data from 330 questionnaires with the adoption of single factor analysis of variance S-N-K test method and LSD multiple comparison analysis. The paper examined residents' willingness to adopt solar photovoltaic power generation among various groups with different housing conditions, including housing ownership, residential floors and residential housing areas. Afterwards, by using a regression model, the paper conducted a regression analysis of the demographic variables influencing their willingness to adopt solar photovoltaic power generation. The results indicated that the types of housing resulted in significant differences in residents' willingness to adopt solar photovoltaic power generation. Housing ownership, residential floors and residential housing areas had significant impacts on their willingness to adopt. Based on these findings, this paper put forward corresponding policy recommendations.

INTRODUCTION

Energy consumption in China is considerable and as such, emissions of carbon dioxide are high. As a result of these resources and environmental problems, there has been great pressure on China to evolve sustainable economic and social development plans. Thus, development of solar energy is one of the alternatives for energy conservation, and emissions reduction which can ensure sustainable development in China.

Objectives

In the context of climate change and energy shortages, solar photovoltaic power generation is increasing. Solar energy plays an important role in a future where reducing the dependence on fossil fuels and addressing environmental issues are a priority (Singh 2013). The International Energy Agency (IEA) predicted that by 2020, world's photovoltaic power generation will account for 2 percent of the total generating capacity (Janjai et al. 2011). The prospect for the development of solar photovoltaic industry is vast. Experts have suggested that countries should intensify policy support and expand domestic markets, so photovoltaic power generation would be available to ordinary people at an early date. Almost 80 percent of greenhouse gases come from production and consumption of energy. Globally and approximately, 40 percent of the average total energy consumption relate to buildings (Omer 2008). Zhao et al. (2015) considered that as a great significance to ensure coordinated development of natural ecological environment, social production, lifestyles, as well as regional economy.

How can photovoltaic power be made into the people's daily lives, and change an existing building into a "small factory" of solar photovoltaic power generation? In order to answer this question, it is of the great significance to explore the willingness of the public, in terms of adopting solar photovoltaic power generation facilities. The willingness to adopt lays the foundation for solar photovoltaic power generation and represents its perspective. So, it is important both theoretically and practically to identify willingness to adopt solar photovoltaic power generation by the general public in different housing conditions.

Literature Review

Previous studies mainly focused on the promotion of renewable energy and solar photo-

*Address for correspondence:
Dr. Hui-ling Song
School of Economics and Management,
China University of Geosciences, Wuhan,
Hubei 430074 China
Telephone: +86 15972985600
E-mail: songhl@cug.edu.cn

voltaic use, consciousness of education, cost of power generation, saving consciousness, recovery period and so on. However, these studies propounded some valuable conclusions. Rehmana and Sahinb (2015) found that the solar PV power generating system not only helps to decrease carbon emission to the atmosphere, but also is comparable in the unit COE with the diesel only system in many sites even though the unit price of the diesel fuel is very low. Hoppmanna et al. (2014) analyzed the evolution of the German feed-in tariff (FIT) system for solar photovoltaic power, a highly effective and widely copied policy instrument targeted at fostering the diffusion and development of renewable energy technologies. And found that the policy has been subject to a considerable amount of changes, many of which are the result of policy makers addressing specific system issues and bottlenecks. Xu et al. (2010) found that city residents have a certain purchase intention of new energy vehicles, but considering convenient conditions, maintenance costs and other factors, the purchase intention cannot be transferred to purchase behaviour. Cai et al. (2012) investigated new energy vehicles and found that perceived risk is the most significant factor that hinders new energy and low-carbon innovation products. Wang et al. (2013) concluded that purchase of attitudes, subjective norms, and perceived behavioral control are main factors affecting consumer purchase intention, while perceived ease of use and perceived usefulness have positive effects on consumer purchase intention. The research of Harder et al. (2011) showed that higher initial investment cost and power price are the driving factors that affect solar photovoltaic system. Based on net present value, return of capital budget, national support strategy and key features of most relevant technicalities, Bortolini (2013) analyzed environmental, economic and financial parameters of solar photovoltaic system. Wang et al. (2013) studied consumption of new energy vehicles in China, and found that relevant reference group influences purchase decision. Gao et al. (2008) studied purchase preference of taxi drivers through the investigation of fleet management and operators. Huijts et al. (2012) believed that residents' attitude will be influenced by perceived cost, risk earnings and technical response, that is,individual behavior will be influenced by perceived cost, risk profit and new technology fear. Islam and Meade (2013) found that education campaigns should explain more about investment criteria, feed-in tariffs and environmental effects. Islam (2014) indicated that technology awareness and energy cost saving have a significant effect on the adoption probability, reinforcing the need for effective education. Radmehr et al. (2014) found that the capital cost of PV is not instrumental in choice, and a lower feed-in tariff could be acceptable. Shi et al. (2013) emphasized introduction of demonstration projects for high-rise residential building, in which the application feasibility and limitation of solar water heating system are studied. Loulas et al. (2012) found that the majority of installations have a maximum six-year payback period. Claudy et al. (2011) found that WTP varies significantly among the four technologies. More importantly, however, home owners hold different beliefs about the respective technologies, which significantly influence their WTP. Haw et al. (2009) found that the problem of high investment cost of BIPV also results in long payback period due to the low electricity tariff rate in Malaysia. Willis et al. (2011) results indicated that primary heating choice is not affected, but older person households are less inclined to adopt micro-generation technologies. Scarpa and Willis (2010) pointed out that whilst renewable energy adoption is significantly valued by households, this value is not sufficiently large, for the vast majority of households.

In addition, some scholars focused on differences in willingness to adopt solar photovoltaic power generation in different regions. Gunderson et al. (2015) evaluated the current and future solar energy potential through the use of grid-connected PV power plants at the scale of countries within the Black Sea catchment. Results shows that climate change will have little impact on the solar radiation resource, while land-use change induces more variability. Zhu (2012) found that residents' understanding of solar photovoltaic power generation is low, and the investment demand for solar photovoltaic power generation is weak. Firdaus et al. (2011) found that government's policy has a great influence on public acceptance and implementation of photovoltaic power generation. Gilberto and Conrado (2013) argued early loss of potential interest. Bazen and Brown (2008) showed that the current level of financial incentive policies is not conducive to the adoption of solar photovoltaic power generation system, and should be improved.

Firdaus et al. (2012) showed that most people do not know government's incentive policies for renewable energy, thus, they are not willing to invest in solar photovoltaic power generation. Bhandari and Stadler (2009) through a study found that the installation cost of photovoltaic power system has a negative impact, while investments on housing of residents and environmental protection awareness have positive effect. As regards willingness of the public to adopt new energy technology, and solar photovoltaic power generation, the existing body of literature has laid a good foundation for this study and future research. However, studies on willingness to adopt solar photovoltaic power generation from the perspective of comparing different housing conditions are very limited.

RESEARCH METHODS AND SAMPLE DATA

Research Methods

Research methods include: literature review, questionnaire survey and statistical analysis.

(1) Literature Review: This was done to deeply analyse related literature on existing domestic, and foreign research findings on public willingness to adopt photovoltaic based on different housing conditions in China. Also, the inadequacies of these research findings were discussed with a view to evolving specifications for further research.

(2) Questionnaire Survey: In order to study promotion of China's popularization of solar photovoltaic power generation and residents' willingness to adopt it, a structured questionnaire was designed from four dimensions. These dimensions are: environmental consciousness and propaganda education, solar photovoltaic power generation cognition, government policy and public willingness to adopt. Each of the dimensions includes several items (variables) (Table 1). In this study, the questionnaire measured relevant variables by taking different housing ownership, housing, total number of layers, different floors, residents of the housing area and willingness to adopt photovoltaic into consideration. The specific location was in accordance with the principle of random sampling in selected cities which allowed respondents to fill out the questionnaires.

(3) Statistical Analysis: The researchers used weighted average of four questions in the questionnaire which are : (1) Under the current policy of government subsidies and feed-in tariff (FIT), are you willing to install solar power generation facilities? (2) What is the range of costs for installing solar power generation facilities? (3) What is the life-time range of solar power facilities you can accept? (4) When will you begin to consider installing your facility at a time when some percentage of residents in your community has already installed? The data obtained were used to measure willingness of public to adopt solar photovoltaic power.

In this study, SPSS statistical analysis software was used by adopting the single factor analysis of variance (one-way ANOVA) of S-N-K test method, and LSD multiple comparison to analyse differences in public willingness to adopt solar photovoltaic power generation, and find significant difference between various groups. The linear regression model was used to make regression analysis on the variables affecting adoption of solar photovoltaic power generation in different living conditions.

Sample Data

A total of 360 questionnaires were handed out and 338 were received, providing response rate of 93.89 percent, among which 330 were valid, accounting for 97.63 percent. As shown in Table 2, in the demographic variable of gender, males outnumbered females by 3.04 percent; in the demographic variable of age, the youths and the middle- aged (aged between 20 and 49) who are the main power for solar photovoltaic power generation adoption, constituted 93.03 percent; in the dimension of income, the percentage of those earning 1,000 - 6,999 Yuan per month was 85.15 percent. In brief, the sample was fairly typical and representative for Chinese residents (Table 2).

RESULTS

In 1987, the state formulated "general principles of the civil building design" (trial). The design of civil building height and number of layers are clearly defined as 1~3 layers for low- rise residence; 4~6 layers for multi-storey residence; 7~9 layers for medium and high-rise residence;

Table 1: Seventeen indicators of Likert scale in the questionnaire

Dimension	*Questions*	*Answer options*
Environmental Consciousness and Publicity	*1. Whether your personal lifestyle is environmentally friendly*	1) not environmentally friendly; 2) Never pay attention to environmental protection; 3) Average; 4)pay more attention to environmental protection; 5) very environmentally friendly
	2. Environmental contamination of thermal power (coal)	1) no effect; 2)not serious; 3)Average; 4) Severe; 5)very serious
	3. Easiness of the promotion of new energy application	1) not hard; 2)Never too difficult; 3) Average; 4)more difficult; 5)most difficult
	4. Awareness of solar power generation	1) never heard of; 2)occasionally heard of; 3) basic knowledge; 4)good knowledge; 5) best knowledge
	5. Awareness of solar power generation facilities	1) never heard of; 2)occasionally heard of; 3) basic knowledge; 4)good knowledge; 5) best knowledge
Solar-photovoltaic Power Generation Awareness	*6. Necessity of promoting solar power generation*	1) completely unnecessary; 2)unnecessary; 3) Average; 4) necessary; 5) very necessary
	7 If there are alternatives of power supply, are you willing to try the solar power?	1) unwilling; 2)may consider; 3)willing; 4) more willing; 5)most willing
	8. Prospects for solar power generation	1) Pessimistic; 2)relatively pessimistic; 3) Average; 4)optimistic; 5)very optimistic
Government Policy	*9. Degree of understanding of national policies related to solar power generation*	1) never heard of; 2)occasionally heard of; 3) basic knowledge; 4)good knowledge; 5) best knowledge
	10. How important is the influence of current new energy policies on the extension and application of solar power generation?	1)unimportant; 2)not very important; 3)average;4)important; 5)very important
	11. Is government's technical supervision system for regulating solar photovoltaic products effective?	1) ineffective; 2)basically ineffective; 3)effective; 4) relatively effective; 5)Very effective
	12. Under the current policy of government subsidies and feed-in tariff (FIT), are you willing to install solar power generation facilities?	1) unwilling; 2)may consider; 3)willing; 4)more willing; 5) most willing
People's Willingness to Adopt	*13. What is the issue that you concern most when you consider installation?*	1) environment protection; 2)safety; 3) cost effectiveness; 4)roof resources; 5) service life
	14. What is the range of costs for installing solar power generation facilities?	1) under 19,000 Yuan; 2)20,000~39,000 yuan; 3) 40,000~59,000yuan;4)60,000~79,000yuan; 5) 80,000~100,000 Yuan
	15. What is the life-time range of solar power facilities you can accept?	1) 0~5years;2)6~10years;3)11~15years; 4) 16~20years; 5)20-25years
	16.When will you begin to consider installing your facility at a time when some percentage of residents in your community has already installed?	1) 1%~19%; 2)20%~39%;3)40%~-59%; 4) 60%~79% ; 5)80%~100%
	17.The main reasons why you do not want to install solar power generation facilities:	1) high cost; 2) fear of new technologies; 3) long payback period;4)large roof areas needed; 5) lack of appropriate national policy support

Source: Derived from the questionnaires collated by the research group.

Table 2: Distribution of samples

Features	*Frequency*	*Ratio(%)*
1. Gender		
Male	170	51.52
Female	160	48.48
2. Age		
Under 19	0	0.00
20-29	142	43.03
30-39	115	34.85
40-49	50	15.15
Above 50	23	6.97
3.Educational Background		
Secondary school	5	1.52
Vocational school/ high school	22	6.67
professional training/ college	53	16.06
University	141	42.73
Graduate School	109	33.03
4. Monthly income		
Under 999 Yuan	9	2.73
1000~2999 Yuan	71	21.52
3000~4999 Yuan	128	38.79
5000~6999 Yuan	82	24.85
Above 7000 Yuan	40	12.12
5. Industry		
Traditional energy industry	29	8.79
New energy industry	31	9.39
Construction industry	27	8.18
Service sector	35	10.61
Financial industry	41	12.42
Education industry	44	13.33
Government departments	63	19.09
Information industry	35	10.61
Manufacturing industry	5	1.52
Others	20	6.06

Source: Derived from the sample data by the authors using SPSS 20.0.

and more than 10 stories for high-rise residence. Based on these principles, the total number of residential housing and residential floors was classified (Table 3). This was followed by the use of SPSS statistical analysis software, adopting the single factor analysis of variance (one-way ANOVA) of S-N-K test method, and LSD multiple comparison to analyse difference in public willingness to adopt solar photovoltaic power generation, and find significant difference between various groups. The public had different housing ownership and residential housing areas. They also lived in different total layers residence and different floors. Linear regression model was used to make regression analysis on the variables of living conditions, such as housing ownership, residential housing area, residential total layers and residential floors. The specific process is given in Table 3.

Analysis of Different Housing Ownership

(1) Willingness to adopt solar photovoltaic power generation by rental housing residents was the lowest, whereas willingness to adopt by self-established buildings was the highest. As shown in Table 4, the mean willingness to adopt solar photovoltaic power generation in different housing ownership by residents, ranked from highest to lowest is: self-established buildings, houses built with funds collected by the buyers, limited property house, commercial residential buildings and rental housing. The difference between the highest mean (self-established buildings' residents) and the lowest average (rental housing residents) was higher than 36.3 percent. The willingness to adopt by rental housing residents was the lowest, because they did not have housing ownership. Their duration of stay was uncertain and solar photovoltaic power genera-

Table 3: Distribution of samples

Types	*Frequency*	*Ratio %*	*Types*	*Frequency*	*Ratio %*
1. Housing Ownership			*3. Residential Floors*		
Self-establish buildings	24	7	1-3floor	102	31
Commercial residential building	213	65	4-6 floor	95	29
Houses built with funds collected by the buyers	22	7	7-9 floor	45	13
Limited property house	10	3	above 10 floor	88	27
Rental housing	61	18	*4. Residential Housing Areas*		
2. Residential Total Layers			Below 45 m^2	36	11
1-3 layer	37	11	45-89 m^2	71	22
4-6layer	68	20	90-139 m^2	118	36
7-9 layer	81	25	140-179m^2	60	18
above10 layer	144	44	above 180m^2	45	13

Source: Derived from the sample data by the authors using SPSS 20.0.

Table 4: Test results of different housing ownership and sorting

Ownership	*N*	*Mean value*	*Homogeneity test of variances*	*Analysis of variance*
Self-established buildings	24	2.89	0.061	0.001
Houses built with funds collected by the buyers	22	2.76		
Limited property house	10	2.63		
Commercial residential building	213	2.25		
Rental housing	61	2.12		

Source: Derived from the sample data by the authors using SPSS 20.0.

tion equipment should be in use for a long time, hence, they did not want to acquire solar photovoltaic power generation.

However, those that lived in suites and roof areas had more willingness to adopt solar photovoltaic power generation because of the convenience to install the facilities.

(2) Different housing ownership resulted in significant differences in residents' willingness to adopt solar photovoltaic power generation. Using a test of homogeneity of variance, five housing ownership were examined to determine whether these differences were significant. The results as presented in Table 4 showed that 0.061 was greater than 0.05, which indicated that the variance was homogeneous, so the method was appropriate to test the homogeneity of variance. The table also showed that differences in residents' willingness to adopt solar photovoltaic power generation, based on housing ownership were significant ($P<0.05$). It was observed that residents with more stable ownership had higher willingness to adopt solar photovoltaic power generation. Apart from self-established buildings, houses built with funds collected by the buyers and limited property houses cannot be easily transferred due to some restrictions, so the ownership is stable. Unlike commercial housings whose ownership are not stable because that can be easily transferred for economic reasons. Similarly, rental housing residents lack housing ownership, and as such, they are always unwilling to install the solar photovoltaic power generation. It can be inferred that willingness to adopt solar photovoltaic power generation by the last two types of residence was low.

Buildings were grouped into two and S-N-K test method, and LSD multiple comparison anal-

Table 4: Test results of different housing ownership and sorting

Ownership	*N*	*Mean value*	*Homogeneity test of variances*	*Analysis of variance*
Self-established buildings	24	2.89	0.061	0.001
Houses built with funds collected by the buyers	22	2.76		
Limited property house	10	2.63		
Commercial residential building	213	2.25		
Rental housing	61	2.12		

Source: Derived from the sample data by the authors using SPSS 20.0.

Table 5: S-N-K test of different housing ownership on public willingness to adopt solar photovoltaic power generation

Ownership	*N*	*A subset of the set of alpha = 0.05*	
		1	*2*
Self-established buildings	24	2.89	
Houses built with funds collected by the buyers	22	2.76	
Limited property house	10	2.63	
Commercial residential building	213		2.25
Rental housing	61		2.12

Source: Derived from the sample data by the authors using SPSS 20.0.

ysis were further used to analyse the samples. Self-established buildings, houses built with funds collected by the buyers and limited property houses made up the first group while commercial housing and rental housing formed the second group. The results showed that (Tables 5 and 6) there was no significant difference within the same group but, significant difference was noticed between the two groups.

Analysis of Different Layers

In 1987, the state formulated "general principles of the civil building design" (trial). The design of civil building height and number of layers are clearly defined as 1~3 layers are low rise residences; 4~6 layers are multi-storey residences; 7~9 layers are medium and high-rise residences; and more than 10 storeys are high-rise residences. Based on these principles, the total number of residential housing and residential floors was classified (Table 7). Floors were divided into low-rise residence, multi-storey residence, medium and high-rise residence and high-rise residence. Analysis was later conducted based on these four types.

(1) The willingness to adopt photovoltaic power generation by multi-storey residents was the lowest while that of high-rise residents was the highest as shown in Table 7. The rank from highest to lowest is: high-rise residence, low rise residence, medium and high-rise residence and multi-storey residence. The highest mean value (high-rise residence) was 20 percent higher than the minimum mean value (multi-storey residence). The main reason may be that low - rise residences (1~3 layers) are built by individuals for their own use. Also, the roof area is convenient for placing solar power generation facilities, and owners of low-rise residences have the wherewithal to afford solar photovoltaic power generation equipment. Multi-storey residences

Table 6: LSD multiple comparison analysis of housing ownership on public willingness to adopt solar photovoltaic power generation

(I) Ownership	*(J) Ownership*	*Mean difference*	*Standard error (I-J)*	*Q values*	*Significance*
Self-established Buildings					
	Commercial residential building	0.13*	0.21	0.63	0.001
	Houses built with funds collected by the buyers	0.26	0.39	0.67	0.634
	Limited property house	0.64	0.47	1.37	0.615
	Rental housing	0.77*	0.23	3.33	0.013
Commercial Residential Building					
	Self-established buildings	-0.13*	0.21	-0.63	0.001
	Houses built with funds collected by the buyers	0.13*	0.34	0.38	0.011
	Limited property house	0.51*	0.43	1.19	0.000
	Rental housing	0.64	0.14	4.71	0.000
Houses Built with Funds Collected by the Buyers					
	Self-established buildings	-0.26	0.39	-0.67	0.634
	Commercial residential building	-0.13*	0.34	-0.38	0.011
	Limited property house	0.38	0.54	0.71	0.926
	Rental housing	0.51*	0.36	1.44	0.026
Limited Property House					
	Self-established buildings	-0.64	0.47	-1.37	0.615
	Commercial residential building	-0.51*	0.43	-1.19	0.032
	Houses built with funds collected by the buyers	-0.38	0.54	-0.71	0.926
	Rental housing	0.13*	0.44	0.30	0.031
Rental Housing					
	Self-established building	-0.77*	0.23	-3.33	0.021
	Commercial residential building	-0.64	0.14	-4.71	0.062
	Houses built with funds collected by the buyers	-0.51*	0.36	-1.44	0.026
	Limited property house	-0.13*	0.44	-0.30	0.031

Source: Derived from the sample data by the authors using SPSS 20.0. The significance level of mean difference is 0.05.

Table 7: Test results and sorting of the different layers

Number of floor levels	*N*	*Mean value*	*Homogeneity test of variances*	*Analysis of variance*
Low - rise residence	37	2.78	0.057	0.001
Multi-storey residence	68	2.35		
Medium and high-rise residence	81	2.47		
High-rise residence	144	2.82		

Source: Derived from the sample data by the authors using SPSS 20.0.

(4~6 layers) are generally old rooms with no elevators. Occupants of such residences are financially incapable to install solar photovoltaic power generation equipment. Besides, it is difficult to install solar photovoltaic power generation equipment in old residences. Unlike, multi-storey residents, high- rise (7-9 layers) housing residents are generally in better economic conditions. Their cultural level is high, and they have strong environmental consciousness, hence, they are more willing to adopt solar photovoltaic power generation.

(2) Different residential layers resulted in significant differences in residents' willingness to adopt solar photovoltaic power generation. Using a test of homogeneity of variance, four different layers of building were examined to determine whether these differences were significant. The results as presented in Table 7 showed that 0.057 was greater than 0.05, which indicated that the variance was homogeneous, so the method was appropriate to test the homogeneity of variance. The table also showed that differences in residents' willingness to adopt solar photovoltaic power generation, based on layers of building were significant ($P<0.05$). It was observed that low- rise and high-rise residents had strong willingness to adopt solar photovoltaic power generation while multi-storey and medium and high-rise residents had weak willingness to adopt solar photovoltaic power generation. Building layers were grouped into two and S-N-K test method, and LSD multiple comparison analysis were further used to analyse the samples. Multi-storey, medium and high-rise made up the first group while low and high- level formed the second group. The results showed that (Tables 8 and 9) there was no significant difference within the same group but, significant difference was noticed between the two groups.

Analysis of Different Residential Living Floors

(1) Residential floor is positively associated with willingness to adopt solar photovoltaic power generation". Table 10 shows residential floor and the mean of willingness to adopt solar photovoltaic power generation. Ranking from highest to lowest is as follows: 1~3 floor, 4~6floors, 7~9floors, 10 floors and above. The average of the highest floors (10 floors and above) was 13.1percent higher than that of the lowest layer (1~3floors). The higher the floor, the higher the willingness to adopt solar photovoltaic power generation. First, this can be attributed to better sunlight conditions on higher floors which can lead to higher utilization ratio of solar photovoltaic power generation. The lower floors were covered which made residents to be less willing to install solar photovoltaic power generation equipment. Second, residential floor has a certain relationship with the occupant's economy condition. Residents of high floors are in good economic condition and possess high cultural

Table 8: S-N-K test of different layers on willingness to adopt solar photovoltaic power generation

Number of floor levels	*N*	*A subset of the set of alpha = 0.05*	
		1	*2*
Multi-storey residence	68	2.35	
Medium and high-rise residence	81	2.47	
Low- rise residence	37		2.78
High-rise residence	144		2.82

Source: Derived from the sample data by the authors using SPSS 20.0.

Table 9: LSD multiple comparison analysis of different layers

(I) No. of floor levels	*(J) No. of floor levels*	*Mean difference (I-J)*	*Standard Error*	*Error*	*Significance*
Low-rise Residence	Multi-storey residence	0.43*	0.26	1.65	0.048
	Medium and high-rise residence	0.31*	0.25	1.24	0.002
	High-rise residence	-0.04	0.24	-0.17	0.054
Multi-storey Residence	Low rise residence	-0.43*	0.26	-1.65	0.048
	Medium and high-rise residence	-0.12	0.17	-0.71	0.057
	High-rise residence	-0.47*	0.15	-3.13	0.000
Medium and High-rise Residence	Low rise residence	-0.31*	0.25	-1.24	0.002
	Multi-storey residence	0.12	0.17	0.71	0.068
	High-rise residence	-0.35*	0.13	-2.69	0.017
High-rise Residence	Low rise residence	0.04	0.24	0.17	0.054
	Multi-storey residence	0.47*	0.15	3.13	0.000
	Medium and high-rise residence	0.35*	0.13	2.69	0.034

Source: Derived from the sample data by the authors using SPSS 20.0. The significance level of mean difference is 0.05.

Table 10: Test result and sorting of the different living floor

The number of living floor	*N*	*Mean value*	*Homogeneity test of variance*	*Analysis of variance*
1~3floor	102	2.44	0.054	0.000
4~6 floor	95	2.49		
7~9 floor	45	2.54		
Above 10 floor	88	2.76		

Source: Derived from the sample data by the authors using SPSS 20.0.

education level with strong environmental awareness. Thus, they have the wherewithal to purchase solar photovoltaic power generation equipment.

(2) Different residential floors resulted in significant differences in residents' willingness to adopt solar photovoltaic power generation. Using a test of homogeneity of variance, four different residential floors were examined to determine whether these differences were significant. The results as presented in Table 8 showed that 0.054 was greater than 0.05, which indicated that the variance was homogeneous, so the method was appropriate to test the homogeneity of variance. The table also showed that differences in residents' willingness to adopt solar photovoltaic power generation, based on residential floors were significant ($P<0.05$). It was observed that the higher the number of floors, the higher the willingness to adopt solar photovoltaic power generation. Building floors were grouped into two and S-N-K test method, and LSD multiple comparison analysis were further used to analyse the samples. 1~3 floors, 4~6 floors and 7~9 floors made up the first group while 10 floors and above formed the second group. The results showed that (Tables 11 and 12) there was no significant difference within the same group but, significant difference was noticed between the two groups.

Analysis of Different Residential Areas

(1) Housing area is positively associated with willingness to adopt solar photovoltaic power generation. Table 13 shows housing area and the mean of willingness to adopt solar photovoltaic power generation. Ranking from highest to lowest is as follows: below 45m^2, 45~89m^2, 90~139m^2, 140~179m^2, and above180m^{2}e.The highest average (more than 180 m^2) was 37.2 percent higher than the lowest average (below 45 m^2). The larger the housing area, the stronger the willingness to adopt solar photovoltaic power generation. This can be attributed to economic conditions of the residents. Residents of small housing areas live in poor economic conditions. They have low level of education and poor un-

Table 11: S-N-K test of different residents living floor on willingness to adopt solar photovoltaic power generation

The number of	*N*	*A subset of the set of living floor alpha = 0.05*	
		1	*2*
1~3floor	102	2.44	
4~6 floor	95	2.49	
7~9 floor	45	2.54	
Above 10 floor	88		2.76

Source: Derived from the sample data by the authors using SPSS 20.0.

derstanding of solar photovoltaic power generation. Hence, they are unwilling to purchase solar photovoltaic power generation equipment On the contrary, residents of large housing areas are generally in good economic conditions. They have high education level and strong environmental awareness. Hence, they are willing to purchase solar photovoltaic power generation equipment.

(2) Different housing area resulted in significant differences in residents' willingness to adopt solar photovoltaic power generation. Using a test of homogeneity of variance, different housing areas were examined to determine whether these differences were significant. The results as presented in Table 13 showed that 0.066 was greater than 0.05, which indicated that the variance was homogeneous, so the method was appropriate to test the homogeneity of variance. The table also showed that differences in residents' willingness to adopt solar photovoltaic power generation, based on residential floors were significant ($P<0.05$). It was observed that the larger the housing area, the stronger the willingness to adopt solar photovoltaic power generation. Housing areas were grouped into three and S-N-K test method, and LSD multiple comparison analysis were further used to analyse the samples. Under 45 m^2 made up the first group, 45 ~ 89 m^2, 90~89 m^2 and 140~179 m^2 formed the second group while more than 180 m^2 formed the third group. The results showed that (Tables 14 and

Table 12: LSD multiple comparison analysis of different residents living floor

(I) No. of living floor	*(J) No. of living floor*	*Mean difference (I-J)*	*Standard Error*	*Q Values*	*Significance*
1~3 floor	4~6 floor	-0.05	0.14	-0.36	0.431
	7~9 floor	-0.1	0.18	-0.57	0.717
	Above 10 floor	-0.32*	0.14	-2.25	0.002
4~6 floor	1~3 floor	0.05	0.14	0.36	0.431
	7~9 floor	-0.05	0.18	-0.28	0.328
	Above 10 floor	-0.27*	0.14	-1.88	0.018
7~9 floor	1~3 floor	0.1	0.18	0.57	0.717
	4~6 floor	0.05	0.18	0.28	0.328
	Above 10 floor	-0.22*	0.18	-1.23	0.004
Above 10 floor	1~3 floor	0.32*	0.14	2.25	0.002
	4~6 floor	0.27*	0.14	1.88	0.018
	7~9 floor	0.22*	0.18	1.23	0.004

Source: Derived from the sample data by the authors using SPSS 20.0. The significance level of mean difference is 0.05.

Table 13: Test result and sorting of the different housing area

Housing area	*N*	*Mean value*	*Homogeneity test of variance*	*Analysis of variance*
Under 45 m^2	36	2.12	0.066	0.000
45-89 m^2	71	2.45		
90-139 m^2	118	2.48		
140-179 m^2	60	2.53		
above180 m^2	45	2.91		

Source: Derived from the sample data by the authors using SPSS 20.0.

15) there was no significant difference within the same group, but, significant difference was noticed between the two groups.

Regression Analysis of Factors Influencing Adoption of Photovoltaic Power Generation

In order to explore the driving factors for residents' willingness to adopt photovoltaic power generation in different living conditions and further clarify its influence and significance, this study adopted strong and weak willingness as dependent variable (Five-point scale item: unwilling to = 1, can consider to = 2, like = 3, like in comparison= 4, very willing to = 5) and living condition variable as independent variable. Dependent variable (adoption intention) was taken as continuous variables and housing ownership was used as classification variables while residential total layers, residential floors, residential housing areas were continuous variables. Virtual variables were obtained according to the presence of strength of the property and land card (Self-establish buildings=4, Commercial residential building=3, Houses built with funds collected by the buyers=2, Limited property house=1, Rental housing=0).The regression analysis was used to analyse all the variables. The results obtained based on regression coefficient and significant level showed that housing ownership, residential floors and residential housing areas had important influence on public willingness to

Table 14: S-N-K test of different housing area on willingness to adopt solar photovoltaic power generation

Housing area	*N*	*A subset of the set of alpha = 0.05*		
		1	*2*	*3*
Under 45 m^2	36	2.12		
45-89 m^2	71		2.45	
90-139 m^2	118		2.48	
140-179 m^2	60		2.53	
Above180 m^2	45			2.91

Source: Derived from the sample data by the authors using SPSS 20.0

Table 15: LSD multiple comparison analysis of different housing area

(I) Housing area	*(J) Housing area*	*Mean difference (I-J)*	*Standard error*	*Q values*	*Significance*
Under 45 m^2	45-89 m^2	-0.33*	0.18	-1.82	0.014
	90-139 m^2	-0.36*	0.17	-2.18	0.034
	140-179 m^2	-0.41*	0.19	-2.19	0.000
	above180 m^2	-0.79*	0.27	-2.90	0.009
45-89 m^2	Under 45 m^2	0.33*	0.18	1.82	0.014
	90-139 m^2	-0.03	0.13	-0.23	0.721
	140-179 m^2	-0.08	0.16	-0.52	0.062
	above180 m^2	-0.46*	0.25	-1.83	0.039
90-139 m^2	Under 45 m^2	0.36*	0.17	2.18	0.044
	45-89 m^2	0.03	0.13	0.23	0.721
	140-179 m^2	-0.05	0.14	-0.37	0.000
	above180 m^2	-0.43*	0.24	-1.79	0.011
140-179 m^2	Under 45 m^2	0.41*	0.19	2.19	0.000
	45-89 m^2	0.08	0.16	0.52	0.508
	90-139 m^2	0.05	0.14	0.37	0.072
	above180 m^2	-0.38*	0.26	-1.48	0.007
above180 m^2	Under 45 m^2	0.79*	0.27	2.90	0.009
	45-89 m^2	0.46*	0.25	1.83	0.039
	90-139 m^2	0.43*	0.24	1.79	0.011
	140-179 m^2	0.38*	0.26	1.48	0.007

Source: Derived from the sample data by the authors using SPSS 20.0. The significance level of mean difference is 0.05.

Table 16: Linear regression results

Model	*Unstandardized coefficients*				
	B	*Standard error*	*Typical coefficient*	*t*	*Sig.*
Constant	0.526	0.203		2.038	0.200
Housing ownership	0.376	0.048	0.345	6.231	0.001
Residential total layers	0.143	0.036	0.105	3.263	0.061
Residential living floors	0.325	0.052	0.330	6.031	0.000
Residential housing areas	0.362	0.055	0.365	6.037	0.000

Source: Derived from the sample data by the authors using SPSS 20.0.

adopt photovoltaic power generation. The first three factors had significant impact at 5 percent level and the coefficient was positive. Thus, if other conditions are unchanged, stronger housing ownership, higher living floor and larger housing area will result in stronger willingness to adopt solar photovoltaic power generation. It can be inferred from regression coefficients and significant level that residential housing areas had the greatest impact on intention to adopt solar photovoltaic power generation (Table 16).

DISCUSSION

Solar energy is a potential clean renewable energy source and solar photovoltaic (PV) has the most potential for domestic solar power systems in homes and for industrial power generation. Solar power generation demand increases worldwide as countries strive to reach goals for emission reduction and renewable power generations (Hosenuzzaman et al. 2015). Photovoltaic (PV) technology provides an efficient method to produce electricity through a virtually infinite renewable resource at the human time scale: solar radiation (Gundersona et al. 2015). Ma et al.(2015) considered that standalone renewable energy (RE) systems hold the most promising solution to the electrification of remote areas without utility grid access. They demonstrated that the proposed models and optimization algorithm is effective.

The literature review suggests that: (i) there is quite a lot of literature on the solar photovoltaic power generation; yet, as an important aspect of residents' willingness to adopt solar photovoltaic power generation still requires further study; (ii) most of the current researches on the solar photovoltaic power generation related issue are of a qualitative nature, with lack of quantitative and experimental studies on housing residents willingness to adopt solar photovoltaic power generation. Therefore, this paper intends to fill in this gap.

This study conducted survey sampling in Wuhan city to figure out residents' willingness to adopt solar photovoltaic power generation, using single factor analysis of variance and regression analysis method. Specifically, this study examined solar photovoltaic power generation residents would adopt in different housing conditions. It also examined general law of China on housing conditions of residents which can result in differences in willingness to adopt photovoltaic power generation. Both examinations were done so as to provide suggestions for the rapid development and popularization of photovoltaic power generation.

CONCLUSION

It can be concluded that type of housing had significant impact on residents' willingness to adopt solar photovoltaic power generation. Variables, such as housing ownership, floors and number of residential floors and residential housing area are positively related to willingness to adopt solar photovoltaic power generation. With the independence of housing ownership, housing residents' willingness to adopt solar photovoltaic power generation facilities was higher. Resident's willingness to adopt was also higher with increase in number of residential floors and housing areas.

RECOMMENDATIONS

Based on the above conclusions, this paper proposes the following policy recommendations.

(1) Unbundle solar photovoltaic power generation market and target customers that can readily adopt photovoltaic power generation. It

is advisable to consider stable housing ownership, high residential floors, and big residential housing areas for speedy breakthroughs. More importantly, implementation of solar photovoltaic power generation strategies should be adopted.

(2) Development of different promotion strategies for photovoltaic power generation based on housing ownership, residential floors and residential housing areas is necessary. Ability to adopt those strategies will drive the willingness and demand of photovoltaic power generation by all residents.

(3) Vigorous economic development with gradual improvement of public housing conditions. It was shown from this study that housing ownership, residential floors and residential housing areas have significant impact on willingness to adopt photovoltaic power generation. Therefore, improvement of public housing conditions will hasten public adoption of photovoltaic power generation.

(4) As observed in this study, residential housing areas had significant effect on residents' willingness to adopt photovoltaic power generation. So, increasing residential housing areas is one of the key factors for improving willingness of public to adopt solar photovoltaic power generation.

ACKNOWLEDGEMENT

This research was supported by the Natural Science Foundation of China (NSFC) (No. 71173201) and (No. 71473231).

REFERENCES

Bazen EF, Brown MA 2008. Feasibility of solar technology (photovoltaic) adoption: A case study on Tennessee's poultry industry. *Renewable Energy*, 4(3): 62-71.

Bhandari R, Stadler I 2009. Grid parity analysis of solar photovoltaic systems in Germany using experience curves. *Solar Energy*, 83(9): 1634-1644.

Bortolini M, Gamberi M, Graziani A 2013. Multi-parameter analysis for the technical and economic assessment of photovoltaic systems in the main European Union countries. *Energy Conversion and Management*, 74: 117-128.

Cai JL, Zhou MH, Zhang HH 2012. An empirical research on influence factors of low carbon innovation products consumers adoption willingness-put new energy industry as example. *Consumer Economics*, 3: 23-26.

Claudy MC, Michelsen C, O'Driscoll A 2011. The diffusion of micro-generation technologies-assessing the influence of perceived product characteristics on home owners' willingness to pay. *Energy Policy*, 39(3): 1459-1469.

Firdaus MS, Roberto RI 2011. An evaluation of the installation of solar photovoltaic in residential houses in Malaysia: Past, present, and future. *Energy Policy*, 39(12): 7975-7987.

Firdaus MS, Abu BM, Roberto RI 2012. Solar photovoltaic in Malaysia: The way forward. *Renewable and Sustainable Energy Reviews*, 16(7): 5232-5244.

Gao HO, Kitirattragarn V 2008. Taxi owners' buying preferences of hybrid-electric vehicles and their implications for emissions in New York City. *Transportation Research Part A*, 42: 1064-1073.

Gilberto MJ, Conrado AM 2013. Grid-connected photovoltaic in Brazil: Policies and potential impacts for 2030. *Energy for Sustainable Development*, 17(1): 40-46.

Gundersona I, Goyetteb S, Gago SA 2015. Climate and land-use change impacts on potential solar photovoltaic power generation in the Black Sea region. *Environmental Science and Policy*, 46: 70-81.

Harder E, Gibson JMD 2011. The costs and benefits of large-scale solar photovoltaic power production in Abu Dhabi, United Arab Emirates. *Renewable Energy*, 36(2): 789-796.

Haw L, Sopian K, Sulaiman Y, 2009. Public Response to Residential Building Integrated Photovoltaic System (BIPV) in Kuala Lumpur Urban Area. *Proceedings of the 4th IASME/WSEAS International Conference on Energy and Environment*, Cambridge (UK), February, pp. 212-219.

Hoppmanna J, Huentelera J, Giroda B 2014.Compulsive policy-making—The evolution of the German feed-in tariff system for solar photovoltaic power. *Research Policy,* 43(8): 1422-1441.

Hosenuzzaman M, Rahima NA, Selvaraj J 2015. Global prospects, progress, policies, and environmental impact of solar photovoltaic power generation. *Renewable and Sustainable Energy Reviews*, 41: 284-297.

Huijts NMA, Molin EJE, Steg L 2012. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable and Sustainable Energy Reviews*, 16: 525-531.

Islama T, Meade N 2013. The impact of attribute preferences and attitudinal constructs on adoption timing: The case of solar photo-voltaic (PV) cells for household level electricity generation. *Energy Policy*, 55: 521-530.

Islam T 2014. Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. *Energy Policy*, 65: 340-350.

Janjai S, Laksanaboonsong J, Seesaard T 2011. Potential application of concentrating solar power systems for the generation of electricity in Thailand. *Applied Energy*, 88: 4960-4967.

Loulas NM, Karteris MM, Pilavachi PA 2012. Photovoltaics in urban environment: A case study for typical apartment buildings in Greece. *Renewable Energy*, 48: 453-463.

Ma T, Yang HX, Lu L, Peng JP 2015. Pumped storage-based standalone photovoltaic power generation system: Modeling and techno-economic optimization. *Applied Energy*,137(1): 649-659.

Omer AM 2008. Energy, environment and sustainable development. *Renewable and Sustainable Energy Reviews*.12: 2265-2300.
Radmehr M, Willis K, Kenechi UE 2014. A framework for evaluating WTP for BIPV in residential housing design in developing countries: A case study of North Cyprus. *Energy Policy*, 70: 207-216.
Rehmana S, Sahinb AZ 2015. Performance comparison of diesel and solar photovoltaic power systems for water pumping in Saudi Arabia. *International Journal of Green Energy*, 12(7): 702-713.
Scarpa R, Willis K 2010. Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies. *Energy Economics*, 32 (1):129-136.
Shi J, Su W, Zhu M, Chen H 2013. Solar water heating system integrated design in high-rise apartment in China. *Energy and Buildings*, 58: 19-26.
Singh GK, 2013.Solar power generation by PV (photovoltaic) technology: A review. *Energy*, 53: 1-13.
Wang Z, Wang C, Hao Y 2013. Influencing factors of private purchasing intentions of new energy vehicles in China. *Journal of Renewable and Sustainable Energy*, 5: 063133.
Willis K, Scarpa R, Gilroy R 2011. Renewable energy adoption in an ageing population: Heterogeneity in preferences for micro-generation technology adoption. *Energy Policy*, 39(10): 6021-6029.
Xu GH, Xu F 2010. Impact factors of purchase decision of new energy automobile. *China Population Resources and Environment*, 20(11): 91-95.
Zhao SD, Guo HB, Wang YW 2015. Ecological environment and traditional craft: Taking Huizhou three carvings as an example. *Anthropologist*, 21(1, 2): 80-88.
Zhu ZY, Sun BH, Yang J 2012.The investigation and study about household photovoltaic power generation policy cognition and demand. *Economic Review*, 5: 66-69.