Trade-off in energy policy: Evidence from a best-worst discrete choice experiment

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Abstract

This study addresses the critical issue of climate change awareness in Pakistan by evaluating the Pakistani citizens' willingness to adopt energy reforms to reduce CO_2 emissions. Using best-worst scaling, we examined five key attributes important for reforming the Pakistan energy policy: CO_2 emission reduction, energy independence, employment impact, transition time, and changes in energy price. The findings reveal a strong preference for reducing CO_2 emissions, enhancing energy independence, increasing employment, and accelerating policy implementation. Meanwhile, Pakistan residents revealed concerns about potential increases in energy bills. The analysis showed that male, urban, educated, full-time employed, middle-aged (35-44), married individuals with children, high-income, and environmentally conscious respondents were more willing to trade-off for CO_2 reduction. In contrast, apprehension about potential job losses and higher energy bills was prevalent across all subgroups. The study recommends diversifying energy sources, including nuclear and hydro-energy, as a strategic approach to balance environmental goals with economic stability in Pakistan. These insights into public energy policy preferences can inform policymakers and researchers in similar developing countries of sustainable energy strategies.

Keywords: CO_2 emission, Unemployment, Trade-off, Energy reform

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1. Introduction

Growing concerns about climate change encourage nations to develop policies and regulations to reduce CO_2 emissions (IPCC, 2014). However, South Asia has been described as a hotspot for global energy development, particularly for coal power plants. While coal is the most carbon-intensive fuel among all fossil fuels, it is predominantly used for power generation in South Asian countries. In South Asia, Pakistan has been desperate to reduce its long and crippling energy shortage and sustain stable energy prices by tapping into the vast indigenous coal reserves in the Thar region (Jillani, 2022). Thar's coal reserves are approximately 175 billion tons, making it the world's 16th-largest coal deposit (Raza *et al.*, 2022). Hence, the domestic use of coal would reduce its reliance on imported fossil fuels and enhance local employment.

Meanwhile, there is increasing pressure from the United Nations and European Union for China to stop funding overseas coal projects. Additionally, Pakistan is a member of the Paris Agreement, which aims to limit global warming to below 2ºC. To achieve this goal, Pakistan has committed to reducing its emissions by 20% by 2030. Therefore, Pakistan's government is developing a plan to reduce the share of fossil fuels, especially coal, in power generation. In 2021, the government updated its Nationally Determined Contributions (NDCs) goal, which strongly focuses on reducing CO_2 emissions by increasing the share of renewable energy up to 60%.

Thus, public acceptance and participation in policy are necessary; however, not much is known about how much the citizens of Pakistan are willing to accept this policy shift. Additionally, the people in Pakistan need to understand the trade-offs and be aware that there are no simple solutions, and any choice will have direct implications (Accenture, 2010). To capture such trade-offs, this study uses the best-worst scaling (BWS) to understand public preference regarding the energy transition towards renewable energy. The BWS provides a sophisticated way to gauge public preference for policy outcomes (Peterson & Feldman, 2018).

In addition to examining the potential impacts of the policy, this study also explores the factors that influence its feasibility and acceptability, such as the possible effects on employment and energy affordability. Moreover, this study reveals the public's preferences and willingness to pay to reduce CO_2 emissions, taking into account the socio-demographic characteristics of the respondents, such as their age, education, and income level. Kosenius and Ollikainen (2013) argue that transitioning to a low-carbon energy system requires balancing the trade-offs between various outcomes, such as environmental benefits and economic costs.

Several studies have used the choice experiment method to analyze the public's willingness to pay for mitigation policies to reduce CO_2 emissions (Alberini *et al.*, 2018; Azarova *et al.*, 2019). Similarly, Peterson and Feldman (2018) used the choice experiment to examine the energy policy with a focus on external effects such as reduction in CO_2 emission, energy costs, and job creation. In contrast, Aruga *et al.* (2021) conducted a similar study for Poland that includes all our attributes in the choice experiment. Our analysis is focused on the external effect of energy reform in Pakistan, which is highly dependent on fossil fuels for energy production. Moreover, this study will help policymakers understand people's preferences to make policies successful.

The majority of the choice experiment research is related to energy policy in developed nations (Alberini *et al.*, 2018; Azarova *et al.*, 2019; Diederich & Goeschl, 2014; Peterson & Feldman, 2018; Tol, 2013) using Carbon tax. In comparison, this is the first-choice experiment study conducted in a developing nation, specifically Pakistan. Secondly, policymakers in developing countries face significant uncertainty regarding public preference and the acceptability of energy policy outcomes. Therefore, this study offers an empirical approach to fill this gap by capturing public preference and perceptions of the risk associated with energy reform.

Our results indicate that respondents strongly prefer reducing CO_2 emissions. The respondents were willing to pay an extra 0.47% in their energy bill to reduce CO_2 emissions and an extra 0.33% to achieve higher energy independence. They were also willing to reduce the dependency on fossil fuels and implement the policy sooner. The respondents were willing to compensate 274 jobs for reducing CO_2 emissions, 189 jobs for raising energy independence, and 1145 jobs to implement the policy one year earlier.

Furthermore, within our subgroup samples, we found respondents who strongly preferred reducing CO_2 emissions and desired a policy that would shift toward energy independence quickly. However, some respondents showed strong concern over the policy that leads to unemployment and increased energy bills. Moreover, the respondents who are married and have children also show a favorable preference for reducing CO_2 emissions and raising energy independence by implementing the policy sooner. Nevertheless, all sub-groups show strong concern about employment loss and rising energy bills due to the implementation of energy policy.

Several policy implications can be drawn from this paper. We found that sudden policy change without considering the consequences will lead to failure of policy reform. Most respondents show high concern over employment loss and rising bills. Therefore, policymakers should consider the consequences of policy reform in the energy sector and provide suitable alternative solutions. To better engage people in effective policy reform, the government should guarantee at least job replacement in another industry to compensate for the rise in bills.

The remainder of the paper is organized as follows. Section 2 provides an extensive background of the energy policy in Pakistan. Section 3 introduces the choice experiment and empirical strategy. Section 4 presents the estimation and interpretation. Section 5 offers the concluding remarks.

2. Background of Energy Industry and Policy

2.1. Energy Industry in Pakistan

A policy that directly addresses CO_2 reduction and other greenhouse gases can negatively and positively affect the economic situation, especially for a nation that highly depends on imported fossil fuel and domestic coal. Reducing reliance on imported fuel to cut CO_2 emissions through an energy transition towards renewable energy can have severe short-term consequences and cause political instability in countries that rely heavily on these industries.

Pakistan has abundant coal deposits, particularly in the Thar region, with an estimated 175 billion tons of lignite coal (Akhtar *et al.,* 2018). According to the IEA, Pakistan used about 16.8 million tons of coal in 2023, more than double the amount used in 2015. Coal-related development in Pakistan is primarily driven by the China-Pakistan Economic Corridor (CPEC), which has expanded coal energy generation from 0.15 GW in 2015 to 7.2 GW in 2023. Pakistan has significant coal reserves that can help stabilize its supply chain and provide affordable energy to consumers. Furthermore, the coal mining and associated energy sectors offer substantial employment opportunities, serve as a crucial source of household income, contribute to foreign reserves, and constitute a significant portion of budget revenue. This underscores the importance of conducting energy policy to sustain and diversify energy sources. Additionally, Pakistan has tremendous potential to generate solar and wind power, with several well-known wind corridors and high solar irradiation levels.

Pakistan's energy policy is driven by the objectives of ensuring energy security, affordability, and sustainability. As a signatory to the Paris Agreement, Pakistan has committed to reducing its greenhouse gas emissions by 20% by 2030, compared to a business-as-usual scenario. In 2019, the government approved the Alternative and Renewable Energy Policy, which aims to increase the share of renewable energy in the power sector to 20% by 2025 and 30% by 2030. The government updates its NDC goals in 2021, setting a target of reducing its projected emission by 50% by 2030, banning coal imports, and phasing out coal-fired power plants. Pakistan has adopted various measures to improve energy efficiency and regional energy cooperation initiatives to import hydropower.

2.2.Energy Policy in Pakistan

The national policy transition in Pakistan is a legal requirement under the Electricity Act of 1910, the National Energy Efficiency and Conservation Act of 2016, and the Pakistan Climate Change Act of 2017. These Acts mandate promoting and implementing energy efficiency and conservation measures across various sectors. The main goals of these Acts are to ensure energy security and reduce the negative impact on the environment.

Globally, Pakistan is considered a small emitter of CO_2, yet it is already under severe strain from current and future threats of climate change. However, reliance on fossil fuels and investment lead to a rise in greenhouse gas emissions. The coal phase-out offers Pakistan substantial prospects for enhancing renewable (Song *et al.*, 2023). Coal is the most intensive carbon emission fuel, and reducing its use is crucial for achieving the goal of the Paris Agreement. In line with this, energy policy reform is urgently needed and implemented immediately. In response, the government has taken several high-priority actions in its NDCs for 2021: (1) increasing the share of renewable energy, including hydroelectric power, to 60% by 2030, (2) improving energy efficiency, (3) aiming for 30% electric vehicles by 2030, and (4) targeting a 50% reduction in projected emissions by 2030 (5) banning coal imports and phasing out coal-fired power plants.

The NDCs' 2021 goal of Pakistan can negatively affect jobs in energy sectors and may change energy independence and household energy bills. Therefore, it is crucial to know what kind of energy policy change the people are more willing to accept in order to maintain the balance between various energy policy attributes.

3. Methods

3.1. Best-Worst Scaling (Case-3) Technique

In this study, we applied the BWS method to analyze people's attitudes toward potential energy policy. The BWS technique is the stated preference method (Van Schoubroeck *et al.*, 2023) introduced by Louviere and Woodworth (1983) in their pioneer research to gauge individual preference. The BWS, also known as maximum difference scaling, has been applied to various issues such as food safety (Finn and Louviere (1992), consumer behavior research (Auger *et al.*, 2007; Burke *et al.*, 2013), food preference (Cheng *et al.*, 2022), and energy and environmental economics (Aruga *et al.*, 2021; Azarova *et al.*, 2019). The BWS technique is based on random utility theory (Thurstone (1927) for the Method of Paired Comparison (MPC) to elicit consumer preference. The main objective of MPC is to trade-off between pair items.

The random utility model (Louviere & Flynn, 2010), which serves as the theoretical foundation for BWS, is expressed below:

$$V_{ijt} = X_{ijt}\delta + \epsilon_{ijt} \qquad (1)$$

In eq (1), the V_{ijt} represents the indirect utility derived by each respondent (i) on choice set (t) having a select choice alternative (j), X_{ijt} is the vector of attributes, δ represents the coefficient of attributes, and ϵ_{ijt} is the unobserved random disturbance term.

The BWS technique has several advantages, such as being free of bias, not undergoing cultural bias due to respondents' behavior, and helping to rank consumer preferences easily. In the BWS method, the highest-ranked alternatives in a given choice set were identified as the best or preferred option, while the worst or least preferred option was selected from the remaining two choice sets (Lusk & Briggeman, 2009). The best-worst choice is chosen by the respondent with the given attributes, and then the investigator can model the impact of these attributes on the participants' utility (Aruga *et al.*, 2021).

Policy decisions require consideration beyond mere preference selection, not to select the most preferable option. Thus, Policymakers should evaluate not only preferred choices but also the entire range of preferences. In doing so, they can maximize the information obtained from respondents while preserving the structure of attributes and levels in the choice experiment. Therefore, we apply case 3 of Best-Worst Scaling (BWS), a multi-profile case where individuals select the best and worst profiles in each choice set, including three or more profiles.

There are two approaches to analyzing the BWS-Case 3, but the modeling approach is most commonly used in applied studies. There are three standard models of analysis: Maximum difference (maxdiff), sequential, and rank-ordered logistic (ROL) (Lancsar *et al.*, 2013). These three models assume that individuals can select the best profile from the choice set that gives maximum utility and then select the worst profile. Still, the three models' assumptions regarding choosing the best and worst are different. In this study, we apply the ROL model because individuals select the best (i) profile among the P profile since the utility for the *i*th profile is maximum. Individuals are then asked to choose the worst *k* profile from the remaining two profiles (P-1) since the utility for the *k* profile is the least maximum.

3.2.Statistical Analysis

Willingness to pay for BWS-Case 3 group data is typically analyzed using Rank-Ordered Logistic (ROL) regression (Aruga *et al.*, 2021; Cheng *et al.*, 2022). The ROL model can be understood as a sequential application of the common multinomial logit (MNL) model. ROL regression for the RUM specification assumes that individuals rank choice alternatives from best to worst (Cheng *et al.*, 2022). Let $r_{ijt} = (r_{i1j} \ldots\ldots, r_{ijt})$ be the respondent's choice in descending order of preference. In every stage, the respondents selected alternative j as the most preferred choice among the remaining J options.

$$P_r\left[V_{it}(r_{i1t}) > V_{it}(r_{i2t}) \ldots\ldots, V_{it}\left(r_{ijt}\right)\right] = \prod_{h=1}^{J-1} \frac{exp\ (X_{ijt}(r_h\delta)}{\sum_{m=h}^{J} exp\left(X_{ijt}(r_m)\delta\right)} \qquad (2)$$

where $X_{ijt}(r_h)$ includes an alternative's attributes that receive rank h in the ordered set.

We used STATA 16 to perform the full sample and subgroup analysis using the *rologit* command.

3.3.Willingness to Pay (WTP)

Marginal willingness to pay is calculated as (Haab & McConnell, 2002),

$$\frac{\partial \widehat{WTP}_J}{\partial x_j} = \frac{\hat{\beta}_j}{\hat{\beta}_m} \qquad (3)$$

where β is the estimated parameter for attribute j and $\hat{\beta}$ is the parameter estimate on price. We use the method following Krinsky and Robb (1986) to estimate the 95% confidence interval for each attribute and each model's marginal WTP.

3.4.Attributes and Level Selection

In this study, people's preferences for energy policy aimed at reducing CO_2 emissions are analyzed using a stated preference choice experiment. In the discrete choice experiment, the respondents indicate their preferred set of (K) alternatives where $K \geq 2$ (Alberini *et al.*, 2018). Selecting attributes and their level is crucial for understanding respondents' preference toward potential energy policy. Five attributes describe the alternatives in this study: i) level of CO_2 emission reduction, ii) energy independence rate, iii) change in energy industry employment level, iv) change in energy bill per household, and v) time transition required for policy implementation (see Table 1).

Table 1
Attributes and Level Selection

Attributes	Level	Source
Reduction in CO_2 emission	10%, 15% 20%, 25%, 30%	The base level is selected based on the Paris Agreement 2015.
Energy Independence	50%, 60%, 70%, 80%, 90%	The energy independence level is selected based on Pakistan's import energy dependency rate in 2020.
Change in Employment level	+16000, +8000, 0, -8000, -16000	The baseline is "no change" in employment level.
Time for Transition	6yrs,8yrs,10yrs,12yrs,14yrs	The baseline line was selected as 10 years based on the government's target to achieve the Paris Agreement goal by the end of 2030.
Change in Energy Price	+40%, +20%, 0, -20%, -40%	The baseline is "no change" in household energy bills.

All five attributes can generate 3,125 (= 5^5) possible alternatives, known as the full factorial experimental design. However, requiring respondents to choose such a large number of options would be overly complex and overwhelming. The study applied a D-optimal main-effects fractional factorial design (Louviere *et al*., 2000) to create five blocks, each containing five questions. In each choice set, the status quo option is consistently included as one of the five attributes, remaining unchanged across all sets. Respondents were randomly assigned to one of the five blocks. The design and block definition were implemented using R software, following the coding framework provided by Aizaki *et al*. (2014).

3.5. Data Collection

The data were collected through face-to-face structured interviews conducted from July to September 2023. A group of students were hired to carry out the survey. The target population consisted of citizens responsible for energy-related and financial decisions in their respective households. To ensure the validity of the survey, the questionnaire was designed using the online application Survey CTO, which allowed for real-time monitoring of data collection online.

Secondly, a few questions were doubly included to detect inconsistencies in respondents' answers. Respondents who provided conflicting answers to these double-check questions were excluded from the dataset. Thirdly, an online location-check question was added, requiring respondents to confirm their location before completing the survey. This feature helped us verify the geographical position of respondents and ensure data collection from diverse households, which helped us locate the respondents' position by collecting data from different households.

Lastly, before conducting the final survey, a pilot study was carried out to pre-test the questionnaire and attribute levels. The pilot survey involved a sample of approximately 100 responses collected by the interviewer to evaluate the validity of the questionnaire and the data collection techniques.

Table 2
Socio-demographic Characteristics

	Sample share	%	Expected	Population census	%	Chi-square
Gender						
Male	306	53.87	291	106,318,220	51.19	1.59
Female	262	46.13	277	101,344,632	48.81	
Region						
Rural	349	61.44	361	132,013,789	63.56	1.09
Urban	219	38.56	207	75,670,837	36.44	
Age-Group						
18-24	155	27.29	137	26,791,328	24.16	5.81
25-34	156	27.46	156	30,552,880	27.55	
35-44	103	18.13	111	21,675,878	19.55	
45-54	73	12.85	76	14,877,196	13.42	
55-64	52	9.15	49	9,286,847	8.37	
65 & above	29	5.11	39	7,712,816	6.95	
Education						
Primary School (5^{th})	74	13.03				
High School (6-10^{th})	89	15.49				
Intermediate (12^{th})	127	22.54				
Bachelors/MSc (16 Years)	170	30.11				
Masters (18 Years)	94	16.37				
PhD	14	2.46				
Residence of Coal Basin Region						
Yes	120	21.30				
No	448	78.70				
Employment Status						
Employed (Full Time)	166	29.40				
Employed (Part-Time)	84	14.96				
Students and employed	40	7.04				
Students and Unemployed	88	15.58				
Unemployed	190	33.45				
Family Income						
Below 30,000	64	11.27				
31,000-60,000	180	31.69				
61,000-100,000	152	26.76				
Above 100,000	172	30.28				
Married						
Yes	310	54.58				
No	255	44.89				
Widow	3	0.53				
Children						
Yes	190	33.45				
No	378	66.55				
Children (Sibling below 18 years)						
Yes	220	38.73				
No	348	61.27				
Attitudes Question						
Environmental Awareness						
Yes	279	49.12				
No	161	28.35				
Moderate	128	22.53				
Trust in the current energy policy						
Yes	101	17.78				
No	349	61.45				
Moderate	118	20.77				
Ties to the energy industry						
Yes	313	55.11				
No	255	44.89				

To ensure adequate sampling, the questionnaire is based on quota sampling to ensure a representative population sample. To achieve this, we implemented a pre-selection process with three questions regarding gender, region of living, and age. The Quota and demographic distribution of the final survey (n = 568) is given in Table 2.

In addition to the choice experiment data, socio-demographic information was collected to analyze respondents' willingness to support energy reform policies based on their characteristics. The next part of the questionnaire focuses on questions related to environmental awareness, interest, and ties with the energy industry, which help us explore people's behavior in selecting their preferences.

4. Results

4.1. Descriptive Statistics

The final survey was conducted using quota sampling to obtain an adequate sample. We implement a pre-selection process with three questions regarding gender, living area, and age group. The socio-demographic characteristics of the sample and Pakistan Bureau of Statistics 2017 data are given in Table 2. To examine the representation of the sample, we compared the demographic characteristics of our respondent group with those reported by the Pakistan Bureau of Statistics 2017. Table 2 shows that our sample's average percentage of males and females is 53.73% and 46.27%, which coincides with survey-reported data. Similarly, our sample comprised 61.79% rural and 38.21% urban populations. Furthermore, we also compared the age-group data of our sample with the Pakistan Bureau of Statistics 2017 and found similar results.

4.2. BWS DCE Results

Table 3

Full Sample Rank Order Logistic Regression

Attributes	Coefficient	MWTP[2] (% of the price)	WTP 95% Confidence Interval	MWTP Employment Change
CO_2 Reduction (% reduction)	.00273 *** (.0015)	.474 %	-0.067 to 1.016	-274 jobs
Domestic Energy Independence (%)	.00188 *** (.0007)	.327 %	0.058 to 0.599	-189 jobs
Energy Sector Employment (Jobs)	.00001 *** (.000)	.002 %	0.001 to 0.002	
Time of Transition (Years)	-.0114 *** (.0039)	-1.72 %	-3.352 to -0.599	1145 jobs
Energy Price (% of the bill)	-.00575 *** (.0003)			579 jobs
Observation	17040			
N	568			
McFadden Psuedo R^2	.021			

*** > 1%, ** > 5%, * > 10% level of significance

The rank-ordered logit model was used to estimate the respondents' preferences for different aspects of Pakistan's energy policy. Table 3 shows the estimation results, which are statistically

[2] Marginal Willingness to Pay (MWTP): As mentioned earlier in the description of the attribute levels, the regression analysis is conducted using the percentage change in electricity bills. Consequently, the MWTP is expressed as the percentage increase or decrease in electricity bills per unit change in the respective attribute.

significant at a 1% significance level. The sign of the attribute coefficients is consistent with our expectations. Respondents demonstrated a positive attitude towards reducing CO_2 emissions to improve the environmental quality for future generations, mirroring findings from studies in developing countries (Afroz & Ilham, 2020; Kaczmarczyk & Urych, 2022). This suggests a growing global prioritization of intergenerational environmental equity, even in nations balancing development and sustainability. Respondents also favor increasing energy independence (critical given Pakistan's 70% reliance on imported fossil fuel) and creating more jobs in the energy sector, which is one of the objectives of the National Electricity Plan 2023-2027 (Ministry of Energy, 2023). However, resistance to higher energy bills and preference for shorter timelines reflect pragmatic economic constraints. These findings align with the previous studies by Aruga et al. (2021) for Poland and Peterson and Feldman (2018) for the USA, who found that people generally prefer energy policies that enhance environmental quality.

Marginal willingness to Pay (MWTP) measures the trade-off between the cost and the benefit of an energy policy attribute. It indicates how much money or how many jobs the respondents are willing to give up for a marginal change in any attribute of the energy policy. In Table 3, the MWTP for CO_2 reduction shows that the respondents are willing to pay an extra 0.47% on their energy bills for a 1% decrease in CO_2 emission. This implies that the respondents highly value CO_2 reduction, emphasizing Pakistan's unique challenge in balancing environmental and economic priorities. The MWTP for energy independence reveals that the respondents prefer to increase energy independence and reduce dependence on imported fossil fuels, which are often polluted and expensive. Respondents are willing to pay an additional 0.33% on their energy bills for a 1% increase in energy independence.

Additionally, respondents preferred a short period to implement the energy transition policy as soon as possible. They are willing to pay 1.72% more on their energy bills to implement the policy one year earlier. This shows that the respondents are concerned about the urgent need for emission reduction. The MWTP for employment shows that the respondents preferred a policy that creates more energy sector jobs. They are willing to pay 1% more on their energy bills for every 1000 extra jobs in the energy sector.

Lastly, regarding employment loss, the MWTP results reveal that respondents are willing to trade off employment to reduce CO_2 emissions. This means that respondents are willing to have nearly 274 jobs displaced for a 1% reduction in CO_2 emissions. Additionally, they are willing to accept the displacement of 189 jobs due to energy reform for every 1% increase in energy independence. Furthermore, to expedite energy reform implementation a year earlier, respondents are willing to accept the displacement of 1145 jobs in the energy sector. These findings provide valuable insights into respondents' trade-offs regarding different attributes within the energy policy, shedding light on their priorities and preferences.

4.3. Subgroup Analysis

Regarding the policy perspective, it is crucial to identify the priorities within the subgroup and elucidate the key motivations driving the current study. The marginal willingness to pay (MWTP) for environmental benefits and other policy attributes, along with their corresponding 95% confidence intervals, are presented in Table 3a-3f.

Table 3a represents the results of the gender subgroup analysis. The findings suggest that males exhibit a stronger preference for reducing CO_2 emissions compared to females. Similarly, Arachchi and Managi (2021) found that males show greater environmental knowledge than females. Additionally, males are more concerned about potential employment displacement resulting from policy changes, while females prefer energy independence more strongly than males. Consequently, females have a more direct and practical understanding of the challenges posed by unreliable or expensive energy supplies, which makes them more supportive of energy independence. On the other hand, male respondents may prioritize other concerns, such as economic growth or industrial developments, over energy independence, reflecting their greater participation in external labor markets and entrepreneurial activities (Khalid & Razem, 2022). Furthermore, residents in urban areas are willing to pay more for their energy bills to reduce CO_2 emissions but express worries about potential job losses due to policy implementation.

The results of Table 3b suggest that people with degrees and full-time employment favor reducing CO_2 emissions and prefer that energy policy be implemented sooner. Educated and full-time employment provides individuals with the knowledge, resources, and motivation to support efforts to reduce CO_2 emissions. Tianyu and Meng (2020) found that males are more aware of the environmental challenges, have the means to make sustainable choices, and understand the importance of protecting the environment for future generations. Furthermore, higher education enables the respondents to be more concerned about the adverse effects and the potential employment displacement resulting from policy changes (Arachchi & Managi, 2021).

In Table 3c, it is evident that married individuals with children often exhibit a greater willingness to pay for reducing CO_2 emissions due to their heightened sense of responsibility for future generations. This sense of responsibility is rooted in a desire to ensure their children's better environmental and economic future (Goh & Matthew, 2021). Additionally, respondents with children are more inclined to support the earlier implementation of energy policies to achieve CO_2 emission and energy independence targets. They also consider energy policies' broader societal and economic implications, particularly concerning their families' well-being and employment prospects.

Considering the age group in Table 3d, we observe that the middle age group, precisely 25-34 and 34-44 age respondent results, are statistically significant compared to other groups. Notably, the younger generation within this age group shows a positive willingness to pay their energy bills to reduce CO_2 emissions and achieve higher energy independence (Irfan *et al.*, 2020). This could be because people aged 25 to 44 are more concerned about a better future and environment for living. They are also receptive to a rapid transition towards renewable energy, but respondents at age 25 express significant concerns regarding potential employment impact. In Pakistan, students graduate from university at the age of 25, and their main focus is employment, which shows a high concern regarding the effect on employment.

From Table 3e, we observed that high-income family are willing to pay more in their energy bills to achieve a high percentage of reduction in CO_2 emission. They favor achieving greater energy independence to reduce reliance on imported fossil fuels, a leading cause of environmental degradation. Similarly, Matthies and Merten (2022) suggest that high-income families are more willing to invest in clean technology, reducing their carbon footprint and energy costs. Moreover, they prefer a rapid transition towards renewable energy rather than a delayed one, but the main challenge is the employment loss of potential policy implementation. In contrast, the low- and middle-income family have monthly incomes that only meet their monthly necessities, which is why they have the lowest willingness to pay for reducing CO_2 emissions.

Table 3f represents the results of the tested attitudinal or affiliation characteristics. Factors such as ties to the energy industry and expressing environmental interest significantly impact the respondents' estimated preferences. Therefore, respondents have ties with the energy industry, and environmental awareness has the highest prioritization for reducing CO_2 emissions, achieving higher energy independence, and short transition time for implementing any potential energy policy. High environmental awareness is the main factor in reducing environmental degradation (Lima *et al.*, 2021). Additionally, respondents show significant concern for the employment impact of any potential policy implementation in each subgroup. Hence, employment is the main hurdle for policymakers in implementing any energy policy to achieve the CO_2 and energy independence targets.

Table 3a
Subgroup WTP: Gender & Living

	Gender				Region			
	Female WTP	Female WTP 95% CI	Male WTP	Male WTP 95% CI	Rural WTP	Rural WTP 95% CI	Urban WTP	Urban WTP 95% CI
Reduction CO_2	.376	-.261 to 1.01	.921 *	-.065 to 1.90	.275	-.471 to 1.02	1.04 **	.226 to 1.86
Energy Independence	.307 **	-.007 to .623	.223	-.252 to .698	.557 ***	.178 to .935	-.115	-.506 to .274
Employment	.001359 ***	.0009 to .0018	.002364 ***	.001 to .003	.001738 ***	.001 to .002	.001807 ***	.001 to .002
Time Transition	-1.78 **	-3.39 to -.179	-1.62	-4.04 to .798	-1.30	-3.17 to .575	-2.23 **	-4.26 to -.256
Observation	7,860		9,180		10,470		6,570	
N	262		306		349		219	
N%	0.46		0.54		0.61		0.39	
Psuedo R^2	0.023		0.013		0.015		.0.22	

*** > 1%, ** > 5%, * > 10% Level of Significance

Table 3b
Subgroup WTP: Respondent having Degree & Employment Status

	Respondent having Degree				Employment Status					
	No WTP	No WTP 95% CI	Yes WTP	Yes WTP 95% CI	Part-Time WTP	Part-Time WTP 95% CI	Unemployed WTP	Unemployed WTP 95% CI	Full-Time WTP	Full Time WTP 95% CI
Reduction CO_2	.364	-.245 to .974	1.57 **	.252 to 2.89	.772	-.487 to 2.03	.573	-.246 to 1.39	.551 *	-.370 to 1.47
Energy Independence	.395 **	.092 to .700	-.219	-.826 to .386	.459	-.161 to 1.07	.008	-.392 to .409	.519 **	.056 to .983
Change in Employment	.001733 ***	.001 to .002	.001924 ***	.000 to .002	.001451 ***	.000 to .002	.001814 ***	.001 to .002	.001942 ***	.001 to .003
Time Transition	-1.35 *	-2.87 to .174	-3.16 **	-6.36 to .035	-2.05	-5.21 to 1.10	-.520	-2.54 to 1.49	-3.22 ***	-5.59 to -.851
Observation	13,410		3,630		3,750		8,280		5,010	
N	448		120		124		278		166	
N%	0.79		0.21		0.22		0.49		0.29	
Psuedo R^2	0.017		0.019		0.014		0.015		0.023	

*** > 1%, ** > 5%, * > 10% Level of Significance

Table 3c
Subgroup WTP: Household Structure

	Married				Respondent has Children			
	No WTP	No WTP 95% CI	Yes WTP	Yes WTP 95% CI	No WTP	No WTP 95% CI	Yes WTP	Yes WTP 95% CI
Reduction CO_2	.132	-.768 to 1.03	.934 **	.226 to 1.64	.625	-.134 to 1.38	.602 *	-.175 to 1.38
Energy Independence	.137	-.305 to .579	.355 **	.011 to .699	.171	-.199 to .541	.413 **	.028 to .798
Change in Employment	.001674 ***	.000 to .002	.001902 ***	.001 to .002	.001850 ***	.001 to .002	.001656 ***	.001 to .002
Time Transition	-.158	-2.39 to 2.08	-2.68 ***	-4.45 to -.907	-1.48	-3.36 to .409	-2.09 **	-4.04 to -.143
Observation	7,650		9,300		11,340		5,700	
N	258		310		378		190	
N%	0.45		0.55		0.67		0.33	
Psuedo R^2	0.013		0.21		0.014		0.025	

*** > 1%, ** > 5%, * > 10% Level of Significance

Table 3d
Subgroup WTP: Age-Group

	Age-Group											
	18-24 WTP	18-24 WTP 95% CI	25-34 WTP	25-34 WTP 95% CI	35-44 WTP	35-44 WTP 95% CI	45-54 WTP	45-54 WTP 95% CI	55-64 WTP	55-64 WTP 95% CI	65 & above WTP	65 & above WTP 95% CI
Reduction CO_2	-.071	-1.28 to 1.13	.714	-.885 to 2.31	1.53 **	.354 to 2.69	1.17	-.971 to 3.32	.089	-.713 to .892	.612	-.973 to 2.19
Energy Independence	-.187	-.791 to .417	.924 **	.084 to 1.76	.288	-.251 to .827	-.267	-1.30 to .769	.272	-.128 to .673	.591	-.193 to 1.37
Change in Employment	.002349 ***	.001 to .002	.002135 ***	.000 to .003	.001053 ***	.000 to .002	.002811 ***	.001 to .005	.000510 **	.000 to .001	.001111 ***	.002 to .005
Time Transition	-.924	-3.95 to 2.10	1.68	-2.26 to 5.63	-3.61 **	-6.43 to -.889	-1.15	-6.42 to 4.12	-2.03 **	-4.10 to .028	-1.54 ***	-11.1 to -1.96
Observation	4,650		4,680		3,090		2,190		1,560		870	
N	155		156		103		73		52		29	
N%	0.27		0.28		0.18		0.13		0.09		0.05	
Psuedo R^2	0.015		0.009		0.022		0.132		0.058		0.075	

*** > 1%, ** > 5%, * > 10% Level of Significance

Table 3e
Subgroup WTP: Family Income

	Below 30,000 WTP	Below 30,000 WTP 95% CI	31,000-60,000 WTP	31,000-60,000 WTP 95% CI	61,000-100,000 WTP	61,000-100,000 WTP 95% CI	Above 100,000 WTP	Above 100,000 WTP 95% CI
Reduction CO_2	7.51	-7.59 to 22.6	.625	-.402 to 1.65	-.139	-.959 to .681	.803 *	-.106 to 1.71
Energy Independence	1.21	-2.87 to 5.29	.212	-.291 to .715	.002	-.404 to .408	.492 **	.042 to .942
Change in Employment	.00749	-.006 to .021	.00217 ***	.001 to .003	.00111 ***	.001 to .001	.00156 ***	.001 to .002
Time Transition	-1.93	-19.6 to 15.7	1.26	-1.28 to 3.79	-2.12 **	-4.22 to -.034	-3.96 ***	-6.34 to -1.58
Observation	1,920		5,400		4,560		5,160	
N	64		180		152		172	
N%	0.11		0.32		0.27		0.30	
Psuedo R^2	0.007		0.017		0.021		0.022	

*** > 1%, ** > 5%, * > 10% Level of Significance

Table 3f
Subgroup WTP: Respondent Ties to Energy Industry & Environmental (Env) Interest

	Ties to Energy Industry				**Environmental Interest**					
	No Ties Energy Industry WTP	No Ties Energy Industry WTP 95% CI	Ties Energy Industry WTP	Ties Energy Industry WTP 95% CI	High-Env Interest WTP	High-Env Interest WTP 95% CI	Moderate WTP	Moderate WTP 95% CI	Low-Env Interest WTP	Low-Env Interest WTP 95% CI
Reduction CO_2	.256	-.849 to 1.36	.786 **	.176 to 1.39	1.12 ***	.294 to 1.92	.137	-.927 to 1.20	.116	-.963 to 1.19
Energy Independence	-.310	-.858 to .238	.558 ***	.252 to .864	.647 ***	.243 to 1.05	.026	-.500 to .553	-.193	-.728 to .341
Change in Employment	.002306 ***	.001 to .003	.001507 ***	.001 to .002	.001671 ***	.001 to .002	.002248 ***	.001 to .003	.001586 ***	.001 to .002
Time Transition	-1.89	-4.70 to .919	-1.62 **	-3.12 to -.119	-2.97 ***	-4.99 to -.949	-1.80	-4.511 to .901	.623	-2.06 to 3.31
Observation	7,650		9,390		8,370		3,840		4,830	
N	255		313		279		128		161	
N%	0.45		0.55		0.49		0.23		0.28	
Psuedo R^2	0.011		0.024		0.018		.023		0.014	

*** > 1%, ** > 5%, * > 10% Level of Significance

5. Conclusion and policy implications

This study employed the Best-Worst Scaling (BWS) choice experiment to investigate Pakistan's potential energy policy transition towards renewable energy and to assess public willingness to pay for CO_2 emission reduction policies. While the findings may appear expected, such as preference for policies that minimize household costs and employment impacts, they provide critical insights into the socio-economic dimensions of energy transition in developing countries like Pakistan. These findings are relevant for Pakistan and offer valuable lessons for other countries facing relevant challenges in balancing climate goals with economic and social priorities.

Like many developing nations, Pakistan is at a critical juncture in its energy transition. With 70% of its energy consumption reliant on imported fossil fuels, Pakistan faces significant energy security risks, economic vulnerabilities, and environmental degradation. Investigating the willingness to pay for CO_2 emission reductions is essential because it highlights the public willingness to support climate policies while underscoring the need to address socio-economic concerns such as employment and affordability. This study fills a gap in the literature by focusing on a developing country context, where energy transitions are often more complex due to limited resources, institutional constraints, and socio-economic vulnerabilities. The findings are particularly relevant for other low- and middle-income countries (LMICs) that are similarly dependent on fossil fuel and grappling with the dual challenges of climate change and economic development.

The results revealed a favorable preference among respondents for policies that reduce CO_2 emissions, reflecting growing public awareness of climate change. However, concerns about rising household bills and potential job losses in the energy sector underscore the need for policies that balance environmental goals with socio-economic stability. For instance, the International Renewable Energy Agency (IRENA) estimates that Pakistan could generate up to 60% of its energy from renewable sources by 2030, reducing CO_2 emissions by 43%. While this transition could enhance energy security, reduce reliance on imported fossil fuels, and save foreign reserves, it must be carefully managed to mitigate adverse impacts on vulnerable populations. By addressing the concerns of affordability and employment, Pakistan can achieve its climate goals and serve as a model for other countries facing similar challenges. The findings highlight the need for a just and inclusive energy transition, emphasizing that climate action must go hand in hand with social and economic resilience.

The study's empirical findings provide clear, actionable insight for designing and implementing carbon emission reduction policies in Pakistan and other developing countries. The strong positive support for reducing CO_2 emissions and achieving energy independence underscores the need for accelerated renewable energy deployment. Policymakers should establish ambitious targets aligned with Pakistan’s Nationally Determined Contributions (NDCs) for 2030. However, the preference for shorter policy timelines (as evidenced by the high MWTP for faster implementation) suggests that detailed, actionable roadmaps must accompany these targets to ensure timely execution.

The subgroup analysis reveals significant variations in preference across socio-demographic characteristics. The policymaker must adopt inclusive, targeted policies to address these differences. For instance, due to financial constraints, low-income households are less willing to pay for CO_2 reduction. To ensure equity, policymakers should introduce targeted subsidies or graduated energy tariffs to shield vulnerable populations from rising energy costs. Similarly, educated and employed urban residents strongly support environmental policies. Leveraging this support through public awareness campaigns and community engagement programs can build broader societal buy-in for the energy transition.

The results highlight employment loss as a critical barrier to public acceptance of energy policies. To address this, policymakers should compensate and retrain workers in fossil fuel-dependent regions (e.g., Thar coal fields) through skill development programs focused on renewable energy. Furthermore, it creates green job opportunities in sectors like solar panel manufacturing, wind turbine maintenance, and energy efficiency retrofitting, aligning with the high MWTP for job creation in the energy sector. Furthermore, to reduce reliance on imported fossil fuels, policymakers should strengthen regional energy partnerships (e.g., with China and Central Asia) to access affordable renewable energy technologies. Furthermore, seek international climate finance (e.g., Green Climate Fund) to support large-scale renewable energy projects and capacity-building initiatives.

The finding from Pakistan offers important lessons for other countries, particularly LMICs, that are navigating similar energy transitions. For example, the emphasis on minimizing household costs and protecting employment resonates with global concerns about the social acceptability of climate policies. This study highlights the importance of context-specific approaches to energy transitions by demonstrating how public preferences can inform policy design. Moreover, the BWS methodological approach for capturing public preferences can be adapted to other settings, providing a valuable tool for policymakers worldwide.

This study represents an initial attempt to analyze Pakistan's household preference for energy policy. However, it has several limitations. Using stated preference methods may not fully capture real-world decision-making and the sample. At the same time, representatives of standard socio-demographic groups may overlook hidden populations with unique preferences (e.g., coal mining communities or older adults). Future research could address these limitations by incorporating qualitative methods to identify additional attributes and preferences and expanding the sample to include underrepresented groups. Additionally, longitudinal studies could provide deeper insights into how public preferences evolve as energy policies are implemented.

Author Contribution

Qaisar Shahzad: Conceptualization, Methodology, Writing Original draft, Data curation, Software and Analysis. **Kentaka Aruga:** Conceptualization, writing review, Supervision, and Guidance throughout the work.

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Data Availability

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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