

Rethinking willingness to pay for renewable energy electricity in China

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ABSTRACT

With the continuous increase in residential electricity consumption, attention should be paid to the issue of renewable energy power consumed by residents. Rethinking residents' willingness to pay for renewable energy electricity is of great significance to the long-term development goal of renewable energy. This paper finds that residents' willingness to support the development of renewable energy is growing. Respondents with the more participation in renewable energy planning, and the more satisfaction with the implementation of renewable energy policies, as well as a higher recognition of the high cost of renewable energy, are willing to use renewable energy and are willing to pay more for renewable energy power. Moreover, respondents who are willing to use renewable energy are willing to pay more for renewable energy electricity. Although respondents are more willing to use voluntary payment mechanisms for payment, they are more likely to pay more for renewable energy power under the mandatory payment mechanism. At present, there is a large gap between the actual green power purchase behavior of Chinese residents and the expected WTP, mainly because there are many problems in the voluntary subscription mechanism for green power certificates.

Keywords: Willingness to pay; Renewable energy electricity; Willingness to use; Mandatory and voluntary payments; Tradable green power certificate.

NONMENCLATURE

Abbreviations

WTU	Willingness to use
WTP	Willingness to pay

1. INTRODUCTION

Renewable energy requires huge investment and a large amount of subsidies to support its development. From a long-term perspective, demand-side measures as one of the effective means promote the consumption of renewable energy power and stimulate innovation in renewable energy technologies to reduce the cost of renewable energy [1]. For example, a mandatory mechanism that forces everyone to pay additional taxes or surcharges, etc.; a voluntary mechanism that voluntarily subscribes for green electricity certificates, etc. [2]. Moreover, public acceptance is also one of the

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important factors affecting the development of renewable energy and the innovation of renewable energy technologies [3].

In China, the feed-in tariff policy is used to support the development of renewable energy and promote renewable energy technological innovation to continuously reduce costs. This part of the subsidy comes from renewable energy tariff surcharge subsidy imposed by the government on consumers. At present, for electricity other than electricity for agriculture and residents, the collection standard for renewable energy tariff surcharge subsidy has been raised to 0.019 yuan/kWh. Relying on subsidies to develop renewable energy is not a long-term solution. Therefore, in July 2017, the China Green Power Certificate Subscription Trading Platform was launched to alleviating the pressure of subsidy demand. China's green certificate trading market has been officially in operation for about three years and is still in the experimental stage. The design of the policy mechanism has various degrees of deficiencies in terms of benchmark prices, basic quotas, and fines in the green power certificate system, and the transaction status of green power certificates is not as expected [4]. Although purchasing green power certificate is currently a mode for Chinese residents to prove that they consume renewable energy electricity, only a very small number of residents who are more concerned about the renewable energy industry purchase green power certificates. It shows that Chinese residents have insufficient motivations to participate in renewable energy electricity consumption.

In theory, with the popularization of sustainable development, more and more residents are willing to pay a certain fee for renewable energy electricity [5-7]. Is the lack of power to participate in renewable energy electricity consumption due to the decline in residents' willingness to pay? Therefore, rethinking residents' willingness to use (WTU) and willingness to pay (WTP) for renewable energy electricity is of great significance for evaluating investment projects and revising the long-term development goals of renewable energy electricity. With the continuous rise of household

electricity consumption, attention should be paid to the issue of renewable energy power consumed by residents. In addition, as first-tier cities, Beijing, Shanghai, Guangzhou and Shenzhen are metropolises where China's political, economic and social activities are crucial, and demands for electricity are also high. This paper will investigate the residents' WTU and WTP for renewable energy electricity in four first-tier cities (Beijing, Shanghai, Guangzhou and Shenzhen), and determine the factors that affect their WTU and WTP, especially residents' preference for payment mechanisms and their WTP under different payment mechanisms.

2. SURVEY DESIGN AND METHOD

2.1 Survey

Our questionnaire has been distributed to the internet platform called "Questionnaire Treasure", which is a professional data research platform covering more than 1 million users in 346 cities in China. This internet platform will score based on the completeness and frequency of user responses, and users with low scores can be excluded from answering the questionnaire, to a certain extent, which will ensure the quality of the questionnaire. Moreover, most groups with different genders, ages, educational backgrounds, and income levels can access the "Questionnaire Treasure" on their smart-phones. Therefore, it is believed that the respondents of the questionnaire were randomly selected.

The questions in this questionnaire can be divided into two parts. The first part includes ten questions, which are related to the respondent's demographic characteristics and related cognition and behavior, such as gender, age, education level, income, the number of family members, environmental protection behavior, the knowledge of renewable energy, the participation in renewable energy planning, the satisfaction with the implementation effect of renewable energy policies, the trust in government environmental governance, the recognition of the high renewable energy electricity cost, and the preference for payment mechanisms. The second part is WTU and WTP.

In addition, this paper adopts two modes of mandatory payment and voluntary payment on the issue of WTP. Among them, 3215 respondents answered the question of WTP under mandatory payment, and 2212 respondents answered the question of WTP under voluntary payment. Finally, there were 4300 valid samples in total used in our study.

2.2 models

Firstly, the WTU for renewable energy electricity is a 0 or 1 dummy variable. If a linear probability model is used for estimation, there will be a deviation. Therefore, binary logit model or binary probit model is appropriate for this case in our study. The difference between the two models is the distribution. Due to the need to use maximum likelihood estimation, this paper chose to use logit model.

Secondly, the WTP for renewable energy electricity is divided into six categories, which are ordered data. Thus, ordered logit model or ordered probit model is suitable for our study. Same as above, this paper uses ordered logit model.

3. RESULTS AND DISCUSSION

This paper will analyze residents' WTP for renewable energy electricity. But before this, this paper will firstly discuss residents' WTU for renewable energy power. Table 1 shows the results of WTU estimated in the logit model. In the Model (1) of Table 1, the explanatory variables of the social characteristics include gender, age, education, income, and family members. We can find that males are more willing to use renewable energy electricity than females. Older respondents are more willing to use renewable energy electricity, and respondents with higher education and income levels are also more willing to use renewable energy. In addition, respondents with fewer family members are more willing to use renewable energy power. This may be because the fewer family members have less disagreement in the issue on use of renewable energy electricity. In the Model (2) of Table 1, this paper also considers the respondents' cognitions and behaviors. It can be found that if respondents have the

more frequent environmental protection behaviors, the more participation in renewable energy planning, the more satisfaction with the implementation of renewable energy policies, and the higher recognition of the high cost of renewable energy, the respondents are more willing to use renewable energy electricity. Therefore, it is very important to strengthen residents' understanding, participation and recognition of renewable energy.

Table 1 The results of willingness to use

	WTU	
	(1)	(2)
Gender	0.3256*** (0.1169)	0.2797** (0.1202)
Age	0.3034*** (0.0934)	0.1124 (0.0951)
Education	0.3644*** (0.1002)	0.1205 (0.1039)
Income	0.1537*** (0.0431)	0.0823* (0.0440)
Member	-0.3526*** (0.0980)	-0.3536*** (0.1000)
Behavior		0.2763*** (0.0941)
Knowledge		-0.0209 (0.0962)
Participate		0.1765** (0.0847)
Satisfaction		0.2381*** (0.0983)
Trust		0.0874 (0.0937)
Cost		0.3158*** (0.0834)
Constant	0.3835 (0.3743)	-1.6412*** (0.4336)
Log likelihood	-1140.1154	-1071.2498
Pseudo R2	0.0450	0.1027
Observation	4300	4300

Note: ***, ** and * indicate the significance at the 1% level, 5% level and 10% level, respectively. The standard error is reported in the parentheses.

In our study, 3616 respondents are willing to pay renewable energy electricity, making up about 84.09%. Compared with previous studies, the proportion of residents' WTP for renewable energy power has increased. It may also be that residents in China's four first-tier cities will be more willing to pay for renewable energy power.

Table 2 presents the results of WTP for renewable energy electricity based on the ordered logit model. Model (3) in Table 2 lists the coefficients of variables of the social characteristics, residents' cognitions and behaviors, WTU, payment preferences, and payment mechanism received in the survey. The results show that gender, education, income level, family members, knowledge, participate, satisfaction, trust, cost, WTU, payment preference and payment questionnaire type all impact their WTP significantly. Males are willing to pay more for renewable energy electricity than females. It may be because females are thrifter than males. Respondents with higher education and income levels

may receive more clean and low-carbon education and have greater financial strength to bear the cost, so they have strong enthusiasm to pay more for renewable energy electricity. Respondents with a fewer number of family members are less willing to pay more for renewable energy electricity. If respondents have more family members, they can share the cost. The above results are similar to Guo et al. [6], and Xie and Zhao [2]. In terms of residents' cognitions and behaviors, the respondents with more knowledge of renewable energy are willing to pay more for renewable energy electricity. Similar results are found in Xie and Zhao [2]. In addition, respondents who would participate more in renewable energy planning would pay more attention to the renewable energy industry, so they are motivated to pay more for renewable energy power. Besides, respondents who are more satisfied with the implementation of renewable energy policies and have a higher degree of trust in government governance believe that the government can better use the funds to support the development of renewable energy. Therefore, they will also be willing to pay more for renewable energy electricity. Moreover, respondents with higher recognition of the high cost of renewable energy will be also willing to pay higher fees for renewable energy electricity. Taking into account the WTU, this paper found that respondents who are willing to use renewable energy power are willing to pay more for renewable energy power. Regarding the payment mechanism, respondents who prefer the voluntary payment mechanism will pay more enthusiastically. However, respondents under the mandatory payment mechanism will instead give a higher valuation of WTP. Similar results are shown in Guo et al. [6], and Akcura [8].

In the model (4) in Table 2, this paper estimates based on the sample of WTU, and the results are consistent with the model (3) in Table 2. Similarly, in the Model (5) and (6) in Table 2, this paper also estimates based on the sample of mandatory payment mechanism and the sample of voluntary payment mechanism, and the results are basically in line with the model (3) in Table 2. It is worth noting that in the

sample of a compulsory payment mechanism, the impact of respondents' payment preferences on WTP is not significant, but in the sample of voluntary payment mechanism, the effect of respondents' payment preferences on WTP is significant. Although respondents prefer to pay under the voluntary payment mechanism, respondents are more likely to pay more for renewable energy electricity under the mandatory payment mechanism, the results of which are consistent with Akcura [8].

Table 2 The results of willingness to pay

	Pooled sample Model (3)	WTU sample Model (4)	M sample Model (5)	V sample Model (6)
Gender	0.2112*** (0.0610)	0.2298*** (0.0635)	0.1471* (0.0854)	0.2455*** (0.0883)
Age	0.0173 (0.0512)	-0.0174 (0.0535)	0.0793 (0.0673)	-0.0933 (0.0805)
Education	0.1679*** (0.0555)	0.17523*** (0.0584)	0.1925*** (0.0748)	0.1028 (0.0843)
Income	0.1414*** (0.0225)	0.1519*** (0.0231)	0.1573*** (0.0311)	0.1292*** (0.0328)
Member	0.3564*** (0.0519)	0.3614*** (0.0535)	0.3184*** (0.0645)	0.3827*** (0.0788)
Behavior	-0.0086 (0.0479)	0.0056 (0.0498)	-0.0107 (0.0645)	0.0160 (0.0719)
Knowledge	0.0824* (0.0471)	0.0741 (0.0487)	0.0632 (0.0611)	0.0927 (0.0742)
Participate	0.2591*** (0.0408)	0.2373*** (0.0487)	0.2567*** (0.0548)	0.2466*** (0.0617)
Satisfaction	0.1097** (0.0518)	0.1344** (0.0542)	0.0448 (0.0675)	0.1883** (0.0812)
Trust	0.1281*** (0.0499)	0.1023** (0.0520)	0.2067*** (0.0663)	0.0250 (0.0762)
Cost	0.4532*** (0.0455)	0.4905*** (0.0471)	0.4993*** (0.0605)	0.3880*** (0.0700)
WTU	0.5453*** (0.1180)	-	0.6668*** (0.1390)	0.1267 (0.2313)
Payment preference	0.2291*** (0.0861)	0.2586*** (0.0900)	0.1093 (0.1114)	0.3657*** (0.1377)
Payment	-0.5732*** (0.0609)	-0.6050*** (0.0626)	-	-
questionnaire type				
Cut1	3.8892*** (0.2730)	3.4411*** (0.2805)	4.0912*** (0.3373)	3.5264*** (0.4940)
Cut2	5.3640*** (0.2770)	4.8859*** (0.2837)	5.7714*** (0.3448)	4.8350*** (0.4982)
Cut3	6.5782*** (0.2831)	6.1078*** (0.2837)	6.9613*** (0.3538)	6.0796*** (0.5059)
Cut4	7.7198*** (0.2893)	7.2557*** (0.2958)	8.0714*** (0.3624)	7.2843*** (0.5142)
Cut5	8.8708*** (0.2980)	8.4330*** (0.3050)	9.1204*** (0.3730)	8.7064*** (0.5285)
Log likelihood	-6201.5231	-5789.5122	-3351.9849	-2824.6148
Pseudo R2	0.0731	0.0715	0.0901	0.0428
Observation	3896	3623	2119	1777

Note: ***, ** and * indicate the significance at 1%, 5% level and 10% level, respectively. The standard error is reported in the parentheses.

This paper calculates the mean WTP under the baseline scenario, the WTU for renewable energy power scenario, the mandatory payment scenario and the voluntary payment scenario. Under the baseline scenario, the mean WTP is 44.06 yuan/month. Under the WTU for renewable energy power scenario, the mean WTP is 45.49 yuan/month. Under the mandatory payment scenario, the mean WTP is 51.77 yuan/month. Under the voluntary payment scenario, the mean WTP is 34.85 yuan/month. Therefore, the mean WTPs range from US\$ 5.09-7.56 per month.

Based on the mean WTP (34.85 yuan/month) under the voluntary payment scenario, the residents will voluntarily pay 418.20 yuan for renewable energy power a year. In China, it is indistinguishable whether

the electricity received by residents is generated through traditional energy or renewable energy. Therefore, residents cannot directly purchase electricity from renewable energy sources. Residents who want to buy renewable energy power can go to the China Green Power Certificate Subscription Trading Platform to purchase voluntarily, which is a proof of consumption of renewable energy power. According to the data from the China Green Power Certificate Subscription Trading Platform, from July 1, 2017 to June 18, 2020, the transaction prices of green power certificates for wind power range from 128.6-330 yuan/piece, and the average price is 175.1 yuan/piece. The transaction prices of green power certificates for photovoltaic power range from 518.7-900 yuan/piece, and the average price is 668.1 yuan/piece. Therefore, residents are expected to be able to purchase approximately 1-3 wind power green certificates a year, and there is still pressure to purchase photovoltaic green certificates. In fact, as of June 18, 2020, the green power certificate subscription has been trialed for nearly three years. There were 2177 users participating in the China Green Power Certificate Subscription Platform to purchase green power certificates, and a total of 37,816 green power certificates were subscribed. Among them, the vast majority of green power certificates are purchased by companies, and the number of residents purchasing green power certificates on China's green certificate subscription platform is very small. Moreover, these individuals are basically concerned about the energy industry and regard the purchasing behavior of green power certificates as a kind of "self-realization". There is a big gap between residents' actual green power purchase behavior and expected WTP. Chinese residents have insufficient motivations to participate in renewable energy electricity consumption.

In fact, it has been found in many previous studies that the respondents' self-reported attitude towards environmental protection does not guarantee actual environmental behavior. What are the reasons for the "attitude-behavior gap"? First, in the survey, there may be bias when respondents stating their preferences, which may lead to overestimation of WTP

[8]. Nevertheless, this phenomenon is also inevitable in the survey of this paper. Second, for voluntary payment mechanism, the "participation expectation" plays an important role [6,8]. In other words, if respondents knew other respondents participate in purchasing green electricity, they may be encouraged to participate. Therefore, if there is no basis for a certain number of participants, it is difficult to improve the actual behaviors of residents. Third, the respondents may lack trust in green power products and power companies [9], which may also lead to a gap between the stated WTP and the actual WTP. There may be some residents who are willing to pay for renewable energy electricity, but at the same time still doubt whether their money will be used to achieve the goal of increasing the proportion of renewable energy [10]. Residents suffer from information gaps due to poor sales of renewable energy electricity products provided by suppliers and opaque details of the use of funds by suppliers. Therefore, residents need a lot of external information and incentives to become active participants. Finally, the imperfection of the voluntary subscription mechanism for green power certificates is also one of the main reasons. As mentioned above, residents purchase green power certificates mainly out of "self-realization". However, the green power certificates can be sold only once, which weakens their transaction attributes. Moreover, compared with the average prices of international green power certificates, the prices of green power certificates in China is more than 10 times, indicating the costs is high, which also hinders the enthusiasm of residents to participate. Currently, green power certificates are not well traded in areas with relatively developed economies or relatively abundant energy [4]. If the problem of cross-regional transmission and local consumption of renewable energy cannot be solved, it will be difficult for residents to increase their enthusiasm for participation. In addition, the transaction objectives and rules for the voluntary subscription of green power certificates are still unclear, especially the lack of design and introduction of responsibilities and obligations for residents, which may result in insufficient subscription willingness of residents. In China, this kind of voluntary subscription

method that relies on residents' awareness is limited in stimulating residents to pay for renewable energy electricity.

4. CONCLUSIONS

This study found the following conclusions: (1) 92.05% of the respondents are willing to use renewable energy power, and 84.09% of the respondents are willing to pay for renewable energy electricity. Compared with the calculation results of previous studies based on Chinese samples, the value of mean WTP (44.05 yuan/month) has increased, indicating that the power to support the development of renewable energy continues to grow. (2) Respondents who more participated in renewable energy planning, more satisfied with the implementation of renewable energy policies, and have a higher recognition of the high cost of renewable energy are willing to use renewable energy and are willing to pay more for renewable energy electricity. (3) Respondents who are willing to use renewable energy power are willing to pay more for renewable energy power. The mean WTP of respondents who are willing to use renewable energy power is slightly higher (45.49 yuan/month). Therefore, it is necessary to encourage the residents' WTP for renewable energy power. (4) Although respondents prefer to pay under the voluntary payment mechanism, they are more likely to pay more for renewable energy electricity under the mandatory payment mechanism. The mean WTP under the mandatory payment mechanism is 51.77 yuan/month, while the mean WTP under the voluntary payment mechanism is 34.85 yuan/month. (5) The huge cost problem behind the compulsory payment mechanism and residents' preference for voluntary payment mechanisms make the government give priority to trying voluntary payment mechanisms for residents. The increased participation of residents in the voluntary subscription of green power certificates may play an important role in achieving international and national climate goals. However, the current China's voluntary subscription mechanism for green power certification as well as its supporting policies and transaction environment are not perfect, which is not sufficiently attractive to

residents, resulting in a large gap between residents' actual purchase behavior and expected WTP.

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REFERENCE

- [1] Lin BQ, Chen YF. Impacts of policies on innovation in wind power technologies in China. *Applied Energy* 2019, 247: 682-691.
- [2] Xie CB, Zhao W. Willingness to pay for green electricity in Tianjin, China: Based on the contingent valuation method. *Energy Policy* 2018, 114: 98-107.
- [3] Wüstenhage R, Wolsink M, Bürer MJ. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy* 2007, 35: 2683-2691.
- [4] Song XH, Han JJ, Shan YQ, Zhao CP, Liu JP. Efficiency of tradable green certificate markets in China. *Journal of Cleaner Production* 2020, 264: 121518.
- [5] Zhang L, Wu Y. Market segmentation and willingness to pay for green electricity among urban residents in China: The case of Jiangsu Province. *Energy Policy* 2012, 51: 514-523.
- [6] Guo XR, Liu HF, Mao XQ, Jin JJ, Chen DS, Cheng SY. Willingness to pay for renewable electricity: A contingent valuation study in Beijing, China. *Energy Policy* 2014, 68: 340-347.
- [7] Chan KY, Oerlemans LAG, Volschenk J. On the construct validity measures of willingness to pay for green electricity: Evidence from a South African case. *Applied Energy* 2015, 160: 321-328.
- [8] Akcura E. Mandatory versus voluntary payment for green electricity. *Ecological Economics* 2015, 116: 84-94.
- [9] Salmela S, Varho V. Consumers in the green electricity market in Finland. *Energy Policy* 2006, 34: 3669-3683.
- [10] Knapp L, O'Shaughnessy E, Heeter J, Mills S, DeCicco JM. Will consumers really pay for green electricity? Comparing stated and revealed preferences for residential programs in the United States. *Energy Research & Social Science* 2020, 65: 101457.

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