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RESEARCH ARTICLE

Nexus between willingness to pay for renewable energy sources: evidence from Turkey

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Abstract

The willingness to pay (WTP) plays a central role in directing appropriate policy regarding ambitious renewable energy targets. Based on this discrepancy, this study intends to investigate the willingness to pay (WTP) for Turkish citizens regarding green electricity by using a one-way analysis of variance (one-way ANOVA). The interviews were conducted comprising 2500 households in 12 major metropolitan cities of Turkey, which is based on the contingent valuation method and consists of 26 questions. The results indicate that for a 20% share of renewable energy, middle-income groups are willing to pay higher than lower and upper-income groups. Moreover, highly environmentally conscious people tend to pay more for a 20% share of green energy. On the other hand, high-income groups and old age groups indicated a positive and high willingness to pay for a 30% share of renewable energy (RE) sources. In addition, primary school and undergraduate educational groups recorded highly significant results for willingness to pay. The results also indicate that Turkish citizens are willing to pay 9.25 Turkish liras (TL) per month for a 20% share and 4.77 Turkish liras per month for a 30% share of renewable energy in total energy production.

Keywords Renewable energy · Willingness to pay · CV method · One-way ANOVA · Turkey

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Introduction

Human energy needs have increased dramatically in tandem with technological change and economic development in recent years. Also, economic growth has become largely dependent on energy. The world energy system is focused largely on non-renewable energy sources (coal, oil, and natural gas), leading to more than 80% of the world economy's overall energy supply (IEA 2016). Nonetheless, several significant problems have arisen in recent years, associated with the use of non-renewable energy sources such as the rising gap in the demand and supply of energy worldwide (Nematollahi et al. 2016), the growing threat of oil reserve depletion (Bettini and Lazaros 2013), and an increase in the greenhouse gas (GHG) emissions in the atmosphere (LPR 2014). The carbon emitted from the consumption and production of non-renewable energy sources is now acknowledged as the main cause of the ecological crisis facing mankind (LPR 2014).

In recent years, the production of renewable/green energy sources (RES) has gained momentum due to various energy sector crises. According to the IEA (2014) report, the

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contribution of renewable energy sources to reducing carbon emissions will be highest by the year 2050. Currently, green energy accounts for 19.3% of global energy demand and contributes substantially to GHG emission reduction (REN21 2017). Research by Fang (2011) showed that green energy usage could help reduce GHG emissions by about 8.2% by 2050. There are also clear economic benefits of utilizing clean energy technologies. RES can reduce reliance on imported non-renewable energy sources and address the energy access problems for more than 1.4 billion people worldwide facing energy poverty (Sovacool 2013). The deployment of green energy could also contribute to job creation (Cai et al. 2011) and encouraging the development of small-scale businesses in developing countries (Kanase-Patil et al. 2010).

The usage of RES is rapidly growing in both developed and developing countries, including Turkey. Turkey has developed an action plan designed by the Ministries of Power and Natural Resources (MPNR) to reduce energy imports, increase domestic energy supply and produce 30% of the total electricity from RES by 2023. The biggest challenge to attain this goal is the incredibly high cost of producing green energy. The investments needed for renewables are massive and conventional subsidies cannot reach them. The government should take concrete measures to reimburse producers for higher costs and ask consumers about their preferences to encourage the deployment of green electricity in the region.

Nonetheless, a range of concerns need to be resolved before policy formulation, for example, (1) are Turkish citizens prepared to pay a surcharge to support renewable energy over and above local and national subsidies? What is their willingness to pay (WTP) for 20% and 30% of share renewable electricity in total electricity generation? What are the factors that influence their WTP?. Therefore, the primary objectives of this study are to examine the Turkish citizens' WTP for green/renewable energy and to analyze the factors affecting their WTP using one-way analysis of variance (one-way ANOVA). Interviews were conducted face-to-face comprising 2500 households in 12 major metropolitan cities of Turkey based on the contingent valuation method consisting of a total of 26 questions. The study consists of the following sections: literature review, data set, method and application, findings and discussion, conclusions, and policy implications.

Table 1 Means, standard deviations (SD) and standard errors (SE) for WTP for RE

	WTP20%	WTP30%
Number of observations (*N*)	1165	816
Mean	9.25 TL	4.77 TL
Standard deviation (SD)	4.85 TL	0.79 TL
Standard error (SE)	0.14 TL	0.03 TL
Minimum	1 TL	3 TL
Maximum value	25 TL	10 TL

Literature review

Turkey plans to make adequate investments in the field of environmentally friendly renewable energy to reduce environmental pollution and foreign energy dependency (IEA 2012). However, the cost of installation of renewable power plants and facilities is higher than conventional energy. For example, Kotchen and Moore (2007) found that the market price of renewable energy throughout the United States (US) is on average 10% to 30% more expensive than the market price of traditional sources. In addition to government support, household support has an important role in the sustainability of renewable energy investments. Therefore, the willingness to pay for the citizens is important for financial support. The willingness to pay is defined as the maximum price at which the buyer is ready to pay for a certain amount of product or service (Wertenbroch and Skiera 2002).

In previous studies, willingness to pay for renewable energy has been developed using methods such as Tobit, Probit, Logit, Multinomial probit models by examining variables such as income, age, gender, education, household size, environmental awareness, etc. Mozumder et al. (2011) analyzed the factors affecting the willingness to pay of the households living in the state of New Mexico using the Tobit model. Empirical findings showed that education level and gender (female) negatively affected willingness to pay and on the other hand variables such as environmental awareness, income level, and the number of households had positive effects. By using Tobit model, Zorić and Hrovatin (2012) found that the willingness to pay of the Slovenian households for renewable energy was positively related with the variables such as the level of education, gender, environmental sensitivity, and income, but negatively related with the variables such as the number of households and age. According to the questionnaire prepared using the conditional value determination approach on Italy, which is among the developed countries, Bigerna and Polinori (2014) revealed that income level and education level positively affected WTP, and the number of households, gender, and age adversely affected WTP.

Aldy et al. (2012) employed the Logit model and found that the American public was willing to pay an extra $162 per year for renewable energy. By using the Krinsky and Robb's Simulation Model, Bigerna and Polinori (2014) found that the Italian households were willing to pay for 2 months around €12.76. Also, Nomura and Akai (2004) found a monthly average willingness to pay $17 for Japan as a result of a survey using a conditional valuation approach. Moreover, Whitehead and Cherry (2007) employed the Multinomial

Table 2 Descriptive statistics for the first group (WTP20%)

Variables	Number	Percentage of groups
Gender		
Woman	464	39.8
Male	701	62.2
Marital status		
Single	81	7.0
Married	1065	91.4
Widow/divorced	19	1.6
Age		
18–24	57	4.9
25–34	360	30.9
35–44	443	38.0
45–54	227	19.5
55–64	42	3.6
65+	36	3.1
Education		
Primary school	108	9.3
Middle school	159	13.6
High school	645	55.4
Associate degree	29	2.5
Undergraduate	209	17.9
Master/PhD	15	1.3
House status		
Own property	876	75.2
Rent	277	23.8
Lodgings	12	1.0
The ımpact of renewable energy		
Reduction of air pollution	243	20.9
Reducing energy dependence	243	20.9
No damage to the environment	679	58.2
Renewable energy preference and justification		
Expensive (not suitable for budget)	2	0.2
Not thinking that energy addiction is a problem	4	0.3
In any case, demanding renewable energy	1159	99.5
Income		
2001–3000 TL	199	17.1
3001–4000 TL	562	48.2
4001–5000 TL	290	24.9
5001–6000 TL	114	9.8

Table 3 Descriptive statistics for the second group (WTP30%)

Variables	Number	Percentage of groups
Gender		
Woman	307	37.6
Male	509	62.4
Marital status		
Single	54	6.6
Married	751	92.0
Widow/divorced	11	1.4
Age		
18–24	42	5.1
25–34	246	30.2
35–44	312	38.2
45–54	164	20.1
55–64	31	3.8
65+	21	2.6
Education		
Literate	2	0.3
Primary school	72	8.8
Middle school	113	13.8
High school	462	56.6
Associate degree	20	2.5
Undergraduate	138	16.9
Masters/doctorate	9	1.1
House status		
Own property	630	77.3
Rent	174	21.3
Lodgings	12	1.4
The impact of renewable energy		
Reduction of air pollution	172	21.1
Reducing energy dependence	156	19.1
No damage to the environment	488	59.8
Renewable energy preference and justification		
Expensive (not suitable for budget)	2	0.2
Not thinking that energy addiction is a problem	4	0.3
In any case, demanding renewable energy	810	99.5
Income		
2.001–3.000 TL	119	14.6
3.001–4.000 TL	423	51.8
4.001–5.000 TL	194	23.8
5.001–6.000 TL	58	7.1
6.001–8.000 TL	22	2.7

Logit Model and found that the American public was willing to pay an extra $4.24 per month for renewable energy.

Yoo and Kwak (2009) employed a spike model and estimated Korean households' WTP using both a parametric approach and a non-parametric approach. Their results revealed that for the next 5 years, Korean households were willing to pay on average KRW 1681 and KRW 2072 per month for the parametric approach and non-parametric approach, respectively. Moreover, Mozumder et al. (2011) found that the consumers in New Mexico were willing to pay an extra $10 per month in their electricity bills if the share of RES increases to 10% in total energy production.

Batley et al. (2000) investigated the households' WTP for the generation of electricity from RES in Britain using an open-ended question approach. The findings showed that 34% of the respondents were willing to pay an extra amount that accounted for 16.6% of their monthly electricity bills. Using the same open-ended question approach, Zorić and Hrovatin (2012) estimated the willingness to pay of households in Slovenia. They found that the average WTP of Slovenian households was about EUR 4.18 per month.

Table 4 Kruskal-Wallis test results of ıncome variable for WTP20%

	WTP20%
Chi-square (χ^2)	7.587
df (degree of freedom)	3
P value	0.044
N (number of observations)	1165

The *P* value in the Kruskal-Wallis test found to be less than 5%, which indicating statistically significant differences between the averages of income groups in case of willingness to generate 20% of electricity from renewable energy sources. However, post hoc (Tukey) test is used to determine which group is different. Table 5 summarizes the results of the post hoc test.

Using the choice experiment approach, researchers at Michigan State University found that the students, faculty, and staff members were willing to pay $7.02 per semester, $8.95 per semester, and $7.10 per month, respectively, to switch energy from coal to wind (Komarek et al. 2011). Similarly, using the contingent valuation approach, Kim et al. (2013) estimated the WTP of Korean households for the generation of electricity from RES. Their results showed that the households were willing to pay roughly $1.26 per month as an extra amount in their electricity bills. The present studies, as in many countries, have made broader contributions to the method of conditional valuation (CV). In the literature, no study has been found yet determining the WTP for Turkish citizens for renewable energy, and therefore, this study fills the existing gap by analyzing the WTP for renewable energy and factors affecting this WTP such as age, gender, income, education, environmental awareness by adopting one-way ANOVA, and the conditional valuation method.

Data set, method, and application

This study has taken twelve (12) major cities of Turkey (such as Istanbul, Balikesir, Bursa, Izmir, Antalya, Erzurum, Ankara, Gaziantep, Samsun, Trabzon, Kayseri, and Van) and twenty-five hundreds (2500) households people to conduct face-to-face interview survey for data collection. In this study, the conditional valuation method is used for the questionnaire. This method has also been used by Nomura and Akai (2004), Whitehead and Cherry (2007), Nguyen et al. (2020), Hite et al. (2008), Shabbir and Keife (2020), Yoo and Kwak (2009), Zhang and Wu (2012), and Guo et al. (2014). Our questions were based on twenty-six (26) characteristic questions, mainly based on the participants' age, gender, marital status, education level, electricity consumption, monthly income and expenditure, number of households, and their views on and against renewable energy (Shabbir and Muhammad 2019). These questions were used to examine the willingness of the respondents to share their information for renewable energy. The questionnaire is composed of several items (depending on the answers). However, to achieve the objective of this study, 20% share of renewable energy (WTP20%), 30% share of renewable energy (WTP30%), environmental awareness, age, education, and income are used as variables.

The variable income, which represents annual gross income per capita, covering nine income groups such as 1400 TL and below, 1401–2000 TL, 2001–3000 TL, 3001–4000 TL, 4001–5000 TL, 5001–6000 TL, 6001–8000 TL, 8000–10,000 TL, and 10,000 and above. However, their numbers were then reduced to four income groups for WTP20% (2001–3000 TL, 3001–4000 TL, 4001–5000 TL, 5001–6000 TL) and to five income groups for WTP30% (2001–3000 TL, 3001–4000 TL, 4001–5000 TL, 5001–6000 TL,

Table 5 Post hoc test results of ıncome variable for WTP20%

(İ) Income	(J) Income	Average difference (İ-J)	*P* value	Standard error
2001–3000 TLL	3001–4000 TL	− 0.51	0.577	0.399
	4001–5000 TL	− 0.60	0.528	0.445
	5001–6000 T	0.83	0.462	0.568
3001–4000 TL	2001–3000 TL	0.51	0.577	0.399
	4001–5000 TL	− 0.09	0.993	0.350
	5001–6000 TL	1.34*	*0.036*	0.497
4001–5000 TL	2001–3000 TL	0.60	0.528	0.445
	3001–4000 TL	0.09	0.993	0.350
	5001–6000 TL	1.43*	*0.037*	0.535
5001–6000 TL	2001–3000 TL	− 0.83	0.462	0.568
	3001–4000 TL	− 1.34*	*0.036*	0.497
	4001–5000 TL	− 1.43*	*0.037*	0.535

The average difference is significant at 0.05

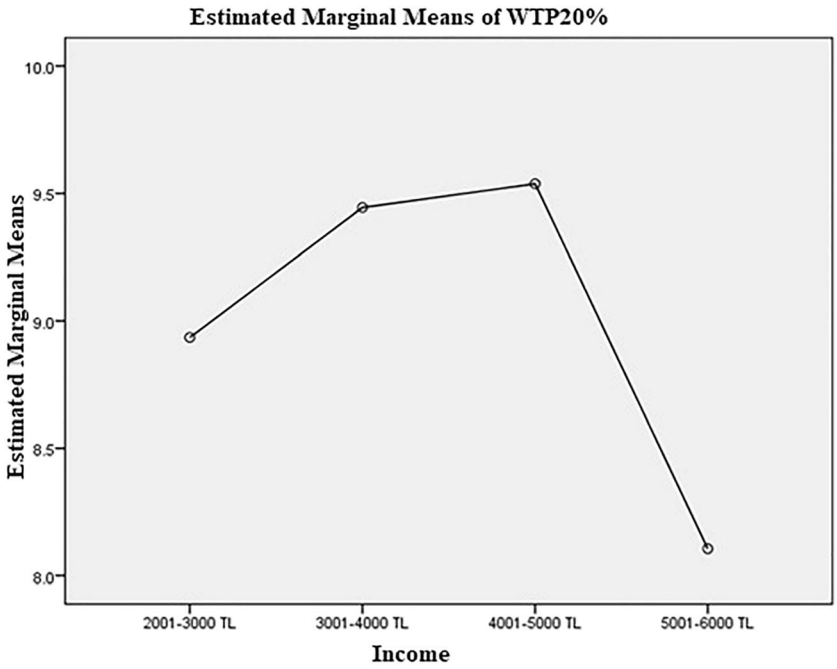

Fig. 1 Estimated marginal means of WTP20% for ıncome variable

6001–8000 TL). Moreover, household age was categorized into six (6) age groups (18–24 years, 25–34 years, 35–44 years, 45–55 years, 55–64 years, and 65 years and over).

Household education levels were measured on a sequential scale, involving nine groups: illiterate, literate, primary school, middle school, secondary school, associate degree, undergraduate, and masters/doctorate. However, their numbers were then reduced to six for WTP20% (primary school, middle school, secondary school, associate degree, undergraduate, and master/doctorate) and seven for WTP30%: literate, primary, middle, secondary, associate, undergraduate, and masters/doctorate. Environmental awareness was measured on a scale of 1 to 10. The lowest number shows that he/she is not conscious at all and the highest number shows that the person is very conscious.

In the first question, the participants were asked how much they would like to pay as an additional amount in their monthly electricity bill if 20% of electricity comes from environmentally friendly RES. In the second question, participants were asked whether or not they would like to pay if the share of RES increases from 20% to 30% in total energy production. The participants who said "yes" in the second question were then asked how much they would like to pay if the share of renewable energy increases from 20 to 30%.

Moreover, the participants were asked two questions to measure their preference regarding sources of renewable energy. In the first question, the views of the participants regarding the impact of green energy and their preferences were asked by allowing them to select one of the following options: reducing air pollution, Turkey's energy dependency reduction, preventing harm to the environment, and the refusal of renewable electricity.

On the other hand, in the second question, the participants were asked why they prefer and do not prefer renewable energy by choosing from the following options: because it is expensive, they do not see air pollution as a problem, they do not think it will reduce energy dependency, it is the

Table 6 Kruskal-Wallis test results of age variable for WTP20%

	WTP%20
Chi-square (χ^2)	5.106
df (degree of freedom)	5
P value	0.403
N (number of observations)	1165

The *P* value in the Kruskal-Wallis test was found to be more than 5%, indicating that there is no statistically significant difference between the mean age groups in the case of WTP20%. Therefore, post hoc testing is not necessary in this case.

Table 7 Kruskal-Wallis test results of education variable for WTP20%

	WTP%20
Chi-square (χ^2)	3.050
df (degree of freedom)	5
P value	0.692
N (number of observations)	1165

The *P* value in the Kruskal-Wallis test was found to be greater than 5%, indicating that there were no statistically significant differences between the mean levels of education in case of willingness to pay for 20% share of renewable energy in total energy production.

Table 8 Kruskal-Wallis test results of environmental consciousness for WTP20%

	WTP20%
Chi-square (χ^2)	29.559
df (degree of freedom)	8
P value	0.001
N (number of observations)	1165

The *P* value in the Kruskal-Wallis test was found to be less than 5%, indicating a statistically significant difference between the means of different groups on the scale of environmental awareness in case of willingness to pay for generating 20% of electricity from renewable energy sources. However, post hoc (Tukey) test is used to determine which groups are different.

responsibility of the state, and they demand renewable electricity in any case (Shabbir and Yaqoob 2019). This study used statistical packages of social sciences (SPSS) software to analyze the survey data set. The analysis is carried out independently for WTP20% and WTP30%, i.e., the same analysis procedures are performed first for participants who want to pay for 20% share of green energy, and then for participants who want to pay for 30% share of green energy in aggregate energy production.

Descriptive statistics

The questionnaire was completed by twenty-five hundred (2500) people appropriately. However, among these twenty-five hundred (2500) respondents, five hundred and nineteen (519) respondents (20.7% of 2500) neither want to pay for 20% share of renewable energy (WTP%20) nor 30% share of renewable energy (WTP30%) in total energy production (Saleem et al. 2019a, b), whereas one thousand one hundred and sixty-five (1165) respondents (46.6% of 2500) wanted to pay for WTP20% and 816 (32.64% of 2500) wanted to pay for WTP30%.

According to Table 1, the values of those willing to pay for a 20% share of renewable energy in total energy production are between 1.00 TL and 25.00 TL, and the values of those willing to pay for a 30% share varied between 3.00 and 10.00 TL. Also, the mean WTP for 20% share is found to be 9.25 TL whereas the mean WTP for 30% share of renewable energy in total energy production is found to be 4.77 TL.

The descriptive statistics for the two sample groups used in the study are shown in Table 2 and Table 3, respectively.

Empirical practice

In this study, the impact of the variables such as age, income, education, environmental awareness, the impact of renewable energy, preferences for renewable energy, and reason for non-

Table 9 Post hoc test results of environmental awareness variable for WTP20%

(İ) Environmental awareness	(J) Environmental awareness	Average Difference (İ-J)	P Value	Standard Error
1	2	− 0.38	1.000	3.570
	4	− 2.50	1.000	4.775
	5	− 1.50	1.000	3.995
	6	− 1.30	1.000	3.390
	7	− 0.53	1.000	3.388
	8	− 1.96	1.000	3.391
	9	− 2.87	0.995	3.394
	10	− 2.67	0.997	3.396
2	1	0.38	1.000	3.570
	4	− 2.12	1.000	3.570
	5	− 1.12	1.000	2.429
	6	− 0.92	0.998	1.197
	7	− 0.15	1.000	1.192
	8	− 1.57	0.927	1.198
	9	− 2.49	0.504	1.209
	10	− 2.29	0.626	1.121
4	1	2.50	1.000	4.775
	2	2.12	1.000	3.570
	5	1.00	1.000	3.995
	6	1.20	1.000	3.390
	7	1.97	1.000	3.388
	8	0.54	1.000	3.391
	9	− 0.37	1.000	3.394
	10	− 0.17	1.000	3.396
5	1	1.50	1.000	3.995
	2	1.12	1.000	2.429
	4	− 1.00	1.000	3.995
	6	0.20	1.000	2.157
	7	0.97	1.000	2.154
	8	− 0.46	1.000	2.158
	9	− 1.37	0.999	2.164
	10	− 1.17	1.000	2.166
6	1	1.30	1.000	3.390
	2	0.92	0.998	1.197
	4	− 1.20	1.000	3.390
	5	− 0.20	1.000	2.157
	7	0.77	0.644	0.414
	8	− 0.65	0.849	0.432
	9	*− 1.57**	*0.020*	0.460
	10	− 1.36	0.093	0.473
7	1	0.53	1.000	3.388
	2	0.15	1.000	1.192
	4	− 1.97	1.000	3.388
	5	− 0.97	1.000	2.154
	6	− 0.77	0.644	0.414
	8	*− 1.42**	*0.020*	0.418
	9	*− 2.33**	*0.000*	0.447
	10	*− 2.13**	*0.000*	0.460
8	1	1.96	1.000	3.391
	2	1.57	0.927	1.198
	4	− 0.54	1.000	3.391
	5	0.46	1.000	2.158
	6	0.65	0.849	0.432
	7	*1.42**	*0.020*	0.418
	9	− 0.91	0.566	0,463
	10	− 0.71	0.858	0.476
9	1	2.87	0.995	3.394
	2	2.49	0.504	1.209
	4	0.37	1.000	3.394
	5	1.37	0.999	2.164
	6	*1.57**	*0.020*	0.460
	7	*2.33**	*0.000*	0.447

Table 9 (continued)

(İ) Environmental awareness	(J) Environmental awareness	Average Difference (İ-J)	P Value	Standard Error
	8	0.91	0.566	0,463
	10	0.20	1.000	0.502
10	1	2.67	0.997	3.396
	2	2.29	0.626	1.214
	4	0.17	1.000	3.396
	5	1.17	1.000	2.166
	6	1.36	0.093	0.473
	7	*2.13**	*0.000*	0.460
	8	0.71	0.858	0.476
	9	− 0.20	1.000	0.502

The average difference is significant at 0.05

preference on the willingness to pay (WTP) for renewable energy is examined. First, it is done by excluding participants' willingness to pay from the analysis with the highest and lowest 5% to minimize the effects of excessive values. After excluding outliers, a one-way analysis of variance (one-way ANOVA) is used. One-way ANOVA is used to investigate whether there are statistically significant differences between the groups of categorical variables (Cobb 1984). If statistically significant differences are found between groups of categorical variables and there are more than two comparable groups, then the post hoc (Tukey) test is used. Post hoc (Tukey) test examines which groups are different (Jarrell 1994). In the post hoc test, if the probability value associated with each group is less than 5%, the groups differ (Giloni et al. 2005; Arif and Shabbir 2019). Since the variables used in the study violate the assumptions of one-way ANOVA, which are the homogeneity of normality and variance, the non-parametric ANOVA analysis, known as the Kruskal-Wallis test, is used to evaluate differences between groups of variables using *P* value below 5% (Saleem et al. 2019a, b; Shabbir et al. 2020). Therefore, in this study, the non-parametric one-way ANOVA (Kruskal-Wallis test) and post hoc tests are used to obtain more valid results.

Table 10 Kruskal-Wallis test results of impact of RE for WTP20%

	WTP%20
Chi-square (χ^2)	0.943
df (degree of freedom)	2
P value	0.624
N (number of observations)	1165

Results and discussion

Effects of selected factors on willingness to pay for 20% share of renewable energy (WTP20%)

This section analyzes the impact of selected variables on willingness to pay for a 20% share of renewable energy. These variables are as follows: income, education, age, environmental awareness, opinions on the impact of renewable energy, the choice of renewable energy, and justification for non-preference. Each variable is analyzed as follows using the Kruskal-Wallis and post hoc test.

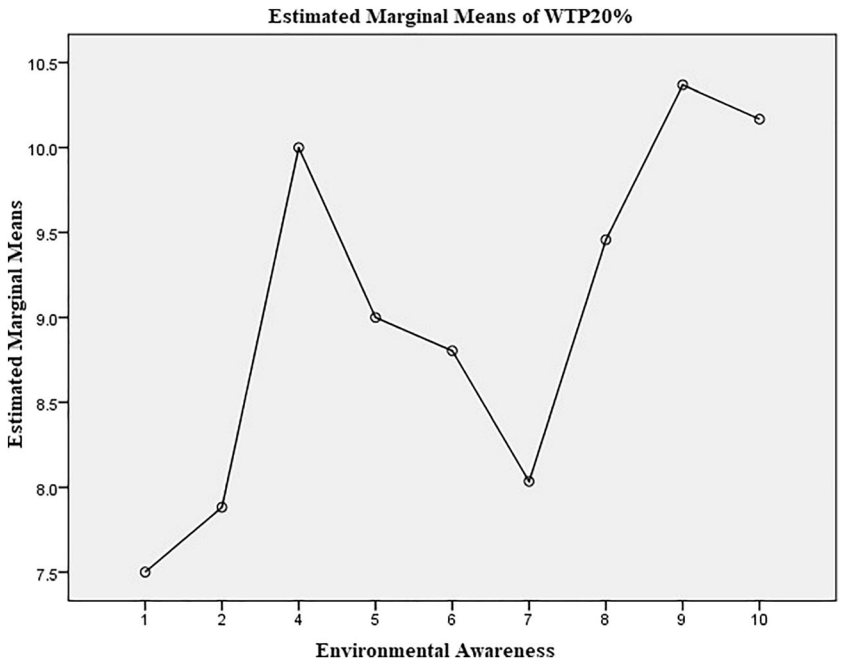

Fig. 2 Estimated marginal means of WTP20% for environmental awareness variable

Table 11 Kruskal-Wallis test results of TTEG-YE for WTP20%

	WTP%20
Chi-square (χ^2)	4.592
df (degree of freedom)	2
P value	0.101
N (number of observations)	1165

Income

Among 2500 respondents, only 1165 (46.6%) agreed to pay for a 20% share of renewable energy (RE) in total electricity generation. The Kruskal-Wallis test is used to test for differences between the means of the following income groups using a *P* value of less than 5%: 2001–3000 TL, 3001–4000 TL, 4001–5000 TL, 5001–6000 TL. Considering the above 46.6% of respondents, a significant impact of income on WTP20% was found using the Kruskal-Wallis test, and the results are shown in Table 4.

As shown in Table 5, the post hoc test revealed significant differences between the following groups: 5001–6000 TL (mean = 8.1, SH = 0.45; SD = 3.96), 2001–3000 TL (mean = 8.94; SH = 0.34; SD = 4.72), 3001–4000 TL (mean = 9.45; SH = 0.20; SS = 4.87), 4001–5000 TL (average = 9.54; SH = 0.28; SS = 5.15). Figure 1 shows the estimated marginal averages of WTP20% for income variable.

As shown in Fig. 1, the willingness to pay of income groups with 5001–6000 TL and 2001–3000 TL is lower than the willingness to pay of income groups with 3001–4000 TL and 4001–5000 TL. These findings demonstrate that the Turkish citizens, whose income lies between 3001–4000 TL and 4001–5000 TL per month, are willing to pay more for 20% share of renewable energy in total energy production.

Age

To identify the statistically significant differences between different age groups (18–24, 25–34, 35–44, 45–54, 55–64, 65+) for 20% share of renewable energy in total energy production, the Kruskal-Wallis test was applied and the results are presented in Table 6.

Table 12 Kruskal-Wallis test results of ıncome variable for WTP30%

	WTP%30
Chi-square (χ^2)	23.255
df (degree of freedom)	4
P value	0.000
N (number of observations)	816

Table 13 Results of post hoc test of ıncome variable for WTP30%

(İ) Income	(J) Income	Average difference (İ-J)	*P* value	Standard error
2001–3000 TL	3001–4000 TL	− 0.11	0.663	0.080
	4001–5000 TL	− 0.04	0.988	0.089
	5001–6000 TL	− 0.35*	*0.034*	0.123
	6001–8000 TL	− 1.03*	*0.000*	0.178
3001–4000 TL	2001–3000 TL	0.11	0.663	0.080
	4001–5000 TL	0.06	0.876	0.067
	5001–6000 TL	− 0.25	0.150	0.107
	6001–8000 TL	− 0.93*	*0.000*	0.168
4001–5000 TL	2001–3000 TL	0.04	0.988	0.089
	3001–4000 TL	− 0.06	0.876	0.067
	5001–6000 TL	− 0.31	0.056	0.115
	6001–8000 TL	− 0.99*	*0.000*	0.173
5001–6000 TL	2001–3000 TL	0.35*	0.034	0.123
	3001–4000 TL	0.25	0.150	0.107
	4001–5000 TL	0.31	0.056	0.115
	6001–8000 TL	− 0.68*	*0.004*	0.192
6001–8000 TL	2001–3000 TL	1.03*	*0.000*	0.178
	3001–4000 TL	0.93*	*0.000*	0.168
	4001–500 TL 0	0.99*	*0.000*	0.173
	5001–6000 TL	0.68*	*0.004*	0.192

The average difference is significant at 5% level

Education

In terms of education, statistically significant differences were not found between different educational levels (primary, middle, secondary, associate, undergraduate, master/doctorate) for WTP20% using the Kruskal-Wallis test. Kruskal-Wallis test results are presented in Table 7.

Environmental awareness

Among 2500 respondents, 1165 (46.6%) wanted to pay for a 20% share of renewable energy in total electricity generation. The Kruskal-Wallis approach is used to test for differences between groups 1 and 10 in the scale of environmental awareness using a *P* value of less than 5% Saleem and Shabbir (2020). The lowest group (1) shows that it is not conscious at all and the highest group (10) shows a high degree of environmental awareness. Taking into account the above 46.6% of respondents, the Kruskal-Wallis test indicates a significant impact of environmental awareness on WTP20%, and the results are shown in Table 8. Taking into account 46.6% of respondents, the Kruskal-Wallis test indicates

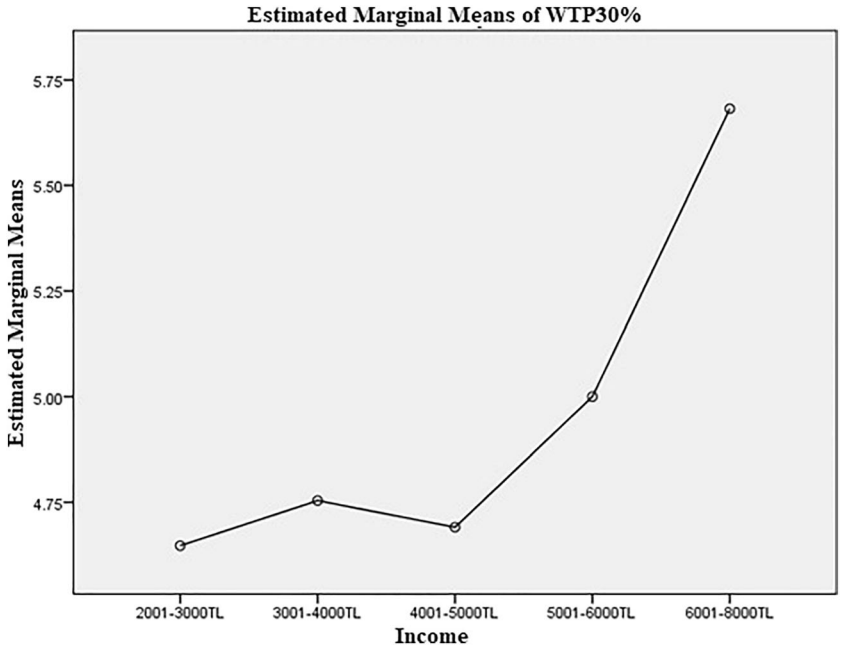

Fig. 3 Estimated marginal means of WTP30% for ıncome variable

that environmental awareness significantly affects WTP20% and the results are shown in Table 8.

In the post− hoc test, the groups differ if the P-value associated with each group is less than 5%. Thus, as shown in Table 9, the Post-Hoc test revealed significant differences between groups 6,7,8,9 and 10. Figure 2 below shows the estimated marginal means of WTP20% for environmental awareness.

Environmental awareness is measured on a scale of 1 to 10. As can be seen in Fig. 2, the highly environmentally conscious groups (9 and 10) are willing to pay more than other groups for 20% share of renewable energy in total energy production.

Impact of renewable energy

However, no statistically significant differences were found between the options showing the effects of renewable energy (reducing air pollution, reducing energy dependence, not damaging the environment) using the Kruskal-Wallis test. Kruskal-Wallis test results related to renewable energy effects for WTP20% are presented in Table 10.

Table 14 Kruskal-Wallis test results of variable age for WTP30%

	WTP30%
Chi-square (χ^2)	16.385
df (degree of freedom)	5
P value	0.006
N (number of observations)	816

Table 15 Results of post hoc test of the variable age for WTP30%

(İ) Age	(J) Age	Average difference (İ-J)	*P* value	Standard error
18–24	25–34	− 0.08	0.988	0.127
	35–44	− 0.08	0.985	0.125
	45–54	− 0.11	0.953	0.131
	55–64	− 0.36	0.332	0.177
	65+	− 1.36*	*0.000*	0.200
25–34	18–24	0.08	0.988	0.127
	35–44	0.00	1.000	0.065
	45–54	− 0.03	0.988	0.077
	55–64	− 0.28	0.366	0.141
	65+	− 1.28*	*0.000*	0.169
35–44	18–24	0.08	0.985	0.125
	25–34	0.00	1.000	0.065
	45–54	− 0.03	0.998	0.073
	55–64	− 0.27	0.367	0.139
	65+	− 1.27*	*0.000*	0.168
45–54	18–24	0.11	0.953	0.131
	25–34	0.03	0.998	0.077
	35–44	0.03	0.998	0.073
	55–64	− 0.24	0.551	0.145
	65+	− 1.24*	*0.000*	0.173
55–64	18–24	0.36	0.332	0.177
	25–34	0.28	0.366	0.141
	35–44	0.27	0.367	0.139
	45–54	0.24	0.551	0.145
	65+	− 1.00*	*0.000*	0.209
65+	18	1.36*	*0.000*	0.200
	25	1.28*	*0.000*	0.169
	35	1.27*	*0.000*	0.168
	45	1.24*	*0.000*	0.173
	55	1.00*	*0.000*	0.209

The average difference is significant at 0.05 level

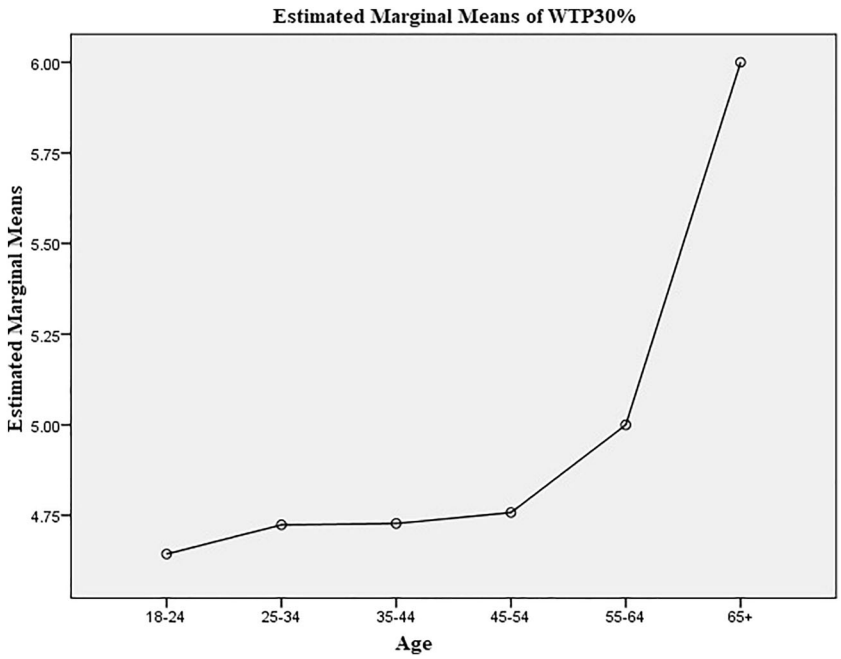

Fig. 4 Estimated marginal means of WTP30% for variable age

Renewable energy preference and reason for non-preference (TTEG-YE)

The Kruskal-Wallis test found that there are no statistically significant differences between the means of the groups indicating the preferences of renewable energy, and the options that indicate its non-preferences (expensive, reduction of energy dependency, in any case requesting renewable energy). Kruskal-Wallis test results related to renewable energy preference and non-preference for WTP20% are presented in Table 11.

Effects of selected factors on willingness to pay for 30% share of renewable energy (WTP30%)

This section analyzes the impact of selected variables on willingness to pay for a 30% share of renewable energy. These variables include income, education, age, environmental awareness, the impact of renewable energy, the justification for preference, and the non-preference of renewable energy. Each variable is analyzed using the Kruskal-Wallis and post hoc test.

Table 16 Kruskal-Wallis test results of variable education for WTP30%

	WTP30%
Chi-square (χ^2)	37.937
df (degree of freedom)	5
P value	0.000
N (number of observations)	816

Income

The eight hundred and sixteen (816) respondents (32.6% of 2500) wanted to pay for the 30% share of renewable energy in total electricity generation. The Kruskal-Wallis test is used to analyze the differences between the averages of the following income groups using a *P* value of less than 5%: 2001–3000 TL, 3001–4000 TL, 4001–5000 TL, 5001–6000 TL, 6001–8000 TL.

Taking into account 32.6% of respondents, the Kruskal-Wallis test indicates that there are statistically significant differences between the averages of income groups, and the post hoc (Tukey) test is used to determine which groups are different. The results of both tests are shown in Table 12 and Table 13.

As can be seen in Table 13, the post hoc test indicates that there are statistically significant differences between the following income groups: 5001–6000 TL (mean 5.0; SE 0.10; SD 0.00), 2001–3000 TL (mean 4, 6; SE 0.07; SD 0.73), 3001–4000 TL (mean 4.75; SE 0.04; SD 0.73), 4001–5000 TL (mean 4.69; SE 0.06; SD 0.79) and 6001–8000 TL (mean 5.68; SE 0.16; SD 1.81). Figure 3 shows the estimated marginal means of WTP30% for the variable income.

As can be seen in Fig. 3, the willingness to pay for income groups of 4001–5000 TL, 2001–3000 TL, and 3001–4000 TL is lower than the willingness to pay for income groups of 5001–6000 TL and 6001–8000 TL. The findings, therefore, reveal that Turkish citizens with incomes ranging from 5001 to 8000 TL are willing to pay more to generate 30% of electricity from renewable energy sources.

Table 17 Results of post hoc test of variable education for WTP30%

(İ) Eduation	(J) Eduation	Average difference (İ-J)	*P* value	Standard error
Primary school	Middle school	0.19	0.278	0.089
	Secondary school	0.29*	*0.002*	0.076
	Associate degree	0.30	0.345	0.150
	Undergradute	0.00	1.000	0.087
	Masters/Phd	0.25	0.869	0.221
Middle school	Primary school	− 0.19	0.278	0.089
	Secondary school	0.10	0.533	0.062
	Associate degree	0.11	0.973	0.144
	Undergradute	− 0.19	0.114	0.075
	Masters/Phd	0.06	1.000	0.217
Secondary school	Primary school	− 0.29*	*0.002*	0.076
	Middle school	− 0.10	0.533	0.062
	Associate degree	0.01	1.000	0.136
	Undergradute	− 0.29*	*0.000*	0.057
	Masters/Phd	− 0.04	1.000	0.212
Associate degree	Primary school	− 0.30	0.345	0.150
	Middle school	− 0.11	0.973	0.144
	Secondary school	− 0.01	1.000	0.136
	Undergradute	− 0.30	0.282	0.142
	Masters/Phd	− 0.05	1.000	0.248
Undergradute	Primary school	0.00	1.000	0.087
	Middle school	0.19	0.114	0.075
	Secondary school	0.29*	*0.000*	0.057
	Associate degree	0.30	0.282	0.142
	Masters/Phd	0.25	0.856	0.216
Masters/Phd	Primary school	− 0.25	0.869	0.221
	Middle school	− 0.06	1.000	0.217
	Secondary school	0.04	1.000	0.212
	Associate degree	0.05	1.000	0.248
	Undergradute	− 0.25	0.856	0.216

The average difference is significant at 0.05

Age

The Kruskal-Wallis test shows that there are statistically significant differences between different age groups (18–24, 25–34, 35–44, 45–54, 55–64, 65+) for WTP30%. However, post hoc (Tukey) test is used to determine which groups are different. The results for both tests are presented in Table 14 and Table 15.

In Table 15, the post hoc test found statistically significant differences between the following income groups: 18–24, 25–34, 35–44, 45-54, 55–64, 65+. Figure 4 shows the estimated marginal average of the willingness to pay for the 30% share of renewable energy for the variable age.

In Fig. 4, the willingness to pay of the age group of 65+ is higher than the willingness to pay of the age groups of 18–24, 25–34, 35–44, 45–54, 55–64 which indicates that Turkish citizens who are 65+ are willing to pay more to generate 30% of electricity from renewable energy sources.

Education

For the variable education, statistically significant differences were found between different levels of education such as primary, middle, secondary, associate degree, undergraduate, and master/doctorate for WTP30% using the Kruskal-Wallis test and post hoc test. The results are shown in Table 16 and Table 17.

As can be seen in Table 17, statistically significant differences were found between primary school, secondary school, and undergraduate education levels. Figure 5 shows the estimated marginal mean of the willingness to pay for 30% share of renewable energy for the variable education.

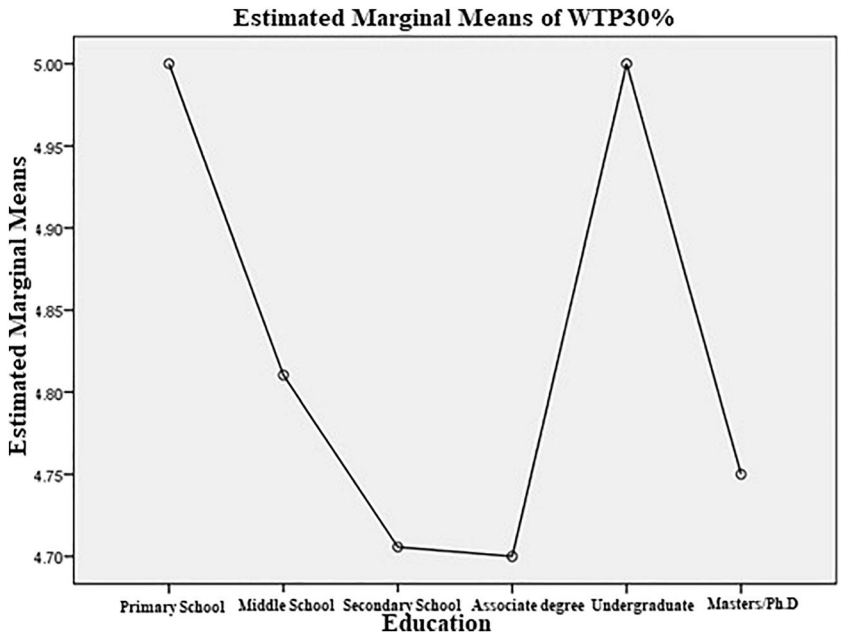

Fig. 5 Education variable estimated marginal means for WTP30%

ln Fig. 5, the willingness to pay of primary and undergraduate level of education is higher than the willingness to pay of other levels of education, which indicates that Turkish citizens with primary and undergraduate level of education are willing to pay more to generate 30% of electricity from renewable energy sources.

Environmental awareness

Kruskal-Wallis test indicates that there are no statistically significant differences between the means of different groups 1 to 10 in the scale of environmental awareness for WTP30%. The test results are presented in Table 18.

Impact of renewable energy

For WTP30%, statistically significant differences were found between the options showing the impacts of renewable energy (reducing air pollution, reducing energy dependence, environmental protection) using the Kruskal-Wallis test and post hoc test. The results are presented in Table 19 and Table 20**.**

Figure 6 shows the estimated marginal means of WTP30% for the variable impact of RE.

In Fig. 6, the WTP of the effect of RE indicated by "reduction of energy dependence" is greater than the WTP of other effects. Therefore, the findings show that Turkish citizens agree that renewable energy could reduce energy dependency and are willing to pay more to generate 30% of electricity from renewable energy sources in Turkey.

Renewable energy preference and reason for non-preference (TTEG-YE)

The Kruskal-Wallis test indicates that there are no statistically significant differences between the groups showing renewable energy preference and non-preference (TTEG-YE) for WTP30%. Kruskal-Wallis results for TTEG-YE are presented in Table 21.

Conclusion and discussion

Energy is an important input for people's housing, industry, agriculture, and transportation needs. Energy demand is increasing over time and is expected to increase in the future. Energy production planning and increasing energy demand are among the most important elements of a country's

Table 18 Kruskal-Wallis test results of environmental consciousness for WTP30%

	WTP30%
Chi-square (χ^2)	1.872
df (degree of freedom)	5
P value	0.867
N (number of observations)	816

Table 19 Kruskal-Wallis test results of the impact of RE for WTP30%

	WTP%30
Chi-square (χ^2)	9.509
df (degree of freedom)	2
P value	0.009
N (number of observations)	816

Table 20 Post hoc test results of the ımpact of RE for WTP30%

(İ) YEE	(J) YEE	Average difference (İ-J)	*P* value	Standard error
Reduction of air pollution				
	Reduction of energy dependence	− 0.22*	*0.011*	0.075
	Environmental protection	− 0.03	0.848	0.060
Reduction of energy dependence				
	Reduction of air pollution	0.22*	*0.011*	0.075
	Environmental protection	0.18*	*0.009*	0.062
Environmental protection				
	Reduction of air pollution	0.03	0.848	0.060
	Reduction of energy dependence	− 0.18*	*0.009*	0.062

The average difference is significant at 0.05

development plans. As a developing economy, especially in the last 20 years, Turkey's energy demand has increased rapidly. However, this increase in energy demand is met by traditional fossil fuels such as oil, coal, lignite, and natural gas. Turkey is heavily dependent on foreign energy sources. Moreover, energy consumption based on fossil fuels creates economic, environmental, and political problems. For these reasons, Turkey should evaluate domestic and clean energy resources to ensure sustainable development.

Turkey has an ambitious goal of minimizing energy imports and maximizing domestic energy supplies. This is based on the action plan proposed by the Ministry of Energy and Natural Resources to generate 30% of electricity from renewable energy sources by 2023. This study estimates Turkish citizens' willingness to pay for 20% and 30% share of renewable energy in total energy production. It is important to examine and understand factors such as income, age, education, renewable energy consumption, the impact of renewable energy, renewable energy preference, and non-preference, which play an important role in analyzing households' willingness to pay for expanding electricity generation from green energy sources. Therefore, in this study, one-way ANOVA and post hoc tests are used to estimate the average willingness to pay of Turkish citizens for renewable energy and to determine the factors determining their willingness to pay for renewable energy.

The findings of this study show that there are statistically significant differences in the willingness to pay for 20% and 30% share of renewable energy among the respondents. According to the results of a 20% share of renewable energy, middle-income groups are willing to pay higher than lower and upper-income groups. Besides, highly environmentally

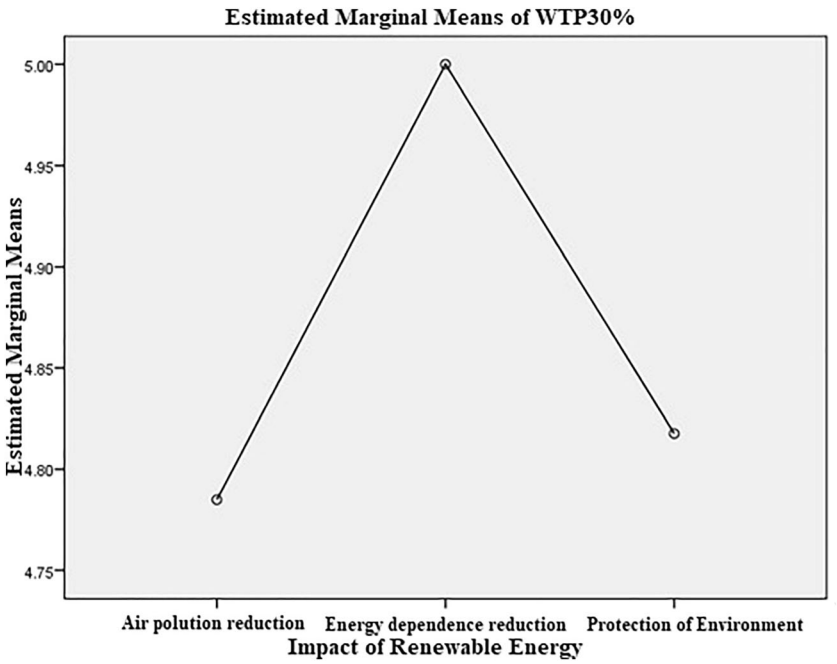

Fig. 6 Estimated marginal means of WTP30% for the impact of RE

Table 21 Kruskal-Wallis test results of TTEG-YE for WTP30%

	WTP30%
Chi-square (χ^2)	2.046
df (degree of freedom)	2
P value	0.360
N (number of observations)	1165

conscious participants tend to pay high for 20% of renewable energy. Moreover, variables such as age, education, the impact of renewable energy, renewable energy preference, and reason for non-preference have no significant impact on WTP20%.

In the analysis, results revealed that willingness to pay for a 30% share of renewable energy in total energy has a positive relationship with age and income. However, the environmentally-conscious variable and the reason for the preference and non-preference of renewable energy did not affect WTP30%. The results also show that groups over 65 years of age and citizens with high income have a high willingness to pay for a 30% share of renewable energy in total energy production. Moreover, the results show that citizens with primary and undergraduate education are willing to pay more for the 30% share of renewable energy, as compared with other education groups.

The findings for WTP30% reveal that an increase in the share of renewable energy in total energy production will help to minimize energy dependence. Therefore, most of the citizens are willing to pay for it shows more willingness to pay for a 30% share of renewable energy in total electricity generation of Turkish citizens to reduce energy dependence. The results also indicate that Turkish citizens are willing to pay 9.25 Turkish liras (TL) per month for a 20% share and 4.77 Turkish liras per month for a 30% share of renewable energy in total energy production. The results show that the majority of the participants are willing to support the green electricity plan in Turkey. The results are in favor of the 2014 action plan framed by the Ministry of Energy and Natural Resources to generate 30% of electricity from renewable energy sources by 2023.

The findings of this study have important implications for policymakers and stakeholders. Based on these findings, utility companies can make marketing strategies suitable for targeting specific age, education, and income groups to provide financial support for the increasing share of renewable energy. Moreover, This study provides useful insights to utility companies and the government to prepare effective channels to charge a reasonable amount for a larger portion of sources of green energy in total energy production to achieve their desired targets.

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