Multicultural Education

Volume 8, Issue 2, 2022

Willingness to Pay for Renewable Energy: A Case Study of Faisalabad

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Article Info

Article History

Received:
July 26, 2021

Accepted:
February 28, 2022

Keywords :
Willingness to Pay, Renewable Energy, Welfare, Faisalabad, Pakistan, Provincial Level

DOI:
10.5281/zenodo.6370447

Abstract

Every economy requires energy consumption to develop, yet the usage of non-renewable energy has negative ecological consequences. One more issue is that nonrenewable sources are scarce in comparison to energy demands. Renewable energy is the only way to solve these challenges in such a situation. Renewable energy investment is growing, UBt it is still in its early stages in Pakistan. Solar panels and wind energy account for the majority of renewable energy investment. Pakistan has a lot of potential for solar energy because the sun shines for 8 to 8.5 hours every day. The major goal of this research was to find out how people in Faisalabad responded towards this possible investment. The study's questionnaire was created utilizing the contingent valuation method. The elicitation approach used to examine the willingness to pay for solar energy was the double bounded dichotomous choice. Face-to-face interviews with 120 respondents were done in Faisalabad's Jinnah colony, Madina Town, Muslim Town, and Sitara sapna colony. In the study's sample, there were 60 residences with solar energy source and 60 were without this facility. The data in this research was analyzed using both parametric and non-parametric methods. Double bounded logistic regression is used in the parametric approach. The total WPAY model and the marginal WPAY model are both used in this technique. literacy, age, wealth, house size, and numbers of residence all have a favorable connection with WPAY in both models. However, in both models, proposal amount has negative association with WPAY. When comparing the non-parametric and parametric approaches, the average WPAY is lower in the non-parametric approach.

Introduction

Energy can be found in a variety of forms, such as oil and gas; coal contains chemical energy (Simon, 2013). Because nonrenewable resources are limited, it is necessary to shift to renewable energy sources. To meet society's needs, energy resources should meet three dimensions: effectiveness, sanctuary, andenvironment safety. Anenergy resource is competitive if it has a little societal cost. The term "energy sanctuary of supply" refers to the availability and reliability of energy. The energy discourse should produce no greenhouse gas emissions (Vattenfall's energy portfolio, 2011). Renewable energy is becoming a faster-growing form of energy since it helps to reduce foreign energy dependency and negative environmental repercussions (Apergis and Payne, 2010). In 2014, the average annual growth rate of solar PV system was 30 percent that was highest among all other forms of renewable energy. n 2014, the solar sector had remarkable expansion, reaching its anticipated capacity of 45 gigawatts (Sharma, 2015). Pakistan's power demand has risen in tandem with the country's economic growth during the last two decades. Pakistan's energy production capability is unjustifiable since the UBlk of its dimensions are relied on overseas purchases of oiland local gas, UBt it is insufficient to meet the mandate of power plants. The economy's electrical demand-supply balance has worsened as a result of high transmission and delivery losses. As a result, the country faces a deficit of power, which not only stifles economic growth UBt also deprives people of basic necessities. Electricity demand rises in tandem with population growth, particularly in the residential sector (GoP 2021). Pakistan's government has also begun solar energy projects, such as the Quid e Azam solar park. It is Pakistan's first and largest solar energy installation, located near Bahawalpur, Punjab. This project is expected to produce 1000MWp of electricity. 100MWp of capacity was created in the first phase, with the remaining 900MWp to be generated in subsequent phases.(Khaliq et al, 2015). Pakistan's parliament is the world's first to be powered entirely by solar energy. For the first time, NEPRA granted a net metering licence to the national assembly, allowing for the contriUBtion of additional electricity to the grid. Israel's parliament has also switched to solar energy, however only 10% of its needs can be met through this scheme (Dawn newspaper, 2006). Because household power usage is increasing every day and accounts for a significant portion of the country's total electricity consumption, there is a need to provide alternate means to electrify them. This study was conducted on the inhabitants of Faisalabad with the objective to determine the willingness of households to pay for renewable energy.

REVIEW OF LITERATURE

Important exploratory topics have emerged as a result of these studies. The idea of planned behavior aids in the development of basic consumer behavior models, UBt it does not include all of the potential impacts. In the new environmental domain, the unified theory of acceptance and use of technology (UTAUT) is used to adopt renewable energy technologies.Gustavsson and Ellegrd (2004) investigated the influence of PV-ESCO on Zambians' livelihoods. Interviews were done with both families with and without solar service facilities for the survey analysis. The results of the survey revealed that families with solar panels paid more than those who got their electricity from other sources(Batidzirai et al 2018,Zulu et al 2021,Han et al 2020).

In the instance of Japan, Nomura and Akai (2004) investigated the WPAY for renewable energy. The study employed a strata strategy for sample collection in 11 major Japanese cities for survey analysis. An email survey was conducted using CVM on 1000 sheets, of which only 37% were returned. The poll employed three sorts of slips, with the first response being a willingness to pay 50, 1000, or 2000 yen per month. Study results confirm the positive attitude towards willingness to pay (Gao et al 2020, Nakano et al 2018).Wijayatunga and Attalage (2005) investigated the socioeconomic and environmental effects of solar household systems on Sri Lankan rural people. The respondents were separated into two groups: those who received a financial incentive for purchasing SHS and those who did not. The results of the survey revealed that a household's ability to repay SHS loans was determined by their income level and type of work. Wiser (2007) studied how people's desire to use renewable energy altered as a result of fixed and controlled payment techniques, as well as how this decision was influenced by whether the facility was provided through government or private networks. The questionnaires were mailed out as part of the survey. By using logit multivariate regression model, this study revealed that the willingness to use renewable energy was higher in the event of a private supply authority and shared compensation, according to the findings. Ku and Yoo (2010) studied how Korean families reacted to the government's goal at minimum getting 11% at of their energy from renewable sources by 2030. By using choice experiment the study identified five attriUBtes and assigned degrees to each of them. People are also more interested in wild life, pollution reduction, and job prospects, according to the findings. As a result, they were willing to pay US$140 million for renewable energy.

RESEARCH METHODOLOGY

Because of the limited time, it was not able to survey the entire district. As a result, respondents were chosen using a multi-stage purposive sampling technique. A total of 120 people were interviewed, including 60 solar energy users and 60 people who used other energy sources. The household's willingness to pay for solar energy is estimated using the contingent valuation technique (CVM).Contingent Valuation (CV) is a way of determining the financial worth of non-market commodities by asking survey interrogations that reveal people's preferences (Carson, 1989).

Studies that used contingent valuation method

Author (year)	Country	Methodology	Object analyzed	Results
Mozumder*et al*.(2011)	US	CV	Additional WPAY for 10% and 20% increase in green electricity	USD 10 for 10% and USD 25 for 20%
Bollino (2009)	Italy	CV	Green electricity	EUR455–9.39
Claudy*et al*.(2011)	Irland	CV		
Zografakis*et al*.(2010)	Greek	CV	Green electricity	Additional EUR 4.08/month
NomuraandAkai(2004)	Japan	CV	Green electricity	JPY 2000/month
Zhang andWu(2012)	China	CV	Green electricity	CNY7.91–10.30
YooandKwak(2009)	Korea	CV	Green electricity	KRW 1345
Lee *et al*.(2005),	Korea	CV	Green electricity	KRW1681–2072
Kim *et al*	Korea	CV	Green electricity	KRW 1345

Source: Own elaboration

For CV questions, the current study employed double bounded dichotomous choice since it is more representative of market conditions. For the estimation of solar energy in this study, two models were used. One for the overall willingness of those who do not have solar energy. Those who have solar panels come in second.

$WPAY = \alpha + \beta_1 Y + \beta_2 A + \beta_3 E + \beta_4 FSZ + \beta_5 HSZ + \beta_6 LB + \mu$

Where:

WPAY = Willingness to pay for solar energy
Y = income of household
A = age of respondent
FSZ = total family members of a house
HSZ = house size of respondent
μ = error term

For econometric estimate, this study used both parametric and non-parametric approaches on data. Non-parametric estimation has been used in discrete CV studies by Kristrom (1990), Haab and McConnell (1997), Carson et al. (2003), and Loureiro et al (2004). On the one hand, nonparametric models are "roUBst and allow greater flexibility," UBt on the other, this model only delivers minimum economic information (Hanemann and Kanninen 1999). The primary advantage of nonparametric modelling (NPM), which is a distriUBtion-free estimate method, is its resistance to distriUBtional misspecification. In contrast to nonparametric distriUBtions, parametric distriUBtions allow exogenous variables to be incorporated in model estimations, such as income and other socioeconomic variables. There are various parametric models available for a DLBC format, such as Hanemann et al 1991's double-bounded logistic model.$\pi yy\ (Bi, UBi\ )=Pr\{Bi \leq \max WPAY \text{ and } UB \leq \max WPAY\ =1-G(UBi\ ;\ \delta)$

1) $\pi nn\ (Bi, LBi\ )=Pr\{Bi \geq \max WPAY \text{ and } UB>\max WT\ \ =1-G(LBi\ ;\ \delta)$
2) $\pi yn\ (Bi, UBi\ )=Pr\{Bi \leq \max WPAY \leq UBi= G(UBi\ ;\ \delta) - G(Bi\ ;\ \delta)$
3) $\pi ny\ (Bi, LBi\ )=Pr\{Bi \geq \max WPAY \geq LBi)\ \ \ \ \ \ \ \ \ \ \ \ = G(Bi\ ;\ \delta) - G(LBi\ ;\ \delta)$

Where i = individual

UB= upper bid
LB =lower bid
Yy = yes yes
Yn =yes no
Nn =no no
Ny = no yes
G = cdf

$$\ln LD\ (\delta)=\{di^{yy} \ln \pi^{yy}(Bi, UBi\ )+di^{nn} \ln \pi^{nn}(Bi, LBi\ )+di^{yn} \ln \pi^{yn}(Bi, UBi\ )+di^{ny} \ln\pi^{ny}(Bi, LBi\ )\},$$

where di^{yy} ,di^{nn} , di^{yn} and di^{ny} are binary-valued indicator variables.

RESULTS AND DISCUSSION

Table 2 shows demographic features that are representative of respondents of survey.Gender, age,house ownership type, education level and income source are all listed in Table 2. Table 2 shows that the majority of respondents were 41 or above (40.1 percent) and had graduation or higher studies (25.8 percent).most of the families had their own houses (94.2 percent) only few did not have (5.8 percent). The majority of families (59.14 percent) have four or more members because three generations typically live in the same house. 40 percent of the respondents were doing own UBsiness for earning..

Demographic characteristics of participants.

Type	Selection	Number	Percent	Type	Selection	Number	Percent
Gender	Male	81	67.50%	education	Uneducated	5	4.2
	Female	39	32.50%		Matric	8	6.7
Age	15-20	1	0.8		Intermediate	10	8.3
	21-30	28	23.4		Graduation	31	25.8
	31-40	32	26.6		M.Phil.	24	20
	41-50	48	40.1		PhD	5	4.2
	Above 50	11	9.2	income source	Own UBsiness	48	40
House Ownership	Owned	113	94.2		Government job	22	18.3
	Rented	7	5.8		Private job	38	31.7

The willingness to pay for solar energy was estimated using two models in this study. One for the overall willingness of those who do not have solar energy to pay for it. MWPAY was estimated for households with solar plates. Total willingness to pay refers to the total amount a person would be willing to spend rather than completely forsake a product in order to reach that consumption level.The marginal willingness to pay is a person's increased willingness to pay for one additional unit.

Parametric approach: Double bounded logistic regression

Total willingness to pay model

Variable	***Coefficient***	***Standard error***	***p-value***
constant	1.383	3.136	0.659
education	0.630 *	0.263	0.016
Age	0.079*	0.039	0.044
income	0.037 **	0.012	0.002
House size	0.016	0.155	0.917
Family size	0.152	0.143	0.286
Log(bid)	-2.119***	0.417	2.2e-16

Observations	***60***
LR test, df, p-value	***82.62, 5 , 0.000***
Aic	***92.64***
Bic	***107.30***

Note: *, **, *** Significant at 1%, 0.1%, 0% level respectively

Except for bid amount, all explanatory factors in the total willingness to pay model exhibit a positive connection with WPAY. However, the size of the house and the size of the family have no bearing. Education is beneficial and significant in this model at the 1% level. The willingness to pay grows by 0.630 units as education improves. Educated people are better aware of many types of energy. At the 1% level, the age variable's coefficient value is also important. The WPAY increases by 0.079 units for every unit increase in age.Households with more than 30year of age are anxious about the energy state and wanted to employ solar plates to power their homes. The most substantial variable in predicting willingness to pay models is income which is significant in both models of the study, according to the results of double bounded logistic regression. The WPAY improves by 0.037 units for every unit increase in income. As the coefficient value for solar energy is 0.016 units, this demonstrate that house size has a encouraging association with WPAY. It is, however, insignificant. In terms of WPAY for solar energy, the family size variable is positive UBt not significant.

Marginal Willingness to pay model

Variable	***Coefficient***	***Standard error***	***p-value***
constant	1.993	(3.967)	0.615
education	0.573**	(0.206)	0.005
Age	0.083''	(0.049)	0.093
Income	0.022**	(0.007)	0.001
House size	0.437**	(0.161)	0.006
Family size	0.169	0.169	0.414
Log(bid)	-2.661***	(0.473)	2.2e-16

Observations60	
LR test, df, p-value	***88.26, 5, 0.000***
Aic	***95.03***
Bic	***109.69***

’’,***, **, *** Significant at 5%, 1%, 0.1%, 0% level respectively**

All independent variables in the marginal WPAY have a parallel connection with WPAY, with the exception of bid amount which is the analogous as in the total willingness to pay model. According to this analysis, literate people are better aware of different types of energy. The marginal WPAY rises by 0.573 units as education rises. This is a significant value of 0.1 percent. The WPAY increases by 0.083 units when age increases by one unit, which is significant at the 5 percent level.Income has a progressive and considerable impact on marginal WPAY for solar energy, according to the results of double bounded logistic regression. The WPAY improves by 0.022 units for every unit increase in income. The findings demonstrate that the link between house size and marginal WPAY, with a coefficient value of 0.1 percent significance. In the case of marginal willingness to pay for solar energy, the family size variable is positive UBt not significant. The bid variable exhibits an extremely substantial negative connection with WPAY.The survival chance drops as the bid amount grows in the non-parametric technique. In the marginal WPAY model, however, initial bids have a higher probability of being accepted than in the total WPAY model. In both models, the mean value of willingness to pay is lower in the non-parametric approach than in the parametric approach, as the theory suggests.

Non-parametric approach

Table 4.29: Survival probabilities

	Total willingness to pay	**Marginal willingness to pay**
Bids	**Survival probability**	**Survival probability**
0	1.0000	1.0000
800	0.8833	0.9333
1000	0.8833	0.9333
1600	0.8167	0.8611
2500	0.7833	0.8250
3000	0.6500	0.7167
5000	0.6500	0.7167
10000	0.5935	0.6298
20000	0.5087	0.4778
Infinity	0.0000	0.0000

The probability of responding yes to a bid in two models, total and marginal willingness to pay, is shown in Table 4.5.3. The survival probability of this bid is 1 if respondents are given the 0 amount. In the total willingness to pay model, the survival probability of 800 and 1000 is the same as 88 percent. The change in probabilities between 1600 and 2500 is negligible. Saying yes to 3000 and 5000 has the same probability as saying yes to 3000 and 5000. In the overall willingness to pay model, the survival probability for bigger bids like 10,000 and 2000 is nearly 50%.

Bids with marginal desire to pay have a higher chance of survival than those with total readiness to pay. Households were given bids based on their current solar system in the marginal willingness to pay programmes. They were given a bid that covered the costs of expanding their PV system. At first bids of 800 and 1000, the likelihood of a yes response from the homeowner is 93 percent. The survival chance falls as the bid amount increases in subsequent stages. However, when compared to the total willingness to pay model, the survival probability at larger bids like 10,000 and 20,000 is lower. The following table depicts the case of voting yes against a bid:

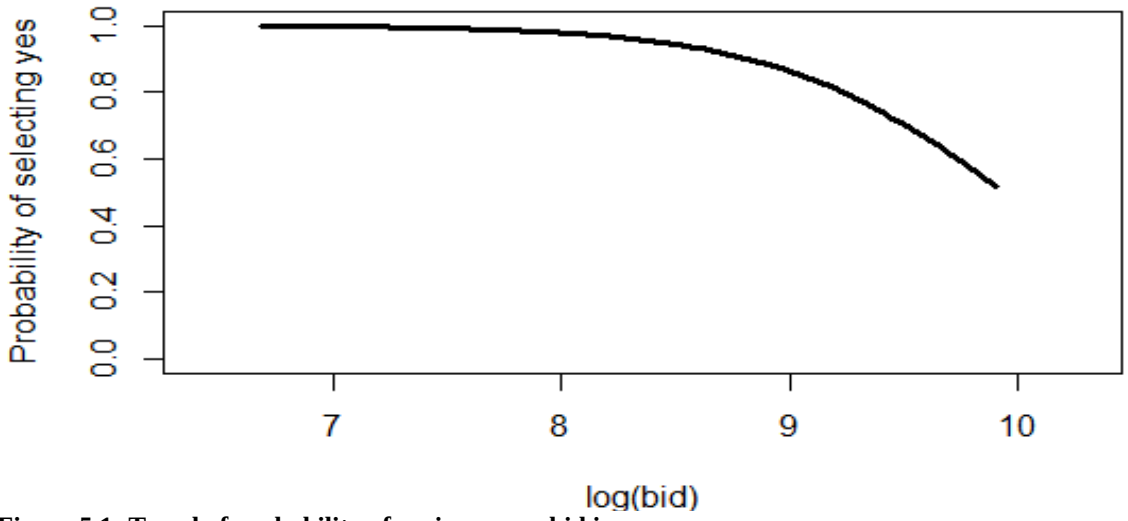

Figure 5.1: Trend of probability of saying yes as bid increases

Willingness to pay estimates

Total willingness to pay	Parametric	Non-parametric
Mean	19536.13	11757.68
Median	13809.37	20000 , NA
	Marginal willingness to pay	
Mean	19420.2	12979.87
Median	45370.78	10000 , 20000

Table 4.5.4 shows the willingness to pay estimates from the total and marginal willingness to pay models. In both models, the non-parametric technique has a lower mean value of willingness to pay than the parametric approach, as the theory indicates. The mean value of the total willingness to pay model utilising the parametric approach is slightly greater than that of the marginal willingness to pay model. The median values of both models are also considerably different. In a non-parametric approach, the median value of the entire WPAY model is between 20000 and higher, which is unknown. In a non-parametric method, the median value of the marginal WPAY model is between 10000 and 20000.

Summary and Conclusion

Because renewable energy is an environmentally benign source of electricity, at least 95 nations have laws in place to encourage investment in renewable energy (IEA, 2015). Solar energy is one of the renewable energy sources that is gaining popularity around the world due to its availability. Pakistan's geographical location makes it a great place for harnessing solar energy.The willingness of Faisalabad residents to pay for solar energy was estimated in this study. Because solar energy is a natural resource, the contingent valuation method is employed to gauge public opinion on its utilization. The survey questioned 120 families, 60 of which had solar panels and 60 of which did not. The total willingness to pay model is used to estimate those who do not have a solar system, whereas the marginal willingness to pay model is used to estimate those who currently have a solar system UBt plan to expand it in the future. WPAY is the dependent variable in the study, with education, age, income, house size, family size, and bid amount as explanatory variables.

Except for bid amount, all explanatory factors in the total willingness to pay model exhibit a positive connection with WPAY. However, the size of the house and the size of the family have no bearing. All independent factors in the marginal willingness to pay model have a positive connection with WPAY, except bid amount, which is the same as in the total willingness to pay model. This study demonstrates that educated people are more conscious of energy forms. Income has a positive and considerable impact on marginal willingness to pay for solar energy, according to the results of double bounded logistic regression.

The survival chance drops as the bid amount grows in the non-parametric technique. In the marginal WPAY model, however, initial bids have a higher probability of being accepted than in the total WPAY model.

Recommendation/ Policy Implications

The study's conclusions include important policy recommendations that might lead the government in considering solar energy adaption by society.

- Higher PV panel prices are a significant barrier to home adoption of solar energy. People will accept solar energy if prices drop.
- In several nations, the government offered loans to those who wanted to install a solar system at home. In Pakistan, this system should be implemented.
- All of Pakistan's solar systems are imported from wealthier countries. The cost of such an import rises even more. We can reach a higher aim of transitioning the energy industry to renewable energy if solar panel production is launched in the country.
- The majority of houses that have installed solar panels are unaware of its superior performance. As a result, they should receive some maintenance training.
- Feed-in tariffs are a powerful incentive for the country to encourage solar energy. As this analysis shows, solar PV system owners have a marginal desire to pay, thus if the government implements an acceptable feed-in tariff rate, these households can contribute to the national grid.
- The grid-connected application of solar systems is the best because it reduces the efficiency and cost of having batteries with solar systems. Households can feed their excess solar energy into the national grid during the day, and the grid will return that electricity to them at night.

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