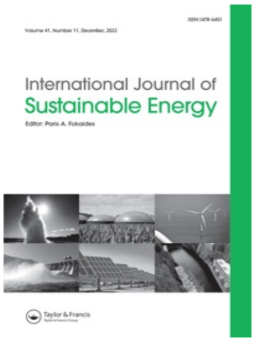

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RESEARCH ARTICLE

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Achieving distributional justice in onshore wind power projects: who should operate and how to contribute to the locals?

Kengo Iwata[a,b], Masashi Hiroki[c], Shinsuke Kyoi[d] and Memi Motosu[e]

[a]Faculty of Business Administration, Tottori University of Environmental Studies, Tottori, Japan; [b]The Research Center for Advanced Policy Studies, Institute of Economic Research, Kyoto University Yoshida-honmachi, Kyoto, Japan; [c]Environmental education business, Japan Environment Association, Tokyo, Japan; [d]Faculty of Humanities and Social Sciences, Yamagata University, Yamagata City, Yamagata, Japan; [e]Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan

ABSTRACT

Resistance to renewable energy projects among residents is increasingly linked to concerns about distributive justice. This study examines how perceptions of fairness in the distribution of benefits and burdens shape residents' preferences regarding hypothetical onshore wind power projects in Japan. Using a hypothetical choice experiment based on an online survey of 2,016 residents across 14 prefectures in wind-suitable regions of Japan, we varied four attributes: (i) project proponent (non-local company, local government, local stakeholder), (ii) community contribution activities, (iii) scale of CO_2 emissions reduction, and (iv) household decarbonization levy. Mixed logit estimation revealed stronger preferences for projects led by local governments or local stakeholders, and for projects implementing community contribution activities, compared to projects led by external companies. Latent class analysis revealed heterogeneity: the positive and moderately negative groups valued local governance and benefit distribution mechanisms, while the strongly negative segment derived minimal utility from these attributes.

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KEYWORDS
Onshore wind power; community acceptance; distributional justice; preference heterogeneity; choice experiments

1. Background and purpose of the study

The urgency of climate change has intensified with recent statements by the UN Secretary-General Antonio Guterres highlighting the critical need for immediate action. The 2023 reports from the Intergovernmental Panel on Climate Change (IPCC) reinforce the view that human activities are driving global warming and leading to severe consequences worldwide. The IPCC stresses that limiting temperature rise to 1.5 °C requires substantial, rapid reductions in greenhouse gas emissions across all sectors (IPCC 2023). At COP28, the global stocktake revealed that current national targets (NDCs) are insufficient to meet the Paris Agreement goals, prompting calls for increased renewable energy deployment and the phasing out of fossil fuels (UNFCCC 2023).

Given the necessity of renewable energy expansion, the Sixth IPCC Assessment Report identified wind and solar power as cost-effective means of achieving significant emission reductions (IPCC 2023). Japan's Ministry of the Environment estimates that the total potential of offshore and onshore wind power, along with solar energy, surpasses twice that of the country's current electricity generation (Ministry of the Environment 2021). The Sixth Basic Energy Plan, approved in 2021, sets ambitious targets for wind power expansion. However, these targets remain below the estimated potential. Despite policy efforts, local opposition to wind power projects has led to project withdrawals, underscoring the importance of improving public acceptance.

Wüstenhagen, Wolsink, and Bürer (2007) defined the social acceptance of renewable energy through three dimensions: socio-political, market, and community acceptance. In this framework, community acceptance is understood to comprise procedural justice, distributional justice, and trust. In this context,

CONTACT Kengo Iwata kengoiw1@gmail.com
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trust refers specifically to trust in project developers and responsible institutions, rather than to general interpersonal trust. Although procedural justice and trust have been extensively studied, research on distributional justice—especially regarding privately led projects— remains relatively limited. Previous cases indicate that local resistance often arises when economic benefits from wind projects flow out of a region. However, empirical evidence remains limited regarding how specific institutional arrangements related to benefit distribution, such as project ownership, influence residents' preferences, particularly in the Japanese context. Furthermore, although community contribution activities are increasingly incorporated into wind power projects, their effectiveness has not been sufficiently examined, particularly in terms of how residents evaluate them and how they affect acceptance. In addition, while choice experiments have been widely used to examine public preferences for renewable energy, many previous studies have primarily focused on physical attributes such as distance from turbines or landscape impacts, whereas fewer studies have explicitly examined institutional aspects related to distributional justice, such as project operators and benefit-sharing mechanisms.

To address these gaps, this study investigates how distributional justice affects acceptance of onshore wind power projects. Through a choice experiment, this study evaluates residents' preferences based on whether the project is led by an external business entity and whether it includes community contribution activities. By doing so, this study builds upon the existing literature and provides empirical evidence on how institutional arrangements related to benefit distribution influence public acceptance of wind power in Japan. Although previous studies have assessed public preferences for wind power facilities in different countries, few studies in Japan have conducted choice experiments in wind-abundant regions. Moreover, previous choice experiments have focused on physical attributes, such as distance from turbines, rather than on key elements that shape social acceptance, such as procedural justice, distributional justice, and trust. This study is academically important and has policy implications for wind-power expansion.

2. Background to the introduction of wind power generation in Japan

The first practical wind farms in Japan were introduced in the late 1980s. In the early stages, deployment was primarily led by local governments, with the main objectives being the utilisation of strong local winds—previously considered detrimental to communities—for regional development, as well as the mitigation of rising fuel costs. However, as installations increased, the existing electricity system faced integration challenges. This led to the development of grid interconnection guidelines, electricity sale regulations, and revisions to the Electricity Business Act to facilitate the adoption of wind power. Additionally, subsidies from NEDO (New Energy and Industrial Technology Development Organisation) helped lower the initial costs, allowing private companies to enter the market (Motosu 2016). Following the 2011 Great East Japan Earthquake, the introduction of the Feed-in Tariff (FIT) improved business predictability and accelerated private-sector investment in wind power. However, the 2012 Environmental Impact Assessment Act temporarily slowed down new projects. Despite a growing trend toward large-scale wind farms and higher single-unit outputs, the number of new installations has remained flat, and the number of turbines has recently declined (Japan Wind Power Association 2024).

While wind power expansion has been promoted, opposition movements have intensified owing to environmental and social concerns, leading to project cancellations, legal disputes, and resistance from local communities, which often view themselves as 'colonies' (e.g. Nakayama 2022; Yamaguchi 2021) for wind power development. Nishizawa (2019) found that conflicts persisted in 40% of the cases, with nearly 20% of the projects being cancelled or suspended. The IEA Task 28 model identifies key factors that influence community acceptance, including environmental concerns, procedural justice, distributional justice, and trust. Distributional justice remains a major issue, as local communities bear risks, whereas external operators monopolise profits. In the Japanese context, this issue has also become increasingly important, as many wind power projects have been developed by external operators, raising concerns about the outflow of economic benefits from local communities. To address this, recent wind projects have sought to share the benefits with local communities, such as branding local agricultural products with wind power logos in Aomori and creating local sales channels in Akita and Chiba (Solar Journal 2017; Kashiwatani 2010; Wind Journal 2023). Offshore wind projects have established regional funds to distribute economic benefits (Nomura Research Institute 2021).

3. Trends in previous research

Community acceptance plays a critical role in the successful implementation of renewable energy projects because local stakeholders' approval is essential for advancing energy transition (Wüstenhagen, Wolsink, and Bürer 2007), and reflects important considerations of energy justice and equity in the distribution of project benefits and impacts. In the UK, despite high public support for wind power, 75% of the projects were cancelled owing to a lack of community acceptance (Bell, Gray, and Haggett 2005). However, beyond community acceptance, broader public attitudes and consumer choices shape the future of decarbonisation (Irfan et al. 2020). The concept of the 'social gap' highlights the discrepancy between public support for wind power and the difficulty of implementing projects at the local level (Bell, Gray, and Haggett 2005).

Studies using choice experiments have explored the trade-offs between wind energy and landscape protection in Italy (Caporale and De Lucia 2015), preferences for wind farms in Virginia (Boyle et al. 2019), and public attitudes in Korea concerning environmental impacts (Lee, Yoo, and Huh 2020). In Germany, spatially explicit models have assessed the social costs associated with wind farm placement (Reutter et al. 2024), whereas in Ireland, surveys have examined attitudes toward intermittency and grid stability (Brennan and van Rensburg 2023). Recent studies have highlighted the influence of social factors on acceptance. Research in Ireland found that distributive and procedural justice significantly affected acceptance levels, while concerns about visual impact were stronger among the opponents (le Maitre et al. 2023). Previous research in Canada has also shown that fair local benefit distribution significantly influences public support for wind power projects (Walker and Baxter 2017). Other studies have examined the role of place attachment (Dugstad et al. 2023) and integrated interdisciplinary acceptance models, identifying economic benefits, trust in governance, and social norms as key factors (Hübner et al. 2023).

Recent studies show that public acceptance of wind power is strongly influenced by perceptions of distributive and procedural justice. For example, Hogan (2025) shows that past local experiences and perceived fairness in benefit distribution affect support for onshore wind projects. Gulbrandsen (2025) finds that opposition can arise when communities perceive unfair benefit distribution, particularly in relation to ownership and compensation. In the context of offshore wind, Bates et al. (2025) demonstrate that perceptions of distributive justice, as well as transparency and trust, play an important role in shaping stakeholder evaluations. Similarly, Martens, Porsius, and Vringer (2025) show that ownership structure and benefit-sharing arrangements influence perceived legitimacy and public acceptance.

In Japan, research on wind power acceptance remains limited, with most studies focusing on existing projects. Motosu and Maruyama (2016) found that attitudes toward energy and landscape aesthetics significantly influence acceptance, whereas procedural justice and operator responsiveness play key roles in supporting new projects. Further studies have confirmed that distrust of operators and perceived unfairness in project implementation negatively affect acceptance (Motosu and Maruyama 2020). Other studies in Japan have identified additional determinants of acceptance. Umezawa et al. (2019) found that community benefits and procedural justice are more influential than environmental concerns. Kumazawa (2017) observed that trust in government and awareness of community benefits positively influence acceptance, whereas perceived risk has a negative impact. In a study on offshore wind projects, Iida and Shimizu (2022) identified two groups of opponents: those with low environmental awareness, and those highly engaged with offshore wind but concerned about project implementation. Recent research has increasingly employed stated-preference methods to assess public attitudes toward renewable energy. Nakano, Miwa, and Morikawa (2018) found that in eastern Japan, willingness to pay (WTP) for renewables is driven by environmental concerns and interest in policy participation, whereas in western Japan, support is linked to electricity market liberalisation. Keeley, Komatsubara, and Managi (2022) used spatial data to analyse key factors affecting social acceptance, whereas Iwata, Kyoi, and Ushifusa (2023) showed that offshore wind power is valued for climate change mitigation but opposed its impact on landscapes.

These studies highlight the important role of distributive justice, governance arrangements, and benefit-sharing mechanisms in shaping public acceptance of wind power. However, empirical studies that operationalise distributional justice through experimentally manipulable institutional attributes and examine its impact on acceptance using choice experiments remain relatively limited. The present study addresses this gap by focusing on distributional justice as a key element of social acceptance. In this study, distributional justice is defined as the fairness of how the benefits of wind power projects are distributed within the local community. The project owner affects whether economic benefits, such as profits and employment opportunities, remain in the local area or flow outside the region. Community contribution activities represent direct ways in which project benefits are shared with local residents. These attributes therefore represent indicators of benefit distribution. They are distinct from procedural justice, which relates to decision-making processes, and trust, which refers to confidence in project developers or institutions.

In addition to conceptual clarification, it is also important to situate this study within established methodological approaches in choice experiment research. Previous choice experiment studies on renewable energy have commonly defined experimentally manipulable project attributes—such as ownership, environmental impacts, and community benefits—and estimated preferences using random utility models. Mixed logit models are widely used to account for heterogeneity in preferences, and more recent studies have applied latent class models to identify distinct respondent groups. Building on this methodological foundation, the present study employs both mixed logit and latent class models and extends prior research by operationalizing distributional justice through institutional attributes, namely project operators and community contribution activities. To keep the choice task manageable, the analysis concentrates on the key institutional attributes related to distributional justice.

This study makes two important conceptual contributions. First, this study defines distributional justice using concrete and observable institutional attributes, namely the project operator and community contribution activities. This allows us to directly examine how governance structure and benefit-sharing mechanisms affect residents' acceptance. Second, this study explicitly distinguishes between local and non-local project operators. This enables us to test whether local control of renewable energy projects increases perceived fairness and public acceptance. The findings aim to inform policies that enhance community acceptance of wind power facilities, contributing to both academic research and practical energy policy at a time when wind power expansion is increasingly urgent. Based on the concept of distributional justice, this study hypothesises that wind power projects operated by locally based entities (local governments or local stakeholders) will be preferred over those operated by external private companies. In addition, projects that include community contribution activities are hypothesised to receive higher levels of preference than those without such contributions.

4. Methods

4.1. Online questionnaire and choice experiments

The survey for this study was conducted online using the web survey monitors of My Voice Communications, Inc., a private research company, from December 1–5, 2023. Prior to participation, respondents were provided with information regarding the purpose of the study and the anonymous statistical treatment of responses at the beginning of the survey. Participation was voluntary, and informed consent was considered to have been obtained through respondents' completion of the survey. The survey covered 14 prefectures in Japan, where a prefecture is a primary administrative division comparable to a state or province in other countries (Figure 1): seven prefectures in the Tohoku Electric Power Company service area (Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima, and Niigata prefectures), which are considered to have more suitable areas for wind power generation than other regions, and seven prefectures in the Kyushu Electric Power Company service area (Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, and Kagoshima prefectures). The survey covered the entire area of each prefecture and not just the areas where wind power generation facilities are actually located. A total of 144 participants (72 men and 72 women) were recruited from each prefecture, resulting in a dataset consisting of 2,016 responses. The sample was constructed using quota sampling to ensure equal numbers of respondents across prefectures and gender, rather than to represent the population distribution of each prefecture. This approach was adopted to enable meaningful comparisons across regions and demographic groups. Therefore, post-stratification weighting was not applied.

This study applies a choice experiment methodology, which is a stated preference method that constructs hypothetical markets through questionnaire surveys to determine respondents' preferences for various attributes of wind power projects (Tsuge, Kuriyama, and Mitani 2011). Although initially

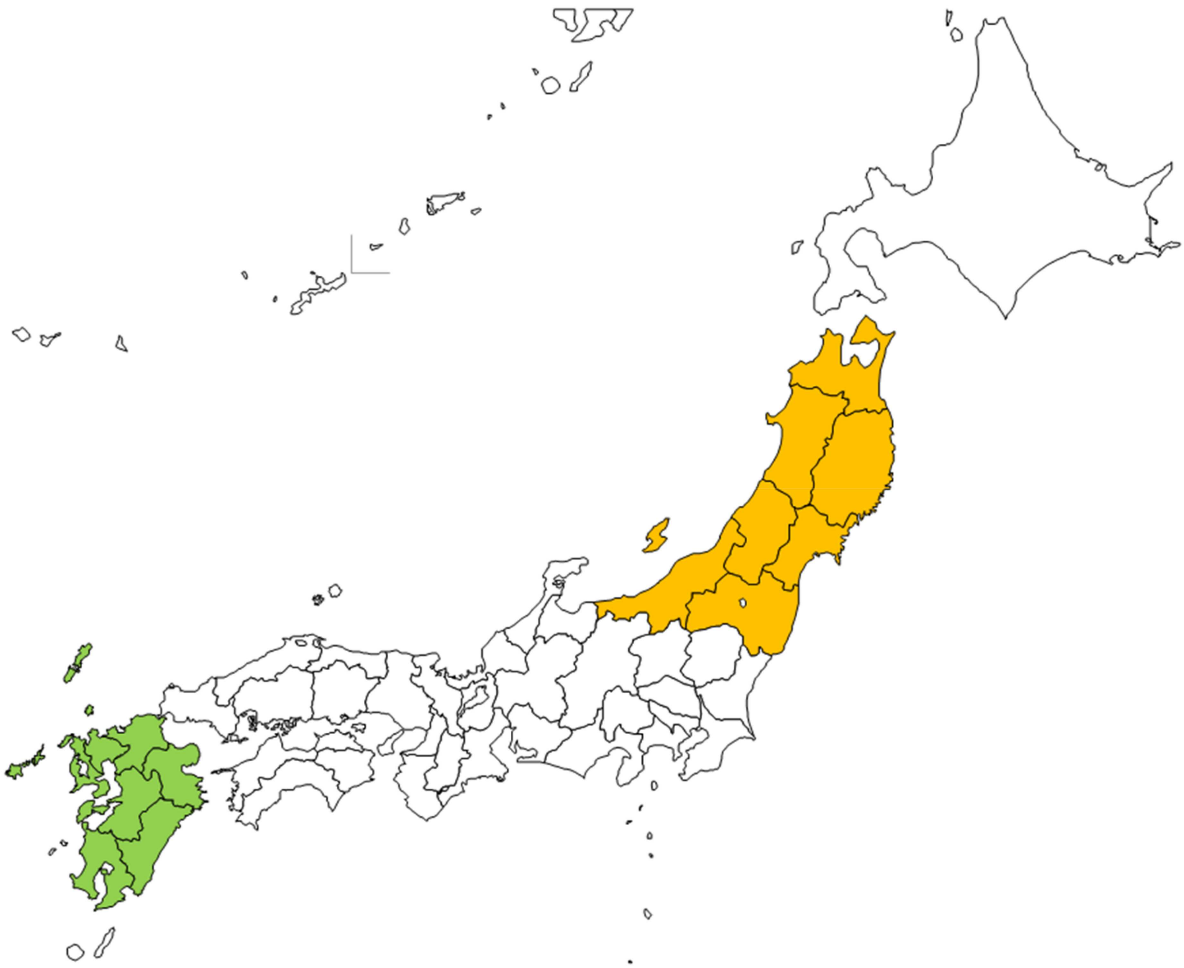

Figure 1. Study areas. The Tohoku region is shown in orange and the Kyushu region in green.

developed in marketing research, this methodology has become widely used in environmental economics, particularly for assessing renewable energy adoption, tourism, and environmental policy design. A key advantage of stated-preference methods is their ability to evaluate non-market goods, such as environmental benefits. By presenting hypothetical scenarios, researchers can analyse how individuals value changes in environmental policies or infrastructure. This flexibility allows policymakers to estimate the marginal willingness to pay (MWTP)[1] for different attributes before implementation (Tsuge, Kuriyama, and Mitani 2011). Choice experiments are designed to mimic consumer decision-making behaviour, reduce cognitive burden, and increase response reliability.

This study's choice experiment evaluates public preferences for onshore wind power projects based on four key attributes: project owner, carbon dioxide reduction effect, community contribution activities, and household decarbonisation levy. These attributes were selected because they represent key aspects of distributional justice identified in previous studies. Specifically, the project owner and community contribution activities reflect how economic and social benefits are shared with local communities, while the carbon dioxide reduction effect represents environmental benefits. These attributes were included to examine how benefit distribution influences residents' preferences and acceptance. The project owner represents the entity responsible for constructing and operating the wind power project and has three options: private companies from outside the region, local governments, and local stakeholders. In this study, 'local stakeholders' refers to locally based actors, such as local residents, local companies, and non-profit organisations, that are involved in the operation of the wind power project. Wind power facilities operated by private companies from outside the region refer to companies headquartered outside the prefecture where the project is implemented (within Japan) and not institutionally or financially embedded in the host region. The carbon dioxide reduction effect is measured by the number of households to which the wind power facility can supply electricity, and is categorised into three levels: 10,000 households, 50,000 households, and 100,000 households. This attribute was designed to represent the climate mitigation benefit of wind power generation, expressed in an intuitive unit, rather than the physical size of the project itself. Community contribution activities refer to project operators' efforts to support local communities. They are classified into three types: provision of funds, human resources, and knowledge. In the choice experiment, each project alternative included only one of these types (i.e. no combinations), to identify the marginal effect of each contribution type on preferences. Finally, the household decarbonisation levy is defined as a mandatory household-level payment to support renewable energy and carbon neutrality policies. Although it is not an official policy name in Japan, it is conceptually based on existing renewable energy surcharges and is used in this study as the cost attribute for estimating MWTP.

Figure 2 presents the conceptual framework of this study. In the choice experiment, distributional justice is operationalized through institutional attributes, namely the project operator and community contribution activities. The project operator determines whether economic benefits remain within the host community or flow outside the region, while community contribution represents mechanisms for redistributing benefits to local residents. These attributes shape perceived fairness in benefit allocation, which in turn affects social acceptance. Project owner and Community contribution are categorical attributes and are coded using dummy variables, with one level omitted as the reference category. Specifically, for Project owner, 'private company outside the region' is the reference level; for Community contribution, 'None in particular' is the reference level. Carbon dioxide and Decarbonisation Levy are coded as continuous variables using the numerical levels shown in the choice tasks. Normal distributions are assumed for the random coefficients because there is no strong prior information on the sign of preferences and because normality flexibly allows for both positive and negative tastes across individuals. Although most respondents are expected to value CO_2 reductions positively, some may value them less or even negatively due to heterogeneous perceptions and trade-offs; the normal distribution accommodates such heterogeneity. Table 1 lists the combinations of attributes and levels, as well as their definitions.

To improve comprehensibility, the carbon dioxide reduction effect was expressed using an equivalent metric based on the number of households whose annual electricity consumption could be supplied by wind power

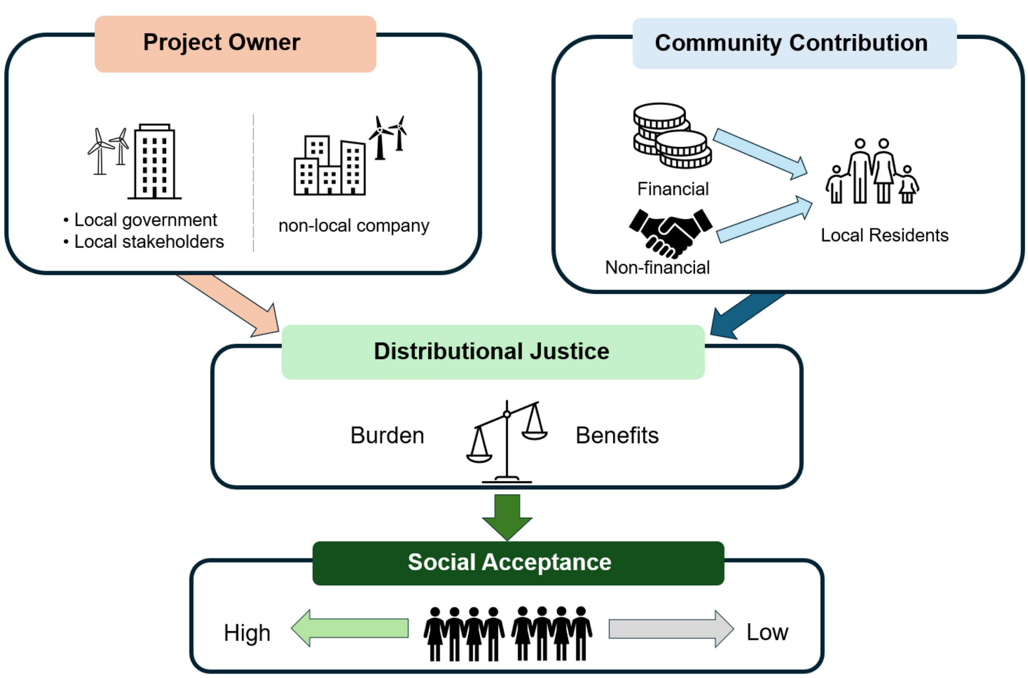

Figure 2. Conceptual Framework: Diagram of a social acceptance framework showing the relationships among project owners, community contribution, distributional justice, and social acceptance.

Table 1. Attributes and levels used in the choice experiment and their definitions.

Attribute	Level	Definition
Project owner	Private company outside the region(base)	Wind power facility is operated by a private company outside the region.
	Local government	Wind power facility is operated by local government in the region.
	Local stakeholders	Wind power facility is operated by local residents, business associations of local companies, non-profit organisations, etc.
CO_2 reduction effect	Equivalent to about 10,000 average households	The power generated by wind power is enough to power approximately 10,000 average households, reducing CO_2 emissions.
	Equivalent to about 50,000 average households	The power generated by wind power is enough to power approximately 50,000 average households, reducing CO_2 emissions.
	Equivalent to about 100,000 average households	The power generated by wind power is enough to power approximately 100,000 average households, reducing CO_2 emissions.
Community contribution activities	None in particular(base)	No community contribution activities are implemented by the wind power generation implementation entity.
	Provision of funds	Funds are provided by the wind power generation entity to the community for activities to solve social issues in the community.
	Provision of human resources and knowledge	Human resources and knowledge necessary for activities to solve local social issues are provided to the community by the wind power generation entity.
Household decarbonisation levy	200 JPY per household per month	Mandatory household payment to support renewable energy and carbon neutrality policies. Each household pays 200 yen per month
	400 JPY per household per month	Each household pays 400 yen per month
	600 JPY per household per month	Each household pays 600 yen per month
	800 JPY per household per month	Each household pays 800 yen per month
	1,000 JPY per household per month	Each household pays 1,000 yen per month

Table 2. Example of choice experiment questions.

Attributes	Option 1	Option 2	Option 3
Project owner	Private company outside the region	Local government	
CO_2 reduction effect	For approximately 50,000 households	For approximately 100,000 households	Not built
Community contribution activities	Provision of funds	Provision of human resources and knowledge	
household decarbonisation levy	200 yen/month/household	1,000 yen/month/household	400 yen/month/household
Choose one most preferred option	☐	☐	☐

generation. Carbon dioxide reduction is typically expressed in terms of annual emission reductions (e.g. tons of CO_2 per year), but such quantities may be difficult for general respondents to interpret. Therefore, this study adopted a household-equivalent metric to communicate the scale of renewable energy generation more intuitively. In addition, the attribute levels were based on realistic electricity generation levels of onshore wind power facilities in Japan. For example, Wind Farm Tsugaru (121.6 MW), one of the largest onshore wind power facilities in Japan, is reported to generate electricity equivalent to the annual consumption of approximately 90,000 households (Kajima Corporation 2021). Based on this real-world reference, the maximum level in this study was set at approximately 100,000 households.

The choice experiment was designed using the Ngene software (ChoiceMetrics 2018) to ensure D-efficiency in the experimental design[2]. This approach generated statistically efficient and unique combinations of attribute levels. A total of 24 non-overlapping choice sets were created and divided equally into four versions, with respondents randomly assigned to one version. Each respondent completed six choice tasks, each consisting of three alternatives: two hypothetical onshore wind power projects and one opt-out option ('rejecting wind power development'). Regardless of their choice, the respondents were required to pay a flat household decarbonisation levy of 400 yen per month per household, ensuring that the economic implications of renewable energy policies were consistently accounted for in their decision-making. Table 2 presents examples of the questions used in the choice experiment.

4.2. Estimation model

This section outlines the analytical methods used in the study. Specifically, this study examines respondents' choice behaviour using both the mixed logit and latent class models. These models examine how different attributes of wind power projects influence respondents' choices and to identify heterogeneity in preferences across individuals. First, it assumes heterogeneity in individual preferences. This reflects people's diverse preferences (McFadden and Train 2000; Train 2009). In the estimation, the discrete choice behaviour of individuals is assumed to be expressed by the random utility model. This framework assumes that each respondent chooses the alternative that provides the highest utility. In this study, utility represents the overall desirability of a wind power project, determined by its attributes such as the project operator, community contribution activities, and cost. Based on an individual's choice, the indirect utility of the individual U_{njt} is defined as follows:

$$U_{njt} = V_{njt} + \varepsilon_{njt} = \beta_n' x_{njt} + \varepsilon_{njt} \tag{1}$$

where V_{njt} is the observable utility value of the random utility, β_n' is the utility parameter of the individual n, and ε_{njt} is an error term that follows an independent and identically distributed type I extreme value distribution and is independent in the time direction. In addition, $n \in (1, 2, \ldots, N)$, $j \in (1, 2, \ldots, J)$, $t \in (1,2, \ldots, T)$ are indices that represent the individual, the alternative in one choice in the choice experiment, and the choice opportunity, respectively. The probability that a respondent n chooses choice i from the choice set $C = \{1, 2, \ldots, J\}$ can be expressed as the probability that the utility of choosing choice i at the choice opportunity t is higher than that of choosing the other choices is as follows:

$$P_{njt} = P(U_{nit} > U_{nkt}) = P(\varepsilon_{nkt} - \varepsilon_{nit} < V_{nkt} - V_{nit}) \quad \forall \quad k \neq i. \tag{2}$$

here, since the error term $\varepsilon_{nkt}, \varepsilon_{njt}$ follows the type I extreme value distribution and is independent in the time direction, the difference in the error term follows a logistic distribution. Therefore, the probability that a respondent chooses an option can be expressed as a conditional logit model (Train 2009):

$$P_{nit}(\beta) = \frac{\exp(\beta' x_{nit})}{\sum_j \exp(\beta' x_{njt})}. \tag{3}$$

The conditional logit model assumes that the utility parameters are identical among all individuals, implying that all individuals share homogeneous preferences. However, this assumption is unrealistic. To address this limitation, the present study employs a mixed logit model that allows for the evaluation of heterogeneous preferences across individuals. The preference parameters of individuals β_n are unknown; therefore, the mixed logit probability is obtained by integrating the distribution β of the conditional logit probability expressed in Equation (3). In other words, it is expressed using a probability density distribution $g(\beta|\theta)$ with parameter θ in the following manner:

$$P_{ni}(\theta) = \int \prod_{t=1}^{T} \left[\frac{\exp\left(\beta'^{x_{nit}}\right)}{\sum_j \exp\left(\beta'^{x_{njt}}\right)} \right] g(\beta|\theta)\, d\beta. \tag{4}$$

However, algebraically performing this integral calculation is challenging. To address this issue, parameter estimation is conducted using the following simulation-based steps:

1. Generate β R times from $f(\beta)$, and let β^r be the β generated r times[3].
2. Substitute the generated β into Equation (2) to obtain R selection probabilities.
3. Calculate the unbiased estimator SP_{ni} of P_{ni} based on the following Equation (4).

$$SP_{ni} = \frac{\sum_r P_{ni}(\beta^r)}{R} \tag{5}$$

Using the obtained unbiased estimator SP_{ni}, the simulated log likelihood (SLL) obtained through simulation is expressed as follows, using a dummy variable d_{ni} that takes the value of 1 when an individual n chooses an option i.

$$SLL(\theta) = \sum_n \sum_i d_{ni} \ln SP_{ni}(\theta) \tag{6}$$

On the contrary, in the latent class model, it is assumed that the preference parameter takes discrete values. In other words, the variation in preferences is not continuous, as in the mixed logit model, but discrete, as expressed by several classes (groups). The preference parameters are expressed as $b_1, b_2, \ldots, b_C$. By using a latent class model, it is possible to divide people into several classes based on their preferences and analyse the diversity of these preferences. Here, if $\beta = b_c$, that is, an individual n belongs to a class c, the choice probability is expressed by the following formula ((7)),

$$P_n(b_c) = \prod_{t=1}^{T}\prod_{i=1}^{J}\left[\frac{\exp(b_c x_{ni})}{\sum_j \exp(b_c x_{nj})}\right]^{d_{ni}}, \tag{7}$$

where d_{ni} is a dummy variable that takes the value one when an individual n chooses option i. Furthermore, the probability π_{nc} of individuals belonging to each class can be estimated using the same approach as the multinomial logit model, enabling an analysis of the factors contributing to preference heterogeneity. Specifically, π_{nc} is calculated through a membership model incorporating explanatory variables Z_n and parameters (θ, where $\theta = (\theta_1, \theta_2, \ldots, \theta_{C-1})$), which are hypothesised to account for the diversity in preferences, as expressed in Equation (8). To ensure identifiability of the parameters, normalisation is required, wherein the parameter for a reference class θ_C is set to zero.

$$\pi_{nc}(\theta) = \frac{\exp(Z_n\theta_c)}{1 + \sum_k^{C-1}\exp(Z_n\theta_k)}. \tag{8}$$

By using Equations (6) and (7), the log likelihood (LL) of the latent class model can be expressed as follows:

$$LL(b, \theta) = \sum_{n=1}^{N}\ln\sum_{c=1}^{C}\pi_{nc}(\theta)P_n(b_c) \tag{9}$$

The EM algorithm was used to estimate the latent class model. This algorithm is a method used for obtaining the maximum likelihood estimator by repeatedly estimating each parameter individually and updating the parameters to be estimated (here b and θ) (Train 2009, Chapter 14). In general, it becomes difficult to numerically maximise the log-likelihood when the number of parameters is large, as in the case of latent class models, or when the log-likelihood function is not globally quadratic. In such cases, the EM algorithm is used to maximise the log-likelihood and obtain the maximum likelihood estimator.

The procedure for the EM algorithm is as follows. Since the class membership of each individual is unobserved, the expected log-likelihood function, expressed in Equation (10), is employed. Here, h_{nc} represents the conditional probability that respondent n belongs to class c, given the choice data of respondent n.

$$E[LL(b, \theta)] = \sum_{n=1}^{N}\sum_{c=1}^{C}h_{nc}\ln[\pi_{nc}(\theta)P_n(b_c)] \tag{10}$$

In addition, from Bayes' theorem, h_{nc} is expressed as $h_{nc} = \pi_{nc}(\theta)P_n(b_c)/\sum_{l=1}^{C}\pi_{nl}(\theta)P_n(b_c)$. In the EM algorithm, the expected log-likelihood expressed in Equation (10) is calculated using the probability h_{nc} that a respondent belongs to a certain class (E-step). Next, the expected log-likelihood is maximised given h_{nc} (M-step). Then, h_{nc} is updated using the estimated parameters (b and θ). An estimate is obtained by iterating these steps until the parameters converge.

Finally, after the estimation of the mixed logit model, individual-specific preference parameters for the random coefficients were recovered using the postestimation procedure implemented in Stata 18 (*mixlbeta* command). This procedure uses simulation to obtain draws from the respondent-specific conditional (posterior) distribution of the random coefficients, conditional on each respondent's observed choices and the estimated mixed logit parameters. A total of 200 simulation draws were used, and the first 50 draws were discarded as burn-in. Individual n 's marginal willingness to pay $MWTP_{ni}$ for a marginal change in an attribute i is computed as

$$MWTP_{ni} = -\frac{\beta_{ni}}{\beta_{price}}, \tag{11}$$

where β_{ni} is the individual-specific coefficient for attribute i and β_{price} is the coefficient for the price attribute.

n latent class models, the number of classes is not uniquely determined by the data and therefore must be specified by the analyst. Both statistical fit and substantive interpretability are considered when selecting the number of classes. Table 3 reports model fit statistics (AIC and BIC) for specifications with alternative numbers of classes. Fit improves when moving from two to three classes, whereas subsequent improvements become comparatively modest (i.e. the reduction in AIC/BIC is much smaller than that observed from two to three classes). In addition to statistical fit, we prioritise interpretability and the practical relevance of the resulting segments. Increasing the number of classes beyond three tends to produce smaller groups and less distinct class profiles, which makes it harder to characterise each class and reduces the usefulness of class-based implications. Taken together, these considerations make the three-class solution the most defensible and balanced specification for our discussion.

5. Survey results and analysis

5.1. Implementation of the questionnaire survey

The percentage of respondents by age group (overall and by gender) is shown in Figure 3. The largest age group was the 60 s, accounting for 28.3% of the total, followed by the 50 s (25.6%). The proportion of older respondents was higher among males than among females. In addition to age, gender, and region, the questionnaire collected additional individual-level variables, including respondents' perceptions, experiences, and attitudes toward wind power generation. These variables were used as explanatory variables in the latent class membership model to analyse preference heterogeneity.

5.2. Results of the questionnaire survey

5.2.1. Public opinion on energy sources

Question 2 of the questionnaire asked the respondents whether each potential energy source for future promotion in Japan should be actively supported (Figure 4). In general, the total of 'should definitely be promoted' and 'can be promoted' for renewable energy was around two-thirds or more of the total, while for thermal power generation, the total of these two was 32.9%, and for nuclear power generation, it was only 25.2%. However, the total of the percentages of respondents who answered that wind power generation should be 'absolutely promoted' or 'can be promoted' was slightly lower than for other renewable energies, and in particular, the total for onshore wind power generation was 65.6%, the only renewable energy to fall below two-thirds of the total.

5.2.2. Expectations and concerns about wind power generation

Question 9 presented the respondents with six items representing the desired outcomes of wind power generation and were asked to indicate the extent to which they hoped that each outcome would be realised (Figure 5). The item that received the most votes (27.5%) was 'energy source that does not rely on imports,' followed by 'countermeasures against climate change,' (18.7%) and 'priority power supply in emergencies' (17.3%). On the contrary, the items that respondents 'could not expect at all' were 'creation of new scenery' (22.0%) and 'creation of new tourist resources' (19.2%), which were significantly higher than the other four

Table 3. Model fit statistics for alternative latent class specifications.

Classes	LL	Nparam	AIC	cAIC	BIC
2	−9016.72	14	18061.44	18153.97	18139.97
3	−8826.18	21	17694.36	17833.14	17812.14
4	−8590.59	28	17237.17	17422.22	17394.22
5	−8455.12	35	16980.25	17211.56	17176.56
6	−8469.48	42	17022.95	17300.52	17258.52

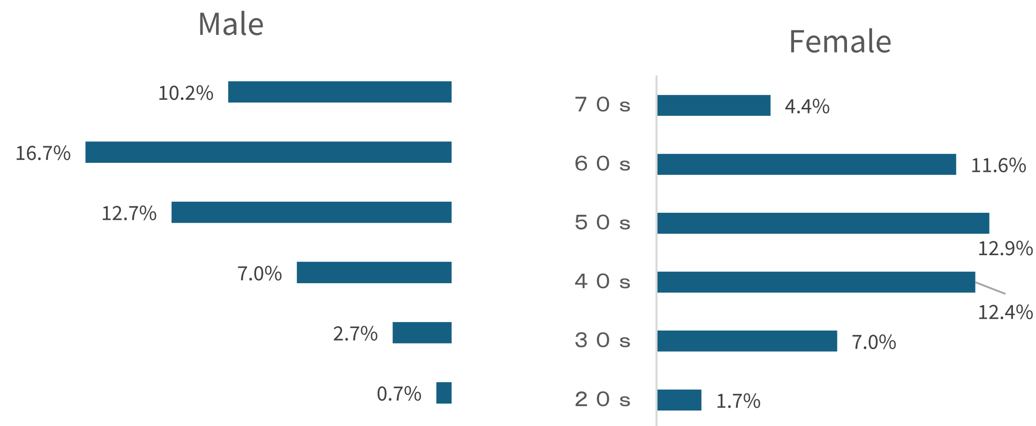

Figure 3. Proportion of respondents by age group. Males and females each account for 50% of the total across all age groups.

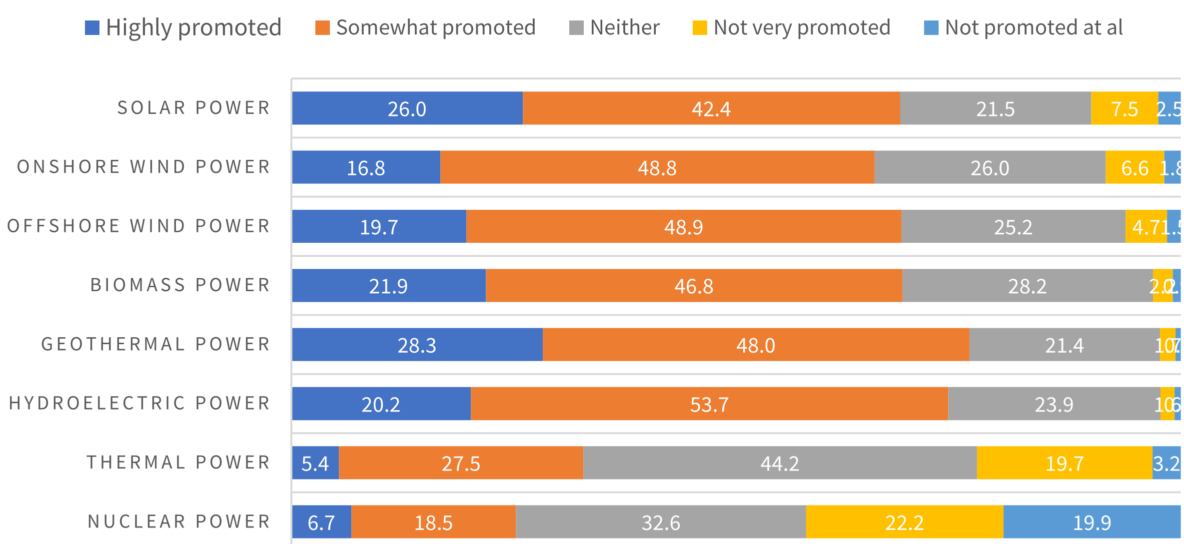

Figure 4. Energy sources that should be promoted (%). Bar graph showing respondents' preferences for promoting different energy sources.

items, which were each less than 10%; thus, expectations for items other than energy and environmental issues are relatively low.

Question 10 presented the respondents with six potential concerns regarding wind power generation and asked them to rate the degree to which they were worried about each concern (Figure 6). The item that the respondents were 'very worried about' was 'accidents such as collapse, durability against natural disasters' at 25.0%, followed by 'health hazards due to noise, vibration, low frequency, etc.' at 24.4%, 'negative impact on animals, plants, such as birds, and the ecosystem' at 18.0%, and 'loss of existing scenery' at 16.5%. On the contrary, the items that the respondents were 'not worried about at all' included 'negative impact on local industries such as tourism and forestry' (9.6%) and 'loss of existing scenery' (9.1%), which were higher than the other items, which were all below 6%. While 'loss of existing scenery' was ranked highly for both 'very worried' and 'not worried at all,' 'instability of power supply' was ranked low for both, which may be because the respondents can easily imagine the loss of scenery, but find it difficult to imagine the instability of power supply. These findings indicate that respondents hold both expectations and concerns regarding wind power generation, particularly related to safety, environmental impacts, and local consequences. Such perceptions may influence their preferences for project characteristics, including who operates the project and whether benefits are shared with the local community.

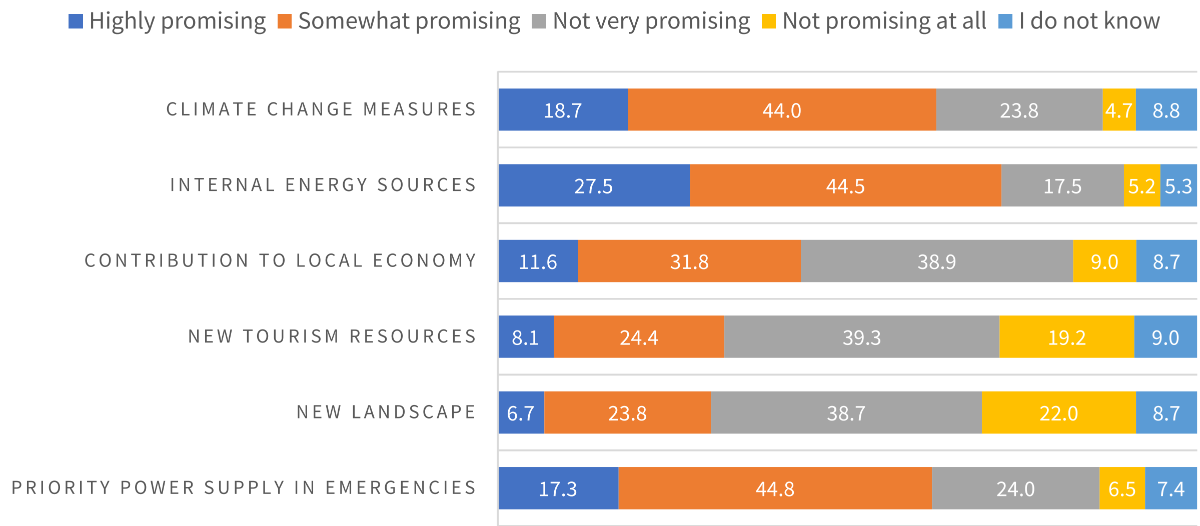

Figure 5. Expectations for wind power generation (%). Bar graph showing respondents' expectations regarding the potential benefits of wind power generation across multiple categories.

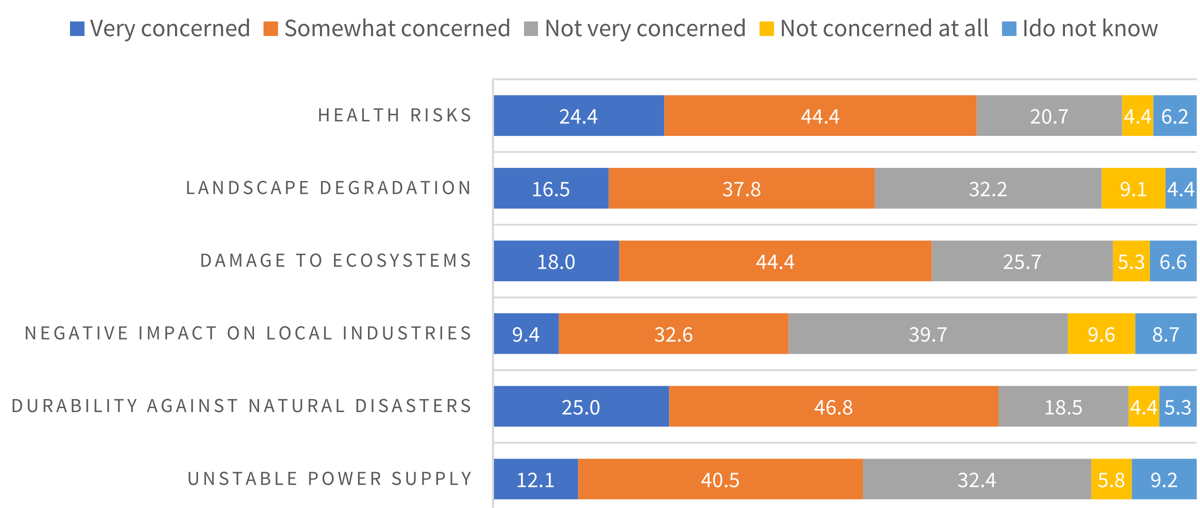

Figure 6. Concerns about wind power generation (%). Bar graph showing respondents' concerns regarding the potential risks of wind power generation across multiple categories.

Therefore, examining distributional justice attributes through the choice experiment is essential for understanding how these factors shape public acceptance.

5.3. Estimation results

This section presents the estimation results obtained from the mixed logit and latent class model analyses. All estimations were performed using the statistical software Stata18.

First, a mixed logit model is employed to assess preference heterogeneity among the respondents. In the mixed logit model estimation, the household decarbonisation levy (cost) is assumed to be a fixed parameter, and all other parameters are assumed to be random parameters that follow a normal distribution. The estimation results obtained using the mixed logit model are listed in Table 4, and the MWTP estimation results are listed in Table 5.

The estimation results show that attributes related to distributional justice—namely, the project operator and community contribution activities—have a strong and statistically significant effect on

Table 4. Mixed logit model estimation results.

	Full sample			Tohoku			Kyushu		
Mean Parameters	Coefficient		Z-values	Coefficient		Z-values	Coefficient		Z-values
household decarbonisation levy	−0.3045	***	−48.47	−0.3065	***	−33.64	−0.3109	***	−33.38
ASC	−0.1691	**	−2.37	−0.2048	**	−1.99	−0.1625		−1.61
Project owner (Local government) dummy	0.7256	***	12.71	0.6684	***	8.00	0.7600	***	9.51
Project owner (Local stakeholders) dummy	0.6329	***	13.79	0.6437	***	9.73	0.6088	***	9.18
CO_2 reduction effect	0.0217	*	1.77	−0.0021		−0.11	0.0430	**	2.52
Community contribution activities (Provision of funds) dummy	0.2437	***	5.10	0.2461	***	3.53	0.2345	***	3.42
Community contribution activities (Provision of human resources and knowledge) dummy	0.2422	***	5.54	0.2360	***	3.72	0.2419	***	3.88
	Full sample			Tohoku			Kyushu		
SD Parameters	Coefficient		Z-values	Coefficient		Z-values	Coefficient		Z-values
Project owner (Local government) dummy	1.1781	***	18.23	1.2607	***	13.45	1.1386	***	12.46
Project owner (Local stakeholders) dummy	0.1242		0.71	−0.1728		−0.69	0.2538		1.33
CO_2 reduction effect	0.4296	***	32.30	0.4413	***	23.08	0.4159	***	22.43
Community contribution activities (Provision of funds) dummy	0.4377	***	3.50	0.5485	***	3.70	0.5684	***	4.30
Community contribution activities (Provision of human resources and knowledge) dummy	0.3179	***	3.12	0.3687	***	2.85	0.3402	**	2.26
Observations	36,288			18,144			18,144		
Log likelihood	−9875.716			−4921.130			−4943.851		

Note:
***$p < 0.01$,
**$p < 0.05$, and
*$p < 0.10$.

Table 5. Estimation results for MWTP using a mixed logit model.

	MWTP(JPY/month/household)	
Variables	Mean	95% Confidence Interval
Project owner (Local government) dummy	232.53	[221.75, 243.32]
Project owner (Local stakeholders) dummy	203.39	[202.88, 203.91]
CO_2 reduction effect	6.40	[0.96, 11.83]
Community contribution activities (Provision of funds) dummy	79.55	[77.16, 81.94]
Community contribution activities (Provision of human resources and knowledge) dummy	79.20	[77.99, 80.42]

respondents' preferences. In particular, the coefficients for local government and local stakeholder operators, as well as those for community contribution activities, are statistically significant at the 1% level. These results indicate that respondents prefer wind power projects in which economic and social benefits are retained within the local community.

In addition, the MWTP is 232.53 yen for the project entity (local government) dummy, indicating a willingness to pay 232.53 yen more than if a non-local private company were selected as the project entity; 203.39 yen for the project entity (local stakeholders) dummy, indicating a willingness to pay 203.39 yen more than if a non-local private company were selected; 6.40 yen for the carbon dioxide reduction effect, indicating a willingness to pay 6.40 yen more per 10,000 households of electricity generated and carbon dioxide emissions reduced by the wind power facility; 79.55 yen for the community contribution activities (provision of funds) dummy, indicating a willingness to pay 79.55 yen more than in the case of no activity when the project entity provides funding for local social issue initiatives; and 79.20 yen for the community contribution activities (provision of human resources and knowledge) dummy, indicating a willingness to pay 79.20 yen more than in the case of no activity when the project entity contributes human capital and expertise to address local social challenges. The MWTP for the two project operator dummies is the highest, followed by the two community contribution activities dummies, which are approximately equal in value.

The explanatory variables for class membership model were derived from the responses to our questionnaire. The questionnaire gathered information on the respondents' attitudes toward environmental and energy issues, their perceived relationship between these issues and local communities, and demographic attributes such as gender, age, and region (Tohoku or Kyushu). Explanatory variables based on the responses to the questionnaire survey were created in the following manner.

Awareness of decarbonisation leading regions: If the respondent selected 'Yes' for Q5 (whether or not the respondent's municipality is designated as a 'decarbonisation leading region'), then one was assigned; if the respondent selected 'No,' then zero was assigned.

Table 6. Estimation results of the utility function using the latent class model.

Variable	Class 1 Coefficient		Class 1 (Z-value)	Class 2 Coefficient		Class 2 (Z-value)	Class 3 Coefficient		Class 3 (Z-value)
household decarbonisation levy (100 yen/month/household)	−0.25	***	(−44.59)	–			–		
ASC	0.65	***	(3.33)	−1.40	***	(−12.02)	4.70	***	(6.50)
Project owner (Local government = 1)	0.81	***	(7.38)	0.93	***	(15.07)	0.79		(1.47)
Project owner (Local stakeholders = 1)	0.41	***	(4.01)	0.63	***	(11.50)	0.58		(1.10)
CO_2 reduction effect	0.05	***	(3.88)	0.18	***	(15.02)	−0.02		(−0.09)
Community contribution activities (provision of funds = 1)	−0.01		(−0.09)	0.23	***	(5.15)	0.06		(0.17)
Community contribution activities (provision of human resources and knowledge = 1)	0.10		(1.15)	0.26	***	(6.42)	−0.21		(−0.55)
Class share	21%			59%			20%		
Log likelihood				−8579.95					

Note:
***indicates significance at the 1% level,
**indicates significance at the 5% level.
—indicates that the parameter is not estimated for the corresponding class.

Agreement with the promotion of decarbonisation in the respondent's municipality: The responses to Q6 are scaled on a 5-point Likert scale (agreement with the respondent's municipality actively promoting the introduction of renewable energy and energy-saving measures); 5 is given if the respondent selects 'should be promoted,' and the number of points given decreases in order, with 1 given if the respondent selects 'oppose'.

Visibility of wind turbines from place of residence: For question 7 (whether or not the respondent can see operational wind turbines from their place of residence), a score of 1 is given if the respondent chooses 'Yes' and a score of 0 if the respondent chooses 'No'.

Experience of hearing the sound of wind turbines: For question 8 (whether or not the respondent has heard the sound of wind turbines), a score of 1 is given if the respondent chooses 'Yes' and a score of 0 if the respondent chooses 'No'.

Expectations for wind power generation: Question 9 (respondents' expectations for wind power generation in terms of 'countermeasures against climate change,' 'energy sources that do not rely on imports,' 'contribution to the local economy (e.g. increased employment and tax revenue),' 'creation of new tourist resources,' creation of new scenery,' and 'priority power supply (in times of emergency)') was evaluated on a 5-point Likert scale, where 1 was assigned if the respondent chose 'I have high expectations' or 'I have some expectations,' and 0 was assigned if the respondent chose 'Other'.

Concerns about wind power generation: Responses to a 5-point Likert scale question (concern about the following issues if a wind power generation facility were to be built near the respondent's place of residence: 'health hazards (due to noise, vibration, low-frequency noise, etc.)', 'loss of existing scenery,' 'impact on the ecosystem (of animals and plants, such as birds),' 'adverse impact on local industry (such as tourism and forestry) negative impact on local industry,' 'natural disasters (accidents such as durability and collapse),' and 'instability of power supply') were assigned a value of 1 if the respondent selected 'very worried' or 'somewhat worried' on a 5-point Likert scale, and a value of 0 if they selected 'not worried' or 'not applicable'.

Relationship with the area of residence: For the five-point Likert scale response to question 3 (how much each of the following statements about the area of residence applies to the respondent: 'I like the area where I live now,' 'I have many opportunities to come into contact with the nature of the area,' 'I trust the local government,' 'I want to continue living in the area where I live now'), a score of 5 was given if the respondent chose 'applies,' and the number of points given was reduced in order, with a score of 1 given if the respondent chose 'does not apply'.

Table 6 presents the estimation results of our latent class model. The coefficient of ASC was negative for Class 2 and positive for Classes 1 and 3, indicating differences in attitudes toward wind power generation across groups. The estimated coefficients for the project operator and community contribution activities also show clear differences in how distributional justice affects preferences. In Class 2, which represents respondents with a favourable attitude toward wind power generation, both local operators and community contribution activities had positive and statistically significant effects. This suggests that distributional justice increases acceptance in this group. In contrast, these attributes were not statistically significant in Class 3, indicating that distributional justice has little effect on respondents who are strongly opposed to wind power generation.

For Class 2 (the group positive about wind power generation), all of the following coefficients were significant at the 1% level: the dummy for the local government, which was the main body of the project, the dummy for the local stakeholders, the effect of reducing carbon dioxide emissions, the dummy for providing funds for local contribution activities, and the dummy for providing human resources and knowledge. By contrast, the group in Class 1, which was slightly negative about wind power generation, was statistically insignificant for the dummy for providing funds for local contribution activities and the dummy for providing human resources and knowledge. The group in Class 3, which was negative for wind power generation, was statistically insignificant for the following: the dummy for the local government as a business entity, the dummy for local stakeholders, the dummy for the provision of funds for community contribution activities, and the dummy for the provision of human resources and knowledge.

The estimation results showed that the utility of the group that was positive about wind power generation was strongly influenced by the project owner, the effect of carbon dioxide reduction, and regional and community contribution activities. On the contrary, the group that was negative about wind power generation was less affected by the size of the carbon dioxide reduction effect and the presence or absence of local contribution activities, as well as by the difference in project owner. In addition, the group that was intermediate between the two (somewhat negative about wind power generation) was shown to be more affected by the size of the carbon dioxide reduction effect and the difference in the project owner but less affected by local contribution activities.

Next, the estimation results of the membership function are analysed and discussed in detail. Of the total population, 21% belonged to Class 1, 59% to Class 2, and 20% to Class 3. Table 7 shows the results of the class membership models for Classes 1 and 2, using Class 3 (the group that is negative about wind power generation) as the reference category. For Class 2 (the group that is positive about wind power generation), as with the two-class estimation, the results for age, agreement with the promotion of decarbonisation in the municipality of residence, expectations of wind power generation (countermeasures against climate change, energy sources that do not rely on imports, creation of new scenery, and priority power supply in emergencies), and concerns about wind power generation (health hazards, loss of existing scenery, and adverse effects on local industry) were significant at the 1% or 5% level. These results suggest that there is no significant difference in the characteristics of the negative and positive groups between the two- and three-class estimations of wind power generation.

In terms of the results of the estimation for Class 1 (the group that is slightly negative about wind power generation), which was based on Class 3, age was significant at the 1% level, and expectations for wind power generation (creation of new tourist resources) and concerns about wind power generation (health hazards, impact on the ecosystem, and negative impact on local industry) were significant at the 5% level. This suggests that people in Class 1 are generally younger than those in Class 3 and that the probability of belonging to Class 1 is higher than that of Class 3 for those who expect wind power generation to create new tourist resources. However, the probability of belonging to Class 3 is higher than that of Class 1 because of concerns about the durability of wind power generation facilities against natural disasters and accidents, such as collapse. Conversely, the probability of belonging to Class 1 is higher than that of Class 3 because of concerns about the durability of wind power generation facilities against natural disasters and accidents such as collapse.

On the contrary, the results for gender, region, awareness of decarbonisation leading regions, visibility of wind turbines from place of residence, experience of the sound of wind turbines, expectations of wind power generation (contribution to local economy), concerns about wind power generation (uncertainty of power supply), and relationship with local community were statistically insignificant, as in the two-class estimation, and the hypothesis that awareness of whether or not the municipality of residence is designated as a decarbonisation pioneer region, visibility of wind turbines, experience of wind noise, and the depth of relationships with the local community may affect the degree of approval of wind power generation could not be supported by the results of the estimation of the membership function in the two-class and three-class models in this study.

Table 7. Results of class membership model.

	Class 1			Class 2			Class 3
Variable	Coefficient		(Z-value)	Coefficient		(Z-value)	(Reference)
Gender	−0.04		(−0.21)	−0.15		(−1.05)	–
Age	−0.04	***	(−5.87)	−0.03	***	(−4.53)	–
Region	−0.15		(−0.90)	0.08		(0.58)	–
Awareness of decarbonisation leading regions	0.23		(0.77)	0.12		(0.48)	–
Agreement with decarbonisation promotion in the municipality of residence	0.13		(1.26)	0.60	***	(6.32)	–
Visibility of wind turbines	0.08		(0.31)	−0.03		(−0.12)	–
Noise of wind turbines	−0.11		(−0.55)	−0.21		(−1.23)	–
Expectation (Countermeasures against climate change)	0.44	*	(1.90)	0.46	**	(2.52)	–
Expectation (As an energy source)	0.36		(1.51)	0.57	***	(2.90)	–
Expectation (Contribution to local economy)	−0.37		(−1.53)	0.18		(0.96)	–
Expectation (Creation of new tourist attractions)	0.66	**	(2.22)	0.38		(1.56)	–
Expectation (Creation of new scenery)	0.37		(1.22)	0.54	**	(2.21)	–
Expectation (Priority power supply)	0.39	*	(1.79)	0.58	***	(3.33)	–
Concern (Health hazards)	−0.33	**	(−1.42)	−0.42	**	(−2.21)	–
Concern (Loss of existing landscape)	−0.22		(−0.99)	−0.98	***	(−5.32)	–
Concern (Impact on ecosystems)	−0.50	**	(−2.19)	−0.17		(−0.88)	–
Concern (Impact on local industry)	−0.46	**	(−2.36)	−0.39	**	(−2.29)	–
Concern (Natural disasters)	0.50	*	(1.97)	−0.14		(−0.68)	–
Concern (Instability of power supply)	−0.05		(−0.29)	0.04		(0.29)	–
Relationship with residential area (like the area)	−0.14		(−0.95)	−0.12		(−1.01)	–
Relationship with residential area (More contact with nature)	0.03		(0.34)	0.06		(0.79)	–
Relationship with residential area (Trust in local government)	0.14		(1.25)	0.08		(0.90)	–
Relationship with residential area (Want to continue living in the area)	−0.09		(−0.69)	−0.03		(−0.30)	–
Constant term	2.28	***	(3.86)	0.63		(1.18)	–
household decarbonisation levy	−0.25	***	(−44.59)		–		–

Note:
***indicates significance at the 1% level,
**indicates significance at the 5% level, and
*indicates significance at the 10% level.
—indicates that the parameter is not estimated for the corresponding class.

6. Discussion and conclusion

This study examined the relationship between the project proponent and the local community as a key factor influencing the social acceptance of onshore wind power generation. More specifically, this study examined how distributional justice—particularly who operates wind power projects and whether projects provide benefits to local communities—influences residents' support for wind power development. The results provide clear evidence that distributional justice is an important factor shaping public acceptance. Respondents showed significantly stronger preferences for projects operated by local governments or local stakeholders and for projects involving community contribution activities. This study hypothesised that social acceptance would be higher when the proponent was a local government or stakeholder rather than an external private company and that community contribution activities would further enhance acceptance. The findings confirm the hypotheses, indicating a clear preference for local governments and stakeholders over external private entities. However, heterogeneity in preferences was primarily observed for local governments, whereas local stakeholders did not exhibit significant diversity in their acceptance levels. The study also demonstrated that community contribution activities enhanced utility with variations in preferences for the type of contribution, such as financial support or the provision of human resources and expertise.

While the carbon dioxide reduction effect was statistically significant in shaping preferences for wind power, its influence was less pronounced than those of project owner and community contribution activities. The respondents exhibited substantial heterogeneity in their valuation of carbon dioxide reduction, with 34.4% expressing a negative WTP for this attribute. This may also reflect concerns about larger-scale wind power projects, as higher CO_2 reduction levels could be perceived as implying larger developments. This polarisation suggests that attitudes toward climate-change mitigation play a crucial role in shaping the acceptance of wind power projects.

By using a latent class model, this study identified three groups: those supportive of wind power (60%), those opposed to it (20%), and a neutral group with slight opposition (20%). Among the supportive groups, factors such as the project owner, local contribution activities, and carbon dioxide reduction effects significantly influenced the preferences. However, among the opposition groups, these factors did not strongly correlate with the perceived project benefits. This suggests that distributional justice is particularly effective in strengthening support among residents who are already conditionally supportive, but has limited influence on those who are fundamentally opposed. This finding highlights that fair benefit-sharing mechanisms can enhance acceptance but may not be sufficient to overcome strong opposition. Notably, opposition was more prevalent among older individuals. This may reflect stronger place attachment or higher sensitivity to potential risks, rather than dissatisfaction with benefit-sharing mechanisms. However, no clear relationship emerged between turbine visibility, noise experience, and community engagement levels. These findings suggest that opposition to wind power cannot be explained solely by dissatisfaction with the distribution of economic benefits. Rather, they indicate that some residents may oppose wind power development itself, regardless of how benefits are distributed. For these individuals, opposition may reflect more fundamental concerns, such as perceived environmental risks, landscape impacts, or general resistance to large-scale wind power development.

In line with this interpretation, the latent class analysis empirically demonstrates heterogeneity in preferences. It suggests that differences in perceived impacts, such as visibility, noise exposure, and related concerns, contribute to variation in acceptance across respondent groups. This supports the interpretation that these factors influence attitudes toward wind power projects, based on empirically identified preference segments.

Our findings have several policy implications. First, although local governments and stakeholders are preferred as project proponents, the increasing scale of wind power projects presents challenges for them as the sole developers. This requires establishing robust support systems that enable local actors to access financial and technical resources. One potential solution is to facilitate partnerships with private external firms, thereby allowing local entities to retain a meaningful role in project governance while leveraging external expertise. However, the survey results indicate that only 40% of the respondents supported such a collaboration, revealing persistent scepticism toward external involvement. This suggests that cooperation alone may not be sufficient to enhance acceptance and that additional mechanisms are required to address the underlying concerns.

Although beneficial, community contribution activities have shown limited effectiveness in significantly shifting opinions among opponents of wind power. The broad geographic scope of the study limited the specificity of the contribution activities, meaning that the respondents were unable to evaluate them based on direct, tangible benefits to their own communities. Considering that community contributions often combine financial and human resource support, policies should mandate their integration into wind power projects. Government initiatives should encourage projects to demonstrate clear local benefits, thus potentially increasing acceptance.

Despite the potential benefits of community engagement and the project structure, the results indicate that opposition to wind power generation persists among certain groups. The latent class model suggests that factors, such as project owner and community contributions, do not necessarily influence those who are fundamentally opposed to wind power development, indicating that their opposition may not be driven primarily by concerns over benefit distribution, but rather by broader concerns related to wind power development itself. This highlights a crucial challenge: increasing acceptance among groups that remain sceptical or neutral about wind power projects requires a distinct approach beyond traditional engagement strategies.

Taken together, these findings suggest that wind power projects are more likely to gain public support when they are operated by local actors and when they provide tangible benefits to local communities. In this sense, achieving distributional justice requires both local involvement in project governance and meaningful community contribution mechanisms.

These findings contribute to the growing international literature on community acceptance of renewable energy by providing new empirical evidence on the role of distributional justice. Previous studies in Europe and North America have emphasised that perceived fairness in the distribution of economic benefits is a key determinant of public acceptance (e.g. le Maitre et al. 2023; Hübner et al. 2023). Consistent with these findings, the present study demonstrates that respondents showed significantly stronger preferences for wind power projects operated by local governments or local stakeholders, as well as for projects implementing community contribution activities, compared to projects operated by private companies from outside the region. This suggests that residents place substantial value on institutional arrangements that ensure local retention of economic and social benefits.

Furthermore, this study extends the existing literature by providing empirical evidence from Japan, where quantitative studies focusing on distributional justice in wind power development remain limited. While previous Japanese studies have identified procedural justice, trust, and environmental concerns as important determinants of acceptance (Kumazawa 2017; Motosu and Maruyama 2016), relatively little empirical research has examined how differences in project ownership and benefit-sharing mechanisms influence residents' preferences. By explicitly incorporating these institutional attributes into a choice experiment framework, this study provides new insights into how distributional justice affects public acceptance in the Japanese context.

6.1. Limitations

Despite these contributions, the limitations and prospects of this study should be recognised. First, the survey deliberately employed the abstract term 'community contribution activities' to maintain conceptual generality. However, this abstract formulation may have limited respondents' ability to evaluate concrete and locally relevant forms of contribution. To develop more precisely tailored community contribution strategies, further research is therefore essential to elucidate the specific forms of contribution valued by the community. In addition, the results of this survey show that elements related to distributional justice (the construction entity and community contribution activities) do not lead to a change in the behaviour of groups that oppose wind power generation. This suggests that the attributes included in this study may not fully capture all relevant factors influencing opposition to wind power development. In particular, factors such as procedural justice and trust, which are related to communication with the local community and the formation of consent when presenting actual wind power generation plans to the local community, may impact behavioural change.

6.2. Future research

While this study focused on distributional justice, the results suggest that improving benefit-sharing mechanisms alone may be insufficient to increase acceptance among strongly opposed residents. Therefore, future studies should examine how transparent decision-making processes, early-stage communication, and meaningful opportunities for local participation affect acceptance. In particular, trust in project developers and public institutions, as well as perceptions of fairness in the planning process, may play a crucial role in shaping attitudes toward wind power projects. Moreover, future research should investigate how these factors interact with distributional justice and how acceptance evolves over time as residents gain more information and experience with actual projects. Such research would contribute to a more comprehensive understanding of the social acceptance of renewable energy.

Endnotes

1. This refers to the amount of money that people are willing to pay for a marginal change in the attributes of goods and services.
2. The choice set that takes into account D-efficiency minimises the variance of the estimated parameters by minimising the determinant of the variance-covariance matrix, and is a design of an efficient choice set (for technical details, see Huber and Zwerina 1996).
3. In this step, it is necessary to repeatedly perform calculations using a large number of random numbers. In order to perform this efficiently, this study used pseudo-random numbers generated by the 'Halton-Draw' method. For technical details, refer to Train (2009).

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Author contributions

CRediT: **Kengo Iwata:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing; **Masashi Hiroki:** Conceptualization, Project administration, Supervision, Writing – original draft, Writing – review & editing; **Shinsuke Kyoi:** Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing; **Memi Motosu:** Supervision, Writing – original draft, Writing – review & editing.

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Data availability statement

Data supporting the findings of this study are available from the first author, upon reasonable request.

Ethics statement

At the time of the survey, an institutional ethics review committee had not yet been established at the Kyoto University Institute of Economic Research, where the authors were affiliated. This study involved an anonymous online survey with voluntary participation and did not collect personally identifiable information. Respondents were informed of the purpose of the study and the anonymous treatment of responses prior to participation.

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