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*Article*

# Assessing the Public's Social Acceptance of Renewable Energy Management in Taiwan

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**Abstract:** Renewable energy (RE) is one of the keys to achieving the global goal of net-zero carbon emissions by 2050. Understanding the factors influencing public participation behavior and social acceptance in RE management (REM) is thus essential to a sustainable energy transition embraced by communities and stakeholders. This study aims to assess nine indicators in REM across three dimensions of social acceptance through the public lens, employing an importance–performance analysis. Our findings reveal a significant gap between the perceived importance and performance of various REM components, suggesting dissatisfaction among respondents. Furthermore, the highest priority for improvement was given to the following strategies: "strengthening communication with residents", "reducing air pollution emissions from power plants", "establishing supervision and management mechanisms", and "building smart grid and power storage equipment" to ensure successful implementation of REM policies. We also found that respondents who were under 50 years of age, lived in Northern Taiwan, had a higher monthly income, and had a better awareness of social acceptance were more likely to participate in the energy transition. The insights gained from this study outline policy implications for improving the public's social acceptance and advancing the development of RE in Taiwan, contributing to the world's carbon-neutral mission.

**Keywords:** importance–performance analysis; public participation; renewable energy; social acceptance; sustainable development

## 1. Introduction

Renewable energy (RE) is recognized as a means for climate change mitigation and carbon emissions reduction. Unlike fossil fuels, RE sources such as solar, wind, hydro, geothermal, and biomass produce electricity without emitting greenhouse gases, which are major contributors to global warming and various environmental concerns such as water and air pollution and ozone depletion [1]. These sources are inexhaustible and abundant worldwide as they harness energy from natural processes that are continually replenished [2]. Increasing consumption of fossil fuels to meet the current energy needs has sparked concerns about an energy crisis. Many countries, including Taiwan, have invested in research on and application of renewable alternatives and technologies to achieve energy and climate objectives. Diversifying energy sources is especially critical to island nations as they are more prone to extreme weather events and often rely heavily on imported fossil fuels for electricity generation.

Taiwan is a small island country with over 97% of the energy supply coming from foreign fossil fuels [3]. As a result, it is facing a significant amount of greenhouse gas emissions [4]. In the past years, the Taiwanese government has implemented numerous policies and programs promoting RE

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development to increase energy dependence and flexibility, and reduce vulnerability to geopolitical tensions and price fluctuations. However, given the political determination and governmental pressure, additional obstacles have emerged during the implementation of numerous RE projects across the globe. While RE sources are often positively perceived by the public, their development has raised several environmental, social, and economic concerns [5,6], making social acceptance one of the greatest obstacles to a successful energy transition [7,8]. Research and debates on social acceptance have been growing exponentially in recent years [9,10], yet, issues regarding social acceptance remain difficult to address and require urgent actions on both global and regional scales if the 2050 net-zero emissions mission is to be attained.

Understanding the public's social acceptance and preference for RE development is thus crucial to achieving governmental policies and transitioning to cleaner and more sustainable alternative sources of energy [11]. However, literature regarding the social acceptance of RE development in Taiwan remains scant. Our study aims to identify factors influencing social acceptance of RE management (REM). First, we established the impact indicators of REM on the basis of the three dimensions of social acceptance. Second, we evaluated the public's perceptions of the social acceptance of REM using an importance–performance analysis (IPA). Finally, we measured the public's participation in REM on the basis of their socio-economic backgrounds. To our best knowledge, this study is the first to reflect in detail the assessment of the current management of RE within the country through the lens of the public and stakeholders involved. Although this study focuses on the case of Taiwan, its findings can be beneficial and applicable to other countries, especially smaller island nations with high populations and limited resources.

The paper is structured as follows: The second section provides a literature review that examines the three dimensions of social acceptance of RE, followed by an application of IPA within the context of RE. The third section introduces the case study and outlines the research methods and analyses employed. The fourth section presents the empirical results, while the fifth section engages in a detailed discussion of these results. Finally, the concluding section summarizes the key findings and their policy implications.

## 2. Literature Review

### *2.1. Social Acceptance of Renewable Energy*

Social acceptance is a complex and challenging phenomenon [12,13] that can be analyzed according to three dimensions: socio-political, market, and community acceptance [7,14]. In RE development projects, socio-political acceptance refers to the approval of technologies or regulations by local residents, policymakers, or other key stakeholders. Previous evidence on a global scale indicated a high public acceptance rate for RE innovations, particularly wind power and solar power, which misled policymakers and developers to neglect this crucial element when implementing RE programs [7]. However, problems indeed occurred once moving onto more local scales when siting decisions and investment took place. The lack of support for RE related policies from these actors has then become the main barrier to the implementation stage [7]. Such policies demand regulatory frameworks and standards that effectively support and boost both market and community acceptance [15] (e.g., the establishment of regulations to implement and promote RE and pollution control standards to ensure safety and efficiency), resulting in the ultimate achievement of the general social acceptance.

The second dimension of social acceptance, community acceptance, entails responses to the siting of specific RE projects or proposals by local communities where RE systems are installed. Every energy solution entails positive and negative social-ecological impacts [16]; thus, resistance to RE projects is commonly documented, often reflecting the NIMBY (Not In My Back Yard) syndrome [15,17,18]. In this context, NIMBY can be simply defined as a characterization of opposition by communities to RE projects in their hometowns, causing potential social conflict and economic losses [19]. One notable example was the local resistance that caused the cancellation and delay of 37.5% of solar photovoltaic and wind power projects in South Korea in 2016 [20]. However, NIMBY is not necessarily against all RE innovations as residents might still identify themselves as RE supporters as long as those RE facilities are not in close proximity. The opposite effect, called PIMBY (Please In My Back Yard), has also been observed, with the resistance level decreasing instead of increasing when a project is perceived as beneficial, resulting in a positive view by neighboring communities [19]. One specific feature of community acceptance is its time dimension, as people tend to become more accepting over time [7,21,22], starting from high acceptance prior to implementation to relatively low acceptance during the siting stage and then regaining a higher level of acceptance once a project settles [7]. Barriers to RE systems regarding the aspect of community acceptance include the absence of knowledge of technologies, projects seen as not useful and necessary, as well as health, environmental, and esthetic concerns [15]. Factors such as the specific details of a RE project, the extent and impact on land cover, noise, glare, ownership structure, and management are critical considerations for residents [23]. Thus, open communication and transparency from manufacturers could determine the success of a project.

Finally, the last dimension, known as market acceptance, refers to the process of market adoption of a RE product or technology by consumers, investors, and intra-firm [12,24]. This study specifically focused on consumers and the factors that influence their choices in the retail RE market. Undeveloped supply channels, lack of green alternatives' visibility and availability, difficult procurement of equipment, unwieldy requirements for entry, doubt about the stability and reliability of authorities, developers, and technologies, as well as barriers created by existing suppliers, etc. are some barriers that hinder the participation of potential consumers in the RE movement [15].

### *2.2. Application of the Importance–Performance Analysis*

Importance–performance analysis is a methodological tool traditionally used to formulate products, services, and effective marketing strategies [25]. Its main purpose is to evaluate a given item's importance perceived by relevant stakeholders and determine the actual performance of the item [26]. This approach allows the identification of indicators that require either improvement, mobilization, stabilization, or deployment in order to guide businesses on how to allocate resources effectively [27].

The attributes are often measured using a Likert scale and typically displayed in a two-dimensional grid (matrix), with importance on the vertical axis and performance on the horizontal axis, which divides the IPA matrix into four quadrants, as shown in Figure 1. Importance indicates respondents' preference for specific indicators in REM, while performance refers to their actual level of satisfaction with those indicators. Attributes located in Quadrant I (Keep up the good work) indicate high levels of both importance and performance. Thus, companies should continue to maintain or exploit their major strengths and competitive advantages. Quadrant II (Concentrate here) harbors attributes with high importance but poor performance, which demands the most attention and effort since it reflects elements in which a company fails to meet customers' satisfaction. Immediate action to improve these attributes needs to be prioritized. Quadrant III refers to attributes with low significance and performance levels (Low priority), requiring the least attention and/or no extra effort to enhance. Finally, attributes belonging to Quadrant IV are suggestive of low importance yet high performance (Possible overkill), which can be interpreted as over-performance. While these attributes have minimal influence on a company's success, they consume significant resources. Cutting costs and redirecting operating funds where needed are considered effective strategies [28].

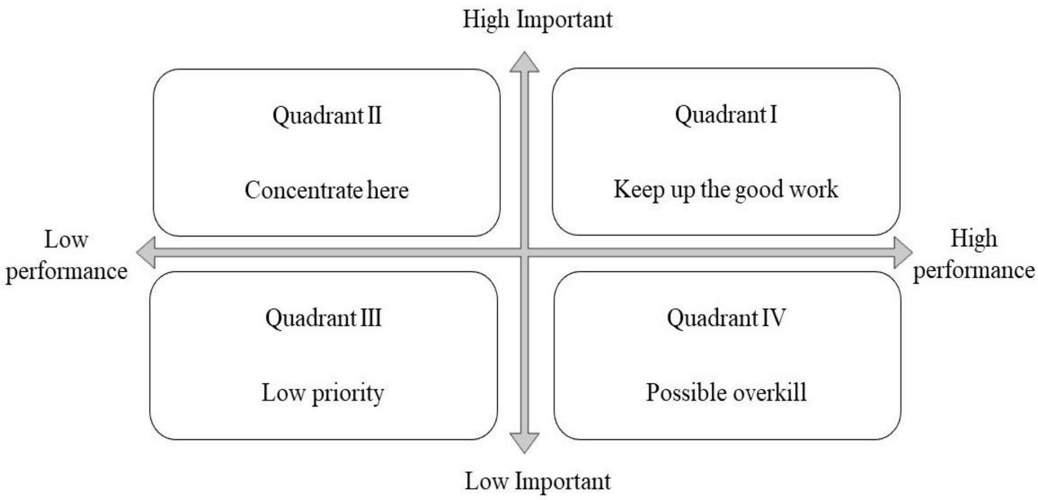


**Figure 1.** The importance–performance analysis matrix [25].

The IPA approach has been widely and successfully used in various research fields, including tourism, business, management, and conservation [29-32]. However, only a few studies have specifically used IPA in research on RE, especially in the context of Taiwan. To our best knowledge, there is only one published paper that employed IPA to look at the willingness to join government-led RE installation projects from the perspectives of (mostly) enterprises in Taiwan [33]. This study thus provides a distinctive opportunity to incorporate local perspectives into the management of RE through the lens of IPA. The assessment process helped identify attributes that are most crucial to respondents as well as those that require improvement to meet their satisfaction. In addition, we elicited factors affecting the public's willingness to participate in RE projects and discussed recommendations for future actions and policy implications that promote RE development and transition.

## 3. Materials and Methods

### *3.1. Case Study*

As of recent data, Taiwan imported 96.7% of its energy needs, with 92.7% from coal, gas, and oil [3]. The country is undergoing an energy transformation aimed at phasing out nuclear power and achieving 20% renewable energy generation by 2025 [34]. Although the Taiwanese government has been active in promoting RE development and energy efficiency measures to reach both national and global targets, in 2023, low-carbon or clean energy sources only accounted for 7.2% of the country's electricity, including nuclear (3.9%), biomass and waste (1.3%), solar (0.9%), wind (0.5%), hydro (0.3%), and others (0.3%) [3].

This study targeted Taiwan's population aged 20 and above by August 2021 when surveys were conducted and sought to compare differences between people living in two main regions: the northern regions and the non-northern regions. The population of 20-year-olds in the northern regions was 8,887,128, while that in the non-northern regions was 10,754,518.

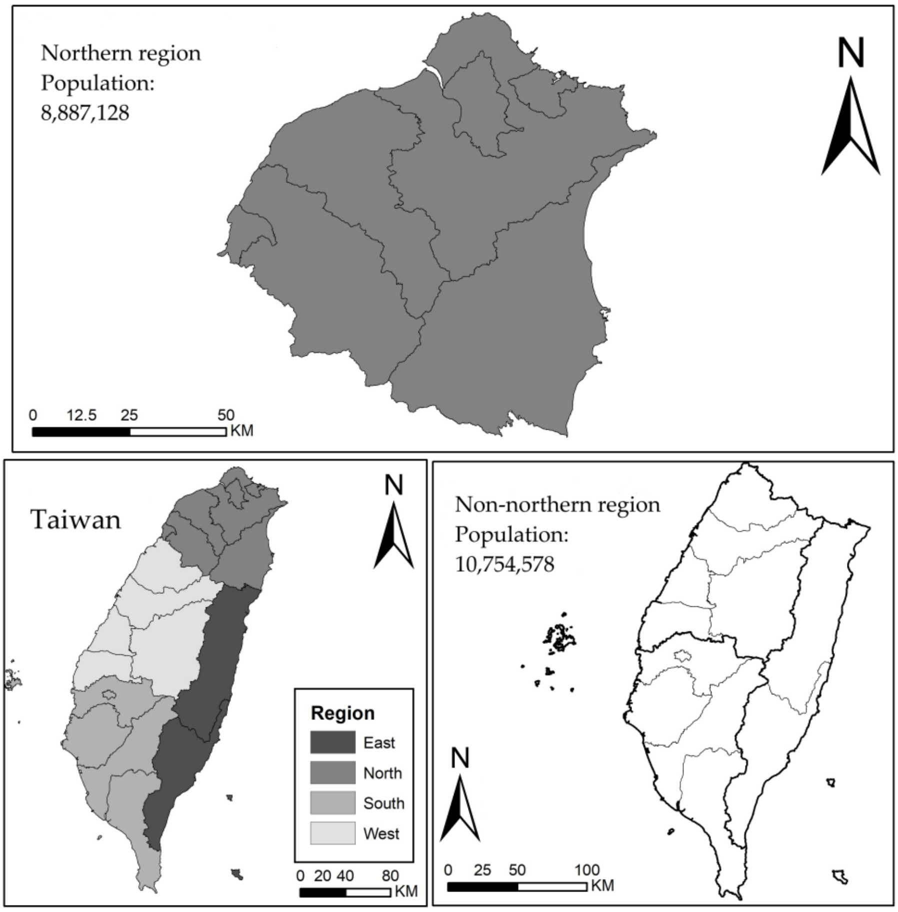


**Figure 2.** Surveyed areas in the northern and non-northern regions of Taiwan.

*3.2. Questionnaire Design*

The study aimed to explore the public's perspectives toward REM. Thus, REM indicators for the IPA were first developed on the basis of a literature review on REM and the results from semi-structured interviews with eight stakeholders involved in the field of RE. These included academic scholars, educators, and NGO personnel. A total of nine indicators were identified and categorized into three groups following the three dimensions of social acceptance [7,14] (Table 1). The first group – socio-political acceptance, which refers to the acceptance of RE policies and technologies, comprised of (1) Improving knowledge of RE to ensure that the public receives sufficient information during RE development and operation [35-37], (2) Reducing air pollution emissions from power plants to enhance environmental and public health [35,36], and (3) Providing power-saving incentives to households and businesses to improve energy efficiency and reduce energy costs [8,35,37]. Regarding the second group – community acceptance, which describes the degree to which consumers can accept innovative RE products in the market, the following indicators were included: (4) Strengthening environmental and ecological procedures to minimize impacts on biodiversity while implementing RE projects [13,35], (5) Establishing supervision and management mechanisms to enforce environmental and social safeguards and monitor the performance of RE projects, and (6) Strengthening communication with residents through consultation processes and public engagement [8,35,37]. Finally, the third group – market acceptance, which explores the acceptance of RE by local stakeholders from the community's perspective, consists of (7) Procuring new power generation and conversion equipment that is technology-enhanced and RE-friendly to help producers reduce emissions, improve production efficiency, and lower operating costs [7,38], (8) Building smart grid and power storage equipment to help accommodate RE sources, manage energy demand, enhance consumer engagement, and ensure resilience and cost-effectiveness in power distribution [39,40], and

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(9) Developing public green vehicles that are powered by RE sources to improve environmental and public health quality as well as sustainable urban development [7,41].

We then conducted an online pre-test survey with 50 respondents to test the validity and reliability of our research questions. Further modifications were made before a formal questionnaire was subsequently developed. The questionnaire consisted of three main sections. The first section addressed questions related to respondents' perceptions and attitudes toward RE and its development. The second section used the IPA to evaluate respondents' perceived importance of the REM indicators and their perspectives on the performance of these indicators. Respondents were asked to rate the nine indicators on a 5-point Likert scale ranging from 1 (very unimportant/strongly dissatisfied) to 5 (very important/strongly satisfied) for both importance and performance elements. Lastly, the third section collected respondents' socio-demographic information, such as age, gender, educational level, monthly income, occupation, political view, and residential area.

**Table 1.** Social acceptance types and their REM indicators.

| Type of social acceptance | Indicator | Code | Reference |
|---|---|---|---|
| Socio-political acceptance | Improving public knowledge of renewable energy (KNOWLEDGE) | 1 | [35-37] |
| | Reducing air pollution emissions from power plants (POLLUTION) | 2 | [35,36] |
| | Providing power-saving incentives (INCENTIVES) | 3 | [8,37] |
| Community acceptance | Strengthening environmental and ecological assessment procedures (PROCEDURES) | 4 | [13,35] |
| | Establishing supervision and management mechanisms (SUPERVISION) | 5 | [13,35] |
| | Strengthening communication with residents (COMMUNICATION) | 6 | [8,35,37] |
| Market acceptance | Procuring new power generation and conversion equipment (EQUIPMENT) | 7 | [7,38] |
| | Building smart grid and power storage systems (SMART GRID) | 8 | [39,40] |
| | Developing public green vehicles (GREEN VEHICLES) | 9 | [7,41] |

### *3.4. Data Collection and Analysis*

The appropriate sample size in each target district was determined according to its population. An online survey was conducted from January to September 2022. Questionnaires were sent to eligible respondents who were 20 years old and above. Before starting the questionnaire, they were first presented with an introduction to research objectives and survey purposes. They were then required to provide consent and approval to report the collected data from the survey. All respondents were informed that their participation is voluntary, their identities are anonymous, and that they can withdraw at any stage of the survey.

The collected data were quantitatively processed using IBM SPSS Statistics 22. First, the public's socio-demographic data and their awareness of and behaviors toward REM were analyzed descriptively. This was followed by calculating the matrix framework to assess the mean scores and rankings of the perceived importance and performance of the REM indicators. The original values of the nine indicators collected by the survey were averaged according to the classification and then changed to coordinate values with standardized values (Z-score) with importance as the horizontal axis and performance as the vertical axis. The coordinate values were then plotted on the plane coordinates [31,32]. A gap analysis was performed to measure the difference between respondents' level of satisfaction with each indicator and its corresponding perceived importance. The gap was quantified by subtracting the mean importance score of an indicator from its respective performance

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score. A negative gap value signifies discontent with a key indicator, whereas a positive gap value indicates satisfaction with it. Paired sample t-tests were used to evaluate statistically significant differences between respondents' perceptions of the I-P of REM solutions, with $p < .05$ indicating significance.

In the following analysis stage, we used a logistic regression model (LRM), based on the binary choice theory, to examine the impact of the respondents' characteristics (independent variables) and their perceptions of and behaviors toward REM on their willingness to pay (WTP) for a REM program (dependent variable). Two sets of logit and probit models were developed; each consisted of the same dependent variable and independent variables. However, only the mean importance was incorporated in Model I of each model as the independent variable, while only the mean performance was included in Model II. The goodness of fit (GOF) of both models was evaluated using the Akaike information criterion (AIC) and Log-likelihood ratio (LLR).

## 4. Results

### *4.1. Descriptive statistics*

A total of 702 valid questionnaires were collected and analyzed. Table 2 presents a descriptive analysis of the demographic characteristics of the participants. Of all respondents, 311 belonged to the northern regions, while 391 resided in the non-northern areas. There were slightly more males (52.6%, n = 369) than females (47.4%, n = 333). The majority (84.9%, n = 596) received an education at the undergraduate and post-undergraduate levels and had a monthly income of 20,001–60,000 NTD (66.4%, n = 466). More than half held no political views, while 49% belonged to specific parties. Moreover, participants from the north (61.7%, n = 192) were less likely to have political affiliation compared to those from different regions (42.5%, n = 166). In terms of perceptions toward sustainable development, 60.8% (n = 427) perceived the environment as the most important factor, followed by the economy (27.4%, n = 192) and society (11.8%, n = 83). Most respondents (95.3%, n = 669) claimed to support the development of RE.

**Table 2.** Summary of surveyed respondents' socio-demographic characteristics.

| Variable | Total (n = 702) | | Northern region (n = 311) | | Non-northern region (n = 391) | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Gender | | | | | | |
| Male | 369 | 52.6 | 165 | 53.1 | 204 | 52.2 |
| Female | 333 | 47.4 | 146 | 46.9 | 187 | 47.8 |
| Marital status | | | | | | |
| Single | 371 | 52.8 | 151 | 48.6 | 220 | 56.3 |
| Married | 331 | 47.2 | 160 | 51.4 | 171 | 43.7 |
| Age | | | | | | |
| 20-29 | 134 | 19.1 | 60 | 19.3 | 74 | 18.9 |
| 30-39 | 142 | 20.2 | 68 | 21.9 | 74 | 18.9 |
| 40-49 | 167 | 23.8 | 78 | 25.1 | 89 | 22.8 |
| 50-59 | 145 | 20.7 | 64 | 20.6 | 81 | 20.7 |
| 60 and above | 114 | 16.2 | 41 | 13.2 | 73 | 18.6 |
| Education | | | | | | |
| Junior high or below | 15 | 2.1 | 4 | 1.3 | 11 | 2.8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Senior high | 91 | 13.0 | 36 | 11.6 | 55 | 14.1 |
| Undergraduate | 415 | 59.1 | 177 | 56.9 | 238 | 60.9 |
| Post-graduate or above | 181 | 25.8 | 94 | 30.2 | 87 | 22.3 |
| Monthly income | | | | | | |
| Up to NTD 20,000 | 107 | 15.2 | 54 | 17.4 | 53 | 13.6 |
| NTD 20,001–40,000 | 247 | 35.2 | 95 | 30.5 | 152 | 38.9 |
| NTD 40,001–60,000 | 219 | 31.2 | 87 | 28.0 | 132 | 33.8 |
| NTD 60,001–80,000 | 68 | 9.7 | 40 | 12.9 | 28 | 7.2 |
| Above NTD 80,000 | 61 | 8.7 | 35 | 11.2 | 26 | 6.7 |
| Support RE development | 669 | 95.3 | 301 | 96.8 | 368 | 94.1 |

Table 3 shows respondents' preferences for the currently available RE sources in Taiwan. Rooftop solar was the most favored type, chosen by 77.1% of respondents (n = 541), followed by biomass and waste (54.3%, n = 381) and offshore wind (52.7%, n = 370). In contrast, geothermal (32.8%, n = 230) and land-based wind (27.5%, n = 193) were the least preferred options. When comparing the two regions, the northern respondents generally had a higher preference for most RE sources compared to non-northern ones, except for the ground-based solar, with 31.2% of the northerners (n = 97) and 35% of the non-northerners (n = 137) voted for this energy type.

**Table 3.** Preferences for RE sources and motivations to support ground-mounted solar systems

| **Variable** | **Total (n = 702)** | | **Northern region (n = 311)** | | **Non-northern region (n = 391)** | |
|---|---|---|---|---|---|---|
| | n (rank) | % | n (rank) | % | n (rank) | % |
| *Preferred renewable energy sources* | | | | | | |
| Solar-ground | 234 (5) | 33.3 | 97 (6) | 31.2 | 137 (5) | 35.0 |
| Solar-roof | 541 (1) | 77.1 | 244 (1) | 78.5 | 297 (1) | 76.0 |
| Wind-land | 193 (7) | 27.5 | 90 (7) | 28.9 | 103 (7) | 26.3 |
| Wind-offshore | 370 (3) | 52.7 | 174 (2) | 55.9 | 196 (3) | 50.1 |
| Biomass & Waste | 381 (2) | 54.3 | 173 (3) | 55.6 | 208 (2) | 53.2 |
| Hydroelectric | 348 (4) | 49.6 | 163 (4) | 52.4 | 185 (4) | 47.3 |
| Geothermal | 230 (6) | 32.8 | 113 (5) | 36.6 | 117 (6) | 29.9 |
| *Motivations to support ground-mounted solar systems* | | | | | | |
| Project sites located > 1 km away from residential areas | 224 (4) | 31.9 | 107 (4) | 34.4 | 117 (6) | 29.9 |
| Adjusting panels to green color | 216 (5) | 30.8 | 81 (6) | 26.0 | 135 (4) | 34.5 |
| Arranging panels into a designed pattern | 212 (6) | 30.2 | 93 (5) | 29.9 | 119 (5) | 30.4 |
| Planting companion honey plants | 309 (3) | 44.0 | 156 (3) | 50.2 | 153 (3) | 39.1 |
| Integrating agriculture, fishery, or animal husbandry | 375 (2) | 53.4 | 166 (2) | 53.4 | 209 (2) | 53.5 |
| Project sites used in a more ecological way | 450 (1) | 64.1 | 218 (1) | 70.1 | 232 (1) | 59.3 |

We conducted a further investigation into the public perspectives regarding the currently supported measures for on-ground solar energy development, particularly in light of the significant promotion of such initiatives in Taiwan over recent years. Measures with the highest ranks were 'Project sites used in a more ecological way' (64.1%, n = 450), followed by 'integrating agriculture, fishery, or animal husbandry' (53.4%, n = 375) and 'planting companion honey plants' (44%, n = 309). Meanwhile, the following three measures were less of the public's concern: 'project sites located > 1 km away from residential areas' (31.9%, n = 224), 'adjusting panels to green color' (30.8%, n = 216), and lastly 'arranging panels into a designed pattern' (30.2%, n = 212).

*4.2. Perceived Importance and Performance of Renewable Energy Management*

Table 4 presents the means of the importance and performance of each of the indicators. The results reveal that both groups of the northern and non-northern participants assigned high importance to all REM indicators, with mean scores of 4.23 and 4.13, respectively. Results from the gap analysis showed significantly negative gaps across all indicators, where perceived importance scores were considerably higher than performance scores.

The northerners considered 'strengthening communication with residents' (COMMUNICATION; mean I = 4.34) and 'reducing overall power system air pollution emissions' (POLLUTION; mean I = 4.34) the most important indicators, followed by 'establishing supervision and management mechanisms' (SUPERVISION; mean I = 4.31) and 'building smart grid and power storage systems' (SMART GRID; mean I = 4.25). They also reported the largest performance gaps in these four indicators, suggesting strong dissatisfaction from respondents. Similar patterns were evident within the non-northerner group, where 'COMMUNICATION' (mean I = 4.24) was identified as the most critical element, alongside 'SUPERVISION' (mean I = 4.24). This was followed by 'POLLUTION' (mean I = 4.23) and 'SMART GRID' (mean I = 4.13). The most significant performance gaps were also ascribed to these four indicators.

Both groups referred to 'procuring new power generation and conversion equipment' (EQUIPMENT; mean I = 4.01) as the least important solution. All social acceptance indicators showed no significant differences between the northern and non-northern areas as well as among I-P levels for all citizen groups.

**Table 4.** Mean scores, gap analysis, and results of paired sample t-tests of REM indicators.

| Code | Indicator | Mean (rank) | | Gap P-I | t-value | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| | | I | P | | | |
| Total (N = 702) | | | | | | |
| 1 | KNOWLEDGE | 4.16 (5) | 3.40 (1) | −0.76 | 17.66 | .0001 |
| 2 | POLLUTION | 4.28 (2) | 3.28 (4) | −1.00 | 20.75 | .0001 |
| 3 | INCENTIVES | 4.16 (5) | 3.39 (2) | −0.77 | 16.89 | .0001 |
| 4 | PROCEDURES | 4.13 (6) | 3.27 (5) | −0.86 | 18.66 | .0001 |
| 5 | SUPERVISION | 4.27 (3) | 3.23 (6) | −1.04 | 21.52 | .0001 |
| 6 | COMMUNICATION | 4.29 (1) | 3.20 (7) | −1.09 | 23.18 | .0001 |
| 7 | EQUIPMENT | 4.01 (8) | 3.28 (4) | −0.73 | 17.26 | .0001 |
| 8 | SMART GRID | 4.19 (4) | 3.27 (7) | −0.92 | 19.63 | .0001 |
| 9 | GREEN VEHICLES | 4.10 (7) | 3.34 (3) | −0.76 | 17.83 | .0001 |
| | Overall mean | 4.18 | 3.30 | −0.88 | | |
| Northern region (N = 311) | | | | | | |
| 1 | KNOWLEDGE | 4.23 (4) | 3.40 (1) | −0.83 | 12.48 | .0001 |
| 2 | POLLUTION | 4.34 (1) | 3.25 (4) | −1.09 | 14.94 | .0001 |
| 3 | INCENTIVES | 4.21 (5) | 3.33 (2) | −0.88 | 13.19 | .0001 |
| 4 | PROCEDURES | 4.17 (6) | 3.19 (6) | −0.98 | 13.76 | .0001 |
| 5 | SUPERVISION | 4.31 (2) | 3.18 (7) | −1.13 | 15.39 | .0001 |
| 6 | COMMUNICATION | 4.34 (1) | 3.17 (8) | −1.17 | 16.39 | .0001 |
| 7 | EQUIPMENT | 4.09 (8) | 3.22 (5) | −0.87 | 13.49 | .0001 |
| 8 | SMART GRID | 4.25 (3) | 3.22 (5) | −1.03 | 14.09 | .0001 |
| 9 | GREEN VEHICLES | 4.16 (7) | 3.27 (3) | −0.89 | 13.21 | .0001 |
| | Overall mean | 4.23 | 3.25 | −0.98 | | |
| Non-northern region (N = 391) | | | | | | |
| 1 | KNOWLEDGE | 4.10 (5) | 3.41 (2) | −0.69 | 12.53 | .0001 |
| 2 | POLLUTION | 4.23 (2) | 3.31 (6) | −0.92 | 14.51 | .0001 |
| 3 | INCENTIVES | 4.12 (4) | 3.43 (1) | −0.69 | 11.02 | .0001 |
| 4 | PROCEDURES | 4.10 (5) | 3.34 (4) | −0.76 | 12.76 | .0001 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | SUPERVISION | 4.24 (1) | 3.27 (8) | −0.97 | 15.13 | .0001 |
| 6 | COMMUNICATION | 4.24 (1) | 3.23 (9) | −1.01 | 16.47 | .0001 |
| 7 | EQUIPMENT | 3.96 (7) | 3.32 (5) | −0.64 | 11.18 | .0001 |
| 8 | SMART GRID | 4.13 (3) | 3.30 (7) | −0.83 | 13.75 | .0001 |
| 9 | GREEN VEHICLES | 4.05 (6) | 3.39 (3) | −0.66 | 12.12 | .0001 |
| | Overall mean | 4.13 | 3.33 | −0.80 | | |

Notes: I: Importance; P: Performance; Paired sample t-tests significant at .05

*4.3. Importance–Performance Matrix of Renewable Energy Management*

Figure 3 provides a visual representation of the public's perspectives toward REM solutions, comparing the northern and non-northern respondents. Out of nine indicators, six were placed in the same quadrants. Specifically, Quadrant II (Concentrate here) consists of two indicators from the community acceptance dimension: 'establishing supervision and management mechanisms' (SUPERVISION) and 'strengthening communication with residents' (COMMUNICATION). There was only one indicator situated in Quadrant III (Low priority) – 'procuring new power generation and conversion equipment' (EQUIPMENT). The most similarities were observed in Quadrant IV (Possible overkill), which comprises three RE solutions: 'improving public knowledge of renewable energy' (KNOWLEDGE), 'providing power-saving incentives' (INCENTIVES), and 'developing public green vehicles' (GREEN VEHICLES).

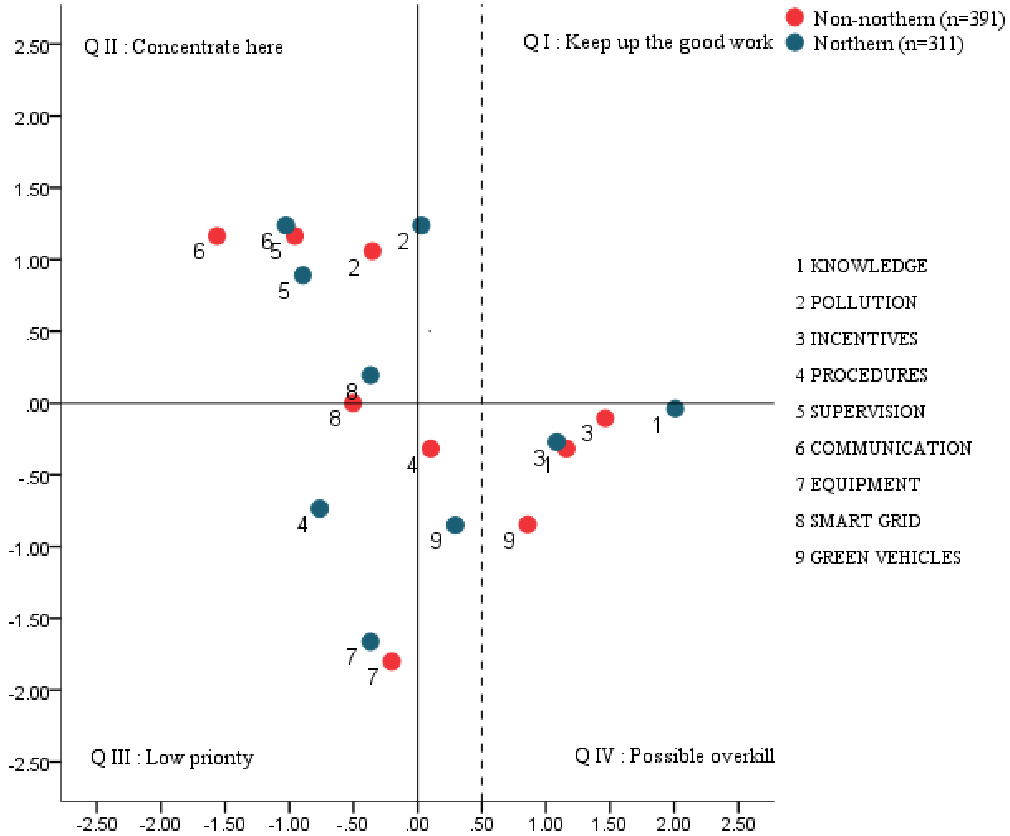


**Figure 3.** Importance–performance grid of REM indicators by northern and non-northern regions.

There were three slight differences in quadrant placement between the two groups of respondents. The first one concerned 'reducing air pollution emissions from power plants' (POLLUTION), which was assigned to Quadrant I (Keep up the good work) by the northerners but to Quadrant II (Concentrate here) by the non-northerners. This was also the only indicator being placed in Quadrant I, suggesting general poor performance in all indicators. Another difference was observed in 'strengthening environmental and ecological assessment procedures' (PROCEDURES). Participants from the north suggested that it belonged to Quadrant III (Low priority), while those from non-northern regions assigned it to Quadrant IV (Possible overkill). Finally, the indicator 'building smart grid and power storage systems' (SMART GRID) was considered important to be improved by the northern respondents as it was positioned in Quadrant II (Concentrate here). However, this indicator was not clearly assigned by the non-northerners as it was placed between Quadrant II and Quadrant III.

### *4.4. Public Participation Behavior in Renewable Energy Management*

Four socio-demographic factors (i.e., age, monthly income, region, and political views) and four attitudinal and behavioral factors (i.e., support for RE, attitudes toward sustainable development which included three types of concern: environmental, social, and economic concern), as well as the overall I-P means of REM indicators were specified as independent variables (Table 5). The AIC values from both models were at acceptable levels, providing the best trade-off between model complexity and GOF. The LLR values were all greater than the chi-square value (15.09), confirming the robustness of our modeling of public participation behavior in REM.

In both models, age negatively corresponded to respondents' participation behavior, while region, monthly income, and political preference were positively correlated. The results suggest that residents under 50, with higher income, lived in the northern areas, and had political affiliations were more likely to participate in REM. In terms of attitudinal and behavioral factors, support for RE, environmental concern, and social concern were positively correlated with the dependent variable, indicating that those who were supportive of the development of RE and were concerned about their environment and community when it comes to sustainable development were more likely to participate in REM.

**Table 5.** Estimated results of the public's participation behavior in REM

| Variable | Logit Model | | | | Probit Model | | | |
|---|---|---|---|---|---|---|---|---|
| | Importance of REM (Model I) | | Performance of REM (Model II) | | Importance of REM (Model I) | | Performance of REM (Model II) | |
| | Coeff. | Std. Error | Coeff. | Std. Error | Coeff. | Std. Error | Coeff. | Std. Error |
| Constant | −0.00*** | 0.00 | −0.00*** | 0.00 | −0.00*** | 0.00 | −0.00*** | 0.00 |
| Age [1] | −0.83*** | 0.18 | −0.81*** | 0.18 | −0.48*** | 0.11 | −0.47*** | 0.11 |
| Monthly income [2] | 0.57** | 0.26 | 0.56** | 0.26 | 0.32** | 0.15 | 0.32** | 0.15 |
| Region [3] | 0.38** | 0.19 | 0.40** | 0.19 | 0.23** | 0.11 | 0.24** | 0.11 |
| Political preference [4] | 0.30 | 0.19 | 0.32* | 0.19 | 0.18* | 0.11 | 0.19* | 0.11 |
| Support [5] | 0.86** | 0.39 | 0.95** | 0.38 | 0.50** | 0.23 | 0.56** | 0.23 |
| Environmental concern [6] | −0.42 | 0.80 | 1.13** | 0.56 | −0.25 | 0.47 | 0.66** | 0.32 |
| Social concern [7] | −0.26 | 0.80 | 1.24** | 0.58 | −0.15 | 0.47 | 0.73** | 0.34 |
| Economic concern [8] | −1.04 | 0.80 | 0.52 | 0.55 | −0.62 | 0.47 | 0.29 | 0.32 |
| Importance mean | 0.33** | 0.17 | - | - | 0.20** | 0.10 | _- | - |
| Performance mean | - | - | −0.07 | 0.10 | - | - | −0.04 | 0.06 |
| LLR [9] | 68.45 | | 65.17 | | 69.37 | | 65.84 | |
| AIC [10] | 744.3 | | 747.6 | | 743.4 | | 747.0 | |
| AIC/n | 1.060 | | 1.065 | | 1.059 | | 1.064 | |
| Chi-square value | $\chi^2$ (9, 0.01) = 15.09 | | | | | | | |

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Notes: ***p-value < .01, **p-value < .05, *p-value < .1. [1] Age: 1 = 50 years old and above, 0 = otherwise. [2] Monthly income: 1 = NTD 60,001 and above, 0 = otherwise. [3] Region: 1 = northern, 0 = non-northern. [4] Belong to a political party: 1 = yes, 0 = no. [5] Support RE development: 1 = yes, 0 = no. [6] Agree that the environment is of highest priority in sustainable development: 1 = yes, 0 = no. [7] Agree that the society is of highest priority in sustainable development: 1 = yes, 0 = no. [8] Agree that the economy is of highest priority in sustainable development: 1 = yes, 0 = no. [9] LLR: Log-likelihood ratio. [10] AIC: Akaike information criterion.

## 5. Discussion

### *5.1. Preferences for Renewable Energy Sources*

The public's significant preference for rooftop solar energy suggests a strong inclination towards decentralized energy solutions that can be implemented at the individual or community level. This preference aligns with global trends, where rooftop solar is often seen as a practical and accessible way for households to enhance energy security while avoiding disturbing green spaces [42,43]. In Taiwan, the development of solar energy is currently characterized by an absence of clear policies and designated locations, resulting in a predominant focus on large-scale ground-mounted photovoltaic (PV) systems situated primarily in rural areas. This trend has led to the encroachment of PV installations on agricultural and forestry lands, consequently causing landscape degradation and various environmental and social challenges [6,44,45]. Such encroachments may intrude upon vital agricultural and fisheries production areas, thereby posing potential risks to the nation's food production capacity and overall food security. This could explain why on-ground solar systems were ranked relatively low (33.3%, n = 234). Future initiatives should focus on installing PV systems in urban and rural built-up areas involving both the residential (e.g., household roofs, community-shared rooftops) and non-residential sector (e.g., commercial and public buildings, industrial and agricultural facilities, educational institutions, parking structures, etc.) [42,43,46].

The second most preferred source of green energy was biomass and waste, corresponding with Chaikumbung's meta-analysis of consumer preferences for RE, which synthesized data from 92 studies conducted across 21 countries. In this paper, biomass also ranked second, following solar energy and preceding wind energy [47]. To encourage the production and utilization of regional solid-derived wastes, the Taiwanese government has invested over one billion US dollars in the biomass energy sector [48]. In addition, the country has established multiple waste-to-energy facilities that transform municipal solid waste into electricity, reduce landfill usage, and lower greenhouse gas emissions. This effort is expected to substantially enhance the social economy and promote the adoption of renewable biomass and waste energy. However, there are concerns about land use, deforestation, and competition with food production when it comes to energy produced from organic materials (e.g., agricultural residues, wood, dedicated energy crops, and animal waste) [49,50]. Policies should focus on promoting sustainable agricultural practices, integrating biomass into rural economies and local energy needs, as well as ensuring locally sourced biomass materials. Regarding municipal solid waste and industrial waste, public opposition can arise due to concerns about emissions and health risks associated with incineration during the conversion processes. Investment in advanced technologies such as combustion systems and flue gas treatment could help mitigate such environmental impacts [51]. Efforts to increase transparency, community involvement, and public awareness of the importance of waste management and circular economy principles are crucial for gaining long-term support.

Public interest in offshore wind energy reflects the recognition of its potential for large-scale energy generation. Taiwan has been actively expanding its wind energy infrastructure, focusing on both offshore and land-based projects to meet its RE goals. The island's geographical location, with strong winds from the northeast during winter and typhoons in summer, makes it ideal for offshore wind power generation. Offshore wind energy, in particular, has gained significant prominence, with Taiwan leading the Asia-Pacific region (excluding China) in offshore wind development. By 2024, Taiwan further solidified its position with the commissioning of the 900 MW Greater Changhua 1 and 2a project, the largest offshore wind farm in full operation within the country and in the region.

Although on-land wind farms also contribute to the energy mix, their expansion is limited by Taiwan's mountainous terrain, which has already exhausted most suitable sites over the past decades [48]. In addition, public opposition has grown due to concerns about noise pollution, proximity to residential areas, and visual impacts, all of which contribute to the resistance against further development of onshore wind projects. These factors help explain why land-based wind farms were ranked lowest in public preferences, driving Taiwan's shift towards prioritizing offshore wind development as a more feasible and less contentious alternative.

### *5.2. Motivational Factors for Supporting Ground-mounted Solar Systems*

The results reveal significant insights regarding community preferences and concerns. The public's desire for sustainable land use during solar development suggests a growing awareness and prioritization of ecological balance in RE initiatives. Utilizing project sites ecologically can significantly enhance biodiversity and habitat restoration, as well as minimize land degradation to ensure that the land remains productive for future generations [52,53]. For instance, integrating pollinator-friendly plants in solar farms can create habitats that support the already declining populations of beneficial insects, ultimately contributing to conservation efforts. Pollinators play a critical role in global ecosystems as they improve the reproduction of many crops and wild plants, enhance food security and boost local agricultural yields [54,55]. Planting native wildflowers and nectar-rich plants at solar farms, therefore, creates synergies between energy production and agriculture.

Furthermore, the integration of practices such as agriculture, fishery, or animal husbandry was also of concern to respondents, reflecting a strong inclination towards multifunctional land use. Agrovoltaics, which involves the simultaneous use of land for agriculture and solar energy production, can maximize land productivity while reducing the ecological footprint of energy projects [56]. This approach not only improves the sustainability of solar projects but also supports local economies and food production, illustrating a public interest in co-benefits that extend beyond energy generation. Solar farms that incorporate crops, livestock, or aquaculture could help create jobs and stimulate local markets, which is especially crucial in rural development. Research indicates that such practices can improve the economic viability of both agriculture and solar initiatives, making them more appealing and acceptable to communities [8,43,56,57].

In contrast, measures such as ensuring a specific distance between project sites and residential areas, along with aesthetic modifications such as green-colored panels and patterned panel arrangements, were of less concern to respondents. This suggests a prioritization of functional and ecological outcomes over visual or spatial considerations, offering critical insights into public attitudes toward solar energy projects. Despite proximity concerns being common in debates over RE infrastructure, the lower ranking of this issue indicates that the Taiwanese public may be more receptive to nearby solar facilities than previously anticipated. This could reflect a growing public awareness of the environmental and energy security benefits associated with solar power. Furthermore, solar farms tend to generate less noise and visual disturbance compared to other energy sources like wind turbines or coal plants, possibly reducing the level of concern about their proximity [58]. However, ground-mounted PV systems were generally not a top choice. These findings underscore the importance of ensuring that solar initiatives align with community priorities, especially through a focus on ecological sustainability and the integration of local agricultural practices [43,54,57]. Such an approach could enhance public acceptance and support for future on-ground solar developments in Taiwan.

### *5.3. Prioritized Areas in Renewable Energy Management*

Our findings show an apparent public concern regarding the performance of two indicators from the aspect of community acceptance, which are supervision and management mechanisms and communication with residents regarding RE development and management. Supervision and management mechanisms are crucial in minimizing the ecological impacts of RE projects. These include measures to protect local biodiversity, mitigate habitat disruption, and ensure sustainable land use. The recognition of the high importance yet inadequate implementation of this aspect indicates a growing concern within communities regarding the long-term environmental implications of RE infrastructure. For a small island nation like Taiwan, coupled with harsh weather conditions, the unintended consequences of poorly managed RE projects (e.g., soil erosion, disruption of the water table, loss of agricultural productivity, etc.) pose a significant threat. For instance, large-scale solar farms, if not developed with a focus on environmental sustainability, have the potential to substantially alter local landscapes, exacerbating these ecological risks [57,58]. The failure to properly supervise such impacts can create distrust among residents, especially in areas where environmental preservation is vital to local livelihoods [6]. Hence, improving the transparency and effectiveness of management mechanisms is critical to gaining and maintaining community trust in RE initiatives [13,35]. In addition, the poor delivery of communication strategies related to RE development and management could exacerbate the existing issues. When residents are not adequately informed or engaged in the planning process, they may feel excluded from decisions that affect their environment and community [8,35,37]. Lack of information or misinformation can lead to resistance, even if the projects have potential benefits. Effective communication is not just about informing the public but also about involving them in decision-making. It is crucial to ensure that residents understand the ecological benefits of RE projects and the measures being taken to mitigate any negative impacts. Clear and consistent communication helps address community concerns, foster cooperation, and ensure transparency. Ensuring that communities feel heard and their concerns are addressed can mitigate opposition and promote a sense of ownership over local RE developments. Public participation in environmental monitoring or decision-making about designing processes or choosing sites can align RE projects with community values [11,40,59].

The socio-political dimension of social acceptance plays a crucial role in the development of renewable energy projects, as it reflects both public opinion and the alignment of energy policy with societal priorities [7,14]. The reduction of air pollution, particularly from traditional power plants, was reported as important and should be improved. In many communities, this goal is seen as paramount, as air pollution poses direct health risks and contributes to broader environmental problems such as climate change and ecosystem degradation. Respondents' prioritization of mitigating emissions from power plants highlights a growing awareness of the negative externalities associated with fossil fuel-based energy production. It suggests that public support for RE is not only driven by a desire for cleaner energy alternatives but also by concerns about the immediate and long-term health impacts of air pollution. As communities become more aware of the link between energy production and air quality, their willingness to support RE initiatives increases, especially if these projects are perceived as effective in reducing pollution [35,36]. This presents a significant opportunity for the Taiwanese government to advance its RE development agenda in alignment with the global objective of achieving net-zero carbon emissions. Concurrently, as the fossil fuel industry remains operational, sustained efforts must be directed toward mitigating the environmental and public health impacts associated with these power plants. Such a dual approach, promoting the transition to RE while addressing the immediate consequences of fossil fuel use, will be essential in balancing Taiwan's energy needs with its environmental responsibilities.

Finally, regarding market acceptance, building smart grids and power storage systems was the public's priority. The emphasis reflects the need for advanced infrastructure to support the integration and efficiency of RE sources. These technologies are crucial for addressing some of the key challenges associated with RE, such as intermittency and grid stability [39,40]. Smart grids, which use digital technology to monitor and manage energy flows, enable more efficient use of energy resources by balancing supply and demand in real-time. This is particularly important for RE, as sources like solar and wind are variable, depending on weather conditions and time of day. By enabling dynamic adjustments to energy distribution, smart grids ensure a more reliable and resilient energy system, which is essential for maintaining public confidence in RE. Similarly, power storage systems, such as large-scale batteries, play a critical role in mitigating the intermittent nature of renewables. By storing excess energy produced during peak production times and releasing it when demand is high, or generation is low, storage systems help smooth out fluctuations and ensure a consistent energy supply. For RE to gain full market acceptance, the infrastructure supporting it must be robust, flexible, and capable of ensuring energy security. Moreover, the development of these technologies can stimulate further social acceptance by attracting investment and fostering innovation in the energy sector [7,11,12,15]. As these technologies become more widespread, they can lower costs, improve the efficiency of energy systems, and ultimately accelerate the transition to a low-carbon economy.

### *5.4. Determinants of Renewable Energy Development*

The findings indicate that residents under 50, with higher incomes, political affiliations, residing in northern Taiwan, and having environmental and social concerns about RE development, were more likely to participate in REM, highlighting important determinants of RE in Taiwan. These factors suggest that public participation is not equally distributed across all demographic and social groups, aligning with existing studies [16,60].

Different age groups tend to have varying levels of awareness, technological engagement, and motivations that influence their adoption of RE sources. Younger generations often have greater exposure to environmental education and awareness of climate change issues, making them more inclined to support and engage in RE as it provides long-term benefits [61]. Furthermore, they are also typically more familiar with new technologies and thus more open to adopting RE solutions. They may see participation in REM as an investment in their community's future well-being and environmental health [62-64]. Higher-income individuals are also often better positioned to invest in RE since its technologies typically have higher upfront costs, which they might be more willing and able to bear the financial burden for long-term gains.

Furthermore, higher-income individuals can afford energy-efficient appliances and home upgrades, which complement RE usage and reduce overall energy consumption [65]. In Taiwan, the middle and upper classes often come from urban areas where information regarding government incentives, subsidies, and tax breaks designed to encourage RE adoption is more accessible compared to the countryside. This might also be the reason why respondents from the north were more likely to support REM, considering it is the political and financial centre of Taiwan and the country's main hub of technological development. This region benefits from stronger government support for RE initiatives and greater access to clean energy technologies. The concentration of economic and political power in the north would lead to more opportunities for residents to engage with RE projects. In contrast, the less developed areas may face logistical and financial barriers that limit their ability to engage with RE systems.

Political values and beliefs were recognized as significant determinants of attitudes toward and acceptance of RE transition, as they heavily influence both public opinion and policy preferences on environmental issues [16,66], thereby affecting their willingness to support or oppose RE projects. While most political parties in Taiwan demonstrate support for RE to some extent, their approaches vary significantly across the political spectrum. The Democratic Progressive Party pursues an ambitious RE agenda, including the phased elimination of nuclear power and a strong emphasis on expanding solar and wind energy. In contrast, the more conservative party – the Kuomintang, adopts a more cautious stance, advocating for a balanced energy strategy that maintains nuclear power as a stable energy source alongside renewable options. Smaller parties also promote RE development, but their policies emphasize environmental sustainability to different degrees. These variations reflect distinct priorities within the broader context of energy transition and climate policy in Taiwan. A more in-depth investigation into how political discourse shapes public perspectives on RE development is thus crucial, given the significant role that political narratives and communication play in influencing public opinion and policy outcomes.

## 6. Conclusions and Implications

This study demonstrates a creative approach that integrates the IPA into the three-dimensional social acceptance of REM, which, to the best of our knowledge, is the first paper that offers insights into public perspectives and preferences for REM. In addition, it helps to address the research gap in the analysis of the often-overlooked residential sector. We identified prioritized attributes for the effective REM Taiwan, as well as determinants affecting public support in RE development. Although the results are derived from the case study of Taiwan, our findings and methods are highly applicable to other regions that recognize the importance of public participation in the RE transition.

Our results imply that measures should primarily focus on improving the highly important yet poorly performed attributes to address public concerns. Measures aimed at enhancing supervision and management mechanisms could include strengthening regulatory frameworks, enhancing monitoring and compliance systems, and establishing independent supervisory bodies. Communication and public consultations should be part of the approval process, allowing stakeholders to express their views and share their knowledge and experience. Engaging local communities and stakeholders throughout the RE project lifecycle, from planning to operation, can improve social acceptance and help identify potential environmental or social concerns early on. In addition, in terms of technological development in RE, improving smart grids and power storage systems is essential for enhancing the efficiency and reliability of RE integration. By investing in advanced grid infrastructure, energy storage technologies, data management systems, grid decentralization, and cybersecurity measures, governments and industry stakeholders can modernize energy systems and better manage the variability of RE sources. Nevertheless, since fossil fuels still dominate Taiwan's energy mix, although the country is making significant efforts to increase its RE capacity, reducing air pollution emissions from power plants while simultaneously advancing RE development is crucial for the country’s environmental sustainability, public health, and energy transition goals.

More importantly, policymakers and energy developers need to consider various factors ranging from socio-economic, political, and regional to behavioral and attitudinal when designing RE programs. Younger residents, higher-income individuals, and urban populations may be more receptive to such programs, but efforts should be made to engage other demographic groups, particularly those with less financial capacity or those in rural areas, to reduce energy injustices. Incentives and projects must be made accessible to all income levels and geographic regions to avoid deepening social and economic inequalities. The geographic concentration of REM in northern Taiwan suggests that certain regions may be more advanced in energy transition efforts. Expanding RE infrastructure and management initiatives to other regions, particularly the less developed areas, will be crucial for ensuring a nationwide transition to clean energy. The role of political affiliation in RE participation underscores the importance of strong political advocacy for environmental issues. Political engagement can mobilize resources, influence public opinion, and shape energy policies that support the growth of RE. These determinants of REM participation reveal both opportunities and challenges for the future of RE development. Addressing disparities in engagement and ensuring broad-based participation will be essential for achieving a sustainable energy transition.

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## References

1. Dincer, I. Renewable energy and sustainable development: a crucial review. *Renewable and Sustainable Energy Reviews* **2000**, *4*, 157-175, doi:https://doi.org/10.1016/S1364-0321(99)00011-8.
2. Panwar, N.L.; Kaushik, S.C.; Kothari, S. Role of renewable energy sources in environmental protection: A review. *Renewable and Sustainable Energy Reviews* **2011**, *15*, 1513-1524, doi:https://doi.org/10.1016/j.rser.2010.11.037.
3. Energy Administration; Ministry of Economic Affairs. *Energy statistics handbook 2023*; 2023.
4. EPA, E.P.A. Taiwan greenhouse gases inventory. EPA, Taipei, Taiwan. **2021**.
5. Bergmann, A.; Colombo, S.; Hanley, N. Rural versus urban preferences for renewable energy developments. *Ecological Economics* **2008**, *65*, 616-625, doi:https://doi.org/10.1016/j.ecolecon.2007.08.011.
6. Jones, P.; Comfort, D.; Hillier, D. Spotlight on solar farms. *Journal of Public Affairs* **2015**, *15*, 14-21, doi:https://doi.org/10.1002/pa.1482.
7. Wüstenhagen, R.; Wolsink, M.; Bürer, M.J. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy policy* **2007**, *35*, 2683-2691.
8. Roddis, P.; Roelich, K.; Tran, K.; Carver, S.; Dallimer, M.; Ziv, G. What shapes community acceptance of large-scale solar farms? A case study of the UK's first 'nationally significant'solar farm. *Solar Energy* **2020**, *209*, 235-244.
9. Enevoldsen, P. Onshore wind energy in Northern European forests: Reviewing the risks. *Renewable and Sustainable Energy Reviews* **2016**, *60*, 1251-1262, doi:https://doi.org/10.1016/j.rser.2016.02.027.
10. Enevoldsen, P.; Sovacool, B.K. Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. *Renewable and Sustainable Energy Reviews* **2016**, *53*, 178-184, doi:https://doi.org/10.1016/j.rser.2015.08.041.
11. Azarova, V.; Cohen, J.; Friedl, C.; Reichl, J. Designing local renewable energy communities to increase social acceptance: Evidence from a choice experiment in Austria, Germany, Italy, and Switzerland. *Energy Policy* **2019**, *132*, 1176-1183, doi:https://doi.org/10.1016/j.enpol.2019.06.067.
12. Batel, S. Research on the social acceptance of renewable energy technologies: Past, present and future. *Energy Research & Social Science* **2020**, *68*, 101544, doi:https://doi.org/10.1016/j.erss.2020.101544.
13. Motz, A. Consumer acceptance of the energy transition in Switzerland: The role of attitudes explained through a hybrid discrete choice model. *Energy Policy* **2021**, *151*, 112152, doi:https://doi.org/10.1016/j.enpol.2021.112152.
14. Linnerud, K.; Toney, P.; Simonsen, M.; Holden, E. Does change in ownership affect community attitudes toward renewable energy projects? Evidence of a status quo bias. *Energy Policy* **2019**, *131*, 1-8, doi:https://doi.org/10.1016/j.enpol.2019.04.039.
15. Rosso-Cerón, A.M.; Kafarov, V. Barriers to social acceptance of renewable energy systems in Colombia. *Current Opinion in Chemical Engineering* **2015**, *10*, 103-110, doi:https://doi.org/10.1016/j.coche.2015.08.003.
16. Kim, K.J.; Lee, H.; Koo, Y. Research on local acceptance cost of renewable energy in South Korea: A case study of photovoltaic and wind power projects. *Energy Policy* **2020**, *144*, 111684, doi:https://doi.org/10.1016/j.enpol.2020.111684.
17. Zoellner, J.; Schweizer-Ries, P.; Wemheuer, C. Public acceptance of renewable energies: Results from case studies in Germany. *Energy policy* **2008**, *36*, 4136-4141.
18. Economou, A. Renewable energy resources and sustainable development in Mykonos (Greece). *Renewable and Sustainable Energy Reviews* **2010**, *14*, 1496-1501.
19. Jobert, A.; Laborgne, P.; Mimler, S. Local acceptance of wind energy: Factors of success identified in French and German case studies. *Energy policy* **2007**, *35*, 2751-2760.
20. Woo, J.; Chung, S.; Lee, C.-Y.; Huh, S.-Y. Willingness to participate in community-based renewable energy projects: A contingent valuation study in South Korea. *Renewable and Sustainable Energy Reviews* **2019**, *112*, 643-652.
21. Wilson, G.A.; Dyke, S.L. Pre-and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). *Land use policy* **2016**, *52*, 287-296.
22. Wolsink, M. Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy policy* **2007**, *35*, 2692-2704.
23. Roddis, P.; Carver, S.; Dallimer, M.; Norman, P.; Ziv, G. The role of community acceptance in planning outcomes for onshore wind and solar farms: An energy justice analysis. *Applied Energy* **2018**, *226*, 353-364, doi:https://doi.org/10.1016/j.apenergy.2018.05.087.
24. Vuichard, P.; Stauch, A.; Wüstenhagen, R. Keep it local and low-key: Social acceptance of alpine solar power projects. *Renewable and Sustainable Energy Reviews* **2021**, *138*, 110516, doi:https://doi.org/10.1016/j.rser.2020.110516.
25. Martilla, J.A.; James, J.C. Importance-performance analysis. *Journal of marketing* **1977**, *41*, 77-79.
26. Tseng, M.-L. Importance–performance analysis of municipal solid waste management in uncertainty. *Environmental Monitoring and Assessment* **2011**, *172*, 171-187, doi:10.1007/s10661-010-1325-7.
27. Wong, M.S.; Philip, G.; Fearon, C. Evaluating E-government in Malaysia: An importance-performance grid analysis (IPA) of citizens and service providers. *International Journal of Electronic Business* **2009**, *7*, 105-129.

28. Azzopardi, E.; Nash, R. A critical evaluation of importance–performance analysis. *Tourism Management* **2013**, *35*, 222-233, doi:https://doi.org/10.1016/j.tourman.2012.07.007.
29. Lai, I.K.W.; Hitchcock, M. Importance–performance analysis in tourism: A framework for researchers. *Tourism Management* **2015**, *48*, 242-267, doi:https://doi.org/10.1016/j.tourman.2014.11.008.
30. Boley, B.B.; McGehee, N.G.; Tom Hammett, A.L. Importance-performance analysis (IPA) of sustainable tourism initiatives: The resident perspective. *Tourism Management* **2017**, *58*, 66-77, doi:https://doi.org/10.1016/j.tourman.2016.10.002.
31. Chen, H.-C.; Tseng, T.-P.; Cheng, K.; Sriarkarin, S.; Xu, W.; Ferdin, A.E.J.; Nguyen, V.V.; Zong, C.; Lee, C.-H. Conducting an Evaluation Framework of Importance-Performance Analysis for Sustainable Forest Management in a Rural Area. *Forests* **2021**, *12*, 1357.
32. Nguyen, L.B.; Chen, H.-C.; Seekings, T.B.W.; Dhungana, N.; Chen, C.-C.; Lee, C.-H. Integrated Adaptation Strategies for Human–Leopard Cat Coexistence Management in Taiwan. *Sustainability* **2024**, *16*, 4031.
33. Chen, W.-C.; Chen, W.-K.; Chen, C.-W.; Lo, C.-C. An empirical study of willingness to renewable energy installation using importance-performance analysis: The case of Taiwan. *Journal of Industrial and Production Engineering* **2019**, *36*, 451-460.
34. Ministry of Economic Affairs. Energy Transition Promotion Scheme: Promote Green Energy, Increase Nature Gas, Reduce Coal-fired, Achieve Nuclear-free. Availabe online: https://www.moea.gov.tw/MNS/english/Policy/Policy.aspx?menu_id=32904&policy_id=19 (accessed on
35. Gebreslassie, M.G. Public perception and policy implications towards the development of new wind farms in Ethiopia. *Energy Policy* **2020**, *139*, 111318, doi:https://doi.org/10.1016/j.enpol.2020.111318.
36. Kim, J.-H.; Nam, J.; Yoo, S.-H. Public acceptance of a large-scale offshore wind power project in South Korea. *Marine Policy* **2020**, *120*, 104141, doi:https://doi.org/10.1016/j.marpol.2020.104141.
37. Moon, W.-K.; Kahlor, L.A.; Olson, H.C. Understanding public support for carbon capture and storage policy: The roles of social capital, stakeholder perceptions, and perceived risk/benefit of technology. *Energy Policy* **2020**, *139*, 111312.
38. Xin-gang, Z.; Ling, W.; Ying, Z. How to achieve incentive regulation under renewable portfolio standards and carbon tax policy? A China's power market perspective. *Energy Policy* **2020**, *143*, 111576, doi:https://doi.org/10.1016/j.enpol.2020.111576.
39. Lowitzsch, J.; Hoicka, C.E.; van Tulder, F.J. Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? *Renewable and Sustainable Energy Reviews* **2020**, *122*, 109489, doi:https://doi.org/10.1016/j.rser.2019.109489.
40. Kamlage, J.-H.; Drewing, E.; Reinermann, J.L.; de Vries, N.; Flores, M. Fighting fruitfully? Participation and conflict in the context of electricity grid extension in Germany. *Utilities Policy* **2020**, *64*, 101022, doi:https://doi.org/10.1016/j.jup.2020.101022.
41. Priessner, A.; Hampl, N. Can product bundling increase the joint adoption of electric vehicles, solar panels and battery storage? Explorative evidence from a choice-based conjoint study in Austria. *Ecological Economics* **2020**, *167*, 106381, doi:https://doi.org/10.1016/j.ecolecon.2019.106381.
42. Schulte, E.; Scheller, F.; Sloot, D.; Bruckner, T. A meta-analysis of residential PV adoption: the important role of perceived benefits, intentions and antecedents in solar energy acceptance. *Energy Research & Social Science* **2022**, *84*, 102339, doi:https://doi.org/10.1016/j.erss.2021.102339.
43. Mamkhezri, J.; Thacher, J.A.; Chermak, J.M. Consumer Preferences for Solar Energy
44. A Choice Experiment Study. *The Energy Journal* **2020**, *41*, 157-184.
45. Hu, Z. Towards solar extractivism? A political ecology understanding of the solar energy and agriculture boom in rural China. *Energy Research & Social Science* **2023**, *98*, 102988, doi:https://doi.org/10.1016/j.erss.2023.102988.
46. Moore-O'Leary, K.A.; Hernandez, R.R.; Johnston, D.S.; Abella, S.R.; Tanner, K.E.; Swanson, A.C.; Kreitler, J.; Lovich, J.E. Sustainability of utility-scale solar energy – critical ecological concepts. *Frontiers in Ecology and the Environment* **2017**, *15*, 385-394, doi:https://doi.org/10.1002/fee.1517.
47. San-Martín, E.; Elizalde, P. Determinants of rooftop solar uptake: A comparative analysis of the residential and non-residential sectors in the Basque Country (Spain). *Renewable and Sustainable Energy Reviews* **2024**, *203*, 114711, doi:https://doi.org/10.1016/j.rser.2024.114711.
48. Chaikumbung, M. Institutions and consumer preferences for renewable energy: A meta-regression analysis. *Renewable and Sustainable Energy Reviews* **2021**, *146*, 111143, doi:https://doi.org/10.1016/j.rser.2021.111143.
49. Chen, H.H.; Lee, A.H.I. Comprehensive overview of renewable energy development in Taiwan. *Renewable and Sustainable Energy Reviews* **2014**, *37*, 215-228, doi:https://doi.org/10.1016/j.rser.2014.04.055.
50. Arodudu, O.; Holmatov, B.; Voinov, A. Ecological impacts and limits of biomass use: a critical review. *Clean Technologies and Environmental Policy* **2020**, *22*, 1591-1611, doi:10.1007/s10098-020-01911-1.
51. Rosillo-Calle, F. A review of biomass energy–shortcomings and concerns. *Journal of Chemical Technology & Biotechnology* **2016**, *91*, 1933-1945.

52. Makarichi, L.; Jutidamrongphan, W.; Techato, K.-a. The evolution of waste-to-energy incineration: A review. *Renewable and Sustainable Energy Reviews* **2018**, *91*, 812-821.
53. Lovich, J.E.; Ennen, J.R. Wildlife Conservation and Solar Energy Development in the Desert Southwest, United States. *BioScience* **2011**, *61*, 982-992, doi:10.1525/bio.2011.61.12.8.
54. Gómez-Catasús, J.; Morales, M.B.; Giralt, D.; del Portillo, D.G.; Manzano-Rubio, R.; Solé-Bujalance, L.; Sardà-Palomera, F.; Traba, J.; Bota, G. Solar photovoltaic energy development and biodiversity conservation: Current knowledge and research gaps. *Conservation Letters* **2024**, *17*, e13025, doi:https://doi.org/10.1111/conl.13025.
55. Tölgyesi, C.; Bátori, Z.; Pascarella, J.; Erdős, L.; Török, P.; Batáry, P.; Birkhofer, K.; Scherer, L.; Michalko, R.; Košulič, O. Ecovoltaics: Framework and future research directions to reconcile land-based solar power development with ecosystem conservation. *Biological Conservation* **2023**, *285*, 110242.
56. Walston, L.J.; Barley, T.; Bhandari, I.; Campbell, B.; McCall, J.; Hartmann, H.M.; Dolezal, A.G. Opportunities for agrivoltaic systems to achieve synergistic food-energy-environmental needs and address sustainability goals. *Frontiers in Sustainable Food Systems* **2022**, *6*, 932018.
57. Pascaris, A.S.; Schelly, C.; Burnham, L.; Pearce, J.M. Integrating solar energy with agriculture: Industry perspectives on the market, community, and socio-political dimensions of agrivoltaics. *Energy Research & Social Science* **2021**, *75*, 102023.
58. Gorjian, S.; Ebadi, H.; Jathar, L.D.; Savoldi, L. Solar energy for sustainable food and agriculture: developments, barriers, and policies. In *Solar energy advancements in agriculture and food production systems*, Elsevier: 2022; pp. 1-28.
59. Rule, T.A. Solar, wind and land: Conflicts in renewable energy development; Routledge: 2014.
60. Langer, K.; Decker, T.; Menrad, K. Public participation in wind energy projects located in Germany: Which form of participation is the key to acceptance? *Renewable Energy* **2017**, *112*, 63-73, doi:https://doi.org/10.1016/j.renene.2017.05.021.
61. Heng, Y.; Lu, C.-L.; Yu, L.; Gao, Z. The heterogeneous preferences for solar energy policies among US households. *Energy Policy* **2020**, *137*, 111187, doi:https://doi.org/10.1016/j.enpol.2019.111187.
62. van Rijnsoever, F.J.; van Mossel, A.; Broecks, K.P.F. Public acceptance of energy technologies: The effects of labeling, time, and heterogeneity in a discrete choice experiment. *Renewable and Sustainable Energy Reviews* **2015**, *45*, 817-829, doi:https://doi.org/10.1016/j.rser.2015.02.040.
63. Cousse, J. Still in love with solar energy? Installation size, affect, and the social acceptance of renewable energy technologies. *Renewable and Sustainable Energy Reviews* **2021**, *145*, 111107.
64. Paravantis, J.A.; Stigka, E.; Mihalakakou, G.; Michalena, E.; Hills, J.M.; Dourmas, V. Social acceptance of renewable energy projects: A contingent valuation investigation in Western Greece. *Renewable Energy* **2018**, *123*, 639-651.
65. Segreto, M.; Principe, L.; Desormeaux, A.; Torre, M.; Tomassetti, L.; Tratzi, P.; Paolini, V.; Petracchini, F. Trends in social acceptance of renewable energy across Europe—a literature review. *International journal of environmental research and public health* **2020**, *17*, 9161.
66. Stigka, E.K.; Paravantis, J.A.; Mihalakakou, G.K. Social acceptance of renewable energy sources: A review of contingent valuation applications. *Renewable and sustainable energy Reviews* **2014**, *32*, 100-106.
67. Bidwell, D. The role of values in public beliefs and attitudes towards commercial wind energy. *Energy Policy* **2013**, *58*, 189-199, doi:https://doi.org/10.1016/j.enpol.2013.03.010.