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Environmental Impacts and Social Acceptance of Wind Farms: An Empirical Study in Western Macedonia, Greece

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Abstract

Wind energy constitutes an important component of the transition towards renewable and low-carbon energy systems. Despite its environmental and economic advantages compared with conventional fossil-fuel-based electricity generation, the development of wind farms is frequently accompanied by concerns regarding their effects on ecosystems, biodiversity, landscapes, land use, and local communities. These concerns may influence public attitudes and create a gap between general support for renewable energy and the acceptance of wind energy projects at the local level. This study investigates public perceptions of wind energy and the social acceptance of wind farms in Western Macedonia, Greece. Primary data were collected through a structured questionnaire administered electronically and in printed form to 200 residents of the region. The survey examined respondents' awareness of environmental and energy issues, perceptions of renewable energy, ecological concerns, emotional responses to wind farms, and willingness to accept wind-energy installations at different locations. The findings reveal a complex pattern of attitudes. Although 71% of respondents considered renewable energy sources to contribute positively to electricity generation from environmental and economic perspectives, acceptance was strongly influenced by project location. While 66% were willing to accept a wind farm in an isolated area, 53.5% were unwilling to accept one near their place of residence. Moreover, 56.5% believed that decisions concerning wind-farm siting should involve all relevant stakeholders. The findings highlight the importance of appropriate spatial planning, environmental assessment, public participation, and targeted communication in improving the social acceptance of wind-energy projects.

Keywords: Social acceptance, environmental impacts, public perception, energy transition, Western Macedonia

Introduction

The transition from fossil-fuel-based electricity generation towards renewable energy sources has become a central component of contemporary energy and environmental policy (Hassan et al., 2024). Increasing concerns regarding climate change, depletion of conventional energy resources, environmental degradation, and energy security have accelerated efforts to develop cleaner forms of electricity generation. Within this transition, wind energy has emerged as one of the most mature renewable energy technologies and has increasingly contributed to the diversification of electricity generation systems (McKenna et al., 2025).

Wind energy offers several advantages in comparison with conventional energy sources (EE&RE, 2023). Wind is a renewable and practically inexhaustible resource, electricity generation from operating wind turbines does not require the combustion of fossil fuels, and the technology can contribute to reducing dependence on imported fuels and limiting greenhouse-gas emissions. The broader development of renewable energy sources can therefore support both environmental objectives and the transition towards more sustainable energy systems (Ahmed et al., 2024).

Nevertheless, renewable energy technologies cannot be regarded as entirely free from environmental impacts (Rahman et al., 2022). The development of wind farms requires physical infrastructure, including wind turbines, foundations, access roads, electricity networks, and other associated facilities. Depending on the location and characteristics of a project, these interventions may affect land use, biodiversity, ecosystems, fauna and flora, and the visual characteristics of the landscape. The construction of access roads and artificial surfaces may also contribute to habitat fragmentation and changes in natural ecosystems (Gao et al., 2025). Consequently, the environmental advantages of wind energy at the broader energy-system level coexist with potential environmental impacts at the local level.

This distinction between global benefits and local impacts is particularly important for understanding public attitudes towards wind energy. Research has repeatedly demonstrated that high levels of general support for renewable energy do not necessarily translate into acceptance of specific energy projects. Wind energy may generate positive associations because of its contribution to cleaner electricity generation and climate-change mitigation while simultaneously producing concerns regarding landscape alteration, biodiversity, noise, land use, and proximity to residential areas (Arias et al., 2025). Social acceptance is therefore not determined exclusively by the technical performance or environmental benefits of the technology.

The literature has described this discrepancy as a "social gap" between general attitudes towards renewable energy and attitudes towards specific local projects (Bell et al., 2013). The implementation of wind-energy infrastructure is consequently both a technological and a social process. Public perceptions, emotions, expectations, trust, perceived fairness, local characteristics, and opportunities for participation may influence whether a proposed wind farm is accepted or opposed (Perlaviciute et al., 2018; Wüstenhagen et al., 2007).

One interpretation frequently associated with opposition to locally situated infrastructure is the Not In My Back Yard (NIMBY) concept(Primc & Slabe-Erker, 2020; Wolsink, 2007). In its simplest interpretation, individuals may support a technology or infrastructure in principle but oppose its development near their own homes or communities. Previous studies of wind energy have observed discrepancies between general support and local acceptance. However, the literature also warns against explaining local opposition solely through NIMBY-type motivations. Wolsink (2007), for example, argues that public attitudes towards wind-power implementation must also be examined in relation to equity, fairness, decision-making procedures, and the characteristics of individual projects (Wolsink, 2007). Similarly, broader approaches to the social acceptance of renewable energy emphasise that acceptance is multidimensional and operates at different levels, including general socio-political acceptance and community acceptance of particular projects.

Public participation is particularly relevant in this context. The planning of wind-energy projects involves decisions regarding the distribution of environmental impacts and benefits across communities and territories (Walker & Baxter, 2017). When local residents perceive decision-making procedures as opaque, externally imposed, or insufficiently inclusive, opposition may intensify independently of attitudes towards renewable energy as a technology. Conversely, meaningful public participation and appropriate communication can contribute to trust and improve the legitimacy of planning decisions (Janhunen et al., 2018). Previous research has therefore highlighted the importance of procedural justice, public involvement, and community participation in renewable-energy development.

Emotional responses constitute another important dimension of social acceptance. Decisions concerning energy infrastructure are not necessarily based solely on technical knowledge or rational evaluations of costs and benefits. Cognitive and emotional processes interact in the formation of risk perceptions and attitudes (Lu, 2025). Energy technologies can produce positive or negative imagery, and the visual presence of wind turbines may influence how individuals experience and evaluate the surrounding landscape. Research on renewable-energy projects has consequently drawn attention to emotional responses as a component of responsible decision-making and public acceptance.

Visual impact is especially relevant to wind-energy infrastructure because wind turbines are highly visible structures and are frequently installed in elevated or open landscapes (Afridi et al., 2024; Bishop & Miller, 2007). Their perceived aesthetic impact depends on several factors, including distance, visibility, landscape characteristics, turbine size, movement, previous experience, and individual preferences. Visual effects may therefore contribute to both positive and negative responses. For some individuals, wind turbines may represent technological progress and environmental sustainability, whereas for others they may be associated with industrialisation or degradation of natural landscapes (Bošnjaković et al., 2024).

Environmental concerns also extend beyond visual impacts (Rehbein et al., 2020). Wind farms may affect biodiversity through habitat loss, fragmentation, disturbance, and potential interactions with wildlife. Particular attention has been given to birds and bats, especially where installations intersect with migration routes, feeding areas, or sensitive habitats (Tolvanen et al., 2023). The construction of access roads and associated infrastructure may create additional ecological pressures through vegetation removal, soil disturbance, and fragmentation. Such impacts underline the importance of environmental assessment and careful site selection (Kantar, 2019; Soulis et al., 2015).

Land-use considerations are similarly important (Sun et al., 2022). Although the physical footprint directly occupied by turbines and associated infrastructure can represent only a portion of the overall wind-farm area and agricultural or other activities may continue around wind turbines, development may nevertheless modify landscapes and create new infrastructure corridors (Aydin et al., 2010). Geographic Information Systems and multicriteria spatial assessment can therefore contribute to the identification of appropriate locations by incorporating environmental, geographical, social, and infrastructural characteristics into the planning process.

These issues demonstrate that the relationship between environmental protection and wind-energy development cannot be reduced to a simple opposition between renewable energy and conservation. Wind power contributes to broader objectives of reducing dependence on fossil fuels, but inappropriate siting may generate significant local environmental concerns (Bashir, 2022). The challenge is therefore to minimise negative impacts while retaining the environmental and energy benefits of renewable electricity generation.

This challenge becomes particularly important in regions undergoing substantial changes in their energy systems. Western Macedonia provides a relevant geographical context for examining such attitudes (Ziouzios et al., 2021). The region has historically been strongly associated with electricity production, while contemporary changes in the energy sector increase the relevance of renewable-energy development. At the same time, wind-energy projects are present or proposed across parts of the region, making questions of environmental impact, spatial planning, and community acceptance directly relevant to residents (Josimović et al., 2021).

Understanding local attitudes is therefore essential for identifying the factors that may facilitate or obstruct renewable-energy development (Zaharuddin et al., 2025). The present study focuses on residents of Western Macedonia and examines their knowledge of energy and environmental issues, ecological concerns, emotional responses to wind farms, general attitudes towards wind energy, and willingness to accept wind farms under different siting conditions.

The empirical investigation was designed around thirteen questions in addition to respondents' demographic characteristics (Bhandari, 2025). The questionnaire sought to capture several dimensions of public perception rather than treating acceptance as a single binary attitude. In particular, the survey explored awareness of the environmental impacts of conventional electricity generation, perceptions of the environmental and economic contribution of renewable energy, ecological concerns, support for wind energy, exposure to wind-farm landscapes, emotional responses, willingness to accept installations in isolated areas or near respondents' places of residence, willingness to engage actively as supporters or opponents, and views regarding participation in siting decisions (Kalogiannidis et al., 2025; Sander et al., 2024).

The central research question is therefore: How do environmental awareness, perceptions and location-related considerations shape the social acceptance of wind farms among residents of Western Macedonia?

More specifically, the study examines whether generally favourable perceptions of renewable energy coexist with reservations concerning wind farms at the local level and whether the geographical proximity of a proposed installation influences willingness to accept it (le Maitre et al., 2024). It also investigates the role respondents assign to public and institutional participation in decisions concerning wind-farm siting.

By combining the environmental dimension of wind-energy development with empirical evidence on public perceptions, the study aims to contribute to the discussion on socially acceptable renewable-energy planning. Rather than considering public opposition simply as resistance to renewable energy, the analysis seeks to identify the tensions between recognition of the benefits of wind energy, concerns regarding its environmental impacts, and preferences concerning the location and governance of wind-energy infrastructure.

Theoretical background

Environmental implications of wind-energy development

The environmental assessment of energy infrastructure requires consideration of both the benefits generated by a technology and the negative impacts associated with its construction and operation (Hugé, 2017). The existence of environmental impacts does not necessarily imply that an activity should be abandoned. Instead, environmental-impact assessment provides a framework for identifying potential changes, evaluating their significance, comparing alternatives, and designing measures to prevent or mitigate adverse effects.

Wind energy presents a characteristic example of this balance(IRENA Renewable Power Generation Cost, 2020). During operation, wind turbines generate electricity without the direct combustion of fossil fuels, contributing to the reduction of emissions associated with conventional electricity production. At the same time, wind-energy development requires interventions in the physical environment. The significance of these interventions depends strongly on project scale, geographical location, ecological sensitivity, existing land uses, and the infrastructure required for construction and grid connection.

One of the most important ecological concerns is the potential loss and fragmentation of natural habitats. The construction of roads, turbine foundations, and other artificial surfaces can alter existing ecosystems and facilitate further disturbance. These effects can become particularly important in environmentally sensitive areas. Rehbein et al. (2020) highlighted the potential overlap between renewable-energy development and areas of high biodiversity importance, demonstrating the need to integrate conservation considerations into renewable-energy planning(Rehbein et al., 2020).

Wildlife impacts have received considerable attention in the wind-energy literature (Teff-Seker et al., 2022). Birds may be affected through collision risk, displacement, habitat alteration, or disturbance, particularly when wind farms are situated near migration routes, nesting areas, or feeding grounds. Similar concerns apply to bats, for which wind-energy development may create direct mortality risks and broader conservation challenges(Hamed & Alshare, 2022). The magnitude of these impacts is highly site-specific, reinforcing the importance of pre-construction studies, monitoring, appropriate siting, and mitigation measures (Leung & Yang, 2012).

Vegetation and soil may also be affected during the construction stage. Excavation, road construction, removal of vegetation, and the operation of heavy machinery can disturb local ecosystems and contribute to soil erosion. Restoration following construction and the rapid re-establishment of vegetation can therefore form important components of environmental management.

Landscape impacts differ from many other environmental effects because their evaluation contains a strong perceptual component (Guan, 2022). Wind turbines alter the visual character of a landscape, but the significance assigned to this alteration varies among observers. Research has demonstrated that distance, contrast, movement, landscape characteristics, and social variables influence the perceived visual impact of wind turbines (Guo et al., 2024). Consequently, visual impact cannot be understood only through the physical dimensions of wind turbines; it must also be considered through public perception.

Appropriate spatial planning is therefore fundamental to sustainable wind-energy development. Spatial assessment can identify locations where energy potential can be combined with lower ecological and social impacts (Ateeq et al., 2025; Imam et al., 2024). GIS-based approaches are particularly useful because they allow planners to integrate multiple geographical and environmental criteria into the evaluation of potential sites. Such planning can contribute both to environmental protection and to social acceptance by reducing conflicts associated with inappropriate siting.

Social acceptance of wind energy

Social acceptance has emerged as one of the central non-technical challenges associated with renewable-energy development(Segreto et al., 2020). General surveys often indicate considerable support for renewable energy, yet individual projects can encounter substantial local opposition(Fast, 2013). This apparent contradiction suggests that attitudes towards renewable-energy technologies are dependent on scale and context.

Wüstenhagen et al. (2007) conceptualised social acceptance as a multidimensional phenomenon rather than a single measure of public support (Wüstenhagen et al., 2007). This perspective is particularly relevant to wind energy because an individual may simultaneously support renewable-energy policy, recognise the environmental advantages of wind power, and oppose a specific project because of its location or perceived local impacts.

Bell et al. (2013) describe the difference between broad public support and local responses as a social gap (Bell et al., 2013). Understanding this gap requires examination of the processes through which particular projects are planned and experienced. Physical proximity, perceived environmental impacts, landscape values, distribution of costs and benefits, trust, and participation may all affect community responses (Tsiaras et al., 2025).

The NIMBY concept has frequently been used to interpret this discrepancy. The concept describes situations in which individuals support infrastructure in principle while resisting its construction near their own place of residence. Studies have identified location-sensitive patterns of support for renewable-energy facilities. However, the NIMBY interpretation has been criticised when it is used as a universal explanation for opposition. Wolsink (2007) emphasises that fairness and equity can be more important than narrowly defined "backyard" motivations(Wolsink, 2007). Local opposition may therefore represent concerns regarding environmental quality, procedural fairness, landscape protection, distribution of benefits, or exclusion from decision-making rather than simple self-interest.

Public participation, trust, and decision-making

The governance of wind-energy development is closely related to social acceptance (Campos et al., 2025). Environmental planning affects communities and stakeholders with different interests, expectations, and perceptions of risk. Public participation provides a mechanism through which these perspectives can be incorporated into planning decisions.

Research on renewable-energy projects has highlighted the relationship between trust, community, and acceptance. Similarly, Janhunen et al. (2018) identified public participation as an important element in the acceptability of wind farms (Janhunen et al., 2018). These findings suggest that communication should not be treated merely as a strategy for persuading communities after key decisions have already been made. Instead, participation can form part of the decision-making process itself.

Procedural considerations are particularly important for wind-farm siting because environmental impacts and benefits are spatially distributed (Klok et al., 2023; Westerlund, 2020). Residents living near an installation may perceive themselves as bearing a disproportionate share of visual or environmental impacts while broader energy and climate benefits are distributed across society. Transparent planning procedures and meaningful stakeholder participation can therefore contribute to perceptions of fairness and legitimacy.

This perspective also helps explain why technical evidence alone may be insufficient to resolve conflicts. Even when a project complies with environmental requirements, opposition may remain if residents perceive the planning procedure as unfair or believe that their concerns have not been considered. Conversely, involving citizens, local authorities, experts, and central institutions can create a more inclusive basis for decision-making.

Environmental awareness and emotional responses

Public perceptions of wind energy combine cognitive and emotional dimensions (Ruddat, 2022). Knowledge of climate change, fossil-fuel impacts, and renewable-energy benefits may influence attitudes, but individuals also respond emotionally to energy infrastructure and landscape change.

Slovic et al. (2007) demonstrated the importance of affect in risk perception and decision-making, while subsequent research has examined emotional responses specifically in relation to energy projects (Slovic et al., 2007). Wind farms can evoke images of environmental progress and technological modernisation, but they can also generate feelings of loss or concern associated with landscape transformation.

The visual dimension of wind energy is therefore connected with social acceptance (Hübner et al., 2023). Previous experience and repeated exposure may affect how individuals perceive wind turbines, although the direction and magnitude of this relationship are not necessarily uniform. The thesis on which the present study is based raises the possibility that repeated visual exposure may contribute to greater familiarity with wind-energy landscapes. This proposition should, however, be treated as an interpretation requiring further empirical investigation rather than as an established causal relationship.

The combination of environmental awareness, emotional response, geographical proximity, and perceptions of decision-making provides the conceptual basis for the empirical analysis that follows. The survey of residents of Western Macedonia makes it possible to examine whether support for renewable energy remains consistent when respondents consider specific siting conditions and whether citizens favour broader participation in decisions concerning the location of wind-energy projects.

Methods

Study design and research area

The empirical component of the study adopted a quantitative, cross-sectional survey design to investigate public perceptions of wind energy and the factors associated with the social acceptance of wind farms. The research was conducted in the Region of Western Macedonia in northern Greece. The geographical focus was selected because wind-energy development is directly relevant to the region and because the broader transformation of its energy system provides an appropriate context within which to examine attitudes towards renewable-energy infrastructure.

The research did not attempt to measure the technical or environmental performance of individual wind farms. Instead, it focused on the perceptions, knowledge, concerns, emotional responses, and stated preferences of residents. Social acceptance was therefore approached as a multidimensional concept involving general attitudes towards wind energy, perceived environmental consequences, emotional reactions, acceptance under alternative siting conditions, willingness to participate actively in public debate, and preferences concerning decision-making.

A total of 200 residents of Western Macedonia participated in the survey. Particular attention was given during questionnaire distribution to obtaining responses from the four Regional Units of Western Macedonia and from different age and educational groups. The sample should nevertheless be interpreted as a research sample rather than as a statistically representative opinion poll of the entire regional population. Participation depended on respondents' willingness to complete the questionnaire, and a considerable number of individuals approached during the data-collection process declined to participate.

Table 1: Sociodemographic characteristics of the study sample (N = 200).

Characteristic	Category	n	%
Gender	Male	95	47.5
	Female	104	52.0
	Other	1	0.5
Age group	16–30	34	17.0
	31–46	57	28.5
	47–60	80	40.0
	61+	29	14.5
Educational level	Other	1	0.5
	Secondary education	67	33.5
	Technological education	60	30.0
	Postgraduate degree	57	28.5
	Doctorate/Postdoctorate	15	7.5
Occupation	Student	19	9.5
	Private-sector employee	47	23.5
	Public-sector employee	55	27.5
	Self-employed	41	20.5
	Unemployed	25	12.5
	Retired	13	6.5
Regional Unit	Kozani	59	29.5
	Florina	47	23.5
	Kastoria	49	24.5
	Grevena	45	22.5

Characteristic	Category	n	%
Settlement type	City	124	62.0
	Small town	22	11.0
	Community/village	48	24.0
	Countryside	6	3.0
Proximity to existing wind farm	Very close	7	3.5
	Relatively close	74	37.0
	Far	86	43.0
	Unaware of nearby installations	33	16.5

Note. Counts are calculated from the percentages reported for N = 200.

Questionnaire design

Data were collected using a structured questionnaire consisting of two main parts. The first part recorded basic socio-demographic characteristics, including gender, age group, educational level, occupational status, Regional Unit of residence, type of settlement, and whether respondents lived in an area where wind-farm installations were present nearby.

The second part contained thirteen questions designed to explore different dimensions of perceptions and social acceptance of wind energy. The questions addressed respondents' awareness of the environmental impacts associated with conventional electricity generation; their views regarding the contribution of renewable energy sources to environmental and economic aspects of electricity generation; ecological and pollution-related concerns; their overall position towards wind energy; frequency of visual exposure to wind farms; emotional responses associated with producing their own electricity; emotional images generated by the sight of a wind farm; perceptions of wind energy as beneficial or harmful to people and the environment; acceptance of wind-farm installation in an isolated area; acceptance near the respondent's place of residence; acceptance elsewhere outside the respondent's residential area; willingness to become actively involved as a supporter or opponent of wind energy; and preferences regarding who should participate in decisions on wind-farm installation and siting.

Several questions provided predefined response categories while also allowing respondents to select an "other" option and provide additional comments. This feature was particularly useful in questions concerning ecological concerns and siting preferences, where some respondents stressed that acceptance depended on specific characteristics of the location. Among the issues raised in these open responses were the need for spatial planning, avoidance of forested or environmentally sensitive areas, consideration of ecosystem characteristics, environmental permitting, and the suitability and efficiency of the proposed location.

The design of the questionnaire reflected the broader objective of identifying apparent inconsistencies between general attitudes towards renewable energy and attitudes towards specific local wind-energy developments. In particular, the parallel use of questions regarding isolated locations, proximity to respondents' homes, and locations outside their own residential area allowed the study to examine the extent to which geographical proximity influenced stated acceptance.

Data collection and analysis

The questionnaire was created using Google Forms and was distributed both electronically and in printed form. Combining electronic and paper distribution was intended to broaden participation and reduce dependence on a single method of recruitment.

Responses from 200 participants were collected and subsequently compiled through the Google Forms environment. The original study analysed the responses descriptively and presented the distributions primarily as percentages and graphical charts. Accordingly, the present article reports descriptive statistics rather than inferential statistical tests.

The analysis was organised around four broad dimensions. The first concerned environmental and energy awareness, including knowledge of the impacts of conventional electricity generation and perceptions of renewable energy. The second concerned environmental and emotional responses to wind farms. The third examined the effect of location on acceptance. The fourth considered participation, public involvement, and attitudes towards decision-making.

Because the survey was designed primarily as an exploratory investigation of public opinion, no causal relationships are inferred from the results. Associations discussed in the article should therefore be interpreted as patterns emerging from the distribution of responses rather than as statistically demonstrated causal effects.

Results

Environmental awareness and perceptions of renewable energy

The findings indicate that a substantial proportion of respondents possessed at least some awareness of the environmental consequences of conventional electricity generation. In the first survey question, the largest response category, representing 47% of participants, indicated a relatively high level of awareness of environmental impacts associated with conventional sources of electricity, such as lignite combustion.

This result is particularly relevant in the context of Western Macedonia, where conventional electricity generation has historically had a strong physical and economic presence. Awareness of the environmental consequences of fossil-fuel-based generation provides an important background against which attitudes towards renewable energy can be interpreted.

Participants were generally positive regarding the contribution of renewable energy sources to the electricity system. In response to the second question, 71% considered renewable energy sources to contribute positively from environmental and economic perspectives. By comparison, 12.5% evaluated their contribution negatively and 16.5% stated that they did not know.

The result indicates that renewable energy enjoyed substantial general support among the participants. However, subsequent questions demonstrate that positive assessments of renewable energy at an abstract level did not automatically translate into unconditional support for wind-energy projects.

Environmental concerns remained prominent. In the third question, 33% of respondents reported both ecological and pollution-related concerns, while 31% reported ecological concerns specifically. A further 28.5% indicated that they did not have such concerns, while the remaining respondents provided other views.

Open comments illustrate that environmental concerns were not necessarily directed against renewable energy as such. Some participants referred to climate change, while others focused on whether environmental conditions attached to projects were properly implemented. Additional comments raised concerns regarding infrastructure construction, development without comprehensive spatial planning, and the occupation of substantial areas of otherwise undeveloped land.

The general position towards wind energy itself was considerably more divided than the positive evaluation of renewable energy sources as a broader category. In the fourth question, 41% selected a position indicating passive or non-active support, while 32.5% expressed a neutral position. More explicit positions were less common: 15% expressed opposition and 11.5% active support.

These responses illustrate an important feature of the dataset. A large majority recognised positive aspects of renewable energy, yet attitudes towards wind energy were more cautious and less strongly supportive. This suggests that respondents differentiated between the general concept of renewable electricity and the practical development of wind-energy infrastructure.

Exposure and emotional responses to wind farms

Respondents differed in the frequency with which they encountered wind farms visually. The largest group, 39.5%, reported seeing a wind farm approximately every week. A further 22.5% reported monthly exposure and 21.5% daily exposure, while smaller proportions reported less frequent encounters.

Wind-energy infrastructure was therefore not an entirely abstract concept for a substantial part of the sample. Many participants were periodically or frequently exposed to wind-farm landscapes, providing an important context for the interpretation of their emotional responses.

When participants were asked how they would feel if they produced their own energy on their property or through their own installation, 73% reported that they would feel enthusiastic. A further 16% indicated a neutral response and 11% indifference.

The very high level of enthusiasm in this question suggests that the idea of renewable-energy production can generate strongly positive responses when individuals perceive a more direct relationship between themselves and the production of energy. This result differs noticeably from responses concerning large wind-farm installations and illustrates the importance of context in energy attitudes.

The visual and emotional response to wind farms was substantially more mixed. When participants were asked about the emotional images generated by viewing a wind farm, 35% reported mixed feelings. Sadness was reported by 25%, enthusiasm by 21%, and neutral or indifferent feelings by 18%.

The absence of a dominant positive emotional response is important. Although wind energy was generally recognised as environmentally beneficial, the physical appearance of wind farms produced a heterogeneous emotional reaction. The finding reinforces the idea that environmental attitudes towards renewable technologies cannot be inferred solely from support for climate or energy-policy objectives.

When respondents were asked whether they considered wind energy an ally or an enemy of people and the environment, 46.5% described it as an ally. Another 38.5% were uncertain, 10.5% considered it an enemy, and approximately 4% stated that they did not know.

Taken together, these results indicate a broadly favourable but cautious perception. Almost half of participants identified wind energy positively, yet a large group remained uncertain. This uncertainty is relevant because it represents a potentially important segment of the population whose attitudes may be influenced by project characteristics, environmental safeguards, information, and participation in planning.

Acceptance according to wind-farm location

The strongest pattern in the survey emerged when respondents were asked about the location of wind farms.

When the proposed installation was described as being located in an isolated area, 66% stated that they would willingly accept the wind farm. Only 17.5% indicated unwillingness, while 12.5% were indifferent. Other participants provided conditional responses.

These additional comments are particularly informative. Some respondents questioned the meaning of an "isolated" area and argued that an apparently remote mountain area could nevertheless be environmentally valuable. Others stated that their support would depend on the ecosystem, the existence of protected areas, forest cover, or an appropriate spatial plan. One respondent indicated preference for offshore development, while others argued that wind farms should be constructed wherever technical studies demonstrated the highest efficiency.

The high acceptance rate for isolated locations changed considerably when participants were asked about an installation near their own place of residence. In this case, 53% stated that they would be unwilling to accept the wind farm, whereas 30.5% indicated willingness and 13.5% were indifferent. Some open responses again introduced conditions, such as the actual distance from residences.

Thus, the proportion expressing willingness declined from 66% for an isolated location to 30.5% for a location near the respondent's residence. At the same time, unwillingness became the majority response when proximity to the participant's own residential environment was introduced.

A related pattern appeared when respondents were asked whether they would accept a wind farm elsewhere, outside their own residential area. In this case, 45.5% stated that they would willingly accept the installation, 27.5% were unwilling, and 24% were indifferent, with the remainder providing other responses.

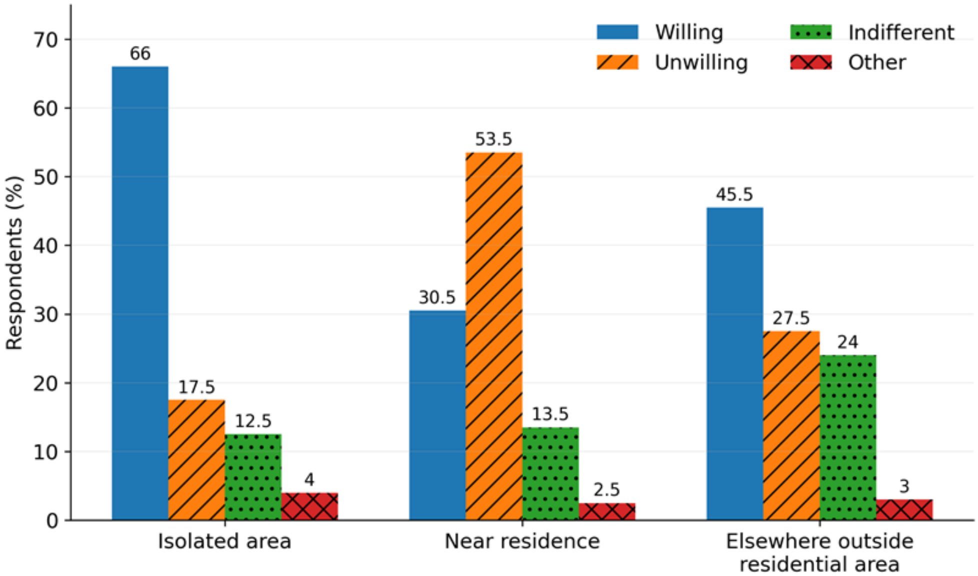

Figure 1: Willingness to accept wind-farm development according to project location

The comparison among these three questions demonstrates that social acceptance was highly sensitive to location. Support was strongest when the installation was described as geographically separated from the respondent's own residential environment and weakest when proximity to home was explicitly introduced.

This pattern represents one of the central findings of the study. Participants could simultaneously recognise the benefits of renewable energy, perceive wind energy as an ally of people and the environment, and accept wind farms in more distant locations while expressing reluctance towards installations close to their own residences.

Public involvement and decision-making

The questionnaire also explored whether respondents would become actively involved as supporters or opponents of wind energy. The largest group, 48.5%, indicated that they would not take active action as either opponents or supporters. A further 23% stated that they might become active, while 10% indicated that they would take active action.

The predominance of non-active positions is consistent with the earlier finding that many respondents adopted passive or neutral attitudes towards wind energy. Public opinion should therefore not be interpreted exclusively through highly visible supporters and opponents. A substantial part of the population may hold opinions without becoming actively involved in public conflict.

The final question examined who respondents believed should participate in decisions concerning wind-farm installation and siting. The most common response, selected by 56.5% of participants, was that decisions should involve all relevant actors. Experts alone were selected by 36.5%, while only small minorities favoured decision-making exclusively by citizens, local authorities, or central government.

This finding provides evidence of a preference for inclusive decision-making. Rather than assigning responsibility exclusively to technical experts or political institutions, a majority of respondents favoured the involvement of multiple stakeholders.

Table 2: Distribution of responses to the wind-energy perception and acceptance questionnaire.

Survey item	Response distribution
Q1. Awareness of environmental impacts of conventional electricity generation	None 4.5%; minimal 30.0%; considerable 47.0%; full 18.5%
Q2. Perceived contribution of renewable energy sources	Positive 71.0%; negative 12.5%; do not know 16.5%
Q3. Main ecological/pollution concerns	Both ecological and pollution-related 33.0%; ecological 31.0%; no concerns 28.5%; pollution-only/other 7.5%
Q4. Position towards wind energy	Opposition 15.0%; neutral/not concerned 32.5%; passive support 41.0%; active support 11.5%
Q5. Frequency of seeing a wind farm	Daily 21.5%; weekly 39.5%; monthly 22.5%; every 6 months 9.0%; yearly 7.5%
Q6. Feeling about producing own energy	Enthusiastic 73.0%; indifferent 11.0%; neutral 16.0%
Q7. Emotional response to an onshore wind farm	Sadness 25.0%; enthusiasm 21.0%; neutral 18.0%; mixed feelings 35.0%; other 1.0%
Q8. Wind energy as ally or enemy	Ally 46.5%; enemy 10.5%; unsure 38.5%; do not know 4%
Q9. Acceptance in an isolated area	Willing 66.0%; unwilling 17.5%; indifferent 12.5%; other 4.0%
Q10. Acceptance near place of residence	Willing 30.5%; unwilling 53.5%; indifferent 13.5%; other 2.5%
Q11. Acceptance elsewhere outside residential area	Willing 45.5%; unwilling 27.5%; indifferent 24.0%; other 3.0%
Q12. Active action as supporter/opponent	Yes 10.0%; no 48.5%; maybe 33.0%; do not know 8.5%
Q13. Preferred participants in siting decisions	Experts 36.5%; citizens 3.0%; local authorities 2.0%; central government 2.0%; all of the above 56.5%

Note. Percentages reproduce the response distributions displayed in the original questionnaire charts.

Discussion

The findings reveal that public attitudes towards wind energy in Western Macedonia cannot adequately be described as either supportive or oppositional. Instead, respondents demonstrated a combination of environmental awareness, general support for renewable energy, uncertainty regarding specific wind-energy impacts, mixed emotional responses, and strong sensitivity to project location.

One of the clearest results is the difference between general support for renewable energy and acceptance of wind farms near respondents' homes (Lindvall et al., 2026). Seventy-one percent of participants considered renewable energy sources to make a positive environmental and economic contribution to electricity generation. Similarly, 46.5% described wind energy as an ally of people and the environment, compared with only 10.5% who considered it an enemy. Nevertheless, 53% were unwilling to accept a wind farm near their own place of residence.

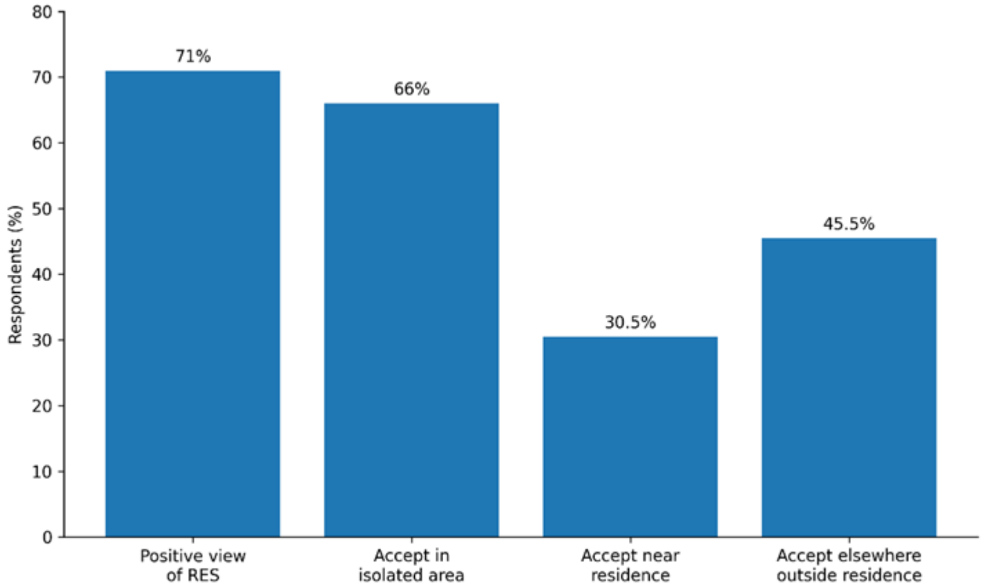

Figure 2: General support vs location-specific acceptance

At the same time, 66% were willing to accept a wind farm in an isolated area and 45.5% were willing to accept an installation elsewhere outside their residential area. These differences demonstrate an attitude–location gap that resembles patterns reported in previous wind-energy research (Kaltenborn et al., 2023).

The result can initially be interpreted through the NIMBY concept, since general recognition of the benefits of wind energy coexists with reduced acceptance when the infrastructure is brought closer to the respondent's own residential environment (Carley et al., 2020; Leiren et al., 2020). Similar differences between general and local acceptance have been discussed in earlier studies of wind power(Oliveira et al., 2025).

However, describing all local reluctance simply as NIMBY behaviour would oversimplify the responses obtained in the present survey

(Delcayre & Bourdin, 2025). Open comments demonstrate that some participants were concerned not merely with distance from their homes but also with ecosystem characteristics, forested areas, protected zones, environmental requirements, and the absence of coherent spatial planning. These concerns are qualitatively different from an unconditional position of "support the technology, but build it somewhere else."

This distinction corresponds with the criticism of simplified NIMBY explanations in the international literature. Wolsink (2007) argues that wind-energy opposition is often better understood through questions of fairness, equity, siting quality, and decision-making than through assumptions of selfish local resistance(Wolsink, 2007). In the present study, the strong preference for collective participation in siting decisions supports this broader interpretation.

The result that 56.5% believed that all relevant actors should participate in decisions is particularly significant. Only 36.5% preferred decisions to be taken by experts alone, while very small proportions selected individual governmental or citizen groups as sole decision-makers. Respondents therefore appeared to favour a collaborative governance model incorporating technical knowledge, public interests, and institutional responsibility (Laode Nusriadi et al., 2023).

This preference is consistent with the broader literature on community participation and procedural justice. Public participation has been identified as an important factor in the acceptability of wind farms, while studies of renewable-energy development emphasise the role of trust and community relationships (Hosan et al., 2024). Participation can increase the legitimacy of decisions even when it does not eliminate disagreement.

The survey results therefore suggest that environmental communication should not be understood simply as a means of persuading citizens to accept predetermined projects (Mytych, 2024). Communication should form part of a transparent planning process in which the environmental characteristics of candidate sites, expected benefits, potential impacts, mitigation measures, and alternative locations are clearly explained (Moser, 2010).

The mixed emotional responses to wind-farm landscapes provide an additional dimension. Only 21% associated the visual presence of a wind farm with enthusiasm, whereas 25% reported sadness and 35% mixed emotions. These results suggest that wind turbines carry symbolic and aesthetic meanings beyond their function as electricity-generating infrastructure.

This finding is consistent with studies showing that visual perceptions of wind-energy developments depend on landscape characteristics, visibility, distance, and social variables. A wind turbine may represent clean energy and technological progress to one observer while representing industrialisation of a natural landscape to another (Duranay et al., 2024).

Such emotional responses should not automatically be treated as irrational (Brosch & Steg, 2021). Environmental decision-making involves both cognitive evaluation and affective processes, and emotions can influence judgments of risk and acceptability. The survey results therefore support an approach to social acceptance that recognises both technical/environmental assessment and subjective experience.

An interesting finding concerns the frequency with which respondents encountered wind farms. Almost 40% reported seeing wind farms weekly, while more than one fifth reported daily exposure. The original study suggested that repeated visual exposure might eventually contribute to greater familiarity with wind-energy landscapes (Kirchhoff et al., 2022). This possibility is plausible, but the present cross-sectional dataset cannot establish such a relationship. No longitudinal comparison was conducted, and the questionnaire does not demonstrate that more frequent exposure caused greater acceptance. Future research could test this hypothesis by comparing attitudes across groups with different levels and durations of exposure (Kizielewicz et al., 2025).

The very positive response to the possibility of producing one's own energy is also noteworthy. Seventy-three percent indicated enthusiasm at the idea (Nyasapoh et al., 2022). This result suggests that attitudes towards energy infrastructure may vary according to the perceived relationship between citizens and energy production. Individuals may respond more positively when energy production is associated with personal participation, autonomy, or direct benefit than when it is experienced as externally developed infrastructure (Skoczkowski et al., 2024).

The survey was not designed to test ownership models or economic benefit-sharing, so no causal conclusion can be drawn from this finding. Nevertheless, it suggests a potentially important direction for subsequent research (Knauf & le Maitre, 2023). Studies comparing acceptance of externally owned wind farms, community energy projects, cooperative ownership, and direct local-benefit mechanisms could provide greater insight into the relationship between participation and acceptance.

Environmental concerns were also substantial (Maduku, 2024). Approximately one third of respondents reported combined ecological and pollution-related concerns and a similar proportion reported specifically ecological concerns. Open comments referred to infrastructure works, environmental conditions, spatial planning, forest areas, and ecosystems (Lin et al., 2025). These responses reinforce the importance of integrating biodiversity and landscape considerations into renewable-energy planning.

Wind energy has significant environmental advantages over fossil-fuel-based electricity production, but these advantages do not eliminate the need for site-specific environmental assessment. Wind farms may interact with birds and bats, habitats, vegetation, soil, and landscapes, while access roads and associated infrastructure can contribute to ecological fragmentation (Dang et al., 2026).

Consequently, one of the most important practical implications of this study is that social acceptance and environmental protection should not be approached as separate policy objectives (Baker, 2024). Appropriate siting can serve both. Avoiding ecologically sensitive areas, evaluating cumulative impacts, considering landscape characteristics, and communicating the evidence used in site selection may reduce environmental impacts while simultaneously strengthening the perceived legitimacy of projects (Dong et al., 2025).

GIS-based environmental and multicriteria approaches can assist in this process by integrating technical potential with ecological and social constraints (Cook & Pétursson, 2025). In regions where multiple renewable-energy projects are developed, strategic spatial planning may be particularly important in preventing perceptions of uncontrolled or fragmented development (Chen & Gong, 2025).

The findings are especially relevant to Western Macedonia (Boulogiorgou & Kaldellis, 2025). The region has a long-standing relationship with large-scale energy production, and the transition towards a different energy model creates both opportunities and social challenges. Residents' familiarity with energy infrastructure does not necessarily imply automatic acceptance of new renewable-energy projects (le Maitre et al., 2023). The transition therefore requires attention not only to installed capacity and technological substitution but also to how new infrastructure is distributed across landscapes and communities (Kaya et al., 2025).

An additional finding concerns the relatively moderate level of active mobilisation. Almost half of respondents stated that they would not actively participate as either supporters or opponents of wind energy (Sanchez Nieminen & Laitinen, 2025). This suggests that highly visible public conflicts may not necessarily reflect the distribution of attitudes within the wider population. Public debates can become dominated by strongly mobilised groups, whereas a substantial group may remain passive, uncertain, or conditionally supportive.

For policymakers and project developers, this has two implications. First, consultation should reach beyond organised supporters and opponents. Second, uncertainty should not automatically be interpreted as opposition. The 38.5% of respondents who were uncertain whether wind energy was an ally or enemy of people and the environment represent an important group for evidence-based information and meaningful consultation(Scheidel et al., 2020).

The results ultimately suggest that social acceptance is dynamic and conditional. Respondents' views varied depending on whether they were considering renewable energy in general, wind energy as a specific technology, the visual image of wind farms, an isolated site, or a site near their own homes. A single survey item asking whether citizens "support wind energy" would therefore fail to capture important aspects of public opinion.

Study limitations

Several limitations should be considered when interpreting the findings. First, the sample consisted of 200 participants and should not be considered statistically representative of the entire population of Western Macedonia. The original data-collection process encountered substantial reluctance to participate, with some potential respondents citing lack of time, lack of interest, insufficient knowledge, or broader dissatisfaction. The final sample therefore reflects the views of individuals who agreed to participate and may be affected by self-selection bias.

Second, although efforts were made to distribute the questionnaire across the four Regional Units and across different demographic categories, the study did not employ a probability-sampling design. Generalisation of the percentages to the entire regional population should consequently be avoided.

Third, the analysis is descriptive. The available survey results identify important distributions and contrasts, particularly regarding location, but do not establish statistically significant relationships between demographic characteristics and attitudes. Future research should employ larger samples and inferential statistical techniques to examine whether age, education, occupation, place of residence, previous exposure to wind farms, and other variables significantly predict acceptance.

Fourth, the questionnaire was relatively concise and addressed multiple dimensions of wind-energy perception through thirteen main questions. During data collection, at least one participant commented that some questions were too superficial to capture the full complexity of public concerns. A future survey could therefore use validated multi-item scales for environmental concern, institutional trust, perceived fairness, place attachment, risk perception, landscape impact, and social acceptance.

Fifth, some responses displayed apparent inconsistencies. For example, participants could recognise significant benefits from renewable energy while simultaneously expressing reluctance regarding wind-energy installations. Such responses are not necessarily errors; they may reflect genuinely multidimensional attitudes. Nevertheless, questionnaire design, interpretation of wording, individual experiences, and contextual factors may all affect response consistency.

Finally, the study is cross-sectional. It captures attitudes at a particular period and cannot determine how acceptance changes before, during, or after the construction of wind farms. Longitudinal research could examine whether greater familiarity, changes in information, direct experience with projects, or changes in local benefits influence attitudes over time.

Conclusions

This study examined perceptions of wind energy and the social acceptance of wind farms among 200 residents of Western Macedonia, Greece. The results demonstrate that public attitudes towards wind-energy development are considerably more complex than a simple division between supporters and opponents.

A substantial majority of participants recognised the positive contribution of renewable energy: 71% considered renewable energy sources beneficial from environmental and economic perspectives. Almost half also described wind energy specifically as an ally of people and the environment. Nevertheless, environmental concerns remained important, particularly regarding ecological impacts, landscape alteration, infrastructure development, and spatial planning.

The strongest finding concerned the influence of location. While 66% of respondents were willing to accept a wind farm in an isolated area, willingness declined markedly when the proposed installation was located near their place of residence. In that scenario, 53% expressed unwillingness and only 30.5% willingness. Acceptance increased again when the installation was described as being elsewhere outside the respondent's residential area.

This pattern confirms the existence of a substantial gap between general support for renewable energy and local acceptance of specific infrastructure. Although the pattern is compatible with the NIMBY concept, the open responses indicate that opposition cannot be attributed solely to personal proximity. Respondents also raised legitimate concerns regarding ecosystems, forests, protected areas, environmental compliance, and the absence of coherent spatial planning.

Consequently, local resistance should not automatically be interpreted as opposition to the energy transition itself. Citizens may simultaneously support renewable energy and demand more careful siting, stronger environmental safeguards, and greater participation in decisions affecting their communities.

The preference for inclusive governance was clearly reflected in the final survey question. A majority of 56.5% believed that decisions concerning wind-farm installation and siting should involve all relevant actors rather than being assigned exclusively to experts, citizens, local authorities, or central government. This finding highlights the importance of public participation as part of renewable-energy planning.

The results also demonstrate the role of emotional and visual responses. Wind farms generated mixed feelings among a substantial proportion of participants, reinforcing the need to recognise landscape perception as a meaningful component of social acceptance. Environmental communication should therefore address not only technical performance but also biodiversity, landscape quality, local concerns, spatial alternatives, and the reasoning behind siting decisions.

For Western Macedonia, these conclusions are particularly relevant. The transition towards a more sustainable energy system should combine renewable-energy development with environmental protection and social legitimacy. Appropriate spatial planning, scientifically documented environmental assessment, transparent communication, and early participation of local communities can help reduce conflict and improve the quality of decision-making.

The objective should not be to eliminate all disagreement. Energy infrastructure inevitably creates trade-offs between environmental, economic, social, and spatial interests. Instead, policy should establish processes through which these trade-offs are evaluated transparently and fairly.

Future studies should repeat and extend the survey using larger and probabilistically selected samples. Comparative research across different Greek regions could identify whether the patterns observed in Western Macedonia are specific to the local energy context or reflect broader national trends. Longitudinal studies could also investigate whether attitudes change as residents gain greater experience with wind-energy infrastructure. Finally, combining quantitative surveys with qualitative interviews or focus groups would provide a deeper understanding of why citizens accept, reject, or conditionally support particular projects.

Overall, the study demonstrates that successful wind-energy development depends not only on technical and economic feasibility but also on the relationship between renewable-energy projects, the environments in which they are located, and the communities that experience them. Social acceptance is therefore not an external obstacle to the energy transition; it is an integral component of sustainable energy planning.

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