JEL: Q01, Q21, Q41, Q56

Huynh Viet Khai, Huynh Le Thao Tran, Nguyen Van Ngan, Tran Thi Thu Duyen

Can Tho University
Vietnam

CHOICE MODELING APPROACH TO EVALUATE THE ECONOMIC VALUE OF RENEWABLE ENERGY DEVELOPMENT

Purpose. *This research aims to quantify the willingness to pay (WTP) of urban residents in the Mekong Delta for the environmental and social benefits associated with renewable energy projects. By analysing their preferences and priorities regarding renewable energy implementation, this study aims to contribute to the increasing knowledge on the drivers of sustainable energy transitions in developing regions.*

Methodology / approach. *This paper leverages a choice modeling (CM) framework to analyse the economic viability of renewable energy investments in Vietnam. The CM technique is advantageous for its ability to capture individual preferences for complex goods or services characterised by multiple attributes and trade-offs. This enables a detailed assessment of the diverse economic values associated with renewable energy sources, beyond their traditional energy generation capacity, including environmental externalities, social impacts, and potential synergies with other sectors.*

Results. *Residents showed significant WTP for renewable energy initiatives improving landscape aesthetics, wildlife habitats, air quality, and job opportunities. Higher income, education, and knowledge level are positively associated with greater WTP. Younger respondents showed a strong position in favor of renewable energy sources. Households with more children were less likely to support the status quo, and married respondents were more pro-renewable. Perceived community involvement emerged as a significant factor in supporting renewable energy policies.*

Originality / scientific novelty. *This study represents a novel application of CM within the Vietnamese context, providing valuable quantitative data for policymakers and stakeholders. By estimating WTP for specific renewable energy attributes, we inform cost-benefit assessments and support the development of efficient policies for managing renewable energy investments. This data facilitates resource allocation and prioritisation of projects with the highest societal value.*

Practical value / implications. *Our findings underscore the crucial role of public awareness and education in driving renewable energy implementation. Residents with a clear understanding of the benefits demonstrate a higher WTP. Hence, we recommend a multifaceted communication strategy to educate the public about the environmental, social, and economic benefits of renewable energy. This involves utilising diverse channels like community meetings, media outreach, online platforms, and expert engagement to disseminate accurate and engaging information. By fostering knowledge and understanding, we can cultivate a strong public mandate for renewable energy investment, facilitating informed decision-making and accelerating the transition to a sustainable energy future in the Mekong Delta.*

Key words: *choice experiment (CE), climate change, sustainable development, willingness to pay (WTP), Vietnam.*

1. INTRODUCTION

The 21st century has witnessed a confluence of critical energy challenges. Global fossil fuel depletion looms, with the International Energy Agency (IEA) predicting exhaustion of oil, natural gas, and coal within 41.1, 60.3, and 117 years, respectively (WEO, 2022). Moreover, the burning of these fuels exacerbates climate change through greenhouse gas emissions like CO_2, SO_x, and NO_x, posing severe environmental and health threats (Quang, 2014). These concerns, coupled with geopolitical instability surrounding fossil fuel resources, have pushed industrialised nations towards renewable energy as a vital alternative. Notably, global renewable energy investment increased by 45.5 % in 2022, reaching almost USD 500 billion (Lucia, 2024).

Developing countries like Vietnam face a critical challenge: reconciling rapid economic growth with the urgent need for sustainable energy solutions. Statista reports that in the first ten months of 2022, Vietnam's power production and demand reached a staggering 226 billion kilowatt-hours (kW·h), with energy demand exhibiting a consistent upward trajectory year-on-year. Notably, the growth rate of power demand is projected to recover to around 8.9 % (Statista, 2023). This increasing demand coincides with depleting primary energy sources, further emphasising the need for alternative energy sources. Additionally, Vietnam faces significant vulnerability to climate change, with rising sea levels posing a threat to 8.5 % of its land area and potentially displacing 20 million people (MOIT, 2009). Sustainable energy development can prove crucial in mitigating these risks.

Fortunately, Vietnam has a large potential for renewable energy. Large wind resources, with average speed of more than 6 m/s at 65 m altitude, offer a 512 GW capacity. Solar radiation presents additional promise, ranging from 4 kW·h/m²/day in the north to 5 kW·h/m²/day in the central and southern regions (MOIT, 2009). As an agricultural powerhouse, Vietnam also has vast biomass resources, including energy wood, crop residues, livestock waste, and urban organic waste. Leveraging these diverse renewable energy sources holds immense potential for meeting future energy demands, supporting socio-economic development, and safeguarding the environment. Recognising this potential, the Vietnamese government is actively engaged renewable energy development. The National Power Development Plan for 2021–2030 sets a target for increased renewable energy production, while incentive mechanisms implemented through Decisions No. 11/2017/QD-TTg and No. 39/2018/QD-TTg have accelerated renewable energy implementation. Furthermore, the National Renewable Energy Development Strategy to 2020 with a view to 2050, outlined in Decision No. 1855/QD-TTg, establishes ambitious targets for renewable energy market share within primary commercial energy: 3 % by 2010, 5 % by 2020, and 11 % by 2050.

Within Vietnam, the Mekong Delta (MD) is becoming a particularly promising region for renewable energy development. As the country's "Rice bowl", the MD has abundant biomass resources. Recent economic growth and rising living standards have further emphasised the need for alternative energy in the region. Addressing this need would not only foster economic development and mitigate pollution but also contribute to mitigating the problems of global climate change. Despite the undeniable potential of wind and biomass resources in Vietnam and the MD specifically, there are few studies devoted to the development of renewable energy in the region.

This paper aims to bridge this gap by investigating the willingness to pay (WTP) for different attributes associated with benefits of renewable energy in the MD. Based on these findings, it proposes solutions for advancing renewable energy development, promotion of the region towards a “green economy” and sustainable growth. The findings offer valuable guidance for policymakers seeking to optimise future renewable energy policies in Vietnam.

2. LITERATURE REVIEW

This study uses a choice modeling (CM) framework to estimate Vietnamese households’ willingness to pay (WTP) for the benefits of renewable energy. While CM applications in Vietnamese renewable energy research remain scant, a robust body of international research sheds light on potential investment opportunities and development strategies. Ku & Yoo (2010) used a multinomial probit (MNP) model in a Korean choice experiment, revealing preferences for wildlife protection, pollution reduction, and job creation, but not landscape improvement. Rommel et al. (2016) found that consumer WTP for renewable energy increased when offered by cooperatives or municipal utilities, highlighting the impact of organisational structure on consumer choices in dynamic electricity markets.

Azarova et al. (2019) surveyed 2000 respondents across four nations, identifying solar farms and power-to-gas infrastructure as key drivers of local energy community acceptance, while wind farms had mixed effects and gas plants/power lines had negative impacts. Interestingly, national and local governance structures influenced individual choices in Italy and Switzerland, respectively. Kim et al. (2019) assessed the social acceptance of an offshore wind project, emphasising the importance of minimising environmental costs; their findings show that the project's advantages may not outweigh its disadvantages. Mengelkamp et al. (2019) explored the potential of local energy markets in Germany, finding economic design parameters as the most influential factor for households. Interestingly, regional customers expressed willingness to pay a slight premium for regional electricity offered on the LEM.

Pons-Seres de Brauwer & Cohen (2020) highlight the potential of citizen-led finance in bridging the investment gap, citing a survey-based simulation projecting Euro 176 billion in potential capital, enough to halve the gap and achieve a 32 % renewable energy share by 2030. Finally, Ndebele (2020) finds that South African consumers are willing to pay a 2 % premium for a 10 % increase in renewable energy electricity share, showcasing consumer-driven potential for renewable energy development. Kim et al. (2020) examined Korean project profitability and local acceptance through contingent valuation and choice experiments, suggesting profit-sharing as a potential tool for enhancing both. These international studies offer valuable insights and inform the context of the present research on Vietnamese households’ WTP for renewable energy benefits.

3. METHODOLOGY

3.1. Green energy fund and questionnaire design. To ensure accurate data collection on attitudes towards renewable energy, a carefully crafted hypothetical scenario is necessary. This scenario should be designed in such a way as to evoke genuine belief and engagement from respondents. It begins by detailing Vietnam's current electricity usage and informing them about the benefits of renewable energy, the detrimental impacts of fossil fuels, and Vietnam's renewable energy goals. Highlighting the progress made in domestic renewable energy development and emphasising the potential of this resource as a powerful and inevitable solution for environmental protection will further increase the interest of respondents. Next, the scenario can introduce the concept of a Green Energy Fund, outlining its purpose as a financial mechanism to support renewable energy initiatives in Vietnam. This could include details about infrastructure development, coordinated planning for renewable energy production areas, funding for research and development activities, and the establishment of attractive investment incentives for renewable energy sources. The fund's income would potentially consist of contributions from citizen via monthly electricity bills, equal to or exceeding by government allocations, and additional support from international organisations.

The core element of this research lies in designing a choice modeling (CM) questionnaire with relevant attributes and levels for valuation. To achieve this, we developed diverse renewable energy development scenarios and corresponding attributes through rigorous consultations with local authority experts and environmental economists at Can Tho University. Additionally, we drew upon insights from previous research, such as Ku & Yoo (2010). Table 1 outlines the chosen attributes and their respective levels.

Table 1

Descriptions and levels of selected attributes

Attribute	Description	Levels
Landscape	The improvement in landscape from the renewable energy plant compared to a fossil-fuel power plant (%)	0; 25; 50
Wildlife	The improvement in wildlife from the renewable energy plant compared to a fossil-fuel plant (%)	0; 25; 50
Air pollution	The reduction of air pollution from the renewable energy plant compared to a fossil-fuel plant (%)	0; 70; 100
Job opportunity	Opportunity to create more jobs by using renewable energy plants compared to a fossil-fuel power plant (persons)	0; 10; 30
Donation	Additional electric charges monthly resulting from the expansion of renewable energy projects (VND 1,000)	0; 30; 50; 70; 90; 110

Note. The extent of impact attributed to a fossil fuel power plant is denoted by 0, representing the status quo.

Source: formed by the authors.

The CM model assumes that renewable energy development strategies will positively impact landscape and wildlife, reduce air pollution, and generate more employment opportunities compared to traditional fossil fuel power plants. To take into account individual preferences and avoid possible objections to mandatory payments, the study uses a voluntary recurring monthly donation system integrated into electricity bills for a five-year period. This approach aligns with the findings of Rolfe et al. (2000) regarding the effectiveness of voluntary contributions in capturing the true value of environmental preferences. The specific donation amounts, ranging of VND 30,000; 50,000; 70,000; 90,000; and VND 110,000 per month (approximately USD 1.28, 2.13, 2.98, 3.83, and USD 4.68), were determined based on insights from focus group discussions and a pilot survey.

Data collection for the CM analysis used face-to-face interviews with a randomly selected sample of local citizens residing in urban areas of the MD. Following the experimental design technique for conjoint choice modeling with main effects described by Louviere et al. (2000), 25 orthogonal attribute combinations were generated. These combinations were then evenly distributed across five questionnaire versions, each containing five choice sets (a sample choice set is presented in Table 2). With a total of 625 respondents, the sample encompasses four provinces and one major city within the MD (Figure 1). Each location is equally represented, with 125 respondents from Vinh Long, Soc Trang, Kien Giang, and Dong Thap provinces, and Can Tho City.

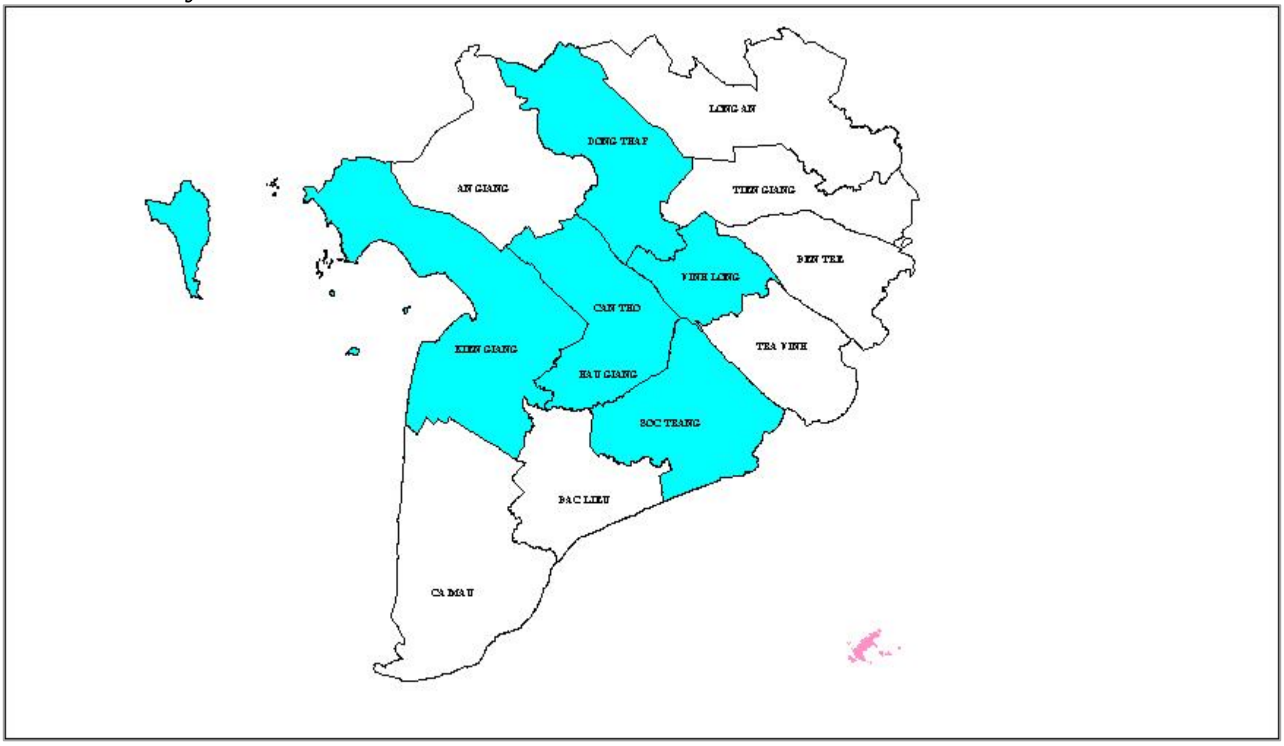

Figure 1. The map of Vietnamese Mekong Delta and study regions

Source: created from Mapinfo Pro 15.0.

3.2. Multinomial logit model. The CM technique, pioneered by Louviere & Hensher (1982), has gained widespread application in diverse fields like marketing, transportation, and tourism (Carson et al., 1995; Morrison et al., 1996). Unlike traditional conjoint methods that rely on ranking or rating, CM presents respondents with sets of attributes and asks them to choose their preferred alternative. This aligns with random utility theory (RUT), making CM well-suited for estimating the passive use values of environmental goods (Adamowicz et al., 1998; Khai & Yabe, 2014). Notably, CM transcends specific sectors and countries, offering a versatile tool for measuring the economic value of goods. This capability stems from its ability to estimate willingness-to-pay (WTP) through choice sets constructed around attribute variations, rather than solely focusing on single options.

A key distinction between CM and contingent valuation lies in the choice complexity presented to respondents. While contingent valuation restricts respondents to a single resource use option, CM requires them to choose between different options within a set. This allows CM to predict choice behavior based on a function of attributes and labels, as demonstrated by Rolfe et al. (2000). Based on Lancaster's consumer choice theory and RUT (Luce, 1959; McFadden, 1974), CM builds upon the assumption that individuals make discrete choices based on maximising their utility. This underlying principle is captured through the formulation of a utility function (U_{ij}):

$$U_{ij} = V_{ij} + e_{ij} = Z'_{ij}\beta + S'_i\delta + e_{ij}. \quad (1)$$

Table 2

An example of a choice set

The following factors will vary according to different policies	Alternative A	Alternative B	Alternative C (Status quo)
Percentage improvement in the landscape of a renewable energy plant compared to a fossil energy plant	25 % improvement	0 % improvement	0
Percentage improvement in the wildlife habitat of a renewable energy plant compared to a fossil energy plant	25 % improvement	50 % improvement	0
Percentage of air pollution reduction from renewable energy plants compared to fossil energy plants	0	100 % reduction	0
The opportunity to create more jobs with a renewable energy plant than with a fossil energy plant	10 persons	0	0
Surcharge on household electricity bill	VND 110.000	VND 70.000	VND 0

Source: formed by the authors.

The latent utility for an observed scenario alternative j in choice set C is comprised of two components: V_{ij}, the systematic and deterministic component, and e_{ij}, the random and error component (Louviere et al., 2000). V_{ij} can be modeled as a function of the renewable energy benefit attributes (Z_{ij}) and respondent characteristics (S_i), with the vectors of parameters β and δ, respectively. However, due to the random component, e_{ij}, the choices cannot be predicted with certainty. Hence, the expression of choice probability is as follows:

$$P_{ij} = P\left(V_{ij} + e_{ij} > V_{im} + e_{im}\right);\ \forall m \in C. \quad (2)$$

The selection of alternative j can be estimated using a multinomial logit model (MNL), as described by McFadden (1974), Maddala (1986), and Greene (2003). This model assumes that the error terms are independently and identically distributed (*IID*) following either a Gumbell or Weibull distribution:

$$P_{ij} = \frac{exp(\mathbf{Z}'_{ij}\beta + \mathbf{S}'_i\delta)}{\sum_{m\in C} \exp{(\mathbf{Z}'_{im}\beta + \mathbf{S}'_i\delta)}}. \quad (3)$$

The utility function in linear parameters for the j^{th} alternative is specified as follows:

$$V_{ij} = ASC + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \cdots + \beta_k Z_k + \lambda_1 (ASC \cdot S_1) + \cdots + \lambda_p (ASC \cdot S_p). \quad (4)$$

The CM model is estimated based on the hypothesis of an observable utility function in additive form, with V_{ij} representing the utility function associated with the alternative j. The socioeconomic and attitudinal variables (non-attribute variables), represented by S_p, are added to the equation by interacting them with the attribute-specific constant (*ASC*), which is unique to each alternative and captures the mean effect of unobserved factors on the error terms for each option. The parameters of β are not specified and can vary between alternatives in the choice set, indicating that the impact of a choice-specific variable on the odds of an option being selected remains the same without considering alternative options (see Table 3 for a description of the attribute and non-attribute variables in the CM model).

Table 3

Variables in the CM model

Variable	Description
	Attribute variables
Donation	Surcharge on monthly electricity bill (unit: VND 1,000)
Land25	25 % improvement in the landscape
Land50	50 % improvement in the landscape
Wild25	25 % improvement in wildlife habitat
Wild50	50 % improvement in wildlife habitat
Air70	70 % reduction in air pollution
Air100	100 % reduction in air pollution
Job10	10 jobs have been increased
Job30	30 jobs have been increased
	Non-attribute variables
Income	Monthly household income of respondents in log
Age	Age of respondents (years)
Education	The education of respondents (years)
Married	Dummy variable equals 1 for married and 0 for single respondents
Child	The number of children in respondents' family
Effect	Dummy variable equals 1 for affected and 0 for unaffected respondents
Knowledge*	Five-point scale indicating the renewable energy resources knowledge of respondents

Note. *Respondents who were asked five questions regarding their knowledge of renewable energy resources received a score of 1 point for responding with "I know well", 0.5 points for stating "I know a little", and 0 points for indicating "I don't know".

Source: formed by the authors.

This study aims to reduce bias and improve the accuracy of the results of the choice model by analysing the MNL model that includes socio-economic attributes, despite the potential violation of Independence of Irrelevant Alternatives (*IIA*). The method of eliminating *IIA* and improving model fit is open to discussion, but this study follows the approach of Rolfe et al. (2000) and Khai & Yabe (2014). To measure the amount of money that respondents are willing to donate for an improvement in an attribute, the marginal willingness to pay (MWTP) is used. The equation for calculating MWTP for these attributes is as follows:

$$\text{MWTP} = -\frac{\beta_{attributes}}{\beta_{Donation}} \quad (5)$$

4. RESULTS

Table 4 presents descriptive statistics for the socio-economic characteristics of the sample. The gender distribution is nearly balanced, with males at 53 % and females at 47 %. The age range spans from 19 to 87 years, with an average of 44.6 years, suggesting a sizable proportion of respondents may be key household decision-makers. Regarding education, the average of over 12 years of schooling indicates a high likelihood of participants being well-informed about the energy-related topics covered in the study. Household income averages around VND 10.5 million monthly, distributed across three brackets: VND 5 million or less (20 %), VND 5-10 million (43 %), and over VND 10 million (37 %). It is noteworthy that approximately 79.8% of respondents, having received information about the willingness of their peers to contribute to the Green Energy Fund, expressed their own willingness to do so, emphasising the potential of community support for such initiatives.

Table 4

Demographic characteristics of respondents

Characteristics	Unit	Mean	SD	Min	Max
Male	-	0.5296	0.499	0	1
Age	Years	44.619	11.670	19	87
Education	Years	12.002	3.476	5	18
Married	-	0.9199	0.289	0	1
Household income	VND 1,000 per month	10,548	6,296	2,000	28,000
Child	Persons	0.921	0.973	0	8
Effect	-	0.798	0.4012	0	1
Knowledge	Points	1.619	1.164	0	5

Source: own estimates.

Table 5 presents the results of the MNL model applied to the choice modeling data. Two model specifications were examined: Model 1 includes only attribute variables, while Model 2 additionally incorporates interaction variables generated by combining socio-economic characteristics, knowledge, and attitudes with alternative-specific constant (*ASC*). Integrating non-attribute variables into the CM model can improve model fit, address potential violations of Independence of Irrelevant Alternatives (IIA) and Independence of Identically Distributed (IID) assumptions, as highlighted by Rolfe et al. (2000). Consistent with this expectation, Model 2 exhibited superior fit compared to Model 1, demonstrated by higher log-likelihood and ρ^2 value. A Swait-Louviere log-likelihood ratio test further confirmed this improvement. The calculated test statistic LR = 293 significantly exceeds the critical value of 18.475 at the 1 % level of significance (7 degrees of freedom), validating the superior fit and results of Model 2. Therefore, Model 2 provides the preferred basis for interpreting the findings of the CM analysis.

Table 5

Estimated results of multinomial logit model (MNL)

Variables	Model 1		Model 2	
	Coefficient	Standard Error	Coefficient	Standard Error
ASC	-0.0949	0.1270	-4.2535***	0.7106
Land25	0.3516***	0.0637	0.3564***	0.0646
Land50	0.4532***	0.0807	0.4620***	0.0818
Wild25	0.5187***	0.0679	0.5220***	0.0693
Wild50	0.3686***	0.0855	0.3739***	0.0878
Air70	0.8850***	0.0778	0.9145***	0.0799
Air100	1.3565***	0.0831	1.4000***	0.0848
Job10	0.3527***	0.0681	0.3655***	0.0694
Job30	0.6845***	0.0825	0.7073***	0.0842
Donation	-1.4608***	0.1148	-1.4989***	0.1174
ASC*Income	-	-	0.2571***	0.0784
ASC*Age	-	-	-0.0106**	0.0042
ASC*Education	-	-	0.0462***	0.0150
ASC*Married	-	-	0.5895***	0.1695
ASC*Child	-	-	-0.1105**	0.0507
ASC*Effect	-	-	1.3875***	0.1039
ASC*Knowledge	-	-	0.1801***	0.0446
Log-likelihood	-2,933.9	-	-2787.4	-
ρ^2	0.1352	-	0.1784	-
Observation	9,264	-	9,264	-

Note. ***, **Indicate statistical significance at the 0.01 and 0.05 level, respectively.
Source: own estimates.

The results in Table 5 reinforce the initial hypothesis and previous research (e.g., Ku & Yoo, 2010) by highlighting the importance of all attributes in shaping consumer preferences for renewable energy projects. As expected, improvements in renewable energy attributes like employment opportunities, landscape aesthetics, wildlife protection, and air quality improvement coincide with positive coefficient signs, indicating their positive impact on respondent satisfaction and WTP. Conversely, the negative coefficient for price reinforces the intuitive expectation that higher costs decrease consumer satisfaction. Notably, Model 2 sheds light on the influence of socio-economic factors through interaction variables. Both income and education, when interacted with alternative-specific constants (*ASCs*), exhibit significantly positive coefficients at the 1 % level, suggesting that individuals with higher socio-economic status have a stronger preference for renewable energy initiatives compared to the status quo. Further insights are revealed by examining individual interaction terms.

The significantly negative parameter associated with *ASC*Age* at the 1 % level implies that younger respondents are more inclined towards renewable energy, while the negative coefficient for *ASC*Child* (5 % level) indicates households with a greater number of children are significantly less likely to prefer the status quo, decreasing the probability of choosing it. Conversely, the positive coefficient for *ASC*Married* (1 % level) highlights a stronger pro-renewable energy stance among married individuals. Similarly, the positive coefficient for *ASC*Knowledge* suggests that respondents with greater understanding of renewable energy are more likely to favor its development.

While coefficient analysis provides valuable insights, elucidating the complete picture of how various factors influence the choice of specific aspects of the renewable energy project requires a more nuanced approach. Therefore, we employ the concept of marginal willingness to pay, which approximates the implicit price for each attribute. This implicit price is obtained by dividing a specific attribute factor by its corresponding price coefficient, as detailed in equation (5). Through MWTP analysis, we can delve deeper into the relative importance and trade-offs associated with different attribute improvements, offering a more comprehensive understanding of consumer preferences for renewable energy development.

Table 6 presents estimates of MWTP for various renewable energy attributes across both models, accompanied by their respective 95 % confidence intervals.

Table 6

Estimation of marginal willingness to pay (MWTP) and 95 % confidence intervals, thsd VND

Variables	Model 1				Model 2			
	MWTP		95 % CI		MWTP		95 % CI	
	Coef.	S.E.	LB	UB	Coef.	S.E.	LB	UB
Land25	24.071***	5.032	14.210	33.933	23.779***	4.966	14.046	33.513
Land50	31.025***	5.807	19.644	42.406	30.823***	5.739	19.575	42.072
Wild25	35.507***	5.597	24.537	46.478	34.828***	5.523	24.004	45.653
Wild50	25.233***	6.400	12.689	37.776	24.943***	6.377	12.444	37.442
Air70	60.585***	6.297	48.243	72.927	61.013***	6.298	48.669	73.357
Air100	92.855***	9.057	75.104	110.606	93.400***	9.039	75.683	111.116
Job10	24.144***	5.104	14.140	34.149	24.384***	5.071	14.445	34.323
Job30	46.855***	6.710	33.703	60.006	47.187***	6.683	34.088	60.286

Notes. CI: Confidence interval; LB: Lower bound; UB: Upper bound;
***Indicate statistical significance at the 0.01 level.
Source: own estimates.

The positive MWTP coefficients consistently indicate residents' willingness to invest more for improved levels of each attribute. For example, urban residents in the MD express a clear preference for renewable energy projects over fossil fuel plants, as evidenced by their readiness to pay an additional VND 24,000 or VND 31,000 monthly for a 25 % or 50 % improvement in the landscape, respectively. Similar trends are observed for wildlife habitat preservation, with households willing to contribute around VND 35,000 and VND 25,000 for a 25 % and 50 % increase, respectively. Reducing air pollution is a particularly important problem, with residents willing to pay additional VND 61,000 (range: VND 49,000–73,000) for a 70 % decrease and impressive VND 93,000 in the absence of any air pollution from renewable energy facilities. This highlights the crucial role that environmental benefits play in shaping public support for renewable energy initiatives, warranting further investigation in future research. Additionally, local job creation through renewable energy projects garners considerable interest, with residents willing to contribute approximately VND 24,000 and VND 47,000 for the opportunity to generate 10 and 30 additional jobs compared to fossil fuel plants, respectively. This finding highlights the potential for renewable energy to not only address environmental concerns but also contribute to regional economic development.

A key advantage of the CM method lies in its ability to estimate WTP for various scenarios with different attribute combinations using the estimated attribute coefficients. This allows for valuable insights into the potential trade-offs and preferences associated with alternative policy options. To explore this further, the study examined three plausible renewable energy strategies, with their respective impacts on household WTP presented in Table 7. The estimated monthly WTP for renewable energy investments across scenarios A, B, and C stands at VND 144,000 (USD 6.13), VND 200,000 (USD 8.48), and VND 196,000 (USD 8.36), respectively. It is noteworthy that the average monthly household income during the survey period amounted to VND 10.5 million (USD 448.85). Therefore, the observed WTPs represent a range between 1.37 % and 1.89 % of the average monthly household income. Similarly, the annual WTP estimates for scenarios A, B, and C are approximately VND 1.728 million (USD 73.53), VND 2.390 million (USD 101.72), and VND 2.356 million (USD 100.27), respectively.

Table 7

Investment scenarios for renewable energy

Attribute	Scenario A	Scenario B	Scenario C
Landscape improvement	25%	25%	50%
Wildlife habitat improvement	25%	25%	50%
Air pollution reduction	70%	100%	100%
New job opportunity	10 persons	30 persons	30 persons
WTP (VND 1,000 per month)	144.005	199.194	196.353
WTP (VND million per year)	1.728	2.390	2.356
WTP for the urban residents in the MD (VND billion per year)	3.456	4.781	4.712

Source: own estimates.

To estimate the total social welfare gain associated with each renewable energy scenario, we multiply the average WTP by the total number of urban households in the MD. Based on the General Statistics Office of Vietnam (GSO, 2020) and an average household size of 3.5 individuals (Statista, 2023), the 2020 urban population of 7 million means approximately 2 million urban households in the MD. The last row of Table 7 presents the collective WTP for each scenario. For instance, the scenario with the highest attribute level (50 % improved landscape, 50 % enhanced wildlife habitat, 100 % air pollution reduction, and 30 additional jobs) demonstrates a combined WTP of VND 4.712 billion (USD 200.53 million) among all urban households in the MD. This highlights the substantial potential welfare gains achieved through strategic investments in renewable energy. Moreover, the diverse attribute combinations explored in this study provide valuable insights into potential trade-offs and societal preferences, opening doors for further investigation of specific policy options within the broader realm of renewable energy development.

5. DISCUSSION

Driven by the global imperative to combat climate change and secure a sustainable energy future, Vietnam is actively pursuing the development of renewable energy sources. The government has set an ambitious target: by 2050, 11 % of the nation's primary energy supply will originate from renewable sources. To achieve this, Vietnam is exploring robust and pragmatic regulatory frameworks, fostering domestic and international collaborations with renewable energy specialists, and investing heavily in domestic technology and energy efficiency projects. These initiatives underscore Vietnam's commitment to integrating renewable energy as a cornerstone of its sustainable energy strategy.

This study used the CM method to measure the WTP of urban residents in the MD for different aspects of renewable energy development. The findings revealed a significant willingness to financially support renewable energy initiatives aimed at enhancing landscape aesthetics, improving wildlife habitats, bolstering air quality, and generating job opportunities. These results align with previous studies conducted in Korea (e.g., Ku & Yoo, 2010), highlighting a common preference for environmental and economic benefits associated with renewable energy.

The study strengthens the existing body of evidence on the influence of socio-economic factors on renewable energy preferences, building upon prior research (Sun et al., 2016; Azarova et al., 2019). As expected, higher income and education level are positively associated with a greater willingness to pay for improved renewable energy scenarios. This finding suggests a potentially fruitful avenue for policy interventions in the form of targeted outreach and education campaigns aimed at these demographic segments. Such efforts could contribute to expanding the base of support for renewable energy initiatives and accelerating the transition to a low-carbon future.

While the present study reveals a robust pro-renewable energy stance among younger respondents, this finding diverges from some existing literature. For instance, Mengelkamp et al. (2019) observed a lower willingness-to-pay threshold for renewable energy investments among younger participants in local energy markets. Similarly, Azarova et al. (2019) found that compared to the 20–35 age group, individuals in the 35–45 and 45–65 age ranges demonstrated a greater likelihood of preferring the status quo in energy transition scenarios. These seemingly contradictory findings highlight the need for further exploration into the intricate relationship between age, environmental preferences, and energy-related decision-making. Future research could delve deeper into factors such as cultural contexts, information access, and risk perception across generations to reconcile these discrepancies and provide a more nuanced understanding of age-related variations in energy preferences. Consistent with the findings of Azarova et al. (2019), this study finds that households with more children show a significantly lower tendency to maintain the status quo regarding renewable energy initiatives.

The study reveals that respondents are more likely to support a project or policy if they perceive that their community is doing the same. This finding implies that future community engagement programs may be more effective when they emphasize community involvement, aligning with similar conclusions drawn in other studies (e.g., Gou et al., 2005; Khai et al., 2020; 2022). Marital status also plays a role, with married respondents demonstrating a stronger pro-renewable energy stance. This aligns with the notion of shared values and decision-making within families, influencing individual preferences. Similarly, higher knowledge level, measured by renewable energy quiz scores, correlate with a greater likelihood of supporting renewable energy policies, echoing findings from Gou et al. (2005), Lee & Heo (2016), and Bamwesigye (2023). This underlines the importance of knowledge dissemination and education campaigns in fostering public support for renewable energy development. This suggests that effective implementation of renewable energy programs necessitates targeted knowledge dissemination and community engagement initiatives that emphasize the collective benefits of such projects, including job creation, improved air quality, and environmental sustainability. Disseminating timely and comprehensive information through diverse media channels (e.g., radio, television, online platforms) and interactive platforms (e.g., contests, forums) can foster public understanding and support for Vietnam's renewable energy goals. Ultimately, such efforts will not only contribute to achieving the 2050 target but also pave the way for more robust cost-benefit analyses for future renewable energy investments.

6. CONCLUSIONS

This study investigated the WTP for renewable energy development among urban residents in the MD of Vietnam. The findings demonstrate a significant positive WTP for initiatives that enhance landscape aesthetics, improve wildlife habitats, bolster air quality, and generate job opportunities. The study strengthens the understanding of socio-economic factors influencing renewable energy preferences. Higher income and education levels were linked to a greater WTP, suggesting targeted outreach and education campaigns aimed at these demographics could be fruitful. Interestingly, a pro-renewable energy stance was observed among younger respondents, which diverges from some previous research. Future studies should explore the intricate relationship between age, environmental preferences, and energy decisions, considering factors like cultural context and information access. Consistent with other studies, this study found that respondents are more likely to support projects with perceived community involvement. Marital status and knowledge level also influenced WTP, underlining the importance of shared values and education in fostering public support.

In conclusion, effective implementation of renewable energy programs requires targeted knowledge dissemination and community engagement initiatives. By emphasising the collective benefits, including job creation, improved air quality, and environmental sustainability, and utilising diverse media channels and interactive platforms, public understanding and support for Vietnam's renewable energy goals can be fostered. This will not only contribute to achieving the 2050 target but also pave the way for more robust cost-benefit analyses for future investments in renewable energy sources.

7. LIMITATIONS AND FUTURE RESEARCH

While this study provides valuable insights into the preferences and willingness-to-pay of urban residents in the MD regarding renewable energy development, its scope necessitates further research. To gain a comprehensive understanding of public perceptions and potential demand for renewable energy investments across Vietnam, future studies should take a broader perspective. Expanding the research scope to include urban residents in geographically diverse regions of Vietnam would facilitate a more holistic assessment of nationwide preferences and potentially reveal regional variations in priorities and concerns. Additionally, incorporating perspectives from rural residents would offer a more nuanced understanding of how different population segments value and engage with renewable energy initiatives. Such a comprehensive approach would provide policymakers with valuable data to inform the design of effective and inclusive renewable energy policies tailored to the specific needs and expectations of diverse communities throughout Vietnam.

Funding: this study received partial funding from the MOET project (B2022-TCT-10).

Acknowledgements: we express our heartfelt gratitude to the dedicated staff and students in the Faculty of Environmental and Resource Economics at Can Tho University for their invaluable support in data collection.

Conflicts of interest: the authors declare no conflict of interest.

REFERENCES

1. Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998). Stated preference approaches for measuring passive use values: choice experiments and contingent valuation. *American Journal of Agricultural Economics*, 80(1), 64–75. https://doi.org/10.2307/3180269.

2. Azarova, V., Cohen, J., Friedl, C., & Reichl, J. (2019). Designing local renewable energy communities to increase social acceptance: evidence from a choice experiment in Austria, Germany, Italy, and Switzerland. *Energy Policy*, 132, 1176–1183. https://doi.org/10.1016/j.enpol.2019.06.067.

3. Bamwesigye, D. (2023). Willingness to pay for alternative energies in Uganda: energy needs and policy instruments towards zero deforestation 2030 and climate change. *Energies*, 16(2), 980. https://doi.org/10.3390/en16020980.

4. Carson, R. T., Wright, J., Carson, N., Alberini, A., & Flores, N. (1995). A bibliography of contingent valuation studies and papers. Natural Resource Damage Assessment, La Jolla, CA.

5. Greene, W. H. (2003). Econometric analysis, 5th ed. Upper Saddle River, NJ: Prentice Hall. Available at: https://pages.stern.nyu.edu/~wgreene/Text/tables/tablelist5.htm.

6. GSO (2020). *Announcement of findings from the 2020 popular life survey*. Vietnamese General Statistics Office. Available at: https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2021/07/thong-cao-bao-chi-ve-ket-qua-khao-sat-muc-song-dan-cu-nam-2020.

7. GSO (2010). Result of Viet Nam: household living standards survey 2010. Statistical Publishing House, General Statistics Office of Vietnam.

8. Guo, X., Liu, H., Mao, X., Jin, J., Chen, D., & Cheng, S. (2014). Willingness to pay for renewable electricity: a contingent valuation study in Beijing, China. *Energy Policy*, 68, 340–347. https://doi.org/10.1016/j.enpol.2013.11.032.

9. Khai, H. V., & Yabe, M. (2014). Choice modeling: assessing the non-market environmental values of the biodiversity conservation of swamp forest in Vietnam. *International Journal of Energy and Environmental Engineering*, 5, 77. https://doi.org/10.1007/s40095-014-0077-5.

10. Khai, H. V., Utsunomiya, Y., Khong, T. D., & Khoi, L. N. D. (2022). Do neighbors affect people's demand for the biodiversity conservation project in the U Minh Ha Peat swamp forest of the Mekong Delta, Vietnam? *Frontiers in Sustainable Food Systems*, 5, 808117. https://doi.org/10.3389/fsufs.2021.808117.

11. Khai, H. V., Van, N. P., & Yabe, M. (2020). Economic value of an ecosystem conservation project: a case study of U Minh National forest in the Vietnamese Mekong Delta. *Journal of the Faculty of Agriculture, Kyushu University*, 65(1), 165–172. https://doi.org/10.5109/2558909.

12. Kim, H. J., Kim, J. H., & Yoo, S. H. (2019). Social acceptance of offshore wind energy development in South Korea: results from a choice experiment survey. *Renewable and Sustainable Energy Reviews*, 113, 109253. https://doi.org/10.1016/j.rser.2019.109253.

13. Kim, K. J., Lee, H., & Koo, Y. (2020). Research on local acceptance cost of renewable energy in South Korea: a case study of photovoltaic and wind power projects. *Energy Policy*, 144, 111684. https://doi.org/10.1016/j.enpol.2020.111684.

14. Ku, S. J., & Yoo, S. H. (2010). Willingness to pay for renewable energy investment in Korea: a choice experiment study. *Renewable and Sustainable Energy Reviews*, 14(8), 2196–2201. https://doi.org/10.1016/j.rser.2010.03.013.

15. Lee, C. Y., & Heo, H. (2016). Estimating willingness to pay for renewable energy in South Korea using the contingent valuation method. *Energy Policy*, 94, 150–156. https://doi.org/10.1016/j.enpol.2016.03.051.

16. Louviere, J. J., & Hensher, D. A. (1982). Design and analysis of simulated choice or allocation experiements in travel choice modeling. *Transportation Research Reccord*, 890, 7. Available at: https://onlinepubs.trb.org/Onlinepubs/trr/1982/890/890-003.pdf.

17. Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). Stated choice methods: analyis and application. Cambridge, Cambridge University Press. https://doi.org/10.1017/CBO9780511753831.008.

18. Luce, R. D. (1959). Decision making – an experimental approach. *Journal of Philosophy*, 56(4), 173–177. https://doi.org/10.2307/2022058.

19. Lucia, F. (2024). Renewable energy investments worldwide – statistics & facts. *Statista*. Available at: https://www.statista.com/topics/10992/global-renewable-energy-investments/#topicOverview.

20. Maddala, G. S. (1983). Limited-dependent and qualitative variables in econometrics. Cambridge, Cambridge University Press. https://doi.org/10.1017/CBO9780511810176.

21. McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers in econometrics* (pp. 105–145). New York, Academic Press.

22. Mengelkamp, E., Schönland, T., Huber, J., & Weinhardt, C. (2019). The value of local electricity – a choice experiment among German residential customers. *Energy Policy*, 130, 294–303. https://doi.org/10.1016/j.enpol.2019.04.008.

23. MOIT (2009). The report on master program on economical and efficient use of energy in Vietnam. Ministry of Industry and Trade of Vietnam.

24. Morrison, M. D., Blamey, R. K., Bennett, J. W., & Louviere, J. J. (1996). A comparison of stated preference techniques for estimating environmental values. Choice Modelling Research Report No. 1. University of New South Wales, Canberra. Available at: https://crawford.anu.edu.au/pdf/staff/jeff_bennett/chmdrr01.pdf.

25. Ndebele, T. (2020). Assessing the potential for consumer-driven renewable energy development in deregulated electricity markets dominated by renewables. *Energy Policy*, 136, 111057. https://doi.org/10.1016/j.enpol.2019.111057.

26. Pons-Seres de Brauwer, C., & Cohen, J. J. (2020). Analysing the potential of citizen-financed community renewable energy to drive Europe's low-carbon energy transition. *Renewable and Sustainable Energy Reviews*, 133, 110300. https://doi.org/10.1016/j.rser.2020.110300.

27. Quang, N. C. (2014). Comment on the challenges of Vietnam's coal industry. *Vietnam Energy Newspaper*. Available at: https://nangluongvietnam.vn/nhan-dinh-ve-nhung-thach-thuc-cua-nganh-than-viet-nam-10249.html.

28. Rolfe, J., Bennett, J., & Louviere, J. (2000). Choice modelling and its potential application to tropical rainforest preservation. *Ecological Economics*, 35(2), 289–302. https://doi.org/10.1016/S0921-8009(00)00201-9.

29. Rommel, J., Sagebiel, J., & Müller, J. R. (2016). Quality uncertainty and the market for renewable energy: evidence from German consumers. *Renewable Energy*, 94, 106–113. https://doi.org/10.1016/j.renene.2016.03.049.

30. Statista (2023). Breakdown of households in Vietnam in 2021, by size. Available at: https://www.statista.com/statistics/1358082/vietnam-household-share-by-size.

31. Statista (2023). Power production and demand in Vietnam from 2013 to the first 10 months into 2022. Available at: https://www.statista.com/statistics/1206469/vietnam-power-demand.

32. Sun, C., Yuan, X., & Yao, X. (2016). Social acceptance towards the air pollution in China: evidence from public's willingness to pay for smog mitigation. *Energy Policy*, 92, 313–324. https://doi.org/10.1016/j.enpol.2016.02.025.

33. WEO (2022). The World Energy Outlook 2022. International Energy Agency (IEA). Available at: https://www.iea.org/reports/world-energy-outlook-2022.

Citation:

Стиль – ДСТУ:
Khai H. V., Tran H. L. T., Ngan N. V., Duyen T. T. T. Choice modeling approach to evaluate the economic value of renewable energy development. *Agricultural and Resource Economics*. 2024. Vol. 10. No. 1. Pp. 284–300. https://doi.org/10.51599/are.2024.10.01.12.

Style – APA:
Khai, H. V., Tran, H. L. T., Ngan, N. V., & Duyen, T. T. T. (2024). Choice modeling approach to evaluate the economic value of renewable energy development. *Agricultural and Resource Economics*, 10(1), 284–300. https://doi.org/10.51599/are.2024.10.01.12.