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SHORT ABSTRACT FOR DISSEMINATION PURPOSES

Abstract

This deliverable, part of the WIMBY (Wind in My Backyard) project under the Horizon Europe programme, presents the development of a Multi-Criteria Satisfaction Analysis (MCSA) framework and an indicator database to measure the acceptance of wind power installations by relevant residents and stakeholders. Based on the foundations of MUlticriteria Satisfaction Analysis (MUSA) method, this framework systematically assesses satisfaction across multiple dimensions, including environmental, economic, and social aspects. The report details the methodological approach, criteria selection, and indicator development processes, providing a solid foundation for the subsequent case study application in WP3. The framework's applicability in geographic or stakeholder-based contexts ensures a comprehensive understanding of satisfaction dynamics, facilitating enhanced stakeholder engagement and informed decision-making in the deployment of wind energy solutions.

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ABBREVIATIONS

Acronym	Description
ADI	Average Demanding Indices
AII	Average Improvement Indices
ASI	Average Satisfaction Indices
DM	Decision Maker
GHG	Greenhouse gas
LCA	Life Cycle Assessment
MCDA	Multi-Criteria Decision Analysis
MCSA	Multi-Criteria Satisfaction Analysis
MUSA	MUlticriteria Satisfaction Analysis

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EXECUTIVE SUMMARY

This deliverable report outlines the progress and findings associated with Task T4.1, aimed at developing a Multi-Criteria Satisfaction Analysis (MCSA) framework tailored for evaluating the satisfaction of wind farms by citizens and other stakeholders. The framework is developed based on the MUlticriteria Satisfaction Analysis (MUSA) method, a specialised form of the Multi-Criteria Decision Analysis (MCDA). The MUSA method serves as a specific method within MCSA framework that aggregates participants' input into a unified measure of overall consensus to assess their satisfaction across various criteria.

This method is designed to elicit preferences on a predefined list of criteria and indicators from a group of participants, to systematically and transparently evaluate the satisfaction of wind farms. This task feeds directly into T4.2 and supports other modelling tasks within WP4. Furthermore, it forms the foundation for the case study application in WP3.

The main results of this deliverable include the development of a detailed MCSA framework for evaluating satisfaction levels with regard to wind farms and a comprehensive database of relevant criteria and indicators to assess environmental, economic, and social impacts. These results will feed into T4.2 for further pilot site demonstration and a comprehensive analysis at a specific case study location (WP3). This deliverable also accommodates and incorporates input from various project partners. Some outputs from WP2, such as those from techno-economic assessments and Life Cycle Assessments (LCA), can serve as references for evaluators conducting the analyses. Additionally, other outputs from WP2 can be compared and harmonised with the MUSA outputs, to delve further into the intra-criteria dynamics.

Attainment of Objectives and Explanation of Deviations

All related task objectives have been successfully achieved as per the planned timeline. There have been no deviations. The collaborative approach and integration of diverse inputs have ensured that the deliverable meets the expected standards and contributes effectively to the overarching goals of the WIMBY project.

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1. Introduction

As global efforts to adopt sustainable energy solutions intensify, the integration of wind power as a renewable energy source is becoming increasingly important[1]. However, such initiatives often face socio-economic and environmental hurdles, particularly in the form of resistance from local communities, as well as common citizens and relevant organizations [2], [3], [4], [5]. To effectively manage and overcome these challenges, a structured approach to decision-making is essential, one that involves stakeholders and thoroughly evaluates their preferences and satisfaction regarding wind installations in the vicinity of their households and economic activities.

Task T4.1 addresses these needs by developing and structuring a satisfaction framework that utilises an MCDA method known as MUSA. MCDA is a decision-support approach that facilitates decision-making when multiple conflicting criteria are involved[6]. It supports a structured evaluation of alternatives, enabling decision-makers (DMs) to balance multiple stakeholder interests and complex project outcomes. By applying MCDA, analysts can navigate the multifaceted decision landscapes, typical of large-scale energy projects, pertaining to environmental and energy planning[7], [8], [9].

Task T4.1 develops a satisfaction measurement and analysis methodology based on a MCDA framework called Multi-Criteria Satisfaction Analysis (MCSA). In this framework, "satisfaction" refers to the positive recognition and satisfaction of stakeholders and residents with the presence and operation of wind farms in their vicinity. Conversely, "acceptability" examines the degree to which off-site stakeholders and broader communities find wind farm proposals agreeable or tolerable, even if they are not directly affected by their physical presence. In essence, both terms evaluate stakeholder perspectives, but from different situational contexts. Depending on the specific requirements of each case, our framework will use either term to tailor the inquiry appropriately. For example, if the wind farms are on-site, the questions will be designed to measure satisfaction; however, if the wind farms are off-site, which are located away from the stakeholders, the framework will assess "acceptability," which will require modifications to the questions accordingly.

The MCSA framework ensures transparent and engaging interactions between analysts and stakeholders, facilitating an inclusive decision-making process that respects and incorporates diverse viewpoints. To develop a comprehensive and effective MCSA framework, Task T4.1 includes the creation of an appropriate list of relevant criteria along with an indicator database. This database is essential for evaluating the satisfaction of wind farms within the vicinity of residents. These indicators, including but not limited to greenhouse gas (GHG) emissions, land use, and biodiversity impacts, are used to assess the environmental and social impacts of wind farms. The selection and refinement of these indicators was conducted through a collaborative process among the WIMBY partners.

In addition, Task T4.1 integrates data and findings from previous work packages, employing techno-economic assessments, Life Cycle Assessments (LCA), and system models to enhance the satisfaction evaluation. Data for the selected criteria are meticulously determined through detailed modelling activities in WPs 1 and 2. This integrated approach ensures that the MCSA framework precisely captures the acceptability of participants associated with wind energy projects.

Ultimately, the satisfaction analysis framework and indicator database established in T4.1 will feed into subsequent tasks of WP4 and support other modelling efforts. This work will improve the management and understanding of stakeholder interactions in wind energy projects and promote broader satisfaction and integration of wind energy solutions into the energy grid.

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2. Methodological Framework

The proposed MCSA framework is specified to adhere to the requirements of the MUlticriteria Satisfaction Analysis (MUSA method [10]). MUSA focuses on the structured and transparent measurement and analysis of satisfaction, with the use of dedicated questionnaires and powerful linear programming techniques (see [11] for a thorough review of the MUSA methodological developments and applications).

MUSA was initially designed to elicit customers' satisfaction and acceptability based on the collective input from a group of evaluators. This approach ensures that diverse perspectives and priorities are considered in the assessment process, leading to a more inclusive and representative evaluation of products and services.

Building on the MUSA as the core methodological approach, we have expanded the analysis to focus on the satisfaction analysis for wind power plants. This framework aims to systematically capture the satisfaction levels of residents and stakeholders, thereby providing a comprehensive evaluation of diverse group responses and preferences.

2.1 Mathematical Foundations of MUSA

MUSA is an intuitive method that quantitatively evaluates participants' satisfaction across multiple criteria [10]. MUSA effectively facilitates the aggregation of individual preferences into a unified understanding of overall acceptance. Its strength lies in its ability to decompose complex preference structures into clearly interpretable satisfaction levels, making it exceptionally well-suited for this study[6]. This method not only captures the nuanced preferences of participants but also ensures that the evaluation process is both accessible and efficient, minimizing their time commitment.

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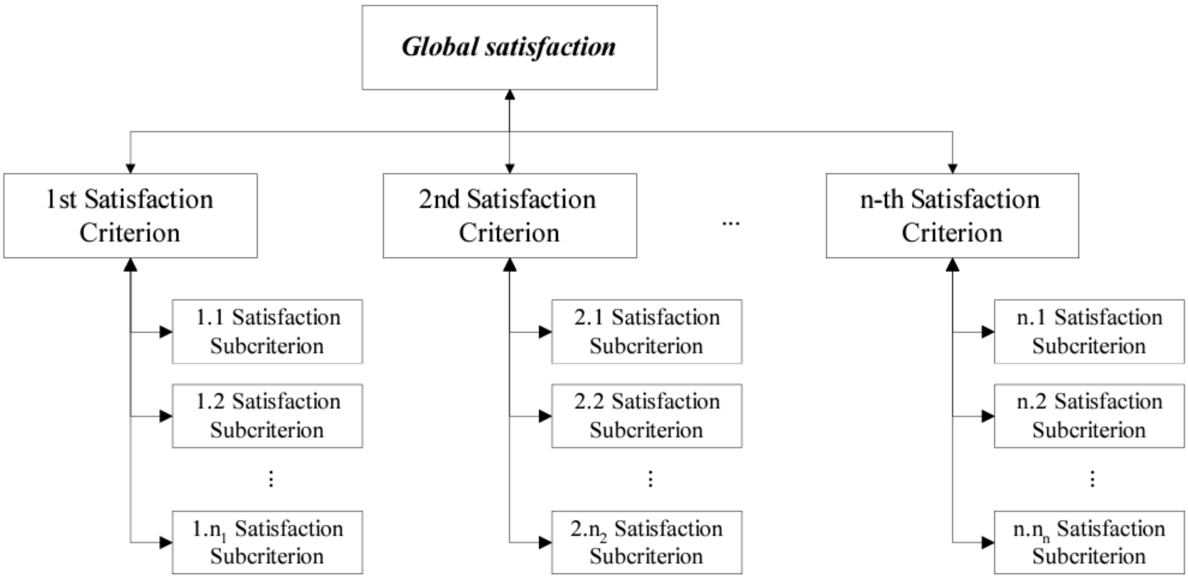

Figure 1 Structure of a MUSA problem

As shown in Figure 1, the MUSA is applied to disaggregate overall global satisfaction into individual satisfactions across multiple criteria, effectively decomposing the complex evaluation into more manageable parts. This hierarchical breakdown allows for a detailed assessment of how each subcriterion contributes to the overall satisfaction level. By employing the MUSA method, the framework can quantitatively measure the impact of each criterion on a global satisfaction scale, enabling evaluators to identify areas of strength and opportunities for improvement within the satisfaction structure. This structured approach provides a transparent and comprehensive view of stakeholder satisfaction.

By employing MUSA, we aim to derive detailed metrics on the prioritization of various attributes influencing wind farms' acceptability, such as visual and noise impacts. This analysis will allow us to construct a comprehensive portrait of public sentiment towards wind farms, identifying both strengths and potential areas for improvement. The goal of our research is to provide policymakers and urban planners with actionable insights to facilitate the promotion of sustainable wind energy solutions.

In our study, participants will be invited to participate in an online survey to express their judgments, encompassing both their overall satisfaction regarding wind farms installed nearby and specific satisfaction levels on the specific criteria. A predetermined α ordinal satisfaction scale is used to capture these judgments, for example, in a 5-point Likert scale: extremely dissatisfied, somewhat dissatisfied, neither satisfied nor dissatisfied,

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somewhat satisfied, and extremely satisfied. This scale simplifies the quantification of participant feedback, enabling clearer and more straightforward interpretation for citizens. Suppose there are n criteria denoted as $G = \{g_1, g_2, \ldots, g_n\}$. In this method, the overall satisfaction function is represented by Y^*, while the partial satisfaction functions corresponding to each individual criterion i are denoted by X_i^*. The relationship between these variables is explained by an ordinal regression analysis equation:

$$Y^* = \sum_{i=1}^{n} b_i X_i^* - \sigma^+ + \sigma^-, \quad (1)$$

$$\sum_{i=1}^{n} b_i = 1, \quad (2)$$

where b_i is the weight of criterion i . Y^* and X_i^* are normalized in the interval $[0,100]$, where the satisfaction level $y^{*1} = x_i^{*1} = 0$ and $y^{*\alpha} = x_i^{*\alpha} = 100, \forall i = 1,2,\ldots,n$. $\sigma^+ \, and \, \sigma^-$ are the overestimation error and underestimation error respectively. Drawing upon the specified equation, MUSA constructs a Linear Programming (LP) model designed to discern how satisfaction across multiple criteria contributes to overall satisfaction with the service. The primary objective is to minimize under- and over-estimation errors for all the respondents to the questionnaire (an illustration of the global satisfaction function for the j^{th} participant's can be found in Figure 2).

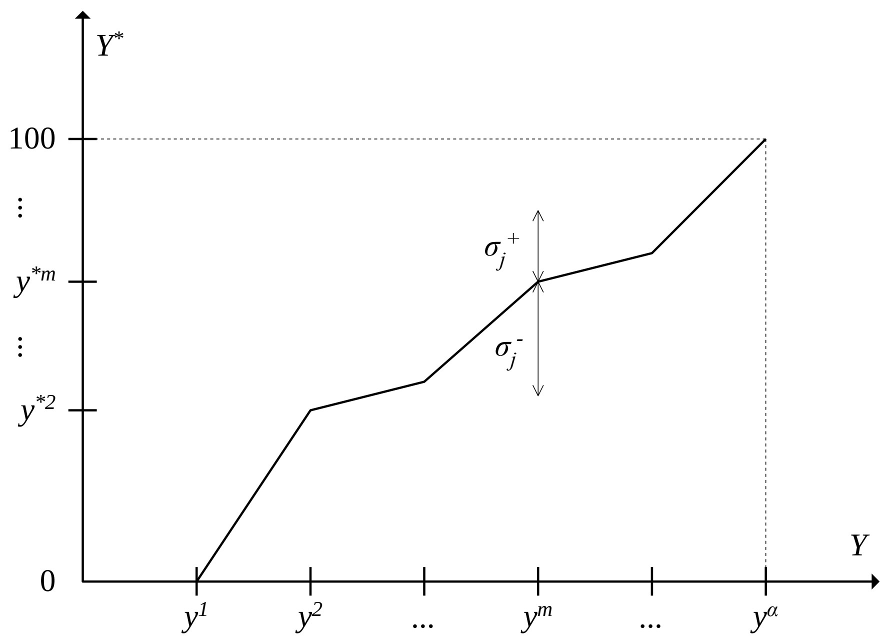

Figure 2 Error variables for the jth participant.

The output generated by MUSA includes a comprehensive set of results, detailing overall satisfaction, which is aggregated from partial satisfactions for individual criteria, weighted appropriately.

After the initial optimization, a series of further optimizations is conducted to determine the highest and lowest possible weights for each criterion. The barycenter of these weight vectors is then calculated to establish the final criteria weights. This method ensures that the derived weights are robust and accurately reflect the priorities of the participants. Additionally, MUSA yields a series of indices that offer deeper insights, thus enhancing the interpretability and reliability of the satisfaction assessment results:

1. **Average Satisfaction Indices (ASI)**: Represent the mean of the global or partial value functions, normalised within the range [0,1]. The higher the value, the higher the satisfaction with the corresponding criteria. ASI is denoted as follows:

$$ASI = \frac{1}{100}\sum_{m=1}^{\alpha} p^m y^{*m}, \tag{3}$$

$$ASI_i = \frac{1}{100}\sum_{k=1}^{\alpha} p_i^k x_i^{*k}\text{, for } i = 1,2,\dots,n, \tag{4}$$

where p^m and p_i^k are the frequencies of customers belonging to the overall satisfaction level and partial satisfaction levels on criterion i, respectively.

2. **Average Demanding Indices (ADI)**: A quantitative measure is assessed for the concept of customers' demand. The average demanding indices are normalised in the interval [-1,1]. If the index reaches a value of 1, it indicates that participants exhibit the highest level of demand. In this scenario, participants are only satisfied with the utmost quality level. On the other hand, an index value of -1 signifies the lowest level of demand, where participants have minimal expectations or demands from the service or product in question. ADI is denoted as follows:

$$ADI = \frac{1 - \frac{\bar{\bar{y}}^*}{50}}{1 - \frac{2}{\alpha}}\text{, for } \alpha > 2, \tag{5}$$

$$ADI_i = \frac{1 - \frac{\bar{\bar{x}}^*}{50}}{1 - \frac{2}{\alpha}}\text{, for } \alpha > 2\text{, and } i = 1,2,\dots,n, \tag{6}$$

where $\bar{\bar{y}}^*$ and $\bar{\bar{x}}^*$ are the mean values of functions Y^* and X_i^*, respectively. The value functions with different demanding levels can be found in Figure 3.

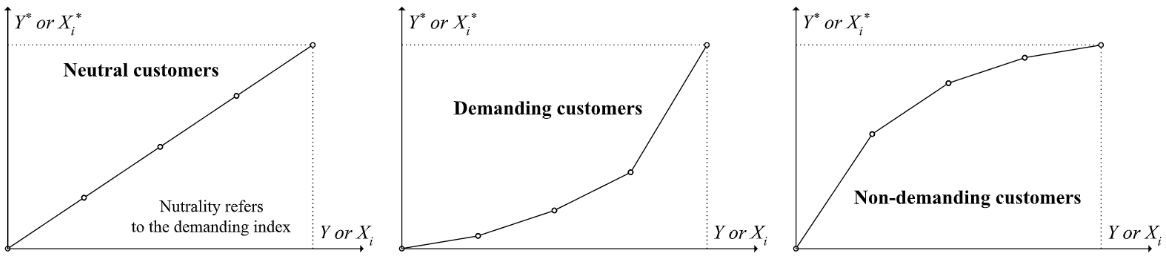

Figure 3 Value functions with different demanding levels

3. **Average Improvement Indices (AII)**: The average improvement indices can show the improvement margins on a specific criterion. These indices are normalised in the interval [0,1]. The improvement index for a given criterion is inversely proportional to its performance level, given a certain weight. Specifically, a higher weight assigned to a criterion, coupled with lower performance in that area, results in a correspondingly higher improvement index for that criterion. This relationship highlights areas requiring enhanced focus for improvement, based on their importance and current performance levels:

$$I_i = b_i(1 - ASI_i), for\ i = 1,2, \ldots, n. \tag{7}$$

Using weights, ASIs, ADIs, and AIIs, two quadrant diagrams can be created. These diagrams provide valuable insights for proposing and developing actions and strategies aimed at enhancing the service or item, specifically in our context, the wind farms. As shown in Figure 4, the diagrams can provide different strategies for specific criteria falling into different areas. Figure 4(a), the relative action diagram, is designed to illustrate the influence of different criteria on overall satisfaction. The x-axis showing the weights of the criteria indicates their relative importance as determined through the analysis. The y-axis, displaying the ASI, represents how well each criterion is meeting the stakeholders' expectations. This diagram helps identify which criteria are critical and performing well versus those that might need more attention due to their high importance but lower satisfaction scores.
On the other hand, Figure 4(b), the relative improvement diagram, focuses on identifying potential areas for improvement within the criteria. The x-axis

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shows the AII, which indicates the potential gain in overall satisfaction that could be achieved by improving each criterion. The y-axis, displaying the ADI, represents the degree of demand or expectation stakeholders have regarding each criterion. This diagram is useful for prioritising improvements by highlighting criteria where small enhancements could lead to significant increases in overall satisfaction, especially those with high expectations but currently low performance.

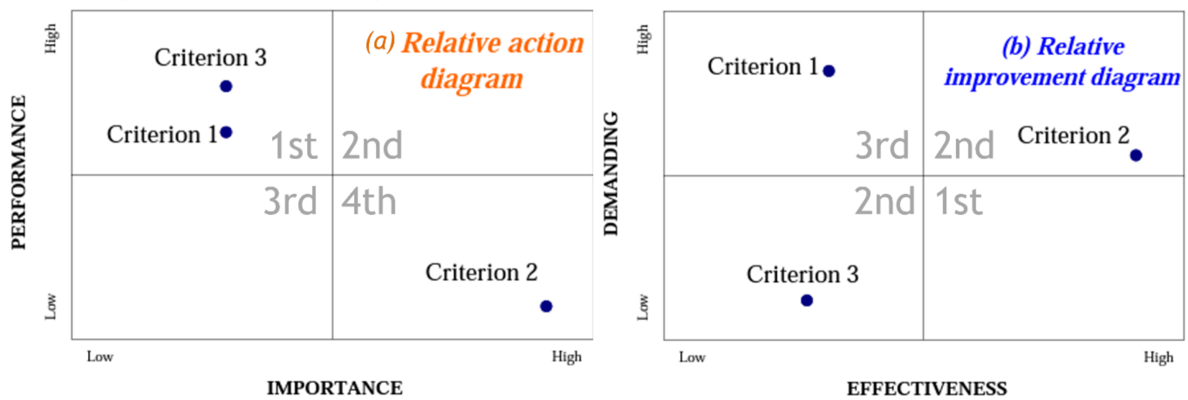

Figure 4 MUSA diagrams: (a) relative action diagram; (b) relative improvement diagram

In the relative action diagram, criteria can be clustered in 4 priorities:

- 1st - Transfer resources: the resources may be better used elsewhere;
- 2nd - Leverage opportunity: these areas can be used as advantage against competition;
- 3rd - Status quo: generally, no action is required;
- 4th - Action opportunity: these are the criteria/subcriteria that need attention.

In the relative improvement diagram, criteria can be clustered in 3 priorities:

- 1st priority: this area can indicate improvement actions since these dimensions are highly effective and customers are not demanding;
- 2nd priority: it includes criteria which have either a low ADI and high AII or a high ADI and low AII;
- 3rd priority: it refers to satisfaction dimensions that have small improvement margin and need substantial effort.

2.2 MUSA-based satisfaction analysis framework

Within WIMBY project, two distinct MUSA frameworks are proposed to analyse satisfaction over wind farms: the stakeholder-based satisfaction analysis framework and the geographic-based satisfaction analysis framework. Each framework is tailored to different scenarios, depending on the availability of the data derived from the pilot sites in WP3. These two

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satisfaction analysis frameworks are designed to engage different types of participants and to elicit different information, specific to each context. It should be noted that if the wind farms are located on-site, the questions will be designed to measure satisfaction; however, if the wind farms are off-site, the framework will be used to assess "acceptability", requiring modifications to the questions accordingly. Despite these differences, the same MUSA questions will be used in both frameworks. Figure 1 provides detailed descriptions and examples of the inputs required for analysis within each MUSA framework:

Table 1 MUSA question information

Satisfaction on criteria	Description	α level ordinal satisfaction scale to describe the judgements of residents on criteria.
	Example Question	Visual Impact on Landscape: How satisfied are you with the aesthetic integration of wind power plants into the local landscape?
	Example Answer	The participant select "Satisfied" from a 5 level scale.
Overall satisfaction	Description	α level ordinal satisfaction scale to describe the judgements of residents on criteria.
	Example Question	Considering all the above-mentioned information together, how satisfied do you feel with the wind farms in your area?
	Example Answer	The participant selects "Very satisfied" from a 5 level scale.

We tentatively propose to use a 5-level ordinal scale for describing satisfaction on criteria and overall satisfaction. Participants can indicate that they are:

- Very Dissatisfied: This means the participant is not at all satisfied and may have strong negative feelings about the aspect in question.
- Dissatisfied: The participant is somewhat unhappy or unsatisfied with this aspect.
- Neutral: The participant neither feel satisfied nor dissatisfied.
- Satisfied: The participant is generally satisfied but might have minor reservations or suggestions for improvement.
- Very Satisfied: The participant is completely satisfied and has a very positive view of this aspect.

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The terms "satisfaction" and "satisfied" will be revised to "acceptability" and "acceptable," respectively, if the wind farms are located off-site. The subsequent subsections detail the two satisfaction analysis frameworks, outlining their inputs, outputs, and requirements.

2.2.1 Geographic-based satisfaction analysis framework

The geographic-based satisfaction analysis framework is ideally suited for cases where data can be collected from participants, based on their geographic locations. This approach is essential for understanding how satisfaction over wind farms varies across different regions. The framework is designed to evaluate the satisfaction levels of various geographic regions, integrating multiple data sources and analytical techniques to comprehensively understand the spatial distribution of satisfaction.

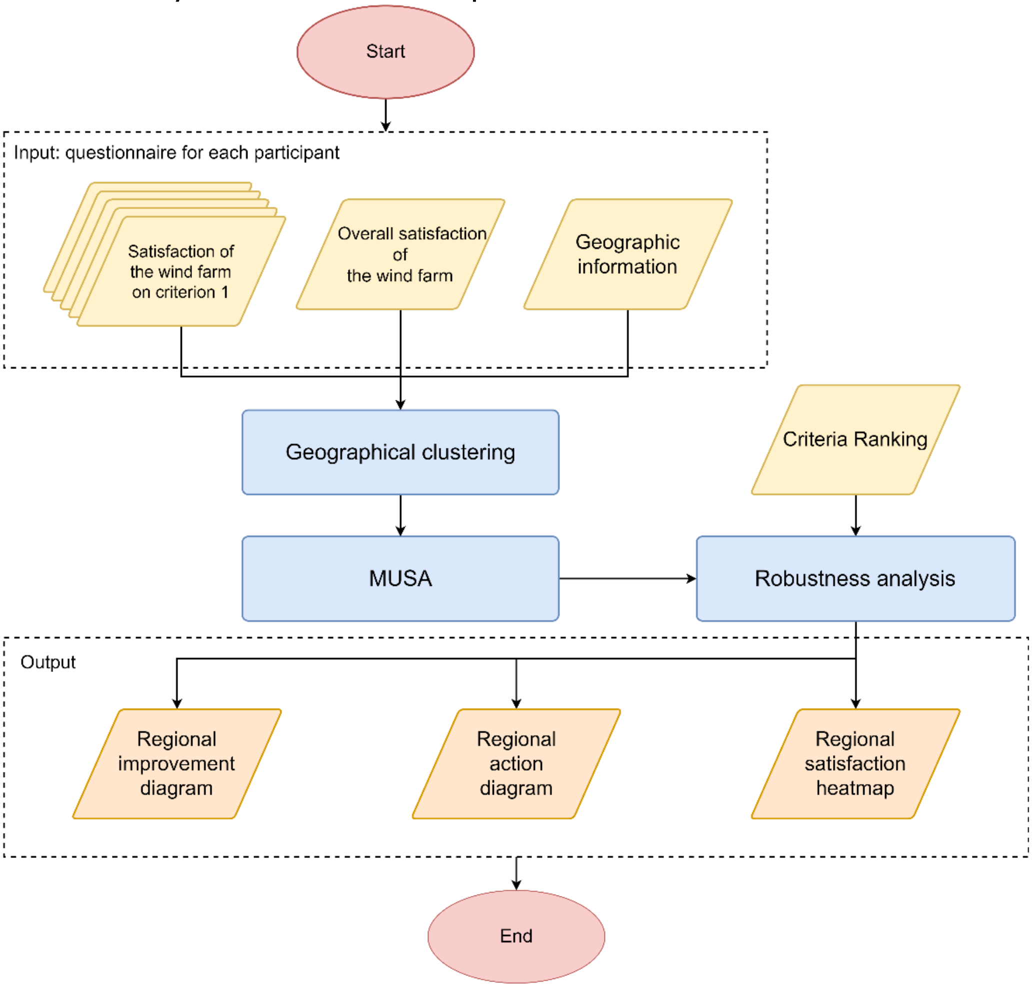

Figure 5 Geographic-based satisfaction analysis framework flowchart

The workflow of the geographic-based satisfaction analysis framework is illustrated in Figure 5. The core input for the framework is derived from the MUSA questionnaires. In addition to standard satisfaction-related questions, the questionnaire also collects certain geographic information of the

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participants to elicit spatial satisfaction levels. This required input from the residents is presented as follows:

Table 2 Geographical-based framework question information

Geographic information (Pantelleria)	Description	Collect detailed geographic data to map participants' locations.
	Example Question	Could you please indicate in which street do you live?
	Example Answer	The participant enters “Via Felice Cavallotti”.
Geographic information (Styria)	Description	Collect detailed geographic data to map participants' locations.
	Example Question	Could you please indicate in which municipality do you live?
	Example Answer	The participant enters “Leoben”.

With the collected data, geographical clustering is performed to segment the study area into distinct regions. This clustering helps in identifying areas with similar satisfaction profiles and understanding regional variations:

Table 3 Geographical-based framework data requirement

	Geographical resolution	Minimum participants
Pantelleria	street-level	20 per district
Styria	municipality-level	20 per municipality

The minimum number of participants is set based on reference [10], which demonstrated the original methodology with 20 participants. MUSA is applied to evaluate satisfaction levels for each geographic cluster. This analysis provides a quantitative measure of satisfaction across different criteria, enabling a detailed understanding of the factors influencing satisfaction in each region.

A robustness analysis is conducted to measure the reliability and validity of the results. Some participants with expertise in the subject matter will be selected to respond to certain additional questions, focusing for instance on the importance or prioritization of the satisfaction criteria. This supplementary information serves to validate the preferences derived from the satisfaction questions. Subsequently, the results of the analysis are visualised through several outputs:

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- Regional Action Diagram: Provides actionable insights for policymakers and planners, suggesting specific interventions tailored to each region with the same structure of Figure 4 (a).
- Regional Improvement Diagram: Highlights the areas and criteria where improvements can enhance satisfaction with the same structure of Figure 4 (b).
- Regional Satisfaction Heatmap: Maps the overall satisfaction levels across different regions, offering a visual representation of areas with high and low satisfaction.

The geographic-based satisfaction analysis framework offers a robust methodology to measure acceptance of wind power plants and provides guidelines and priorities on how to improve it. By integrating detailed satisfaction data with geographic analysis and multicriteria evaluation, this framework helps identify targeted strategies to enhance the benefits of wind power technology across various regions. This comprehensive approach ensures that the diverse perspectives of local communities are considered.

2.2.2 Stakeholder-Based Satisfaction Analysis Framework

The stakeholder-based satisfaction analysis framework is tailored for cases where data can be collected from a variety of stakeholder groups. This approach is critical for discerning how acceptability of wind farms varies among different stakeholders, such as government officials, environmental organisations, and industry experts. By integrating multiple data sources and analytical techniques, the framework provides a comprehensive understanding of each stakeholder group's diverse perspectives and priorities.

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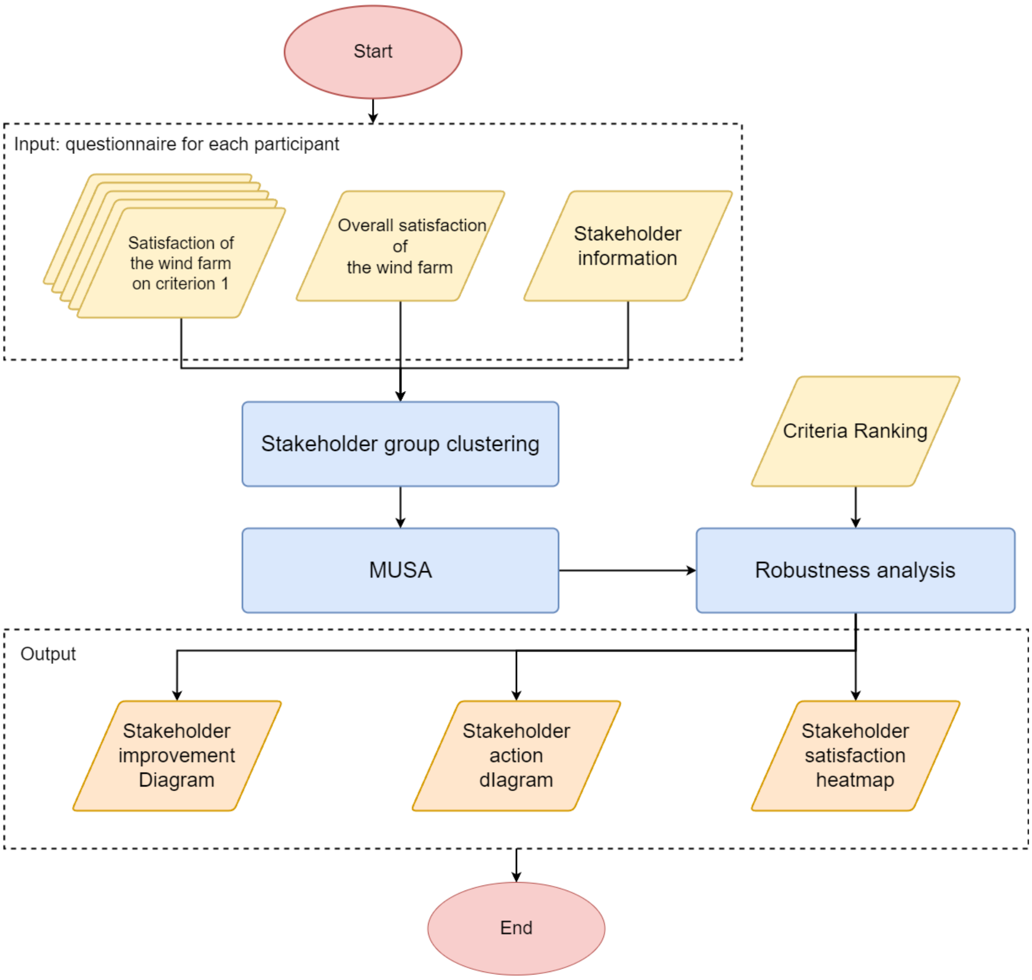

Figure 6 Stakeholder-based satisfaction analysis framework flowchart

The workflow of the stakeholder-based satisfaction analysis framework is illustrated in Figure 6. The core input for this framework is still derived from the MUSA questionnaire. Besides standard satisfaction-related questions, the questionnaire gathers detailed stakeholder data to capture specific perspectives and priorities.

The specific stakeholder-related questions are currently being developed in collaboration with partners from WP2 and WP4, ensuring that the questions are tailored to meet the specific needs and insights of diverse stakeholders. To ensure robustness, specific participants, with a higher level of expertise on energy systems, can be asked to pinpoint the importance of the satisfaction criteria, facilitating a subsequent robustness analysis.

Once the data is collected, stakeholder group clustering is performed to categorise stakeholders into distinct groups. This clustering process helps identify groups with similar satisfaction profiles and understand the variations in satisfaction among different stakeholder groups.

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MUSA is applied to evaluate satisfaction levels for each stakeholder group. This analysis provides a quantitative measure of satisfaction across various criteria, enabling a nuanced understanding of the factors influencing satisfaction in each group.

A robustness analysis is conducted to measure the reliability and validity of the results. Some participants with expertise in the subject matter will be selected and asked additional questions about the hierarchy of the criteria. This supplementary information will serve to validate the preferences derived from the satisfaction questions. Additionally, this input may be used to compare the differences between the MUSA methodology and the Mental Model approach.

The results of the analysis are visualised through several outputs:

- Stakeholder Action Diagram: Provides actionable insights for policymakers and planners, suggesting specific interventions tailored to each stakeholder group with the same structure of Figure 4 (a).
- Stakeholder Improvement Diagram: Highlights the areas and criteria where improvements can enhance satisfaction for each stakeholder group with the same structure of Figure 4 (b).
- Stakeholder Satisfaction Heatmap: Maps the overall satisfaction levels across different stakeholder groups, visually representing areas with high and low satisfaction.

The stakeholder-based satisfaction analysis framework offers a robust methodology for understanding and improving the acceptance of wind farms from the perspective of various stakeholders. By integrating detailed satisfaction data with multicriteria evaluation, this framework helps identify targeted strategies to enhance the benefits of wind power technology for different stakeholder groups. This comprehensive approach ensures that the diverse perspectives of all relevant parties are considered.

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3. Criteria and Indicators

This section outlines the critical elements of our methodology—the criteria and indicators. These are foundational to MCSA as they determine the dimensions along which satisfaction and acceptability of wind farms are assessed. A robust selection of these criteria and indicators is vital for capturing the nuanced perspectives of stakeholders and accurately reflecting the multi-dimensional impacts of WIMBY.

3.1 Selection Process

The process for selecting criteria and indicators in MCDA was meticulous and multi-faceted, ensuring both relevance and comprehensiveness [12]. The strategy for defining criteria within our satisfaction framework starts by identifying key dimensions that ensure comprehensive coverage of various aspects. We establish these criteria dimensions based on the core pillars of sustainability: environmental, social, and economic. This approach not only facilitates thorough identification but also ensures that all relevant aspects are adequately addressed.

The mapping of dimensions includes:

- Environmental Dimension: Focuses on criteria that assess the ecological impacts of wind farms, such as biodiversity, greenhouse gas emissions, and land use changes.
- Social Dimension: Encompasses criteria related to the social implications of wind energy projects, including community acceptance, visual and noise impacts, and local job creation.
- Economic Dimension: Includes criteria that evaluate the economic benefits and costs associated with wind farms, such as energy production efficiency, capital and operational costs, and local economic development.

Within each identified dimension, specific criteria are developed based on a combination of academic research, industry standards, and input from project stakeholders. This multi-source approach ensures that the criteria are comprehensive and reflect both theoretical and practical considerations.

- Literature Review: A thorough review of existing research and case studies provides the basis for identifying relevant criteria within each sustainability dimension. This review helps to ensure that our criteria are rooted in scientifically validated measures and align with global best practices.

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- Interdisciplinary Collaboration: Consulting with our partners, ensuring the comprehensiveness of our criteria. Additionally, we consider data generated during the project, if available and relevant, to possibly support the evaluation in MCSA. This collaboration helps to verify that all relevant sustainability aspects are considered without overlapping or duplicating metrics. By drawing on diverse expertise, we ensure a balanced representation across all dimensions, maintaining the integrity of the sustainability pillars.
- Finalization and Validation: After defining the criteria, they undergo a validation process that includes feedback loops with partners. Adjustments are made based on feedback to refine the criteria further before final adoption in the MCSA framework.

3.2 Description of Criteria and Indicators

Following the abovementioned selection process, Table 4 presents the defined list of criteria. These criteria encompass a comprehensive range of factors crucial for evaluating the environmental, economic, and social impacts by wind farms. It should be noted that performance data for some indicators can be sourced from other tasks within the WIMBY project. This information supports participants in evaluating criteria performances, particularly when they are not familiar with specific aspects of wind farms. For example, within the stakeholder-based MCSA framework, stakeholders who reside at a distance from the wind farm may not be fully aware of its biodiversity impact or GHG emission reductions. This lack of familiarity can influence their ability to accurately assess the wind farm's environmental performance. In such cases, outputs from other tasks can provide insights, helping stakeholders better understand the performance metrics.

Table 4 Tentative criteria list

Dimension	Criterion	Criterion Description	Supplementary Data
Environmental	Biodiversity Impact	Measures for protecting local biodiversity and wildlife.	Output from from T1.4
	GHG Emission Reduction	Contribution to reducing greenhouse gas emissions.	Output from from T2.4
Economic	Community Impact	The overall economic impact of wind power plants, including job	Output from from T2.5

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		creation, economic growth, and any potential disruptions or damages to local economies.	
	Personal Impact	The personal impact experienced by individuals, including changes in energy costs, property values, and any effect on personal or household economics.	/
Social	Social and Lifestyle Impact	Changes in community lifestyle and social dynamics due to wind power plants.	/
	Safety Concerns	Safety measures and protocols associated with wind power plants.	Output from from T2.2
	Community Engagement	Degree of community involvement in planning and operation of wind power plants.	/
	Visual Impact on Landscape	Aesthetics and visual integration of wind power plants in the landscape.	Output from from T2.3
	Noise	Noise levels from wind power plants.	Output from from T2.2

3.2.1 Environmental Dimension

- Biodiversity Impact: This criterion evaluates the measures taken to protect local biodiversity and wildlife in the areas surrounding wind power plants. Assessing biodiversity impact is crucial for understanding how wind projects interact with local ecosystems and for ensuring that development does not detrimentally affect local flora and fauna[13].
- GHG Emissions Reduction: This involves quantifying the contribution of wind power plants to reducing greenhouse gas emissions compared to conventional energy sources. This criterion is central to the environmental benefits of wind energy, highlighting its role in combating climate change[14].

3.2.2 Economic Dimension

- Community Impact: This examines the overall economic effects of wind power plants on local communities, including job creation, economic growth, and any potential disruptions or damages. This

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criterion helps gauge the economic footprint of wind energy projects within local economies[15].

- Personal Impact: It measures the impact on individuals' economic conditions, including changes in energy costs, property values, and other personal economic factors. This criterion reflects how wind energy affects individuals directly, providing a microeconomic perspective on wind power benefits and drawbacks[16].

3.2.3 Social Dimension

- Social and Lifestyle Impact: This assesses how the introduction of wind power plants affects community lifestyles and social dynamics. It considers both positive and negative impacts on the way of life in local communities, which is essential for understanding broader social acceptance[17].
- Safety Concerns: Evaluates the safety measures and protocols associated with wind power plants, ensuring that the operation is safe for workers and the surrounding community. This criterion is vital for maintaining trust and security perceptions among local residents[18].
- Community Engagement: Measures the degree of community involvement in the planning and operation of wind power plants. High levels of engagement often correlate with higher acceptance and smoother implementation of energy projects[19].
- Visual Impact on Landscape: Assesses the aesthetics and visual integration of wind power plants in the landscape. This criterion addresses one of the common criticisms of wind power related to its visual impact on natural and urban vistas[20].
- Noise: Considers the noise levels generated by wind power plants, which can be a significant factor in public acceptance and the quality of life for nearby residents[21].

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4. CONCLUSIONS

The development of two MCSA frameworks and an indicator database, as outlined in this deliverable, represents a significant advancement in the evaluation of wind farms. By employing the MUSA method, the framework provides a detailed and systematic approach to assess the satisfaction of various stakeholders or local residents. The integration of environmental, economic, and social dimensions ensures a holistic evaluation, capturing the multifaceted impacts of wind energy projects.

The geographic-based satisfaction analysis framework allows for a nuanced understanding of how satisfaction levels vary across different regions, facilitating targeted interventions to enhance public acceptance. Meanwhile, the stakeholder-based satisfaction analysis framework provides insights into the diverse perspectives of different stakeholder groups, enabling tailored strategies to address specific concerns and priorities.

The indicator database, developed through rigorous selection and validation processes, ensures that the criteria used for evaluation are both relevant and comprehensive. By incorporating feedback from academic research and project stakeholders, the database reflects the critical factors influencing the acceptance of wind farms.

Overall, this deliverable lays a solid foundation for future work within WP4, and its pilot application in one of the WIMBY case studies in WP3 supporting the broader objectives of the WIMBY project. The insights gained from this framework will not only improve stakeholder interactions and satisfaction management but also promote the successful integration of wind energy into the energy grid, advancing the EU's sustainability goals.

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REFERENCES

[1] J. DeAngelo *et al.*, "Energy systems in scenarios at net-zero CO2 emissions," *Nature Communications 2021 12:1*, vol. 12, no. 1, pp. 1–10, Oct. 2021, doi: 10.1038/s41467-021-26356-y.

[2] K. Langer, T. Decker, J. Roosen, and K. Menrad, "Factors influencing citizens' acceptance and non-acceptance of wind energy in Germany," *J Clean Prod*, vol. 175, pp. 133–144, Feb. 2018, doi: 10.1016/J.JCLEPRO.2017.11.221.

[3] R. Umit and L. M. Schaffer, "Wind Turbines, Public Acceptance, and Electoral Outcomes," *Swiss Political Science Review*, vol. 28, no. 4, pp. 712–727, Dec. 2022, doi: 10.1111/SPSR.12521.

[4] R. McKenna *et al.*, "Exploring trade-offs between landscape impact, land use and resource quality for onshore variable renewable energy: an application to Great Britain," *Energy*, vol. 250, p. 123754, Jul. 2022, doi: 10.1016/J.ENERGY.2022.123754.

[5] D. Caporale, V. Sangiorgio, A. Amodio, and C. De Lucia, "Multi-criteria and focus group analysis for social acceptance of wind energy," *Energy Policy*, vol. 140, p. 111387, May 2020, doi: 10.1016/J.ENPOL.2020.111387.

[6] J. Figueira, S. Greco, and M. Ehrogott, *Multiple Criteria Decision Analysis: State of the Art Surveys*, vol. 78, no. 23. in International Series in Operations Research & Management Science, vol. 78. New York, NY: Springer New York, 2005. doi: 10.1007/b100605.

[7] Z. Li, G. Tian, and A. S. El-Shafay, "Statistical-analytical study on world development trend in offshore wind energy production capacity focusing on Great Britain with the aim of MCDA based offshore wind farm siting," *J Clean Prod*, vol. 363, p. 132326, Aug. 2022, doi: 10.1016/J.JCLEPRO.2022.132326.

[8] B. Kizielewicz, J. Watróbski, and W. Sałabun, "Identification of Relevant Criteria Set in the MCDA Process—Wind Farm Location Case Study," *Energies 2020, Vol. 13, Page 6548*, vol. 13, no. 24, p. 6548, Dec. 2020, doi: 10.3390/EN13246548.

[9] D. Diakoulaki, C. H. Antunes, and A. G. Martins, "MCDA and Energy Planning," *International Series in Operations Research and Management Science*, vol. 78, pp. 859–897, 2005, doi: 10.1007/0-387-23081-5_21.

[10] E. Grigoroudis and Y. Siskos, "Preference disaggregation for measuring and analysing customer satisfaction: The MUSA method," *Eur J Oper*

Res, vol. 143, no. 1, pp. 148–170, Nov. 2002, doi: 10.1016/S0377-2217(01)00332-0.

[11] E. Grigoroudis and Y. Siskos, "Customer Satisfaction Evaluation," vol. 139, 2010, doi: 10.1007/978-1-4419-1640-2.

[12] H. Huang, R. Canoy, N. Brusselaers, and G. te Boveldt, "Criteria preprocessing in multi-actor multi-criteria analysis," *Journal of Multi-Criteria Decision Analysis*, vol. 30, no. 3–4, pp. 132–146, May 2023, doi: 10.1002/MCDA.1804.

[13] M. Neri, D. Jameli, E. Bernard, and F. P. L. Melo, "Green versus green? Adverting potential conflicts between wind power generation and biodiversity conservation in Brazil," *Perspect Ecol Conserv*, vol. 17, no. 3, pp. 131–135, Jul. 2019, doi: 10.1016/J.PECON.2019.08.004.

[14] E. Denny and M. O'Malley, "Wind generation, power system operation, and emissions reduction," *IEEE Transactions on Power Systems*, vol. 21, no. 1, pp. 341–347, Feb. 2006, doi: 10.1109/TPWRS.2005.857845.

[15] L. Okkonen and O. Lehtonen, "Socio-economic impacts of community wind power projects in Northern Scotland," *Renew Energy*, vol. 85, pp. 826–833, Jan. 2016, doi: 10.1016/J.RENENE.2015.07.047.

[16] J. P. Brown, J. Pender, R. Wiser, E. Lantz, and B. Hoen, "Ex post analysis of economic impacts from wind power development in U.S. counties," *Energy Econ*, vol. 34, no. 6, pp. 1743–1754, Nov. 2012, doi: 10.1016/J.ENECO.2012.07.010.

[17] B. Mroczek, J. Banaś, M. Machowska-Szewczyk, and D. Kurpas, "Evaluation of Quality of Life of Those Living near a Wind Farm," *International Journal of Environmental Research and Public Health 2015, Vol. 12, Pages 6066-6083*, vol. 12, no. 6, pp. 6066–6083, May 2015, doi: 10.3390/IJERPH120606066.

[18] S. R. Brouwer, S. H. S. Al-Jibouri, I. C. Cárdenas, and J. I. M. Halman, "Towards analysing risks to public safety from wind turbines," *Reliab Eng Syst Saf*, vol. 180, pp. 77–87, Dec. 2018, doi: 10.1016/J.RESS.2018.07.010.

[19] J. Firestone, B. Hoen, J. Rand, D. Elliott, G. Hübner, and J. Pohl, "Reconsidering barriers to wind power projects: community engagement, developer transparency and place," *Journal of Environmental Policy & Planning*, vol. 20, no. 3, pp. 370–386, May 2018, doi: 10.1080/1523908X.2017.1418656.

[20] C. Manchado, V. Gomez-Jauregui, P. E. Lizcano, A. Iglesias, A. Galvez, and C. Otero, "Wind farm repowering guided by visual impact criteria,"

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Renew Energy, vol. 135, pp. 197–207, May 2019, doi: 10.1016/J.RENENE.2018.12.007.

[21] P. M. Arezes, C. A. Bernardo, E. Ribeiro, and H. Dias, “Implications of Wind Power Generation: Exposure to Wind Turbine Noise,” *Procedia Soc Behav Sci*, vol. 109, pp. 390–395, Jan. 2014, doi: 10.1016/J.SBSPRO.2013.12.478.

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ANNEX

Satisfaction analysis survey

This section introduces the provisional survey designed to gather inputs for the satisfaction analysis framework. The survey design adheres to the ethical guidelines approved by the Paul Scherrer, ensuring compliance with established ethical standards and practices in WIMBY project.

Welcome to the WIMBY Local Wind Power Impact Survey

Part I: Introduction

Why We're Here: Wind power is a key player in our shift to renewable energy, but it's facing a challenge: winning the hearts and minds of the public. That's where the EU-funded WIMBY (Wind In My Backyard) project comes in, and where your input becomes invaluable. We're here to understand the drivers and barriers of social acceptance for wind power across Europe.

Your Role in Shaping Wind Power's Future: This isn't just any survey. It's a chance for you to be part of a bigger movement – to make wind energy a welcome part of our communities. Whether you're a supporter, skeptic, or just curious, your perspective is crucial in helping us address challenges and enhance public support for wind power.

What This Survey Aims to Achieve: We're using state-of-the-art modelling tools to gather your views on wind power plants in your area. Your feedback will help us create tools and information that aid in decision-making for lower-impact and more community-driven wind energy deployment.

Diverse Voices, United Goal: Our focus spans across diverse EU regions, each with its unique climate and social fabric. This survey is part of a citizen science approach to ensure that every voice is heard and considered in the future of wind power.

Your Privacy Matters: We value your privacy and your time. This survey is concise, and your responses will remain confidential. They will be used solely to guide the WIMBY project in making wind power more acceptable and beneficial for communities like yours.

Join the Conversation: Your insights are a step towards a sustainable energy future. Let's start this important conversation about wind power in our communities.

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Thank you for contributing to a future where wind power is not just seen as a technology, but as a part of our collective journey towards sustainable living.

PART II: MUSA Questions

In this part of the survey, we're interested in learning about your satisfaction with various aspects of the wind power plants in our community. You will find a series of statements below, each focusing on a different aspect of the wind power plants. There are no right or wrong answers. We value your honest opinion, as it will help us understand what matters most to our community regarding wind power plants.

Your Response Scale: For each statement, please indicate your level of satisfaction using the 5-point scale provided:

- Very Dissatisfied: This means you are not at all satisfied and may have strong negative feelings about the aspect in question.
- Dissatisfied: You are somewhat unhappy or unsatisfied with this aspect.
- Neutral: You neither feel satisfied nor dissatisfied, or you might not have enough information to form an opinion.
- Satisfied: You are generally satisfied but might have minor reservations or suggestions for improvement.
- Very Satisfied: You are completely satisfied and have a very positive view of this aspect.

QM1 Visual Impact on Landscape: How satisfied are you with the aesthetic integration of wind power plants into the local landscape?

¤ Very Dissatisfied
¤ Dissatisfied
¤ Neutral
¤ Satisfied
¤ Very satisfied

QM2 Noise and Disturbance: How satisfied are you with the noise levels and any disturbance caused by the local wind power plants?

QM3 Biodiversity Impact: How satisfied are you with the measures taken to protect and preserve local biodiversity and wildlife in relation to the wind power plants?

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QM4 GHG Emissions Reduction: How satisfied are you with the contribution of wind power plants to reducing greenhouse gas emissions in your area?

QM5 Community Benefits: How satisfied are you with the economic growth and job creation generated by the local wind power plants?

QM6 Personal Benefits: How satisfied are you with the personal benefits you have experienced (e.g., lower energy costs, improved quality of life) due to the wind power plants?

QM7 Social and Lifestyle Impact: How satisfied are you with the impact of wind power plants on the social dynamics and lifestyle of your community?

QM8 Safety Concerns: How satisfied are you with the safety measures and protocols associated with the local wind power plants?

QM9 Community Engagement: How satisfied are you with the level of community involvement in the planning and operation of wind power plants?

QM10 Considering all the above-mentioned information together, how satisfied do you feel with the wind power plants in your area?

QM11 One question for criterion ranking.

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PART III: Alternative 1

Socio-demographic Information

QD1 What is your age? (Please select your age group.)

¤ 18 - 24 years
¤ 25 - 34 years
¤ 35 - 44 years
¤ 45 - 54 years
¤ 55 - 64 years
¤ 64 or older

QD2 What is your gender?

¤ Male
¤ Female
¤ Prefer not to say

QD3 What is your highest level of education level?

¤ Secondary schools or less (e.g., high school)
¤ College or vocational training
¤ Bachelor's degree
¤ Postgraduate degree (Masters, PhD or higher)

QD4 Are you currently employed?

¤ Yes, full-time
¤ Yes, part-time
¤ No, not employed
¤ Retired
¤ Student

PART III: Alternative 2

Geographical Information

One question to ask for geographical information to generate a heatmap/barometer map.

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[--End–]
We sincerely thank you for your valuable time and participation in this study. Your contribution is instrumental in advancing our research. If you have any further questions or concerns, please do not hesitate to contact us using the information provided in the debriefing section. Once again, thank you for your invaluable contribution to our research.

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