Factors Affecting the Community Acceptance of Onshore Wind Farms: A Case Study of the Zhongying Wind Farm in Eastern China

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Abstract: The conflict between wind energy expansion and local environmental protection has attracted attention from society and initiated a fierce discussion about the community acceptance of wind farms. There are various empirical studies on factors affecting the public acceptance of wind farms, but little concerning the correlation and significance of factors, especially in a close distance to the wind farms. This paper aims to identify, classify, and analyze the factors affecting community acceptance through literature review, questionnaire, variance analysis, and linear regression analysis. A total of 169 questionnaires was conducted in 17 villages around the Zhongying Wind Farm in Zhejiang Province, China. The factors are categorized into four groups: Location-related factors, demographic factors, environmental impact factors, and public participation factors. Through the analysis of variance (ANOVA) and linear regression analysis, the outcome shows the universal rule of community acceptance under the Chinese social background. Finally, recommendations for improving wind farm planning procedures are put forward.

Keywords: onshore wind farm; community acceptance; wind energy planning; environmental impact; public participation; analysis of variance (ANOVA); regression analysis

1. Introduction

Wind energy is recognized as a major renewable energy source alternative. It helps reducing CO₂ emission and mitigating climate change due to its high performance, wide resource distribution, and competitive prices. In the context of the global energy transition, wind energy enjoys great development potential with a global cumulative capacity of 651 GW at the end of 2019 [1] and a projected 5806 GW in 2050 [2]. The brilliant wind energy scenario is expected to meet the ever-growing energy demand, save about 23 billion tons of CO₂, and create millions of new jobs in renewable energy industry chains by 2030 [3].

As a leading country in the wind industry, China has the highest wind capacity in the world (236 GW in 2019), but a low proportion in domestic electricity consumption (around 5.5% at the end of 2019) [4]. Meanwhile, the wind energy expansion is hindered by various barriers [5], such as wind curtailment [6-8], weak grid infrastructure [9,10], and insufficient transition infrastructure [11,12]. Therefore, China is looking for an industrial transition to optimize the wind energy industry. The 13th Wind Energy Five-Year Plan [13] is the strategic plan for guiding wind energy development. It puts forward the new target of optimizing the spatial designation of wind energy and balancing regional energy structure through the transformation from the model of massive and centralized wind farms in the northwest of China to the small, distributed wind farms in the southeast China [14]. The installation of distributed wind farms in densely populated areas can release burdens on grid connection and electricity transition [3]. However, even with favorable attitudes towards renewable energy among the...
general public, proposed wind facilities may be confronted with local opposition and end up being postponed or even canceled [15,16]. The environmental impacts and annoyances contribute to the local resistance, which puts challenges for spatial planning and wind project operation [17]. The research on community acceptance becomes a critical approach to resolve contradictions between the local communities and wind projects, implementing wind projects more efficiently [18].

The lack of public acceptance at the community level is often recognized as the phenomenon of “NIMBYism” (not in my backyard) [19–23]. It refers to citizens who generally agree with a proposed project if it is located far from their homes [24]. However, with in-depth studies on the local resistance, the “NIMBYism” has been criticized for being too simplistic to explain various reasons and complex possibilities of local opposition [25,26]. The reasons, motivations, and values held by the local opponents of wind energy technologies are worth being explored to provide further planning implementation [27].

The public acceptance (i.e., social acceptance) for wind energy is recognized as a signal reflecting the social consensus in the progress of energy transition [18,22,23,28,29]. It was first defined by Carlman in the 1980s during the explosion of renewable energy technologies as a public, political, and regulatory agenda dealing with public opinions to renewable energy [30]. In terms of renewable energy, the connotation of public acceptance is divided into three dimensions: socio-political, market, and community acceptance [18,29,31]. The socio-political acceptance contains the macro-level regimes of legislation, policy, planning regimes, and patterns of local ownership [16]. Market acceptance reflects the acceptance of various stakeholders in the commercialization process of wind energy. Community acceptance represents the most detailed one. It involves the magnitude to which siting decisions are accepted by local stakeholders, particularly residents and local authorities, the way in which policy-making is carried out and how the charges and gains are shared [15,16]. Here the term “community” refers to a group of people sharing the same mutual identity, interests, and responsibilities in a territory-based geographical scope. These three aspects jointly constitute the social consensus of the public acceptance for wind energy.

In this paper, the emphasis is paid mainly on community acceptance because the local inhabitants are the direct victims of renewable facilities, and local opposition is usually the most fierce resistance [22,32,33]. It is necessary to explore the dissension between general public support and local opposition. Literature research and questionnaires are jointly conducted to obtain a comprehensive recognition of how inhabitants form their responses to the implementation of a wind energy project when located in the vicinity of their homes. This paper aims to identify, classify, and analyze the factors affecting community acceptance of wind farms under the institutional and cultural context of eastern China. The correlation between factors and community acceptance will be studied and integrated into planning procedures to improve community acceptance of wind farm deployment and mitigate impacts on residents. The critical issues solved in this paper are the following:

1. What factors influence community acceptance of wind farms?
2. How do these factors interact and form the background of community acceptance?
3. What are the possible recommendations for improving community acceptance of wind farms through the optimization of planning procedures?

2. Methodology

This research attempts to identify, classify, and analyze the factors that affect community acceptance of wind farms through literature review, questionnaire, one-way variance analysis, and regression analysis [34–39].

Firstly, a framework categorizing the potential factors is established based on literature review and fieldwork in the researched area. It has combined various categories of factors in the existing literature and the social background in the rural area of China [36,40].

Secondly, a case study is conducted for obtaining empirical data and the detailed social context at the community level. Zhongying Wind Farm is selected for the case study since it represents the general conflicts between wind energy projects and local communities in a densely populated area.
in eastern China. Various natural and cultural resources in the vicinity of the wind farm are under threat and faced with value deterioration, which causes fierce rejection from communities and related protection authorities [16,36].

Through the pre-investigation, a questionnaire is designed to collect primary data and identify which factors affect the community acceptance for wind energy, and the correlation between the factors and community acceptance (Appendix A). It is supposed that all the factors related to community acceptance in the Chinese context would be categorized through the study of existing publications and fieldwork in Zhongying Wind Farm. The data collected from questionnaires are processed by ANOVA and regression analysis through IBM SPSS Statistics version 23. The analysis aims to reveal the correlation between each factor and community acceptance. Then, detailed recommendations for planning implementation will be put forward to optimize the planning procedures.

Zhongying Wind Farm built in 2012 is located in the Beilun District of Ningbo City in Zhejiang Province, China (Figure 1). It is a mid-size, low-speed wind farm located on the east coast of China. In total, 18 WD103-2500T wind turbines have been installed with an annual electricity generation capacity of 125 million kWh, which can provide green energy for 52,000 households. As shown in Figure 1, the site is close to Donghai Sea, south of Hangzhou Bay and north of Xiangshan Port. The geographical coordinates are 121°38′50″ to 122°11′00″ Eastern longitude and 29°41′30″ to 30°01′00″ Northern latitude. Wind turbines are located on the crest of the Fuquan Mountain range at altitudes of between 140 and 450 m (Figure 2). The nearby areas are alluvial plains with an average elevation of 2–3 m. The southeast wind is dominant in spring and summer, while the northwest wind is dominant in autumn and winter. The annual average wind speed is 6.6 m/s.

**Figure 1.** Location of Zhongying Wind Farm. (Source: ArcGIS Earth).

The research area is set based on a “50 H” clearance, which means the designated radius of study areas is as large as 50 times the height of wind turbines. The research area mainly consists of agricultural land, forest, settlements, and historical cultural land. There are 17 villages around the wind farm, with about 5800 residents in total. Sixty-eight percent of the residents are natives who have lived there since they were born. Thirty-two percent are immigrants who migrated from other provinces, rent houses, and work nearby. Since downtown Ningbo is only about 40 km away, the vast majority of young people have immigrated to big cities for better job opportunities. Around the wind farm, there are a great number of cultural resources, such as Buddhist temples (Changshou Temple, Qinglong Temple, Daci Nunnery), landscape parks, harbors, and scenic areas with high-value landscape and long histories. The wind turbines are located approximately 600 m from the nearest boundary of the village and 1.1 km from the nearest road. They are about 1.4 km as the crow flies from the closest edge of the cultural heritage (Changshou Temple) and 2.1 km from the closest edge of the recreational district (Shangliu Park).
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Figure 2. Plan of Zhongying Wind Farm and wind rose. (Source: original).

Summarized from existing literature and proved by the fieldwork, the factors affecting community acceptance are assembled and categorized in Table 1. In this paper, the validity of these factors will be investigated through questionnaires under specific social backgrounds in China’s rural areas. The questionnaire was designed to have an appropriate length and to be understandable, free of bias. It consisted of four parts: The first part collected socio-demographic data of the interviewees. The second part concerned the individual perception of environmental impacts. In the third part, the attitude towards the local wind farm was investigated with an 11-point Likert-type scale (i.e., 0: Strong opposition, 10: Strong support) [37,41,42]. The interviewees were asked to provide a score regarding their acceptance of wind energy. An open-ended question to obtain additional, intuitive feedbacks about factors was added at the end of the questionnaire.

Table 1. The factors influencing community acceptance of wind farms.

| Factors                          | Description of Factors                                           |
|----------------------------------|------------------------------------------------------------------|
| **Location-Related Factors**     |                                                                  |
| Distance                         | Direct distance from the settlement to the nearest wind turbine   |
| Visual angle                     | The angle between the front views wind turbines and the sight of people |
| Original environment             | Original environment in the locality                              |
| **Demographic Factors**          |                                                                  |
| Age                              | The age of interviewees                                          |
| Gender                           | The gender of interviewees                                       |
| Family                           | The marital status of interviewees                               |
| Education                        | Received educational level of interviewees                        |
| Length of residence              | How many years interviewees live in the community                |
| Occupation                       | The job of the interviewees                                      |
| **Environmental Impact Factors** |                                                                  |
| Visibility                       | The proportion of visible wind turbines                           |
| Noise                            | Whether perceived noise or not                                   |
| Soil & water pollution           | Soil and water pollution in the locality of the wind turbines    |
| **Public Participation Factors** |                                                                  |
| Information                      | Are the interviewees well informed before the project approved?   |
| Compensation                     | Whether the interviewees are satisfied with the compensation or not |
3. Results

3.1. Category of Factors

Various studies have dug into the factors and put forward specific solutions for improving public acceptance. At the macro level, public acceptance has been deconstructed firstly for recognizing the mechanism behind the acceptance. Devine-Wright [43] concentrates on the various influential factors of public acceptance with a novel classification of personal, psychological, and contextual factors. He proposes recommendations for mitigating local opposition and environmental impacts by psychology and other social science instruments. Petrova [32] establishes the “VESPA” model to classify the related factors into four categories: (1) Visual/landscape factors, (2) environmental factors, (3) socioeconomic factors, and (4) procedural factors. Leiren et al. [44] surveyed the community acceptance of wind energy in Europe with six categories of factors: Technical characteristics of wind energy projects, environmental impacts, economic impacts, societal impacts, contextual factors, and individual characteristics. These categories demonstrate public acceptance from various perspectives and propose corresponding countermeasures.

Based on the mainstream classification of the “three-dimensional model” [18], this article concentrates only on the community level, aiming to dig the relationships between factors and community acceptance. Literature review concentrating on the local level has been further conducted. Under a chronological perspective, Wolsink [20,21,45] summarizes the tendency of community acceptance change with a “U-shaped” curve. The acceptance drops from being relatively high before the planning phase to its lowest point during the wind farm site selection and then rebounds to the original level after the long-term operation of wind farms; this corresponds with the local change in attitude towards wind farms as familiarity increases. Under a spatial perspective, Guo et al. [35] propose the theory of “Not in my back yard, but not far from me”, showing an undulating acceptance at the different spatial scales.

Single factors, such as noise [46–48], landscape visual impact [49–52], ecological degradation [53], threat to wild animals, and human physiological health [54,55], have been researched quantitatively. Factors in social and economic categories like property value loss [36,56] and place attachment [23,31,57] have been qualitatively investigated under a broad social context. However, few scientifically reliable studies have included a complete set of contributing factors and analyzed the mechanism to improve public acceptance [58].

Scholars find slight differences in acceptance in communities with different cultural, social, and political backgrounds. Wolsink [21] discusses the institutional, social, and policy factors affecting wind energy acceptance in six countries. American [59], Chinese [34,35], French [60], British [61], and German [58] scholars explore the relationship between community acceptance for wind energy and the regional context by comparing contributing reasons for opposition to wind farms.

Although many articles have summarized the framework of factors related to community acceptance, they have neither experimented in a locality in China nor amended under the Chinese cultural and political context. Therefore, this paper is expected to fill the gap of community acceptance in Chinese rural areas by proposing a new framework, containing comprehensive factors for community acceptance categorized into four groups.

3.2. Variance Analysis

Questionnaires were undertaken in 17 villages and along the roads of rural areas around Zhongying Wind Farm. The evaluation of influential factors was performed by a total of 180 questionnaires, with 169 valid questionnaires returned. These surveys were distributed through a method of random sampling by interviewing people living locally in the research area. The sample accounts for around 3% of the local inhabitants. The detailed data of samples collected from the investigation is given in Table 2. All the samples were classified into four groups by the distance factor: Group 1 (very near) within 1 km; Group 2 (near) within 1–2 km; Group 3 (mid-distance) within 2–4 km; and Group 4
(remote distance) above 4 km (Table 2). In Group 4, the interviewees were nearby residents, passers, and tourists who came here regularly.

| Groups          | Distance to the Nearest Wind Turbine | Source of Respondents | Distance (m) | Number of Interviewees | Population |
|-----------------|--------------------------------------|-----------------------|--------------|------------------------|------------|
| 1. Very near    | <1 km                                 | Shangwang Village     | 710          | 7                      | 379        |
|                 |                                      | Xiaoyang Village      | 790          | 10                     | 293        |
|                 |                                      | Daotou Village        | 570          | 7                      | 776        |
|                 |                                      | Aokou Village         | 670          | 6                      | 60         |
|                 |                                      | Taipingao Village     | 600          | 8                      | 12         |
|                 |                                      | Aodi Village          | 900          | 11                     | 55         |
|                 |                                      | Shanglongquan Village | 1300         | 6                      | 339        |
|                 |                                      | Wangjiatu Village     | 1500         | 10                     | 118        |
|                 |                                      | Dongshan Village      | 1200         | 4                      | 92         |
| 2. Near         | 1–2 km                                | Shangchemen Village   | 1500         | 3                      | 421        |
|                 |                                      | Kunting Village       | 1700         | 7                      | 850        |
|                 |                                      | Ganao Village         | 1650         | 7                      | 327        |
|                 |                                      | Caqiaotang Village    | 1680         | 5                      | 466        |
|                 |                                      | Dongyuan Village      | 1600         | 4                      | 254        |
| 3. Mid-distance | 2–4 km                                | Shanglu Village       | 2200-2800    | 14                     | 590        |
|                 |                                      | Guichi Village        | 2300-3200    | 15                     | 595        |
|                 |                                      | Xiaowan Village       | 2800-3800    | 8                      | 162        |
|                 |                                      | Nearby residents      | -            | 6                      | -          |
| 4. Remote distance | >4 km                             | Passers               | -            | 37                     | 23         |
|                 |                                      | Tourists              | -            | 8                      | -          |

Note: The distance factor refers to the direct distance between the center points of villages where interviews were conducted and the nearest wind turbine.

The average score of community acceptance was 4.8, on an 11-point Likert-type scale from 0 to 10. Further analysis of community acceptance was conducted at a disaggregated level, as listed in Table 1. Firstly, the data collected by questionnaires were processed by dividing four groups: location-related variables, demographic variables, impact variables, and public participation variables. One-way analysis of variance (ANOVA) between each factor (independent variable) and community acceptance (dependent variable) was executed to distinguish the differences between the mean values of two or more groups and the mean values within groups [39].

Table 3 presents the results from the one-way analysis of variance run between 14 independent variables and the dependent variable. Among the 14 correlations run, 11 variables were statistically significant. Distance ($F = 40.740$), visibility ($F = 27.331$), noise ($F = 41.478$), information ($F = 39.671$), and compensation ($F = 26.897$) are statistically significant to the dependent variable, community acceptance for wind turbines. Factors of visual angle ($F = 10.482$), age ($F = 13.364$), family ($F = 6.283$), education ($F = 11.378$), length of residence ($F = 10.876$), and occupation ($F = 9.191$) are also significant with a lower $F$ value. Factors of the original environment, gender, and soil and water pollutions are not correlated to acceptance from a statistical perspective since their $P$-values are over 0.05.

3.3. Regression Analysis

The third step is to introduce all the statistically significant factors into regression to further tease the relative importance of each of the variables and whether each remains significant when controlling for other predictors. In regression analysis, the dependent variable is community acceptance with respect to wind energy. The factors ($n = 11$) proved to be statistically significant in the variance analysis are selected as independent variables. Since the dependent variable is a continuous score, the linear regression model is selected. As shown in Table 4, four linear regression models were run using pooled data from the above 17 communities. Four categories of variables were entered as blocks in the same sequence as in Table 3 to detect the overall contribution of the block to explained variance (i.e., the increase in $R^2$). We use $\beta$ coefficients to detect the relative contributions of each predictor variable in each model.
Table 3. Variance analysis of correlations between potential factors and community acceptance.

| Variables                                   | Categories                                      | F (ANOVA) | P (Significance) |
|---------------------------------------------|------------------------------------------------|-----------|------------------|
| **Location-Related Variables**              |                                                |           |                  |
| Distance                                    | 1: < 1 km, 2: 1–2 km, 3: 2–4 km, 4: > 4 km.    | 40.740 ** | 0.000            |
| Visual angle                                | 1: < 30°, 2: 30–45°, 3: 45–75°, 4: > 75°.     | 10.482 ** | 0.000            |
| Original environment                        | 1: positive, 2: normal, 3: negative.            | 0.112     | 0.894            |
| **Demographic Variables**                   |                                                |           |                  |
| Age                                         | 1: 18, 2: 18–40, 3: 40–60, 4: > 60.             | 13.364 ** | 0.000            |
| Gender                                      | Male, female                                   | 0.448     | 0.504            |
| Family                                      | 1: single, 2: married, 3: widowed/divorced.     | 6.283 *   | 0.002            |
| Education                                   | 1: primary school, 2: secondary school, 3: high school, 4: college/university. | 11.378 ** | 0.000            |
| Length of residence                         | 1: < 5, 2: 5–10, 3: 10–20, 4: > 20.             | 10.876 ** | 0.000            |
| Occupation                                  | 1: primary industry, 2: secondary industry, 3: tertiary industry, 4: civil servant. | 9.191 **  | 0.000            |
| **Environmental Impact Variables**          |                                                |           |                  |
| Visibility                                  | 1: invisible, 2: partly visible, 3: most visible, 4: totally visible. | 27.331 ** | 0.000            |
| Noise                                       | 1: yes, 0: no.                                 | 41.478 ** | 0.000            |
| Soil & water pollution                      | 1: yes, 0: no.                                 | 2.306     | 0.103            |
| **Public Participation Variables**          |                                                |           |                  |
| Information                                 | 1: no, 2: little information, 3: well informed, 4: positively participated. | 39.671 ** | 0.000            |
| Compensation                                | 1: not enough compensation, 0: satisfied with no care about compensation. | 26.897 ** | 0.000            |

Note: *p ≤ 0.05, **p ≤ 0.01.

Table 4. Results from linear regression of community acceptance for wind turbines.

| Independent Variable | Model 1 | Model 2 | Model 3 | Model 4 |
|----------------------|---------|---------|---------|---------|
| Distance             | 0.469 **| 0.316 **| 0.149   | 0.095  |
| Visual angle         | −0.149  | −0.191 *| −0.189 *| −0.150 *|
| Age                  | −0.130  | −0.138  | −0.142  |        |
| Family               | −0.014  | 0.004   | 0.001   |        |
| Education            | 0.156 * | 0.117   | 0.117   |        |
| Length of residence  | −0.215 **| −0.173 *| −0.091  |        |
| Occupation           | 0.082   | 0.080   | 0.053   |        |
| Visibility           | −0.185 *| −0.140  |        |        |
| Noise                | −0.137 *| −0.123 *|        |        |
| Information          | −0.213 **| −0.213 **|        |        |
| Compensation         | −0.160 **|        |        |        |
| Constant             | 3.052   | 5.657   | 7.925   | 8.438  |
| R²                   | 0.334   | 0.496   | 0.525   | 0.576  |
| N                    | 169     | 169     | 169     | 169    |

Note: *p ≤ 0.05, **p ≤ 0.01.

In Model 1, only one variable—distance—was statistically significant (p = 0.000), and this led to a low R² value of 0.334. In Model 2, the introduction of demographic variables made the variables distance, visual angle, education, and the length of residence statistically significant, and the R² increased to 0.496. In Model 3, the introduction of impact variables increased the R² value to 0.525 by adding two significant variables: Visibility and noise. The significance of distance and education dropped. In the final model, with a total of 11 variables from four categories, the R² reached 0.576. Through collinearity statistics, we found that there were no significant relationships between variables. The results showed that in the close distance to wind turbines, the statistically significant variables (p ≤ 0.05) of community acceptance were: Information, compensation, visual angle, and noise.

The following results demonstrate the variance analysis of the significant variables.
3.3.1. Information

Information refers to how much information about wind projects the interviewees got before the wind farm was approved. This variable was the most significant factor in regression model 4 within a close distance of the wind turbines (Figure 3). The information variable’s degrees were divided into four levels: No information, little information, well informed, and participation. Notably, no one among the total of 169 interviewees has ever participated in the wind project. Forty-five percent of interviewees did not receive any information before construction, while they hold a comparatively positive attitude than the other two groups. Thirty-one percent of interviewees received little information through the community, and 24% were well informed. The result revealed that the more information people get, the more negative attitude they hold to the wind energy. Eighty-five percent of interviewees scored below 5 in the “well informed” group, while the proportion was only 31% in the “no information” group.

![Figure 3. Cumulative relative frequency distributions of community acceptance as a function of the information factor.](image)

3.3.2. Compensation

The independent variable compensation was also statistically significant in regression model 4, with the $\beta$ coefficient of “−0.16”. There were two options in the variable: (1) The interviewees were not satisfied with the compensation, which means the compensation factor hindered their support for the wind energy; (2) the interviewees were satisfied or did not care about compensation (Figure 4). Most interviewees (91%) were in the second group. Only 9% of interviewees were not satisfied with the amount of compensation or the way of distribution, and most of them were located within a distance of 2 km to the wind turbines. There was a clear tendency that the interviewees in the first group rejected wind energy with over 87% giving a score below 5. The scores in the second group showed a normal distribution.

3.3.3. Visual Angle

The visual angle refers to the angle between the front views of wind turbines and the sight of people (Figure 5). The front view of wind turbines has the biggest maximum sweep area and causes the most serious visual impact. Fifty-eight percent of interviewees suffer from slight visual impact with the visual angles below 45°, and they hold a comparatively higher acceptance for wind energy. The remaining 42% of interviewees were directly exposed to the front of wind turbines with the visual angles over 45°, and the bigger the visual angle, the lower acceptance they hold to the wind energy. In the first group (>75°), 38% of interviewees gave extremely low scores of 0 and 50% below 2.
3.3.2. Compensation

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In the first group (>75°), 38% of interviewees gave extremely low scores of 0 and 50% below 2. The remaining 42% of interviewees were directly exposed to the front of wind turbines with the visual angles below 45°, and they hold a comparatively higher acceptance for wind energy. The noise was proved to be a significant variable to community acceptance within a close distance (Figure 6). The variable was divided into two degrees: (1) Noise, accounting for 39% of interviewees; (2) no noise, accounting for 61%. Further analysis found that over 83% of interviewees influenced by noise were located within a distance of 2 km to wind turbines, and they showed a lower acceptance for wind energy, with half of the interviewees scoring below 3.

3.3.4. Noise

The noise was proved to be a significant variable to community acceptance within a close distance (Figure 6). The variable was divided into two degrees: (1) Noise, accounting for 39% of interviewees; (2) no noise, accounting for 61%. Further analysis found that over 83% of interviewees influenced by noise were located within a distance of 2 km to wind turbines, and they showed a lower acceptance for wind energy, with half of the interviewees scoring below 3.

3.4. Environmental Impacts and Accompanied Annoyances

The second part of the questionnaire aimed to acquire the individual perception of environmental impact suffered from the wind farm. The critical point here is to analyze comparative impacts among different distances, rather than absolute values. Therefore, the number of respondents who perceived the environmental impact and annoyance was counted and categorized by distance (Figure 7).

Comparisons between the four distance groups indicated that the noise factor ranked first within 4 km of the wind farm, presenting a stable percentage of between 37% and 38%. As the distance increased, the significance of the environmental impacts, which were perceived mainly through auditory, tactile, and olfactory senses, decreased more dramatically than perceived by visual sense. The intensity of the noise was gradually ineffective beyond 4 km and was overwhelmed by other
co-existing influential factors. Conversely, the landscape visual impact showed a dramatic increase from 7% to 67%, followed by the ecological impact from 8% to 17%. The landscape impact was highly concerned in open spaces directly facing the rotating surface of the wind turbines. Furthermore, as the distance increased, the number of influential factors in the environmental impact category showed a gradual decrease from seven to three factors, which illustrated the severe and multiple environmental impacts within a close distance. In this case study, the threshold was about 4 km, equivalent to 50 H (H refers to the height of the wind turbine).

![Figure 6. Cumulative relative frequency distributions of community acceptance as a function of the noise factor.](image)

![Figure 7. Proportion of perceived environmental impact and annoyances in four distance groups.](image)

Interviewees in Group 1 indicated that residents not only suffered from acoustic pollutions, but also perceived serious irritations for their quality of life (18%) and individual health (11%) caused by the continuous and loud “Huhu”-noise, which was related to both decibel level and frequency of noise emission [58]. The noise generated by wind turbine blades can reach 50 to 60 dB within 1 km and cause severe physical and psychological annoyance to residents. Other associated influences such as loss of serenity in the countryside, property value shrinkage, family disharmony, and low social consensus to local wind facilities have brought about broader social influence and public attention. The impact of noise still dominated the second group within 1 to 2 km. Other environmental impacts like soil erosion (10%) and landscape visual impact (14%) obtained more local attention with an increase in distance. From Group 3, the factors threatening health and water quality disappeared, replaced by other impacts like landscape visual impact (23%), ecological impact (23%), and soil erosion (8%). Noise remained a significant reason for local rejection but not the most severe factor. In regions further...
away than 4 km, the dominant factor was replaced notably by landscape visual impact with 67%, followed by ecological impact (17%) and noise (16%).

4. Discussion

This research aims to analyze the determinants and contingencies of community acceptance for wind energy in the locality. Although the capacity of wind energy installed in China ranks first worldwide, there is a lack of social acceptance studies on this topic, especially quantitative research revealing the significance of various potential influential factors. Studies on community acceptance of wind energy have been widely conducted [15,16,32,41,62,63], which are of great help in optimizing site selection, spatial planning, and project operation. Based on face-to-face questionnaires and data collection in rural areas of East China, this paper researches the complexity and features of community acceptance for wind energy by analyzing the driving factors of acceptance. The study also compares the nuances of community acceptance between China and other countries to suggest more suitable planning instruments for China.

4.1. Significant Variables in the Regression Model

Through the one-way variance analysis of each factor separately and a comprehensive linear regression model combining all potential factors, some significant variables are worth to be further discussed.

First, the focus falls on the four significant variables in the regression model: Information, compensation, visual angle, and noise. It is surprising to find that compared with the influencing factors of physical properties, such as noise and visual impact, factors of social construction attributes have greater influence in community acceptance. Information (β coefficient = −0.213) and compensation (β coefficient = −0.160) dominate the highest weights in regression model 4. It reveals that acceptance at the local level is profoundly shaped by social and cultural contexts, as well as the planning implementations. The deeply rooted local identity, sense of belonging, as well as the way how inhabitants treat the natural resources, influence their value system, and then reflect in their attitude towards wind energy.

Conversely to the consensus that more information increases local support [32,33], information is a negative factor to community acceptance in this research, which means that the more information about wind projects people get from official media, the lower support they show to the wind energy. However, further research revealed that there exists a specific social and cultural background of this phenomenon. According to the local planning regulation, inhabitants within 2 km from the wind farm were required to be obligatorily informed. Their low acceptance rate may be attributable to complex comprehensive effects, such as close distance and severe visual impact, not only from the perspective of information acquisition. Enriching the public participation formality and depth can increase local acceptance. Wolsink [21] held that the public’s attitude towards local projects is highly related to involvement: The higher its involvement, the greater the tolerance to wind farms. It was suggested by Pedersen et al. [64] that the respondents economically benefit from a wind project generally felt less annoyance. Conversely, the lack of community ownership was identified as the main reason for local rejection [16]. Based on the first step of open information to the public, deeper communication and involvement between inhabitants and wind projects (e.g., participation, co-decision-making, private investment) can increase the recognition and support of local residents for the project.

Another finding is that reasonable sharing of compensation among stakeholders helps to increase community acceptance, which is proved to be more obvious in less developed regions [35]. The replies of the respondents indicate that compensation from Zhongying Wind Farm has not been distributed to individual villagers but managed by the village committee and used as a fund for village infrastructure facilities. The management and use of compensation by the community collectively make some severely affected inhabitants feel unfair. Through the open-ended questions in the questionnaires, we found that compensation for severely influenced individuals is necessary. Some inhabitants want to obtain specific subsidies from the wind company due to their losses in terms of income, health, and daily
life. Insufficient compensation is one of the reasons for their fierce rejection. Special preferential measures for severely affected residents, such as priority to job opportunities, reducing electricity bills, and mitigating measures to reduce environmental impact, can effectively reduce extreme resistance.

Economic incentives and collective investment are effective solutions for stimulating wind farm acceptance, which includes local electricity price concessions, job creation, and regional economic revitalization. Higher levels of economic and social benefits lead to higher levels of involvement and hence higher degrees of community acceptance. The impression of wind energy could be improved by a series of measures, such as announcing a collective compensation financial plan and naming the wind farm by local landmarks.

Usually, the visual disturbance is a driving force behind opposition [48,65]. However, its connotation is fuzzy and has not been quantified under the social acceptance topic. This research refined the quantitative analysis of the visual impact and found the most influential indicators: Visual angle. The aesthetic/visual-related factors are divided into several definite quantitative variables. It is notable to find that in the regression model 4, the factor of visual angle is more statistically significant than visibility, which has not been mentioned in other literature. The result revealed by the linear regression analysis is consistent with the residents’ response in the questionnaires that the scene directly faced to the wind turbine can bring huge psychological stress to the residents.

There is some evidence of a positive relationship between visual impacts with perceived noise [66–69], which has been corroborated in this case study of Zhongying Wind Farm. An interesting finding is that high visibility of the wind turbine will increase the subjective acoustic annoyance and vice versa. Villagers with high visibility, especially those directly facing the rotating surface of the wind turbines, show lower acceptance than invisible areas (9 out of 24 respondents gave a score of 0 to the nearby wind farm). Within shorter distances, villagers with lower visibility show a comparatively moderate acceptance, which also benefits from the forest’s dampening of noise.

Noise from wind turbines is derived from two sources: The mechanical sound from the gearbox, which can be expected to be reduced in the future with technological advancements, and the aerodynamic noise created by the rotating blades [70]. Compared with the decibel level, the low frequency, quality, and characteristics of turbines’ emitted sound is more intolerable. The constant noise will continuously remind people of the visual image of wind turbines and aggravate the negative impact. In contrast to this, Petrova [32] suggested that a regular and stable sound makes residents feel less disturbed than occasional noise. Some locals even believed that stationary wind turbines present a negative impression of inefficient and depressed industry development.

4.2. Location-Related Factors

Former researchers have broadly discussed the valid spatial range of environmental impacts from wind turbines. Shang and Bishop [71] suggested that the effective influential range for wind turbines is 5 to 10 km. Swofford and Slattery [22] investigated the distance factor over a range of 20 km and found a positive correlation between acceptance and distance. This paper concentrates on the area within 4 km to wind farms (50 H of the turbine’s height), which would be the range necessary for East China’s densely populated area.

The One-way ANOVA reveals that distance factor is correlated to the community acceptance. The closer the distance is to the wind farm, the more critical the distance factor acts influencing community acceptance. Compared with other groups, Group one (within 1 km) showed extremely low acceptance with a score of 2.4, far below the average score of 4.8. With the distance increase, respondents’ attitudes towards wind farms tend to be more moderate. However, it is not the single decisive one and has to be analyzed under a complex framework of coexisting factors, especially the visual angle, topography, the original quality of the environment, etc.
4.3. Demographic Factors

As shown by several empirical studies, the community acceptance of the wind farm is related to demographic features. Various criteria such as age, family status, educational level, length of residence, and occupation affect community acceptance to different extents. The USA [72] and the European Union [29,58,60] have organized regional research projects and published guidelines to improve the community acceptance of wind energy, which particularly emphasizes the relationship between acceptance and demographic characteristics. This study detects the correlation and interaction between demographic features and community acceptance under the social context of rural areas in East China.

Caporale and Lucia [39] advocate that there is a link between community acceptance and age factor. Further studies suggested that age factor, together with other demographic features, shaped the underlying values that determine community acceptance. An integrated perspective should be put forward to analyze demographic factors under dynamic social evolution, especially under the rapid urbanization and aging population. Regarding the difference between younger and older respondents, physiological health and tolerance play a significant role. During the fieldwork around Zhongying Wind Farm, the author received a large number of complaints from older respondents that the noise emission from the wind turbine had reduced their sleep quality, which was most pronounced within a distance of 1 km.

Although there is not a significant correlation between gender and community acceptance, there is a definite difference in participation interests between male and female respondents, which can be attributed to two aspects: Landscape perception and evolutionary theory. For the former, males are more sensitive to the placement of wind turbines than females, which has been demonstrated by Molnarova et al. [73] and Strumse [74]. From the evolutionary perspective, the sense of belonging and territorial possession mean males usually focus on external environmental status and the potential aggression of newly emerging objects. The different social participation features and sensitivity of males and females can provide feasible ideas for planning procedure optimization. However, due to small samples in the specific categories, no clear correlation between family status and community acceptance has been found.

Educational level, which is closely related to the degree of awareness and understanding, is acknowledged as a critical factor to influence the residents’ perception of renewable technologies. A variety of literature proves that the educational level, or familiarity with renewable technologies, could help forming a rational attitude towards local projects, rather than arbitrary rejection [16,22,39,75]. The majority of the residents (80.5%) in the research area received basic education below secondary school. The lack of support is highly related to low common knowledge in rural areas [76]. According to an empirical study [22], improvement of participation and involvement could encourage local people’s enthusiasm to get more knowledge about renewable energy and hold a positive attitude to local projects.

The native residents (living in the locality more than 20 years) show lower acceptance because of the strong sense of belonging and attachment to a place, which is even recognized as a “place protective action” [77]. This emotion reflects the negative attitude towards anything that potentially conflicts with their local identity and scenery. On the other hand, immigrants (living in the locality less than 20 years) are not sensitive to impacts like noise as they concentrate on their work. They will be partly affected by noise at night. If necessary, they can move further away from the wind farm by renting another room. Native residents pay more attention to local identity changes than immigrants, especially in the aesthetic quality of the landscape and local cultural values. Even in remote areas, the installation of giant, visually attractive wind facilities may disrupt a cultural connection between the original landscape and the local community. For the native residents, the landscape’s impact extends beyond mere physical transition to include cultural, symbolic, and socially constructed aspects of that transformation. The locals are deeply influenced by traditional culture and tend to be skeptical about any new facilities that can change their regional identity.
The occupation variable is divided into the primary, secondary, tertiary industry, and civil servant in this research. People working in primary industries are usually exposed to outdoor due to their work needs. They rely on natural resources and view the wind projects more as a disturbance in their industry. However, other occupations suffer less impact and have a more positive attitude to wind energy.

4.4. Environmental Impact Factors

Various environmental impacts have been broadly discussed under the topic of wind farms. However, there is not yet an integrated perspective concerning the spatial distribution features and significance of environmental impacts, and the interaction of various environmental impacts.

The proportion of various environmental impacts changes as a function of distance. Figure 7 can be used as a reference in the detailed planning implementations for mitigation and compensation measures. At close ranges of within 1 km (around 12 h), the noise impact constitutes the main reason for the strong opposition, which has to be avoided in site selection. At medium distances from 1 to 4 km, natural resources like water, forests, soil, wild animals, and ecosystem should be well protected during wind turbine erection and operation. At long distances above 4 km, the actual physical impacts are reduced, while issues like landscape, aesthetic quality, and regional identity constitute the decisive factors for community acceptance.

4.5. Public Participation Factors

There is a tremendous number of studies suggesting that public participation is closely related to community acceptance \[16,22,32,60,78,79\]. Since the collective land policies and village communities in rural areas of China are different from those in Western countries, the guidelines and measures based on empirical studies cannot be introduced abruptly without full consideration of cultural and political background.

The fieldwork revealed the contradiction between the public and the local government. Forty-five percent of the respondents complained about insufficient information during wind farm planning, which left a negative impression on them. Meanwhile, 76% of respondents who gave negative scores below 5 complained about the lack of efficient communication between residents, local authorities, and enterprises. They stated there was not any notification and negotiation with the public before approval. Conversely, the local government claimed that the approval document of Zhongying Wind Farm had been released online before construction. All the procedures complied with the law. Nevertheless, residents tried to put up opinions against site selection.

Transparent and standardized public participation procedures are widely identified solutions to improve community acceptance by increasing the familiarity and goodwill of local people to wind farms. Another crucial factor is the perceived fairness, which means that when respondents receive equal treatment, they feel a sense of fairness and trust \[38\], strengthening their active participation and generating a virtuous cycle. Since local people are less informed with the technology, community acceptance depends mainly on the trust in authorities and project operators. According to Friedl and Reichl \[38\], the procedures of local participation should be improved step-by-step from pre-information, consultation, cooperation, and finally, self-operation.

The challenge for China lies in the fact that public participation does not have a theoretical framework and implementation guidelines complied with the Chinese social context. There is a gap between regulation and practice in terms of participation. Public participation should be integrated into the Chinese social context with proper measures implemented like expert consultation, public meetings, open days, school visits, a website updated with project information and videos, etc. Such measures will improve the public’s awareness of participation and coordinate the conflicts between the wind energy enterprise and local communities. An adequate knowledge base and accurate information with an easy-to-understand content explaining both the advantages and disadvantages of wind energy can reduce local opposition to some extent. Additionally, the media has strengthened the positive
image of wind farm projects by promoting a more vivid idea of “progressive-community” or “green community”, bringing a sense of pride to locals [41]. Some residents even think of wind turbines as green landmarks and symbols of progress [80].

4.6. Limitation in This Research

Since the affecting factors are selected through the literature research, there is a limitation in the process of questionnaire design. Because of the limited time and energy, it is impossible to include all the factors appearing in the literature. The most substantial attention factors were selected in the questionnaire. For instance, the impact on wild animals and psychological impairments on inhabitants have not been included in the questionnaires because they show a weak correlation to community acceptance according to the fieldwork. With further fieldwork and supplement of this research, more specific factors need to be collected.

5. Conclusions and Recommendations

This study clarified the factors influencing community acceptance of onshore wind farms in eastern China and the interaction between various factors in the case study of Zhongying Wind Farm. The on-site investigation and questionnaires ensured the reliability of the results. The linear regression model revealed that information was the most significant factor affecting community acceptance, followed by the factors of compensation, visual angle, and noise.

A set of recommendations proposed for improving planning procedures are the following: Making planning procedures more systematic and transparent is exceedingly vital to increase community acceptance. The reasons for strong opposition are partly due to the fear of the unknown. Preferential policies offer the right solution for reducing local opposition by providing subsidies, tax exemptions, and financial investment priorities for local residents, which will encourage enthusiasm for wind energy development. However, fewer complaints and growing acceptance do not mean the disappearance of influence; the environmental impacts will continue to reduce the environmental quality of local settlements. Therefore, technological and legal standards must be established to prevent irreversible impact on the local environment and the next generation. Community acceptance is merely a sociological reference index showing the public’s attitude but does not mitigate the environmental impact’s intensity.

In East China, research on the environmental impact of wind energy and the community acceptance of renewable energy is at an initial stage. Detailed and concrete investigations are of great necessity to provide empirical data support for decision-making and public participation. This paper contributes to the recognition of community acceptance for wind energy and providing practical recommendations that should be implemented into the planning process.

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Appendix A. Questionnaire for Inhabitants around Zhongying Wind Farm in Ningbo, China

This questionnaire is used for the Ph.D program “Optimizing the visual impact of onshore wind farms upon the landscapes—Comparing recent planning approaches in China and Germany”
in the Faculty of Geosciences, Ruhr-University, Bochum, Germany. Please answer based on your true thoughts. This questionnaire promises that it will only be used for academic research, not for commercial purposes and external publicity.

1. Your age: (1) <18 (2) 18–30 (3) 30–40 (4) 40–50 (5) 50–60 (6) >60
2. Your gender: (1) Male (2) Female
3. What is your marital status? (1) Single (2) Married (3) Divorced (4) Widowed (5) Other
4. Your educational background: (1) Primary school or lower (2) Middle school (3) High school (4) Professional academy (5) University or higher (6) Other
5. Your job: __________________________________________
6. How long do you live here? (1) <1 year (2) 1–5 years (3) 5–10 years (4) 10–20 years (5) >20 years
7. Do you know about Zhongying Wind Farm Project? (1) I know clearly (2) I know about it (3) Not very familiar (4) I don’t know it at all
8. The distance from your residence to the nearest wind turbine: (1) <500 m (2) 500–1000 m (3) 1000–3000 m (4) >3000 m
9. Visibility of the wind turbines from your residence: (1) Invisible (2) Small part visible (3) Most visible (4) Fully exposed
10. Does the environmental impact (noise, flicker) of the wind farm affect your life? (1) Not at all (2) It has a certain impact (3) Medium impact (4) Unbearable impact (5) Other thoughts
11. How long you are affected by the wind farm each day? (1) None at all (2) <1 h (3) 1–3 h (4) 3–5 h (5) 5–8 h (6) >8 h
12. What is your opinion on the visual impact of the wind farm? (1) No impact (2) Positive impact (3) Have negative effects (4) Not clear
13. Does the wind farm project have compensation measures for surrounding residents? (1) No compensation (2) Yes __________________________________________ (3) Unknown
14. Your opinions and suggestions on wind farm planning:

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

Thank you for your participation!

10 March 2019

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