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Bridging the Gap Between Socio-Political and Community Acceptance of Wind Energy: Policy Insights for Sustainable Energy Development

Kaiqi Liu | Shigeo Nishikizawa | Takehiko Murayama | Kultip Suwanteep | Qiao Yu | Wei Zhang

Department of Transdisciplinary Science and Engineering, School of Environment and Society, Institute of Science Tokyo, Yokohama City, Kanagawa, Japan

Correspondence: Kaiqi Liu (liu.k.ag@m.titech.ac.jp)

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ABSTRACT

Wind energy plays an important role in achieving energy transition and sustainable development goals, yet disparities between socio-political and community acceptance continue to hinder project implementation. Understanding this gap is essential for designing more socially responsive wind energy policies. This study conducted a questionnaire survey in Dalian, China, obtaining 342 responses from the general public and 362 from local residents living within 1 km of the wind farms. Using partial least squares structural equation modeling and multigroup analysis, we examined wind energy acceptance and its determinants, including perceived benefits, perceived risks, affective imagery, distance, environmental concern, experience, place attachment, knowledge, participation, subjective norms, and social trust. Results showed significantly higher acceptance among the general public than local residents, mainly due to a pronounced benefit–risk asymmetry and the general public's more abstract assessment of risks. For the general public, affective and social factors played a greater role through perceived benefits, whereas local residents were more strongly influenced by risk perceptions shaped by proximity and firsthand experience. These findings highlight the need to bridge the acceptance gap through more transparent communication, stronger trust-building, clearer benefit-sharing, and meaningful participation, thereby reinforcing sustainable development-oriented energy governance.

1 | Introduction

Meeting energy demands while addressing climate change and pollution is a significant global challenge, particularly for rapidly developing countries such as China. As a clean, scalable, and increasingly cost-competitive renewable energy source, wind energy has become a central component of global energy transitions. It not only reduces greenhouse gas emissions but also strengthens energy security and supports long-term environmental sustainability, thereby contributing directly to Sustainable Development Goals such as SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action) (Wang, Huang, and Li 2024). By 2050, the cost of wind energy is projected to decrease by 37%–49%, further strengthening its contribution to climate mitigation (Wiser et al. 2021). This strategic role is reflected in the rapid global expansion of wind energy in recent years, with China contributing the largest share of this growth. By 2024, global installed capacity is expected to reach 1134.8 GW, with China accounting for 46.0% of total capacity and 39.7% of wind power generation (Energy Institute 2025), highlighting the increasing importance of wind power in achieving long-term sustainable development.

Despite its strategic importance, wind energy development is frequently hindered by social acceptance concerns, a factor central to the success or failure of renewable energy projects within the broader framework of social sustainability and energy governance. One of the most persistent challenges arises from the pronounced gap between socio-political acceptance and community acceptance (Wolsink 2007a). A well-established distinction exists between socio-political acceptance, which reflects general public support for wind energy at the societal level, and community acceptance, which concerns the attitudes of local residents living near wind farms (Wüstenhagen et al. 2007). Wind energy is generally perceived as having high acceptance at the socio-political level; however, concerns and opposition at the local community level persist (Nilson et al. 2024). This divide frequently hinders the approval, siting, and long-term operation of wind power projects (Rodríguez-Segura et al. 2023). With the rapid development of the wind power industry in China, challenges similar to those in other countries have emerged. Increasing concerns from local communities, such as noise, bird strikes, weather-related effects, and visual landscape changes (Guo et al. 2015; McKenna et al. 2025), have led to declining community acceptance and hindered project deployment globally (Guan and Zepp 2020; Müller et al. 2023).

Several theoretical perspectives have been proposed to explain the lower community acceptance. Earlier work often relied on the "Not In My Backyard" (NIMBY) phenomenon (Olve et al. 2025; Wolsink 2000), while later research pointed to deeper tensions between global climate benefits and local concerns, the so-called "Green-on-Green" conflict (Warren et al. 2005). Other explanations emphasize place attachment (Devine-Wright 2007), and procedural and distributive justice concerns (Wolsink 2007b). These perspectives provide important insights into the origins of the acceptance gap.

Despite extensive research on wind energy acceptance, existing studies are fragmented and case-specific, restricting comparability and offering only partial insights into the socio-political–community acceptance gap (Sonnberger and Ruddat 2017). Moreover, many studies have focused on the direct relationships between various influencing factors and wind energy acceptance (Schmidt et al. 2024). Evidence on mediating effects and interaction pathways remains limited, despite growing academic recognition of their importance (Mustafa et al. 2023). These gaps are particularly evident in China, where empirical research remains scarce (Nie et al. 2024; Yuan et al. 2015). Such shortcomings highlight the need for more systematic analysis of acceptance differences and offer meaningful entry points into issues of governance, participation, and social trust, key themes in sustainable development.

Building on these considerations, this work examines the mechanisms underlying the socio-political–community acceptance gap of wind energy in Dalian, China. To develop an integrative analytical perspective, we extend the Technology Acceptance Model (TAM) by incorporating the benefit–risk evaluation framework and key elements from the Theory of Planned Behavior (TPB), enabling perceived benefits, perceived risks, and social–psychological factors to be analyzed within a unified structure. Questionnaire surveys were conducted among the general public (socio-political acceptance) and local residents living near wind farms (community acceptance). Using partial least squares structural equation modeling (PLS-SEM) and multigroup analysis (MGA), we compare acceptance patterns and the determinants shaping them across groups. Accordingly, this study addresses two research questions: RQ1: Do socio-political and community acceptance of wind energy in Dalian differ significantly? RQ2: What key factors explain these differences, particularly through perceived benefits and perceived risks?

This study contributes to the growing literature on wind energy acceptance in two main ways. First, it provides rare empirical evidence from China by directly comparing socio-political and community acceptance within the same regional context, offering a more consistent basis for understanding the acceptance gap. Second, it reveals this gap as a structurally embedded benefit–risk asymmetry and demonstrates how benefit–risk perceptions and other psychological, social, institutional, and spatial factors shape acceptance differently across groups, generating practical insights for energy governance and socially sustainable wind energy development.

The subsequent sections are structured as follows: Section 2 reviews the relevant literature and presents the hypotheses and conceptual model. Section 3 outlines the methods. Section 4 reports the analytical results. Section 5 offers an in-depth discussion of the findings. Finally, Section 6 concludes the study.

2 | Literature Review

2.1 | Theoretical Background

2.1.1 | Social Acceptance

Social acceptance refers to positive attitudes of social groups toward a situation or object, encompassing cognition, emotion, and behavior (Huijts et al. 2012). Some studies distinguish acceptance as an attitudinal outcome from acceptability as a broader evaluative process (Fournis and Fortin 2016). The present study follows the prevailing usage of acceptance, given our focus on group-level attitudes and behavioral intentions toward wind energy. Within renewable energy research, social acceptance is widely seen as crucial to renewable energy project success and to socially sustainable energy governance (Ellis et al. 2023).

Wüstenhagen et al. (2007) categorize social acceptance into socio-political, community, and market dimensions. Socio-political acceptance refers to support for a technology or associated policy at the societal or national level, where the acceptance subjects are the general public, key stakeholders, and political actors. Community acceptance concerns attitudes toward specific local projects, where the acceptance subjects are local residents and stakeholders who are directly affected by the project. Market acceptance focuses on how companies, investors, and consumers evaluate the technology products or related services (Dermont et al. 2017). This study centers on the first two dimensions, which differ clearly in their subjects, scale, and concerns.

During the 1980s, social acceptance received little attention due to widespread public support. However, as local concerns became more visible in the 1990s, community resistance increasingly emerged (Biresselioglu et al. 2024). Although socio-political support is generally high, community acceptance remains challenging. Such societal-level endorsement does not necessarily translate into support for specific wind farm projects, which often face local opposition and implementation barriers (Kraft and Kraft 2025). This persistent gap warrants closer examination.

2.1.2 | Explanations for the Acceptance Gap

Early explanations for the socio-political–community acceptance gap were largely grounded in the NIMBY phenomenon, which attributes local resistance to opposition against developments located near residential areas (Wolsink 2000). However, NIMBY has been widely criticized for overlooking deeper motivations and contextual factors (Bell et al. 2013), with some studies even reporting contrary patterns (Langer et al. 2018). Subsequent research introduced perspectives such as democratic deficit and conditional support, offering more nuanced accounts (Bell et al. 2005).

Other scholars emphasize tensions between global climate benefits and local environmental or landscape concerns, known as the "Green-on-Green" conflict (Warren et al. 2005). Place-based perspectives argue that wind farms may threaten valued environments, reducing acceptance among residents with strong place attachment (Devine-Wright and Howes 2010). Fairness-based studies emphasize procedural and distributive justice, noting that while society benefits, local residents bear concentrated risks (Wolsink 2007b).

More recent work develops multidimensional frameworks encompassing cognitive evaluations, affective and social–psychological factors, and spatial–experiential conditions (Leiren et al. 2020). Kluskens et al. (2024) further conceptualize community acceptance as a dynamic social process shaped by multiple factors. Despite varying terminology, findings consistently show that social, psychological, and contextual drivers jointly shape acceptance differences (Langer et al. 2016).

Existing studies are often case-specific and rarely compare socio-political and community acceptance within a unified framework and context, especially in China. These shortcomings highlight the need for a more systematic and integrative comparison.

2.1.3 | Theoretical Framework

Building on the theoretical perspectives outlined above, this study develops an integrative framework to clarify how multiple cognitive, social, and contextual pathways shape the gap between socio-political and community acceptance, thereby enabling more targeted and effective policy insights for sustainable energy governance (Borch et al. 2020). Drawing on the TPB adapted for the TAM (Huijts et al. 2012; Wong et al. 2024), acceptance is conceptualized as the outcome of cognitive evaluations and socio-psychological processes, into which we incorporate the benefit–risk evaluation approach identifying perceived benefits and risks as core determinants (Guo and Ren 2017; Raj et al. 2025). Following the perspective that acceptance is formed by balancing benefits and risks (Lind et al. 2025), this research theorizes them as key mediating mechanisms.

In line with established explanations such as the NIMBY and the Green-on-Green conflict, the framework further incorporates key determinants shaping acceptance: affective imagery, environmental concern, and perceived knowledge (psychological factors); subjective norms, participation, and social trust (social and institutional factors); place attachment, distance to wind turbines, and experiential familiarity (spatial and experiential factors); and broader energy attitudes—nuclear acceptance (contextual factors). Integrating these elements into a unified benefit–risk structure reflects the multidimensional nature of acceptance and provides a coherent theoretical basis for explaining the socio-political–community acceptance gap.

2.2 | Hypothesis Development

2.2.1 | Perceived Benefits and Perceived Risks

Definitions of all constructs used in this research are provided in Table 1, which summarizes the conceptual foundations for the subsequent hypotheses. As highlighted in prior research, perceived benefits (PB) and perceived risks (PR) constitute two central evaluative dimensions through which individuals form judgments about wind energy. In this study, they are conceptualized as key mediating mechanisms linking broader factors to acceptance of wind energy (AW).

Specifically, perceived benefits cover economic compensation and financial incentives for affected residents (Hübner et al. 2023), positive ecological impacts (Dugstad et al. 2023), and broader benefits to the community or society (Brannstrom et al. 2022).

Similarly, perceived risks encompass health risks resulting from operational noise and shadow flicker (Karasmanaki 2022; Peri et al. 2020); environmental risks such as vegetation damage and threats to wildlife (Tsagkari et al. 2022); landscape risks associated with visual intrusion or scenic degradation (Weinand et al. 2022); and accident-related risks, such as fire, structural failure, and falling ice (Rastayesh et al. 2019; You et al. 2023).

As consistently demonstrated in previous studies (see Table A1), perceived benefits and risks exert significant positive and negative effects, respectively, on wind energy acceptance (Linzenich et al. 2020; Park et al. 2024). Accordingly, the following hypotheses are proposed:

H1. *PB positively influences AW.*

H2. *PR negatively influences AW.*

2.2.2 | Social, Psychological, and Spatial Determinants

Beyond perceived benefits and risks, various social, psychological, and spatial determinants have been shown to influence public evaluations of wind energy. Their conceptual definitions are summarized in Table 1. The following section develops hypotheses for each determinant based on the integrative framework outlined earlier, and the overall conceptual model is shown in Figure 1.

TABLE 1 | Definitions and associated hypotheses of each construct.

Construct	Definition	Hypotheses
Perceived benefits (PB)	Individuals' beliefs about the positive effects and advantages of wind energy (Fishbein and Ajzen 1975; Park et al. 2024).	H1: PB positively influences AW.
Perceived risks (PR)	Individuals' concerns about the negative effects or potential hazards of wind energy (Fishbein and Ajzen 1975; Linzenich et al. 2020).	H2: PR negatively influences AW.
Affective imagery (AI)	Positive or negative emotional associations that individuals spontaneously generate in response to wind energy (Leiserowitz and Smith 2017; Lundheim et al. 2022). AI captures intuitive emotional responses that may operate independently of cognition and influence judgment and decision-making (Asutay and Västfjäll 2024).	H3a: AI positively influences PB. H3b: AI negatively influences PR.
Distance to wind turbine (DW)	Distance between each residence and the nearest wind turbine.	H4a: DW positively influences PB. H4b: DW negatively influences PR.
Environmental concern (EC)	Degree to which individuals are aware of environmental problems and are willing to contribute personal effort to environmental protection, including the concern for ecosystems and the preservation of flora and fauna (Li et al. 2024).	H5a: EC positively influences PB. H5b: EC negatively influences PR.
Experience (EX)	Prior direct experience with wind energy facilities, such as having observed or toured wind farms (Langer et al. 2016; Leiren et al. 2020).	H6a: EX positively influences PB. H6b: EX negatively influences PR.
Place attachment (PA)	Multifaceted emotional bond that people establish with specific locations such as their place of residence (Dugstad et al. 2023; Low and Altman 1992).	H7a: PA positively influences PB. H7b: PA positively influences PR.
Perceived knowledge (PK)	Individual's self-assessment of their understanding of wind energy technologies (Szakály et al. 2021).	H8a: PK positively influences PB. H8b: PK negatively influences PR.
Participation (PT)	Involvement in planning, development, or other processes related to wind energy (Ruddat 2022).	H9a: PT positively influences PB. H9b: PT negatively influences PR
Subjective norms (SN)	Degree to which an individual's behavior is influenced by expectations of other individuals deemed important when making decisions (Ajzen 1991; Gamel et al. 2022).	H10a: SN positively influences PB. H10b: SN negatively influences PR.
Social trust (ST)	Public's willingness to rely on institutions, organizations, or individuals responsible for making decisions in wind energy field (Otto et al. 2023; Sonnberger and Ruddat 2017).	H11a: ST positively influences PB. H11b: ST negatively influences PR.
Acceptance of nuclear energy (AN)	Degree of public support for the use of nuclear energy (Ellis and Ferraro 2016).	H12: AN is negatively correlated with AW.

Abbreviations: AI—affective imagery; AN—acceptance of nuclear energy; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

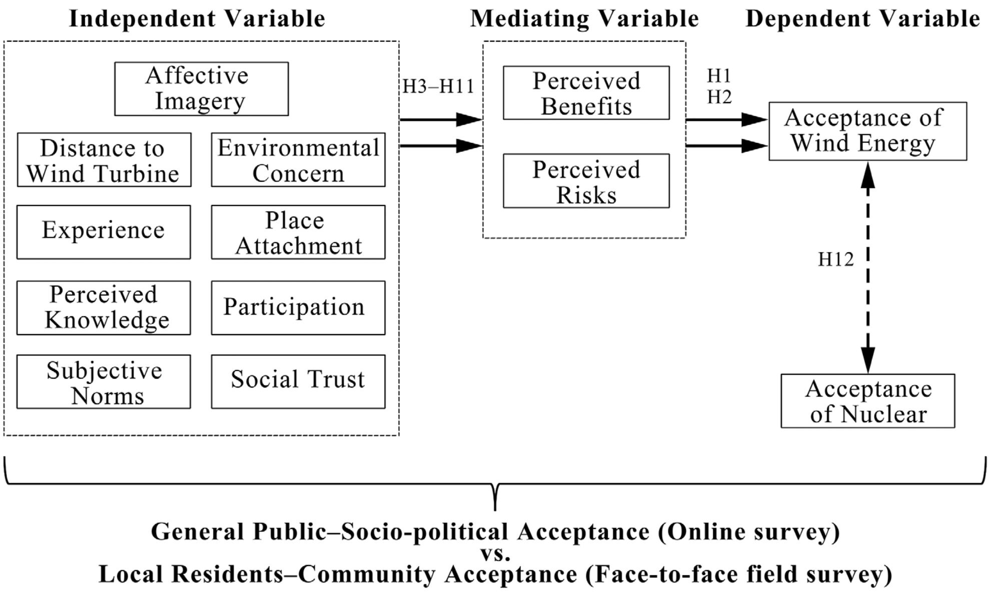

FIGURE 1 | Conceptual model. H1–H12—hypotheses 1–12. H1–H11: structural paths (PLS-SEM) and H12: correlation analysis only (non-structural).

Affective imagery (AI) reflects intuitive, emotion-based associations with wind energy. Positive imagery enhances perceived benefits, such as climate advantages or technological modernity, while also reducing perceived risks by framing wind farms as low-impact and socially desirable (Cousse et al. 2020; Ruddat 2022). Thus,

H3a. *AI positively influences PB.*

H3b. *AI negatively influences PR.*

Distance to wind turbine (DW) is grounded in NIMBY explanations, as closer proximity increases exposure to noise, visual intrusion, or shadow flicker (Pouta et al. 2024). Greater distance reduces these disturbances and enables individuals to recognize broader project benefits, such as community development and environmental improvements, without experiencing local drawbacks (Caggiano et al. 2024). In some cases, place-based identity linked to the wind farms may emerge, contributing to higher acceptance (Firestone et al. 2015). Accordingly,

H4a. *DW positively influences PB.*

H4b. *DW negatively influences PR.*

Environmental concern (EC) typically increases sensitivity to climate and ecological issues. Individuals with stronger concern tend to emphasize environmental benefits (lower carbon emissions, improved local air quality), while to some extent understanding or overlooking the limited negative impacts of wind energy (Čábelková et al. 2022; Lindvall et al. 2024). Therefore,

H5a. *EC positively influences PB.*

H5b. *EC negatively influences PR.*

Experience (EX) with wind farms can shape acceptance through familiarization and direct exposure. Such exposure may highlight tangible or perceived benefits, such as improved local infrastructure. Direct experience may also reduce exaggerated concerns by revealing the limited extent of negative impacts (Langer and Wooliscroft 2018; le Maitre et al. 2024). However, negative experiences may reinforce risk perceptions (Dugstad et al. 2020). These variations often stem from project-specific conditions and types (Ladenburg 2014). Given this,

H6a. *EX positively influences PB.*

H6b. *EX negatively influences PR.*

Place attachment (PA) shapes acceptance depending on how well a wind energy project aligns with the community's identity and values (Mjahed Hammami and Abdulrahman Al Moosa 2021). It can operate through two mechanisms. Strong attachment may heighten sensitivity to landscape change and thereby increase perceived risks (Dugstad et al. 2023; Fischhendler et al. 2021). Furthermore, strong attachment may also enhance recognition of community-level benefits when projects align with local identity or deliver visible improvements (Klok et al. 2023). Thus,

H7a. *PA positively influences PB.*

H7b. *PA positively influences PR.*

Perceived knowledge (PK) increases cognitive certainty and reduces ambiguity when evaluating wind energy. Most studies suggest that higher knowledge levels are associated with more accurate assessments of benefits and lower perceptions of risks (Langer and Wooliscroft 2018; Szakály et al. 2021), although some research reports non-significant or context-dependent effects (Pambudi et al. 2025; Siegrist and Cvetkovich 2000). Accordingly,

H8a. *PK positively influences PB.*

H8b. *PK negatively influences PR.*

Participation (PT) shapes acceptance through informational and procedural mechanisms. Meaningful participation enables the public to better understand the actual benefits and risks of wind projects, reducing misconceptions and unnecessary concerns while enhancing perceptions of procedural fairness and strengthening cooperation between developers and local communities (Karakislak et al. 2023; le Maitre et al. 2023; Shen and Tai 2024). Although poorly designed processes may undermine acceptance, the overall effect of participation is strongly quality-dependent (Hübner et al. 2023; Langer et al. 2017). Therefore,

H9a. *PT positively influences PB.*

H9b. *PT negatively influences PR.*

Subjective norms (SN), central to the TPB (Ajzen 1991), capture perceived social pressure or approval from important others. Individuals are more likely to support wind projects when they perceive support among important peers or reference groups (Hübner et al. 2023; Liobikienė et al. 2021). Conversely, perceiving widespread opposition or risk concerns may lead individuals to adopt similar views to avoid social conflict (Karakislak et al. 2023). The strength and direction of subjective norms effects vary across cultural and social contexts (Chan et al. 2022). Given this, the following hypotheses are proposed.

H10a. *SN positively influences PB.*

H10b. *SN negatively influences PR.*

Social trust (ST) is widely conceptualized as an institutional cue (Siegrist and Cvetkovich 2000), closely linked to perceptions of fairness and justice (Dwyer and Bidwell 2019; Hou et al. 2019). Some scholars argue that trust incorporates fairness perceptions (Caferra et al. 2021), whereas others view it as an outcome of perceived procedural and distributive fairness (Marlin-Tackie et al. 2020). Bates et al. (2025) further suggest that public discussions of "fairness" often implicitly reference trust. Building on these insights, this study conceptualizes social trust as a key institutional proxy construct capturing procedural and distributive fairness in wind energy governance. When individuals trust developers and public authorities to manage planning and operations responsibly, they are more likely to expect fair benefit distribution (Siitonen et al. 2024), and effective risk mitigation (Ruddat 2022; Vallejos-Romero et al. 2020). Accordingly,

H11a. *ST positively influences PB.*

H11b. *ST negatively influences PR.*

Finally, acceptance of nuclear energy (AN) represents a broader attitudinal context. Nuclear energy is often regarded as distinct from other renewables due to its stability and higher accident risks (Lindvall et al. 2025). It is sometimes viewed as a technological alternative to wind energy, potentially competing for public support (Desvallées and Arnauld De Sartre 2023). The relationship between nuclear energy acceptance and wind energy acceptance may be shaped by local media narratives (Bally and Sebi 2025). Although empirical evidence remains limited, the directional association is meaningful for comparative energy-attitude research. Therefore, the following hypotheses are proposed.

H12. *AN is negatively correlated with AW.*

3 | Methodology and Materials

3.1 | Data Collection

This study was conducted in Dalian, Liaoning Province, China, a major wind power base in northern China and the location of the country's largest nuclear power plant. Dalian simultaneously features extensive wind energy deployment and long-established onshore wind farms, which makes it an informative context for examining acceptance patterns in the present study. The target population included the general public of Dalian and local residents living near wind farms, corresponding respectively to socio-political acceptance and community acceptance as commonly defined in the literature. Data were gathered through online and field (face-to-face) surveys utilizing the same questionnaires with standardized wording, minimizing measurement differences. Studying both groups within the same socio-cultural and regulatory environment permits a meaningful comparison of acceptance pathways while holding contextual factors constant.

Locations in Dalian and the selected wind farm sites for the case study are shown in Figure 2. This study was reviewed and approved by the ethics committee of the authors' affiliated institution (Permit No. 2023088) and ensured informed consent, data confidentiality, and the right to withdraw at any time.

The online survey, conducted via Wenjuanxing (wjx.com), targeted the general public of Dalian City. It employed randomized respondent selection within the platform's panel database, which supports the diversity and broad coverage of the sample. Wenjuanxing is a widely used professional survey platform in China and has been employed in numerous academic studies due to its high data credibility and validity (Ding et al. 2024; Wang, Gu, et al. 2024). To ensure that only Dalian residents participated, the platform restricted responses to users whose Internet Protocol addresses were located in the city. Because the general public is geographically dispersed and mostly not directly exposed to wind farm impacts, an online survey provides an efficient and appropriate means of capturing socio-political acceptance. Although the online survey sample was skewed toward younger and more highly educated respondents (Lindholm et al. 2024), this does not compromise the study's focus on explaining acceptance mechanisms.

The field survey targeted residents living near wind farms. Two onshore wind farms, Tuoshan and Dabeishan, were selected as case studies because of their similar unit capacities and > 10 years of operation. The Tuoshan Wind Farm comprises three phases, and this study focused on phases 1 and 2. A comprehensive face-to-face household survey was conducted in all 15 villages within a 1-km radius of the wind farms. Residents within this distance are directly exposed to noise, visual dominance, and other impacts; thus, face-to-face visits ensured accurate identification of households and improved response reliability among elderly or less digitally connected residents. Figure 3 shows a detailed map of the wind farms and surveyed villages.

Although the online and field modes differ, both modes correspond to the characteristics of the two acceptance groups and are commonly used in mixed-mode social science survey research (Bianchi et al. 2017; Fogg-Rogers et al. 2024; Renoth et al. 2023). Whereas previous studies such as Sonnberger and Ruddat (2017) used different items to measure socio-political and community acceptance, this study deliberately employed identical items for both groups to ensure conceptual equivalence and to avoid confounding substantive differences with measurement differences. This approach facilitates direct comparison between the two groups and aligns with established multigroup structural modeling practices, which emphasize maintaining measurement invariance for meaningful cross-group comparisons.

3.2 | Model Specification and Questionnaire Design

Building on the conceptual foundation, the structural model specifies the relationships among the measured constructs. In the structural model, affective imagery, distance to wind turbines, environmental concern, experience, place attachment, perceived knowledge, participation, subjective norms, and social trust are treated as independent variables; perceived benefits and perceived risks serve as mediating variables; and acceptance of wind energy is the dependent variable. Acceptance of nuclear energy is included as an external attitudinal variable reflecting broader contextual conditions. The model structure is consistent with the theoretical relationships and hypotheses developed for this research, and identical measurement items were applied to both groups to maintain conceptual comparability for multigroup analysis.

Based on the conceptual model, this study revised specific questions by referencing previous studies to finalize the questionnaire design (Table A2). These studies share the same

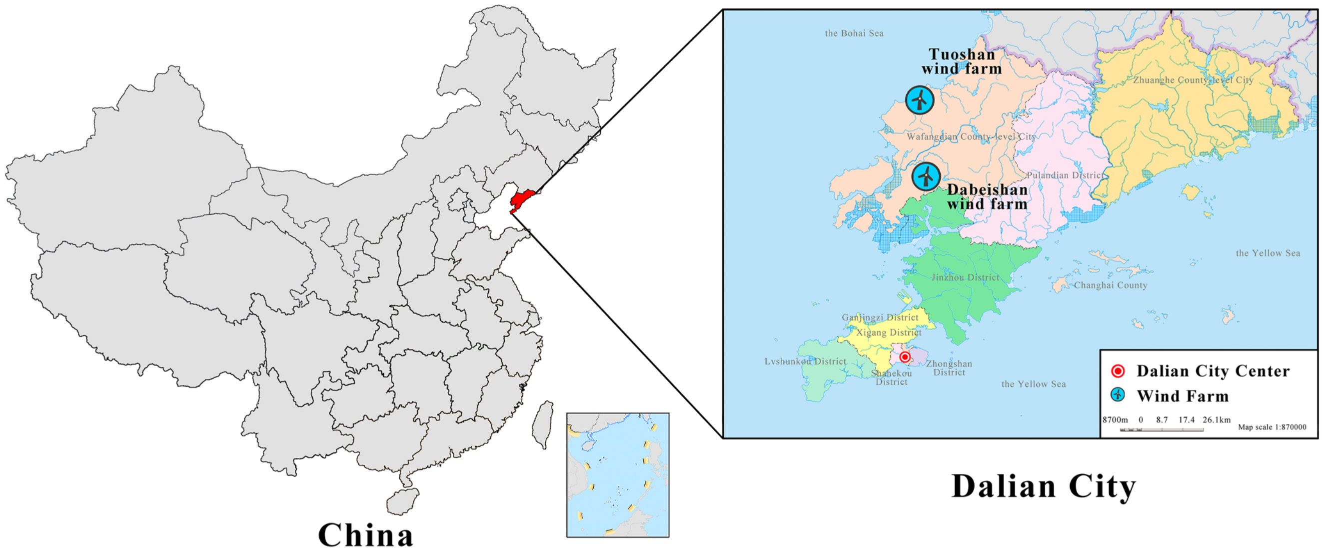

FIGURE 2 | Location of Dalian City.

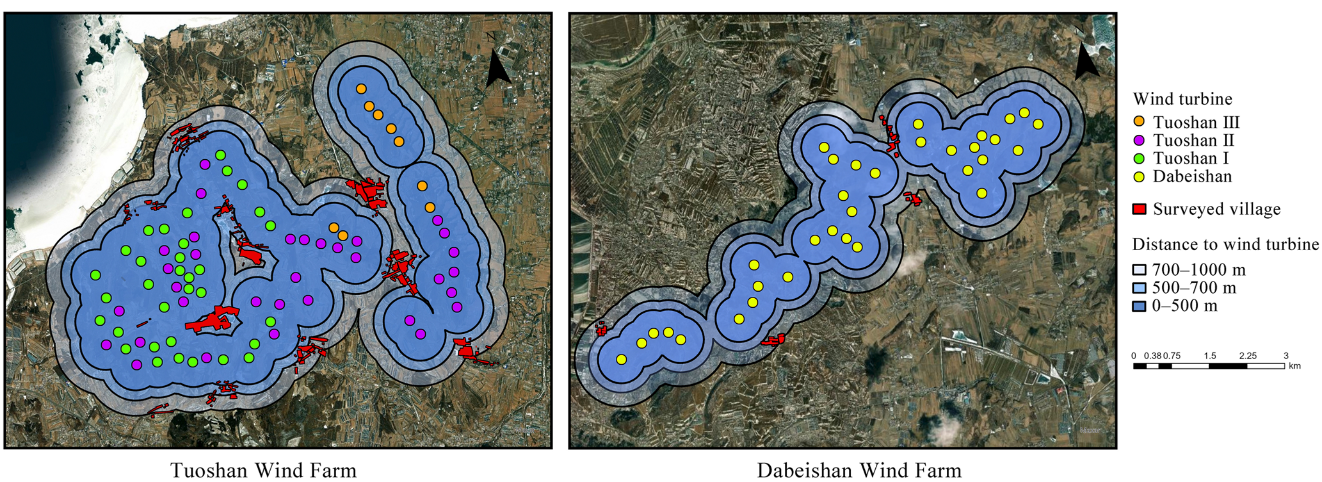

FIGURE 3 | Detailed map of the wind farm and surveyed villages.

conceptual definitions as those used in the present study. Several constructs were measured using single-item indicators due to their clearly defined meanings, a practice widely accepted when constructs are narrow in scope and easily interpretable by respondents (Bergkvist and Rossiter 2009; Hair et al. 2022). The final questionnaire consisted of three parts. The first part collected demographic information of respondents and distance from their residence to the nearest wind turbine. This distance was directly measured in the online survey, whereas it was accurately measured using geographic information systems in the field survey. In the subsequent analysis, distances were coded from 1 to 7, representing nearest–farthest. The second part assessed attitudes of respondents toward wind energy using a five-point Likert scale, where 1 = strongly disagree and 5 = strongly agree. The third part consisted of an open-ended question in which respondents could freely express their concerns and opinions.

To ensure the quality of the questionnaire, the research team conducted a pilot test with five Dalian residents after completing the initial design. Based on their feedback, the wording and sequence of questionnaire items were adjusted to improve readability and validity.

3.3 | Data Analysis

Survey data were analyzed using SPSS 29.0 and SmartPLS 4.0.9.8, employing the following methods:

1. Descriptive statistical analysis: Descriptive and frequency analysis were conducted to summarize the distribution of demographic variables and acceptance levels, providing a basic overview of sample characteristics for both groups.
2. Correlation analysis: Correlation analysis using Pearson correlation coefficients was performed to examine the linear associations between acceptance of nuclear energy and perceived benefits, perceived risks, wind energy acceptance (AN–PB/PR/AW). This provided preliminary descriptive insight to support model interpretation, without implying causality.
3. PLS-SEM: PLS-SEM is a variance-based structural equation modeling method used to assess relationships between variables. Compared to covariance-based structural equation modeling (CB-SEM), PLS-SEM is better suited for analyzing complex models, accommodating latent variables with only one or two indicators, does not necessitate normally distributed input data, and is ideal for exploratory and predictive research (Hair et al. 2011, 2022; Henseler et al. 2009; Urbach and Ahlemann 2010). This method is widely applied in research fields such as management and social sciences (Dash and Paul 2021). Given the number of constructs in the present model, the presence of single-item indicators, and the need to estimate multiple mediating pathways, PLS-SEM provides advantages over CB-SEM, particularly regarding measurement identification and prediction-oriented analysis. A single-sample Kolmogorov–Smirnov test further indicated that the data were not normally distributed (Oliveira et al. 2016). Considering these factors collectively, including the model's complexity, mixed-indicator structure, multi-step mediating relationships, and non-normal data, PLS-SEM was deemed the most appropriate analytical method for this study.
4. Nonparametric partial least squares MGA: This method was used to assess whether significant differences existed in the path coefficients influencing wind energy acceptance between the general public and local residents.

4 | Results

4.1 | Descriptive Statistics

The online survey was conducted from August 11 to November 8, 2023, and the field survey was conducted from August 23 to September 3, 2023. Following the surveys, four criteria were used to screen unreliable data, drawing on previous research (Lehmann et al. 2021; Schlereth and Skiera 2017; Schonlau and Toepoel 2015): (1) responses with excessive extreme answers; (2) no variance in attitude questions or multiple "don't know" responses; (3) logical inconsistencies; and (4) meaningless answers in the open-ended question.

After screening, 342 valid responses were obtained from 395 online questionnaires, with an effective response rate of 86.6%, and 362 valid responses were obtained from 482 field questionnaires, with an effective response rate of 75.1%. The sample size meets the minimum requirements of the inverse square root method (Kock and Hadaya 2018).

4.1.1 | Demographics

Table 2 presents the demographic characteristics of the general public and local residents. Overall, the gender distribution was balanced in both groups. Respondents from the general public were younger, with 91.8% < 46 years of age, whereas 93.1% of local residents were ≥ 46 years of age, reflecting the common age skew toward younger respondents in online surveys. Regarding education, 99.1% of the general public held an education level above junior high school, compared to 95.6% of local residents with junior high school education or below. Regarding annual income, 67% of the general public earned > 60,000 RMB (≈USD 8450) annually, whereas 89.7% of local residents earned < 60,000 RMB. Electricity costs were higher among the general public, with 60.0% spending > 50 RMB (≈USD 7) monthly, whereas 54.4% of local residents spent < 50 RMB monthly. Regarding employment, 84.2% of the general public and 99.2% of the local residents had no work related to wind energy. Additionally, 50.9% of the general public had lived in the area for > 10 years, compared to 97.8% of local residents.

4.1.2 | Respondents' Acceptance

As shown in Figure 4, 95.9% of the general public and 64.9% of local residents held neutral, supportive, or strongly supportive

TABLE 2 | Demographics and distance to wind turbine.

Characteristics	Items	General public $N = 342$		Local residents $N = 362$	
		Frequency	Percentage	Frequency	Percentage
Gender	Male	161	47.1%	195	53.9%
	Female	181	52.9%	167	46.1%
Age	< 18 years	5	1.5%	3	0.8%
	18–30 years	149	43.5%	6	1.7%
	31–45 years	160	46.8%	16	4.4%
	46–60 years	24	7.0%	120	33.1%
	> 60 years	4	1.2%	217	60.0%
Education level	Junior high and below	3	0.9%	346	95.6%
	Senior High school	21	6.1%	15	4.1%
	Junior college	39	11.4%	1	0.3%
	Bachelor's degree	234	68.4%	0	0.0%
	Master or above	45	13.2%	0	0.0%
Annual income	< RMB 10,000	26	7.6%	121	33.4%
	RMB 10,000–30,000	36	10.5%	116	32.0%
	RMB 30,000–60,000	51	14.9%	88	24.3%
	RMB 60,000–100,000	79	23.1%	31	8.6%
	RMB 100,000–150,000	90	26.3%	6	1.7%
	> RMB 150,000	60	17.6%	0	0.0%
Electricity costs	< RMB 20	10	2.9%	6	1.7%
	RMB 20–35	49	14.3%	28	7.7%
	RMB 36–50	67	19.6%	163	45.0%
	RMB 51–75	93	27.2%	91	25.1%
	> RMB 75	112	32.8%	43	11.9%
	Unknown	11	3.2%	31	8.6%
Whether work related to wind energy	Unrelated	288	84.2%	359	99.2%
	Family-related	37	10.8%	2	0.5%
	Self-related	15	4.4%	0	0.0%
	Both self and family-related	2	0.6%	1	0.3%
Residence time	< 6 months	14	4.1%	1	0.3%
	0.5–1 year	21	6.1%	0	0.0%
	1–3 years	38	11.1%	0	0.0%
	3–5 years	41	12.0%	0	0.0%
	5–10 years	54	15.8%	7	1.9%
	> 10 years	174	50.9%	354	97.8%

(Continues)

TABLE 2 | (Continued)

Characteristics	Items	General public $N=342$		Local residents $N=362$	
		Frequency	Percentage	Frequency	Percentage
Distance to wind turbine	0.3–0.5 km	0	0.0%	34	9.4%
	0.5–0.7 km	0	0.0%	137	37.8%
	0.7–1.0 km	0	0.0%	166	45.9%
	1–2 km	4	1.2%	25	6.9%
	2–5 km	22	6.4%	0	0.0%
	5–10 km	42	12.3%	0	0.0%
	> 10 km	274	80.1%	0	0.0%

Note: Exchange rate for reference: 1 USD ≈ 7.1 RMB.

attitudes toward existing wind power plants. Regarding further development of wind energy, 98.0% of the general public and 85.1% of local residents shared this view. Regarding mean values, all acceptance scores exceeded three, indicating neutrality or higher, except for local residents' acceptance of existing wind power plants (2.98). Additionally, the Mann–Whitney U tests for both acceptance types showed p values <0.001, indicating significantly higher acceptance among the general public than among local residents.

4.1.3 | Correlation Analysis

To situate acceptance of nuclear energy within the broader attitudinal context, a Pearson correlation analysis was conducted. As shown in Table 3, in both the general public and local resident samples, acceptance of nuclear energy is positively associated with perceived benefits and acceptance of wind energy and negatively associated with perceived risks. All correlations are statistically significant ($p<0.001$), indicating that the empirical results do not support the expectation stated in H12.

4.2 | PLS-SEM Results

Based on this conceptual model, we employed PLS-SEM to build models for hypothesis testing. To ensure a comprehensive assessment, the same analytical model was estimated separately for two groups: the online survey sample representing the general public and the field survey sample representing local residents.

Following the recommendations of Hair et al. (2022), the PLS-SEM results were analyzed in two steps. The first step involved establishing a measurement model and assessing its validity and reliability. The second step entailed establishing a structural model to assess the hypothesized relationships among latent variables, explained variance, effects, and other related metrics.

4.2.1 | Measurement Model Assessment

To evaluate the reliability and validity of the measurement model, we first assessed the internal consistency reliability and convergent validity using factor loadings (FL), Cronbach's alpha (CA), composite reliability (CR), and average variance extracted (AVE). The results, shown in Table 4, indicated that all FL, CA, and CR values exceeded the recommended threshold of 0.7, and AVE values exceeded the recommended threshold of 0.5 (Hair et al. 2022), confirming that the measurement model had strong reliability and convergent validity.

This study assessed discriminant validity using the Fornell–Larcker criterion (Fornell and Larcker 1981) and Heterotrait–Monotrait ratio (Henseler et al. 2015). The square root of the AVE of each construct exceeded its correlations with other constructs, and all Heterotrait–Monotrait ratios were <0.85 (Tables A3 and A4), confirming that all the constructs were discriminant. The maximum variance inflation factor values for the general public and local resident samples were 2.327 and 1.819, respectively, both well below the recommended threshold of 3 (Hair et al. 2019), indicating no significant multicollinearity.

Additionally, to address potential common method bias from collecting data solely through questionnaires, Harman's one-factor test was conducted following established recommendations (Fuller et al. 2016; Kock et al. 2021). The results showed that a single factor explained 24.1% and 26.9% of the variance for the general public and local resident samples, both well below the 50% threshold (Podsakoff et al. 2003), indicating minimal common method bias.

4.2.2 | Structural Model Assessment

Second, guided by the theoretical model, we assessed the structural paths and tested the hypotheses. A bootstrapping resampling method with 5000 resamples was used to provide reliable statistical inferences regarding the significance, direction, and strength of the paths within the model (Hair et al. 2022). Effect sizes (f^2) were assessed following the criteria of Henseler et al. (2009), where 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

As shown in Table 5 and Figure 5, the general public sample aligned with the hypothesized benefit–risk structure, where perceived benefits significantly positively affected wind energy acceptance (medium effect), while perceived

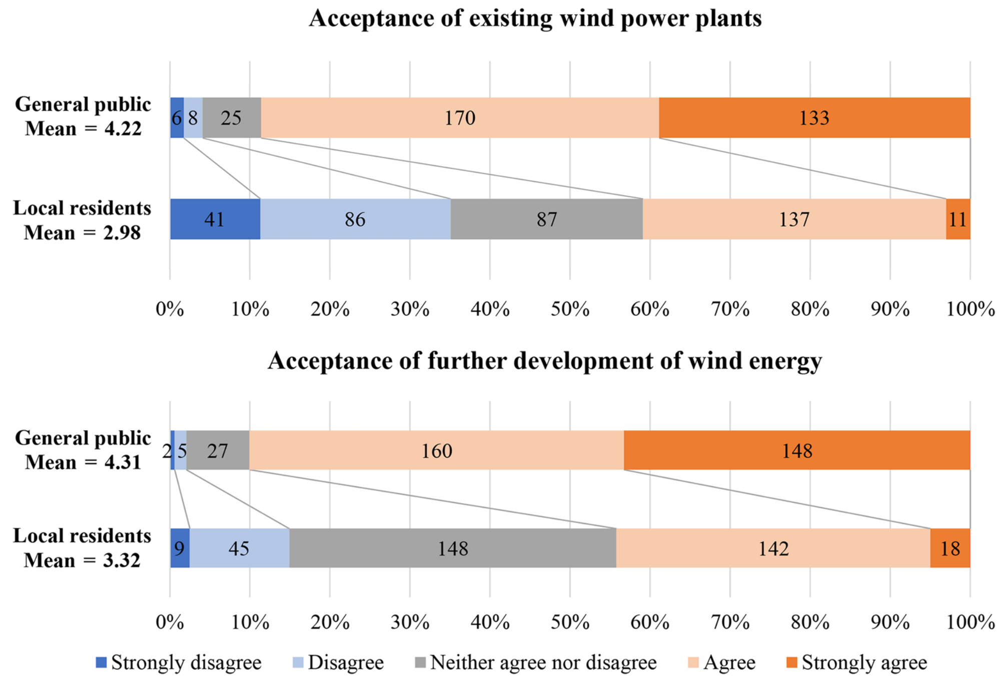

FIGURE 4 | Acceptance of wind energy.

TABLE 3 | Pearson correlations between acceptance of nuclear energy and key variables.

	General public ($N=342$)		Local residents ($N=362$)	
Construct	**Pearson *r***	***p***	**Pearson *r***	***p***
PB–AN	0.219	0.000	0.239	0.000
PR–AN	−0.225	0.000	−0.286	0.000
AW–AN	0.237	0.000	0.337	0.000

Note: Pearson correlation coefficients are reported.
Abbreviations: AN—acceptance of nuclear energy; AW—acceptance of wind energy; PB—perceived benefits; PR—perceived risks.

risks significantly negatively affected wind energy acceptance (small effect). These results showed that higher perceived benefits and lower perceived risks promoted acceptance. Affective imagery, environmental concern, subjective norms, and social trust all significantly positively affected perceived benefits, with social trust showing a medium effect and the others small effects. Place attachment significantly positively affected perceived risks (small effect), whereas subjective norms and social trust significantly negatively affected perceived risks (small effects). These results suggested that, for the general public, wind energy acceptance increased when social trust, environmental concern, and affective imagery enhanced perceived benefits.

Therefore, H1, H2, H3a, H5a, H7b, H10a, H10b, H11a, and H11b were supported in the general public sample. Although participation significantly positively affected perceived risks, with a small effect, the relationship was contrary to the hypothesis; hence, H9b was rejected in the general public sample. Other hypotheses were rejected because of the insignificance of the path relationships.

For the local residents, perceived benefits significantly positively affected wind energy acceptance (medium effect), while perceived risks significantly negatively affected acceptance (medium effect), showing similar benefit–risk pathways to the general public, albeit with varying effect sizes. However, the antecedents of perceived benefits and risks differed. Affective imagery, participation, and social trust significantly positively affected perceived benefits, with social trust showing a medium effect and the others small effects. Affective imagery, distance to wind turbine, and social trust significantly negatively affected perceived risks (small effects). These results demonstrated that, for local residents, wind energy acceptance increased when affective imagery, participation, and social trust enhanced perceived benefits, and when affective imagery, distance to wind turbine, and social trust reduced perceived risks.

Therefore, hypotheses H1, H2, H3a, H3b, H4b, H9a, H11a, and H11b were supported in the local resident sample. Although environmental concern significantly negatively affected perceived benefits, environmental concern and subjective norms significantly positively affected perceived risks. These relationships were contrary to the hypotheses; therefore, H5a, H5b, and H10b were rejected in the local residents sample. Other hypotheses were rejected because of the insignificance of the path relationships.

To further examine the cognitive mechanisms proposed in the framework, Table 6 presents the indirect effects on wind energy acceptance. For the general public, significant mediation occurred only via perceived benefits (AI → PB → AW, EC → PB → AW, SN → PB → AW, ST → PB → AW), and paths mediated by perceived risks were not significant. For local residents, both perceived benefits and perceived risks mediated multiple relationships, highlighting marked differences in the way the two groups related perceived benefits and perceived risks to wind energy acceptance.

TABLE 4 | Reliability and validity of measurement model.

		General public					Local residents				
Construct	Item	Mean	FL	CA	CR	AVE	Mean	FL	CA	CR	AVE
AI	—	4.436	1.000	1.000	1.000	1.000	3.536	1.000	1.000	1.000	1.000
AW	AW1	4.216	0.861	0.720	0.876	0.780	2.975	0.918	0.720	0.875	0.778
	AW2	4.307	0.905				3.318	0.845			
DW	—	6.713	1.000	1.000	1.000	1.000	2.503	1.000	1.000	1.000	1.000
EC	—	4.544	1.000	1.000	1.000	1.000	3.693	1.000	1.000	1.000	1.000
EX	—	3.775	1.000	1.000	1.000	1.000	4.917	1.000	1.000	1.000	1.000
PA	—	4.670	1.000	1.000	1.000	1.000	4.207	1.000	1.000	1.000	1.000
PB	PB1	3.819	0.731	0.713	0.838	0.633	2.069	0.816	0.728	0.846	0.647
	PB2	4.205	0.844				2.707	0.791			
	PB3	4.208	0.808				2.572	0.807			
PK	—	3.547	1.000	1.000	1.000	1.000	1.467	1.000	1.000	1.000	1.000
PR	PR1	2.646	0.818	0.856	0.902	0.698	3.075	0.748	0.776	0.855	0.596
	PR2	2.497	0.873				3.213	0.804			
	PR3	2.541	0.814				3.646	0.812			
	PR4	2.541	0.834				3.003	0.719			
PT	—	2.006	1.000	1.000	1.000	1.000	1.528	1.000	1.000	1.000	1.000
SN	—	3.939	1.000	1.000	1.000	1.000	3.942	1.000	1.000	1.000	1.000
ST	ST1	4.257	0.899	0.720	0.877	0.781	2.890	0.928	0.803	0.910	0.835
	ST2	4.152	0.867				2.912	0.899			

Abbreviations: AI—affective imagery; AVE—average variance extracted; AW—acceptance of wind energy; CA—Cronbach's alpha; CR—composite reliability; DW—distance to wind turbine; EC—environmental concern; EX—experience; FL—factor loading; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

This study also evaluated the model's explanatory and predictive quality using the coefficient of determination (R^2), Q^2 values from the blindfolding test ($Q^2 = 1 - \mathrm{SSE/SSO}$), and the out-of-sample Q^2_predict values obtained through PLSpredict. According to previous studies (Chin 1998; Henseler et al. 2009), R^2 indicates the degree of variance explained by each endogenous construct, with values ranging from 0 to 1; higher R^2 values indicate stronger explanatory power, with R^2 values of 0.67, 0.33, and 0.19 considered substantial, moderate, and weak, respectively. As shown in Table 7, the explanatory power of the endogenous variables across the various sample groups was generally between weak and moderate levels. Only the R^2 value for perceived risks in the general public sample was relatively low; however, it still exceeded the acceptable threshold of 0.1 (Falk and Miller 1992). Additionally, all Q^2 and Q^2_predict values were >0, confirming acceptable predictive relevance and satisfactory out-of-sample predictive performance (Hair et al. 2019; Shmueli et al. 2019).

To evaluate the goodness-of-fit of the model, the standardized root mean square residual was calculated, yielding values of 0.056 for the general public sample and 0.072 for the local resident sample, both below the recommended threshold of 0.08 (Henseler et al. 2014). These results provided sufficient evidence for the model's applicability.

4.2.3 | Multigroup Analysis

This study employed two nonparametric MGA methods, Henseler's MGA (Henseler et al. 2015) and permutation tests (Rasoolimanesh et al. 2016), to assess group differences at the 5% significance level. Following recommended procedures (Henseler et al. 2016), invariance testing was conducted beforehand and confirmed partial invariance, allowing meaningful multigroup comparison. As shown in Table 8, both methods consistently identified significant differences in the following paths: PR → AW, AI → PR, DW → PR, EC → PB, EC → PR, PA → PR, PT → PB, PT → PR, SN → PB, and SN → PR. These results highlighted substantial variations in the way in which benefit and risk perceptions shaped acceptance across the two groups.

5 | Discussion

5.1 | Empirical Foundations of the Acceptance Gap

Building on the conceptual model and empirical results, this study compared the determinants of wind energy acceptance across socio-political and community contexts. Consistent with prior evidence that community acceptance diverges from socio-political acceptance (Sonnberger and Ruddat 2017), our results

TABLE 5 | Direct effects.

Hypothesis	Path	General public					Local residents				
		β	t	p	Decision	f^2	β	t	p	Decision	f^2
H1	PB → AW	0.462	7.738	0.000	Supported	0.273	0.390	9.799	0.000	Supported	0.222
H2	PR → AW	−0.118	2.192	0.028	Supported	0.018	−0.411	10.861	0.000	Supported	0.246
H3a	AI- > PB	0.175	3.076	0.002	Supported	0.042	0.257	5.378	0.000	Supported	0.078
H3b	AI → PR	0.048	0.876	0.381	Rejected	0.002	−0.280	6.161	0.000	Supported	0.102
H4a	DW → PB	0.031	0.623	0.533	Rejected	0.001	0.051	1.022	0.307	Rejected	0.003
H4b	DW → PR	0.115	1.890	0.059	Rejected	0.011	−0.128	3.030	0.002	Supported	0.024
H5a	EC → PB	0.145	3.206	0.001	Supported	0.030	−0.156	2.955	0.003	Rejected	0.024
H5b	EC → PR	0.000	0.008	0.994	Rejected	0.000	0.197	4.120	0.000	Rejected	0.043
H6a	EX → PB	0.029	0.449	0.654	Rejected	0.001	−0.007	0.210	0.834	Rejected	0.000
H6b	EX → PR	−0.043	0.682	0.495	Rejected	0.001	0.036	1.221	0.222	Rejected	0.002
H7a	PA → PB	−0.054	1.211	0.226	Rejected	0.004	−0.049	0.932	0.351	Rejected	0.003
H7b	PA → PR	0.152	2.799	0.005	Supported	0.023	−0.023	0.485	0.627	Rejected	0.003
H8a	PK → PB	−0.004	0.071	0.944	Rejected	0.000	−0.051	1.266	0.206	Rejected	0.003
H8b	PK → PR	−0.021	0.367	0.713	Rejected	0.000	0.046	0.975	0.330	Rejected	0.001
H9a	PT → PB	0.018	0.426	0.670	Rejected	0.000	0.218	3.847	0.000	Supported	0.061
H9b	PT → PR	0.227	3.939	0.000	Rejected	0.056	0.035	0.713	0.476	Rejected	0.002
H10a	SN → PB	0.221	4.335	0.000	Supported	0.067	−0.020	0.445	0.656	Rejected	0.001
H10b	SN → PR	−0.159	2.980	0.003	Supported	0.025	0.113	2.865	0.004	Rejected	0.020
H11a	ST → PB	0.370	5.978	0.000	Supported	0.159	0.378	7.148	0.000	Supported	0.164
H11b	ST → PR	−0.242	3.987	0.000	Supported	0.049	−0.336	7.196	0.000	Supported	0.143

Abbreviations: AI—affective imagery; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; H1–H11—hypotheses 1–11; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

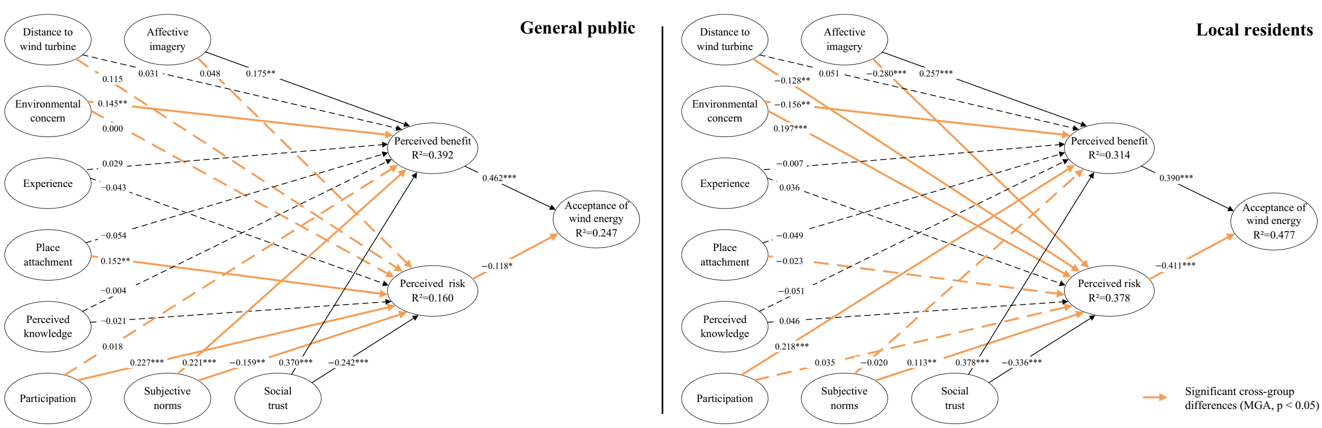

FIGURE 5 | Results of the partial least squares (PLS) algorithm (path significance: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; bold orange lines indicate significant cross-group differences based on multigroup analysis, $p < 0.05$).

indicate that local residents in Dalian exhibit significantly lower acceptance than the general public. Nevertheless, both groups expressed generally positive attitudes, aligning with previous studies conducted in China (Guo et al. 2015; Yuan et al. 2015).

Across the general public and local residents samples, a clear divergence emerges in how individuals evaluate wind energy. In both groups, perceived benefits enhanced wind energy acceptance and perceived risks reduced it, consistent with

TABLE 6 | Indirect effects on acceptance of wind energy.

Path	General public			Local residents		
	β	t	p	β	t	p
AI → PB → AW	0.081	3.024	0.003	0.100	4.781	0.000
AI → PR → AW	−0.006	0.746	0.456	0.115	4.934	0.000
DW → PB → AW	0.014	0.618	0.537	0.020	1.000	0.317
DW → PR → AW	−0.014	1.409	0.159	0.053	2.973	0.003
EC → PB → AW	0.067	2.785	0.005	−0.061	2.993	0.003
EC → PR → AW	0.000	0.007	0.994	−0.081	4.056	0.000
EX → PB → AW	0.013	0.450	0.653	−0.003	0.208	0.835
EX → PR → AW	0.005	0.578	0.564	−0.015	1.206	0.228
PA → PB → AW	−0.025	1.192	0.233	−0.019	0.923	0.356
PA → PR → AW	−0.018	1.823	0.068	0.009	0.483	0.629
PK → PB → AW	−0.002	0.070	0.944	−0.020	1.251	0.211
PK → PR → AW	0.002	0.334	0.739	−0.019	0.970	0.332
PT → PB → AW	0.008	0.428	0.669	0.085	3.696	0.000
PT → PR → AW	−0.027	1.879	0.060	−0.014	0.703	0.482
SN → PB → AW	0.102	3.676	0.000	−0.008	0.441	0.659
SN → PR → AW	0.019	1.676	0.094	−0.046	2.797	0.005
ST → PB → AW	0.171	4.218	0.000	0.148	5.110	0.000
ST → PR → AW	0.028	1.825	0.068	0.138	5.623	0.000

Abbreviations: AI—affective imagery; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

TABLE 7 | Results of R^2, Q^2, and Q^2_predict.

Construct	General public					Local residents				
	R^2	SSO	SSE	Q^2	Q^2_predict	R^2	SSO	SSE	Q^2	Q^2_predict
PB	0.392	1026	798.636	0.222	0.347	0.314	1086	888.048	0.182	0.275
PR	0.160	1368	1232.492	0.099	0.109	0.378	1448	1148.487	0.207	0.345
AW	0.247	684	560.721	0.180	0.165	0.477	724	465.107	0.358	0.408

Abbreviations: AW—acceptance of wind energy; PB—perceived benefit; PR—perceived risk.

previous studies (le Maitre et al. 2024; Wüstenhagen et al. 2007). However, the strength of these effects and the contributions of other determinants, such as affective imagery, distance, environmental concern, participation, subjective norms, and social trust, differ substantially between groups. These cross-group differences indicate that wind energy acceptance is shaped by multiple perceptual and contextual influences rather than by a single dominant factor (Kluskens et al. 2024).

The multigroup analysis further confirms significant heterogeneity in several explanatory pathways, especially the path linking perceived risks to acceptance. Overall, these empirical patterns demonstrate that the socio-political–community acceptance gap stems from deeper variation in evaluative processes, a point further elaborated in the following section.

5.2 | Benefit–Risk Asymmetry as the Core Mechanism

Consistent with earlier findings (Ruddat 2022), our results also indicate that the gap in acceptance between the general public and local residents can be traced to systematic differences in how benefits and risks are evaluated. Although perceived benefits and risks exhibit the same directional effects across both groups, their formation and weighting differ substantially. This imbalance constitutes the primary mechanism underpinning the socio-political–community acceptance gap.

For the general public, perceived benefits were relatively high and perceived risks lower, with benefits exerting a stronger effect on acceptance. This pattern reflects the asymmetrical

TABLE 8 | Multigroup analysis results: General public versus local residents.

Hypothesis	Path	Path difference	Henseler's MGA *p* value	Permutation test *p* value	Significant difference yes/no
H1	PB → AW	0.071	0.321	0.180	No
H2	PR → AW	0.293	0.000	0.000	Yes
H3a	AI → PB	−0.082	0.273	0.128	No
H3b	AI → PR	0.327	0.000	0.000	Yes
H4a	DW → PB	−0.020	0.771	0.795	No
H4b	DW → PR	0.243	0.001	0.028	Yes
H5a	EC → PB	0.301	0.000	0.000	Yes
H5b	EC → PR	−0.197	0.005	0.003	Yes
H6a	EX → PB	0.036	0.622	0.541	No
H6b	EX → PR	−0.080	0.257	0.338	No
H7a	PA → PB	−0.006	0.937	0.894	No
H7b	PA → PR	0.175	0.016	0.007	Yes
H8a	PK → PB	0.047	0.464	0.414	No
H8b	PK → PR	−0.067	0.366	0.486	No
H9a	PT → PB	−0.200	0.006	0.000	Yes
H9b	PT → PR	0.192	0.012	0.016	Yes
H10a	SN → PB	0.241	0.000	0.000	Yes
H10b	SN → PR	−0.272	0.000	0.000	Yes
H11a	ST → PB	−0.008	0.923	0.892	No
H11b	ST → PR	0.095	0.215	0.275	No

Abbreviations: AI—affective imagery; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; H1–H11—hypotheses 1–11; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

nature of benefit–risk evaluations (Slovic 1987). Public benefit perceptions tend to be abstract and framed at the societal level, drawing on broad expectations of climate mitigation and national energy goals (Jami and Walsh 2017), which makes perceived benefits more salient. By contrast, risk perceptions are inherently concrete, experience-based, and tied to potential site-specific disturbances (Ho et al. 2022). However, as the public typically resides far from wind farms, these risks lack personal relevance and are therefore evaluated more diffusely (Caporale et al. 2024). Their evaluations are shaped more by media discourse and institutional narratives than by direct experience, reinforcing benefit-oriented judgments as the dominant basis of acceptance. This tendency aligns with previous findings (Gökçay and Baypınar 2025) and helps explain occasionally weak risk effects in public samples (Bronfman et al. 2012).

Local residents exhibit an opposite pattern, with lower perceived benefits and higher perceived risks, and the two constructs exert moderate and relatively balanced effects on acceptance. Residents' judgments are shaped by place-based experiences, including landscape changes, noise, shadow flicker, construction disturbance, and perceived uncertainties related to long-term operation; several residents mentioned a previous turbine fire in the area. These experiential inputs heighten the salience and personal relevance of risk, making risks more influential for residents, in line with prior work on community acceptance (Lee and Roh 2025; Sonnberger and Ruddat 2017). Moreover, divergences in perceived benefits may stem from limited awareness of potential advantages or skepticism shaped by social or psychological factors (Roh et al. 2019). Some residents reported that although the construction improved local roads, increased maintenance traffic imposed additional burdens, prompting doubts about net community benefits. Others expressed disappointment about the absence of more tangible gains such as lower electricity costs.

Collectively, the benefit–risk asymmetry reflects a structural condition in which benefits are national while risks are local (Sanchez Nieminen and Laitinen 2025), generating the "Green-on-Green" tension described in earlier studies (Warren et al. 2005). The general public and local residents thus develop contrasting evaluative profiles, with the former perceiving more benefits and fewer risks, the latter experiencing the opposite. When residents face higher risks and fewer benefits, the behavioral cost of support increases, consistent with the low-cost hypothesis (Diekmann and Preisendörfer 2003), resulting in substantially lower acceptance and thereby reinforcing the socio-political–community gap. These findings underscore that benefit–risk evaluations are not symmetric constructs but context-dependent cognitive processes shaped by experiential, spatial, and governance conditions.

5.3 | Divergent Psychological and Social Pathways

Beyond benefit–risk evaluations, several psychological and social determinants also contribute to the gap between socio-political and community acceptance. These factors shape wind energy judgments through distinct group-specific pathways.

Affective imagery played an important role for both groups but operated through different pathways. Among residents, it influenced both perceived benefits and perceived risks, reflecting emotional responses grounded in direct experience (Cousse et al. 2020). For the public, affective imagery enhanced perceived benefits only. This pattern suggests that individuals distant from wind farms rely more on symbolic associations of wind energy, such as modernity or environmental friendliness, than on concrete impressions of site-specific impacts (Truelove 2012), highlighting the ambiguity of public risk judgments.

Distance exhibited limited influence among the general public, consistent with evidence that impacts are generally negligible beyond 2 km (le Maitre et al. 2024), where most public respondents resided. In contrast, distance significantly affected acceptance among local residents through perceived risks. Shorter distances heightened awareness of noise and other localized impacts, aligning with prior findings on proximity and perceived hazard (Pouta et al. 2024). This finding partially supports the NIMBY phenomenon, suggesting that it applies mainly within the immediate impact zone of wind farms (San Martin 2023).

Environmental concern produced particularly strong cross-group contrasts. Among the public, higher environmental concern increased perceived benefits only, reflecting an understanding shaped largely by societal narratives on carbon reduction and climate mitigation. In contrast, local residents associated environmental concern with both lower perceived benefits and higher perceived risks, consistent with their direct awareness of ecological and landscape disturbances from wind farm construction and operation. This divergence reinforces the Green-on-Green conflict (Warren et al. 2005).

Place attachment affected only the general public, with higher attachment increasing perceived risks but not reducing acceptance. This suggests that stronger attachment heightens general sensitivity to potential disturbances even among those far from wind farms (Dugstad et al. 2023), yet such abstract concerns are unlikely to meaningfully affect overall support. In contrast, among residents, whose benefit–risk evaluations are shaped primarily by concrete site-specific experiences, emotional bonds to place may exert only minimal influence.

Participation also displayed significant cross-group divergence. Among the public, participation increased perceived risks only, suggesting that engagement exposed individuals to information about potential disturbances, consistent with their generally vague risk perceptions. In contrast, among residents, participation increased perceived benefits and ultimately supported acceptance, indicating greater awareness of economic or infrastructural gains (Brannstrom et al. 2022). However, participation did not reduce perceived risks, implying that current engagement processes were unsatisfactory and may be insufficiently responsive to site-specific concerns (Maqbool et al. 2022).

Subjective norms influenced acceptance asymmetrically across groups, reflecting a fundamentally different social milieu (Ajzen 1991). Among the general public, stronger subjective norms bolstered perceived benefits, reflecting social endorsement of renewable energy transitions. For local residents, subjective norms increased perceived risks, indicating that community-level conversations amplify concerns about local impacts more than they reinforce broader environmental expectations.

Overall, these patterns demonstrate that the psychological and social foundations of acceptance differ substantially across groups, underscoring the importance of local context in interpreting acceptance differences.

5.4 | Governance: Trust, Fairness, and Justice

Beyond individual factors, governance conditions provide a deeper structural explanation for the socio-political–community acceptance gap. In this study, social trust, conceptualized as a proxy for perceived fairness and justice, substantially shaped perceived benefits and risks in both groups. Lower trust among residents limited acceptance and signaled underlying concerns regarding procedural and distributive justice. These results correspond to the trust–acceptability model (Bronfman et al. 2012) and align with classic theories emphasizing that acceptance barriers stem from institutional fairness concerns, namely who participates in decision-making, who receives the benefits, and who bears the risks (Devine-Wright 2007; Wolsink 2007a).

Although the projects examined in the present study complied with China's environmental impact assessment requirements by making project documents publicly available and conducting consultation, local residents expressed limited awareness of consultation procedures, uncertainty about compensation, and doubts about whether their concerns were genuinely considered. This suggests that participation opportunities were not fully accessible in practice. This gap highlights a mismatch between what procedures mandate and how they are experienced, a distinction widely emphasized in sustainability governance research (AlHares 2025; Wolsink 2007b). Such institutional mismatch reflects both informational shortcomings and unequal decision-making power among developers, authorities, and affected communities, which in turn intensifies the asymmetry in benefit–risk evaluations.

Under the Chinese institutional context, participation tends to be consultative rather than deliberative (Huang et al. 2020), and information does not always reach communities, meaning that trust cannot be assumed from formal procedures alone. These findings underscore the importance of more substantive, accessible participation processes (Liu et al. 2023), and align with the goals of strengthening inclusive, sustainable communities (SDG11) and enhancing institutional transparency and credibility (SDG16).

5.5 | Cultural and Energy-System Context

The positive correlation between acceptance of nuclear and wind energy contrasts with earlier findings (Desvallées and Arnauld De Sartre 2023), where nuclear energy is generally not viewed as a climate solution (Sonnberger et al. 2021). In China, however, both are framed as essential clean-energy options within the national energy transition (SCIO 2024). This shared framing may generate perception spillover (Westlake et al. 2023), whereby support for one technology strengthens acceptance of another. The public also views nuclear energy as reducing pollution and climate impacts (Su et al. 2024). Thus, the wind–nuclear relationship reflects institutional narratives shaped by China's cultural and policy context.

5.6 | Non-Significant Factors and Implications

Experience and perceived knowledge were non-significant for both groups, suggesting that short-term exposure to wind farms does not meaningfully shape acceptance, contrary to earlier findings (Langer and Wooliscroft 2018). The absence of knowledge effects indicates that respondents' attitudes were shaped primarily by emotions, trust, and contextual cues. This aligns with evidence showing that personal knowledge often plays only a limited role in benefit and risk judgments (Siegrist and Cvetkovich 2000).

6 | Conclusions and Policy Implications

6.1 | Conclusion

This study aims to examine whether and why socio-political and community acceptance of wind energy differ within the same regional context. Drawing on 704 online and field-survey responses from Dalian, China, this research applies PLS-SEM with multigroup analysis to comparatively examine socio-political acceptance (general public) and community acceptance (local residents) of wind energy. Although both groups express overall support, community acceptance is significantly lower than socio-political acceptance, confirming a systematic acceptance gap.

The acceptance gap is fundamentally driven by asymmetry in benefit–risk evaluations rooted in the nationalization of benefits and the localization of risks. This structural pattern further shapes psychological appraisal, with benefits perceived as abstract and socially constructed and risks as concrete and experience-based. For the general public, perceived benefits outweigh diffuse risks and primarily drive acceptance. Affective imagery, environmental concern, subjective norms, and social trust enhance acceptance mainly by amplifying perceived benefits, reflecting that socio-political acceptance is shaped largely by symbolic representations and social endorsement.

For local residents, by contrast, perceived benefits and risks exert comparable effects on acceptance, indicating a more risk-sensitive evaluative structure. Affective imagery, participation, distance to turbines, and social trust jointly shape acceptance through both benefit and risk pathways. Residents' judgments are shaped by direct experience of noise and construction disturbance, which heightens risk salience while limiting the visibility of tangible community-level benefits, thereby reinforcing lower community acceptance.

Moreover, social trust consistently shapes benefit–risk evaluations across both groups, highlighting its central institutional role in linking governance performance to acceptance. Cross-group differences in trust perception indicate that acceptance depends on transparent and inclusive governance, while institutional mismatches intensify benefit–risk asymmetries. Additionally, the positive association between nuclear and wind energy acceptance further reflects the influence of broader national energy-policy narratives.

Overall, this study advances understanding of the socio-political–community acceptance gap by revealing how structurally unequal distributions of benefits and risks, together with differentiated psychological and institutional conditions, generate systematically divergent acceptance outcomes. By adopting a multi-level and multidimensional analytical framework, the findings strengthen the linkage between acceptance and sustainability governance and provide insight for designing more transparent, inclusive, and socially sustainable wind energy policies.

6.2 | Policy Implications

Effective policies must address the mechanisms underlying the socio-political–community gap. Firstly, communication should be tailored to different groups. Public-facing messages should emphasize the broader benefits of wind energy and its links to climate mitigation and national energy security. For residents, communication must be concrete, transparent, and broadly accessible, providing clear information on noise, ecological impacts, and compensation procedures, and in formats suitable for less advantaged groups. Across both groups, clarifying limited risks and ensuring clear and continuous regulatory oversight are essential for building trust (SDG7, SDG13, SDG16).

Enhancing tangible and equitably distributed local benefits is essential. Current one-off land compensation provides limited satisfaction. Long-term benefit-sharing mechanisms, such as reduced electricity tariffs for nearby villages or the allocation of part of project revenues to local public services and infrastructure, can strengthen community resilience and reduce inequalities (SDG9, SDG10, SDG11).

Risk-mitigation measures should be more substantive. Project planning should account for noise, visual disturbance, and ecological sensitivity from the outset, with greater setbacks from residential areas or support for community-level mitigation. These actions can promote more livable and sustainable local environments (SDG11, SDG12, SDG15).

Finally, participation should move from consultative to more deliberative forms. Accessible, well-communicated, and substantive engagement, paired with visible feedback mechanisms, can translate formal procedures into genuine trust and fairness (SDG11, SDG16). Together, these measures strengthen social legitimacy and support socially sustainable wind-energy transitions.

6.3 | Limitations

Several limitations should be considered when interpreting these findings. First, the study draws on a single case city within China's institutional context. Future research can employ multi-site or cross-national designs to enhance external validity and obtain more generalizable conclusions. In addition, although identical questionnaires were used, differences between online and field surveys may introduce sampling bias.

Moreover, some constructs were measured with single-item indicators. While conceptually clear and common in exploratory acceptance research, this approach limits measurement richness, and future studies can adopt multi-item scales. Additionally, social trust captures perceived institutional quality and procedural fairness, and future research can incorporate more direct justice measures.

Finally, the model did not examine potential interrelationships among independent variables, which may offer deeper insights into the mechanisms shaping public acceptance.

Author Contributions

Kaiqi Liu: conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review and editing, funding acquisition. **Shigeo Nishikizawa:** methodology, data curation, writing – review and editing, supervision, funding acquisition. **Takehiko Murayama:** writing – review and editing, supervision. **Kultip Suwanteep:** writing – review and editing, supervision. **Qiao Yu:** methodology, writing – review and editing. **Wei Zhang:** writing – review and editing.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix A

TABLE A1 | Summary of literature supporting the hypotheses.

Hypotheses	Previously supported?	Key references	Notes
H1	Supported	(Brannstrom et al. 2022; Hübner et al. 2023)	Relationships between PB, PR, and AW are well-established.
H2	Supported	(Ruddat 2022; Sonnberger and Ruddat 2017)	
H3a	Supported	(Cousse et al. 2021, 2020; Lienert et al. 2017)	Positive AI enhances PB, whereas negative AI amplifies PR. AI significantly influences AW.
H3b	Supported	(Cousse et al. 2021, 2020; Lundheim and Löfström 2025)	
H4a	Mixed	(Caggiano et al. 2024; Guo et al. 2015)	Prior studies have reported positive, negative, and non-significant relationships between DW and AW.
H4b	Mixed	(Konisky et al. 2020; Langer et al. 2018; Pouta et al. 2024)	
H5a	Unclear	(Langer and Wooliscroft 2018)	Prior studies have supported a positive association between EC and AW, although the relationships with PB and PR remain inconclusive.
H5b	Unclear	(Lindvall et al. 2024; Yuan et al. 2015)	
H6a	Mixed	(Ladenburg 2014; le Maitre et al. 2024)	Prior studies have reported positive and negative relationships between EX and AW.
H6b	Mixed	(Dugstad et al. 2020; Langer and Wooliscroft 2018)	
H7a	Supported	(Mjahed Hammami and Abdulrahman Al Moosa 2021)	PA simultaneously enhances both perceived PB and PR.
H7b	Supported	(Devine-Wright and Wiersma 2020; Dugstad et al. 2023)	
H8a	Mixed	(Langer and Wooliscroft 2018; Shen et al. 2019; Siegrist and Cvetkovich 2000)	Most prior studies support that PK positively influences AW by enhancing PB and reducing PR, although few studies reported no significant associations between PK and either PB or PR.
H8b	Mixed	(Linzenich et al. 2020; Pambudi et al. 2025; Siegrist and Cvetkovich 2000)	
H9a	Mixed	(Hübner et al. 2023; Langer et al. 2017; le Maitre et al. 2023)	Prior studies support that PT positively influences AW by enhancing PB and reducing PR, although poorly managed participation may have the opposite effect.
H9b	Mixed	(Firestone et al. 2018; Langer et al. 2018; Ruddat 2022; Zhang et al. 2025)	
H10a	Mixed	(Chan et al. 2022; Hübner et al. 2023; Karakislak et al. 2023)	Prior studies reported positive, negative, and non-significant relationships between SN and AW.
H10b	Mixed	(Bozorgparvar et al. 2018; Chan et al. 2022; Liobikienė et al. 2021)	
H11a	Supported	(Ruddat 2022; Siitonen et al. 2024)	ST positively influences AW by enhancing PB and reducing PR.
H11b	Supported	(Ruddat 2022; Vallejos-Romero et al. 2020)	
H12	Supported	(Desvallées and Arnauld De Sartre 2023; Greenberg 2009; Lindvall et al. 2025)	Nuclear and wind energy are perceived as partially substitutable energy sources, and individual preferences for nuclear energy may affect AW.

Abbreviations: AI—affective imagery; AN—acceptance of nuclear energy; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; H1–H12—hypotheses 1–12; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

Appendix B

TABLE B1 | Questionnaire measurement items.

Construct	Full question	Source
AW	I support the wind farm currently operating in my community.	(Brannstrom et al. 2022)
	I support the further development of wind energy in Dalian.	
PB	I believe I can get economic benefits from wind farms.	(Sonnberger and Ruddat 2017)
	I believe wind farms can promote local development.	
	I believe wind farms can improve the local ecological environment.	
PR	I worry about the negative impact on my health due to wind farms.	(Brannstrom et al. 2022; Guo and Ren 2017)
	I worry about the environmental damage caused by the construction and operation of wind farms.	
	I worry about the landscape destruction caused by wind farms.	
	I worry about accidents occurring at wind farms.	
AI	Wind energy leaves me a positive impression when mentioned it.	(Cousse et al. 2020)
AN	I support the nuclear power plant currently operating in Dalian.	(Brannstrom et al. 2022)
	I support the further development of nuclear energy in Dalian.	
DW	What is the distance from your residence to the nearest wind turbine?	(Langer et al. 2018)
EC	I care about environmental issues.	(Guo et al. 2015)
EX	I have already visited wind farms.	(Langer and Wooliscroft 2018)
PA	I feel a strong sense of belonging to this area.	(Dugstad et al. 2023)
PK	I know a lot about wind power technology.	(Langer and Wooliscroft 2018)
PT	I participated in the consultation process for the wind farms.	(Brannstrom et al. 2022)
SN	The support for wind energy from people around me has motivated me to support wind energy.	(Hübner et al. 2023)
ST	I trust the government's planning and regulation of wind farms.	(Sonnberger and Ruddat 2017)
	I trust energy companies to operate and manage wind farms.	

Abbreviations: AI—affective imagery; AN—acceptance of nuclear energy; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

Appendix C

TABLE C1 | Discriminant validity: Fornell–Larcker criterion.

Constructs	AI	AW	DW	EC	EX	PA	PB	PK	PR	PT	SN	ST
General public												
AI	1.000											
AW	0.245	0.883										
DW	−0.090	−0.044	1.000									
EC	0.243	0.188	−0.076	1.000								
EX	0.165	0.177	0.327	0.141	1.000							
PA	0.265	0.253	−0.039	0.285	0.156	1.000						
PB	0.361	0.483	−0.063	0.304	0.202	0.165	0.796					
PK	0.177	0.121	−0.243	0.053	0.356	0.106	0.166	1.000				
PR	−0.033	−0.203	0.137	−0.027	−0.009	0.074	−0.184	−0.078	0.835			
PT	0.039	0.032	−0.045	0.087	0.230	0.038	0.109	0.215	0.169	1.000		
SN	0.198	0.310	−0.021	0.186	0.155	0.148	0.416	0.177	−0.207	0.095	1.000	
ST	0.319	0.406	−0.201	0.236	0.228	0.258	0.530	0.245	−0.255	0.129	0.369	0.884
Local residents												
AI	1											
AW	0.492	0.882										
DW	0.015	0.227	1									
EC	0.218	−0.131	−0.086	1								
EX	0.074	−0.071	−0.107	0.305	1							
PA	0.226	0.027	−0.016	0.419	0.149	1						
PB	0.32	0.591	0.105	−0.177	−0.057	−0.049	0.805					
PK	0.055	0.004	−0.07	0.184	0.105	0.194	−0.016	1				
PR	−0.344	−0.601	−0.233	0.245	0.15	0.023	−0.488	0.067	0.772			
PT	−0.001	−0.105	−0.191	0.188	0.187	0.094	0.095	0.198	0.18	1		
SN	−0.076	−0.084	−0.044	0.088	0.129	0.058	−0.065	0.022	0.186	0.088	1	
ST	0.29	0.607	0.194	−0.213	−0.112	−0.001	0.457	0.054	−0.499	−0.176	−0.065	0.914

Abbreviations: AI—affective imagery; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.

TABLE C2 | Discriminant validity: Heterotrait–Monotrait ratio.

Constructs	AI	AW	DW	EC	EX	PA	PB	PK	PR	PT	SN	ST
General public												
AI												
AW	0.281											
DW	0.090	0.049										
EC	0.243	0.222	0.076									
EX	0.165	0.204	0.327	0.141								
PA	0.265	0.297	0.039	0.285	0.156							
PB	0.408	0.654	0.076	0.356	0.243	0.188						
PK	0.177	0.140	0.243	0.053	0.356	0.106	0.204					
PR	0.042	0.254	0.149	0.029	0.047	0.086	0.219	0.084				
PT	0.039	0.040	0.045	0.087	0.230	0.038	0.142	0.215	0.185			
SN	0.198	0.362	0.021	0.186	0.155	0.148	0.489	0.177	0.221	0.095		
ST	0.375	0.558	0.240	0.281	0.270	0.300	0.728	0.291	0.323	0.151	0.436	
Local residents												
AI												
AW	0.585											
DW	0.015	0.265										
EC	0.218	0.143	0.086									
EX	0.074	0.077	0.107	0.305								
PA	0.226	0.077	0.016	0.419	0.149							
PB	0.374	0.802	0.153	0.208	0.128	0.058						
PK	0.055	0.061	0.070	0.184	0.105	0.194	0.038					
PR	0.392	0.765	0.250	0.271	0.162	0.042	0.650	0.074				
PT	0.001	0.124	0.191	0.188	0.187	0.094	0.105	0.198	0.190			
SN	0.076	0.092	0.044	0.088	0.129	0.058	0.082	0.022	0.204	0.088		
ST	0.320	0.778	0.211	0.239	0.125	0.008	0.592	0.056	0.611	0.194	0.072	

Abbreviations: AI—affective imagery; AW—acceptance of wind energy; DW—distance to wind turbine; EC—environmental concern; EX—experience; PA—place attachment; PB—perceived benefit; PK—perceived knowledge; PR—perceived risk; PT—participation; SN—subjective norms; ST—social trust.