Perception and Annoyance Related to Environmental Impacts of Coastal Wind Farms in Japan

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Summary

According to a survey conducted by the Ministry of the Environment (MOE), wind power has the greatest potential in comparison with other renewable energies in Japan. Although several conflicts have occurred with residents in areas that utilize wind power, because of factors such as operational noise, bird collisions, spoiled scenery, and shadow flicker, little is known about the differences in the geographical features at places where these power sources of power are located. In particular, it is not clear that residents' perceptions and feelings of annoyance are exclusively due to the wind turbines located in the coastal area. This study focuses on the perceptions and feelings of annoyance experienced by residents living near coastal wind turbines. Questionnaires were distributed to municipal governments that included coastal wind farms in their jurisdictional areas to clarify the frequency of complaints pertaining to wind turbines. Moreover, interview surveys were administered to over 100 people who lived within 300 m of the turbines. The results showed the following: (1) Japan contains 39 coastal wind farms that have over 5,000 kWh installation capacity. (2) The perception of shadow flicker was more frequent than that of operational noise, whereas the level of annoyance due to shadow flicker was slightly less than that due to noise. (3) Residents' perception of the noise depends on their distance from the shoreline as well as from turbines, because the back-ground noise from waves can eclipse the noise of turbines. (4) According to a geographical distribution, residents living near multiple turbines were likely to perceive noise and thereby become annoyed.

Keywords: coastal wind farms, environmental impact assessment, perception, annoyance

1. Introduction

The severe nuclear disaster at the Fukushima Daiichi nuclear power plant caused by the huge earthquake and massive tsunami generated wide-spread debate on energy policy throughout Japan. The tsunami that struck the Tohoku area shut down 16 reactors from five nuclear plants in the region. Consequently, all 54 nuclear reactors, including four decommissioned ones, ceased operations on May 5, 2012, for the first time in 42 years. Obviously, this situation represents an unprecedented crisis that has fundamentally changed the Japanese people's understanding of energy issues. Thus, the promotion of renewable energies is crucial to address the current energy crisis in Japan as well as to prevent climate change on a global scale (Nishikizawa, 2012).

The Ministry of the Environment (MOE) released an assessment of potential renewable source availability in Japan (MOE, 2012). According to a survey conducted in FY 2009 and FY 2010, wind power had the highest potential as compared with the other types of renewable energy, which included non-residential use of photovoltaic power, small and medium-scale hydro-electric power, and geothermal power. In spite of its high potential, however, the actual installation of wind power appears to be progressing slowly. The previous target of installing 3 GW of wind power by FY 2010, set by the national government, has not yet been achieved.

A major reason why wind power has not been smoothly introduced in Japan is the adverse environmental impacts related to wind power, such as operational noise, bird collisions, spoiled scenery, and shadow flicker (Azechi et al., 2012). Although the dominant issue concerns the scenic impact and landscape at the proposed sites in contested wind farm developments (Wolsink, 2012), operational noise is one of the most serious impacts on residents in Japan. According to a survey conducted by the MOE, 64 of 389 wind power sites received noise complaints, the highest among complaints related to other environmental components (MOE, 2011).

Moreover, the ratio of occurrence of complaints is higher according to the installation scale: 27% at 5–10 MW capacity sites, 38% at 10–15 MW sites, 44% at 15–20 MW sites and 69% at 20–30 MW sites (MOE, 2011). In addition, the survey

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mentioned that residents' perception of unpleasant sound depends on not only the wind power capacity but also psychological aspects. People who live in areas where they can see the turbines tend to perceive more noise than those who cannot see them. Moreover, a previous survey indicated that people consider wind turbine noise to be more unpleasant than the noise caused by aircraft, road traffic, and railways (Pedersen & Waye, 2004).

In recent years, some studies have discussed the "not in my back yard" (NIMBY) theory as it relates to public or community acceptance of wind power. The term NIMBY is often used by the proponents of such a facility as "a succinct way of discrediting project opponents" (Burningham, 2000). Most researchers now, however, agree that this phenomenon is rather complex (Wolsink, 2000; van der Horst, 2007; Wüstenhagen et al., 2007). As Wolsink (2012) indicates, the current mainstream trend in academic circles leans toward abandoning NIMBY explanations. Although previous studies have affirmed the complexity of community acceptance of wind power, the mechanism for accomplishing this is still unclear, particularly in environmental settings with particular geographical features.

Sufficient research has not been conducted regarding offshore wind farms. Wolsink (2010) focuses on near-shore wind power and concludes that the frequently suggested idea of siting wind farms offshore to solve the problems encountered onshore is naïve and too simple. However, little is known about whether coastal wind farms have environmental impacts. In particular, it is not clear to what extent residents located in coastal areas perceive turbine noise and subsequently regard them as annoying. Therefore, this study focuses on the perceptions and annoyance of residents living near coastal wind farms.

2. Research framework

2-1. Definition and scope

There is no general definition of the "coastal area" in Japan. Thus, for this study, it was defined as a zone located within 500 m of the shoreline. Moreover, this study focuses on coastal wind sites that had over 5,000 kWh installation capacity, which had a relatively high possibility of generating operational noise complaints.

Combining the above definition with previous surveys (NEDO, 2012; NACSJ, 2012), we identified 39 coastal wind sites in 30 municipalities of 16 prefectures in Japan (Fig. 1).

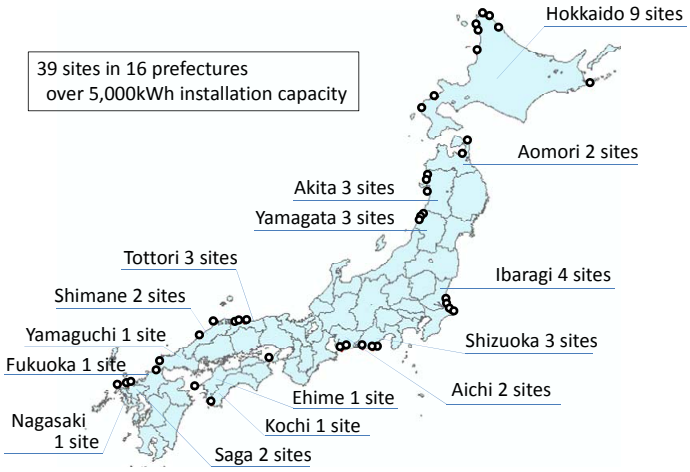

Fig. 1. Site location of coastal wind farms in Japan

2-2. Surveys

Two types of surveys were conducted as follows.

(a) A questionnaire was administered to municipalities containing coastal wind sites as of November 2012. To obtain an overview of a coastal wind site, the questionnaire primarily included the following items: geographical features, the proximity to residents and the shoreline, and the current status of complaints due to wind turbines from local residents. Researchers collected 38 survey sheets from 29 municipalities (collection rate 96.7%).

(b) Individual interviews were conducted with

Table 1. Frequency of Complaints due to Coastal Wind Farms (No. of sites)

		occurred	did not occur	unknown	total
complaint occurrence		17	19	2	38
contents of complaints	noise	9	-	-	29
	shadow flicker	8			
	bird collision	5			
	scenery	2			
	others	5			
distance from residences	0-199 m	2	1	3	33
	200-399 m	10	7		
	400-799 m	1	5		
	800- m	3	4		

114 local residents at two coastal wind sites in December 2012. Two sites were selected according to the geographical features and the occurrence of complaints. Both sites were located in flatlands where further wind power development is expected. Furthermore, while residents brought environmental complaints to the municipality at one site, there were no complaints at the other site. During the interviews, residents were asked about their perceptions and the extent of their annoyance due to wind turbines, such as regarding operational noise, shadow flicker, and disturbance of the scenery.

The responses to most questions were rated on a 5-point verbal rating scale. For instance, when respondents were asked about their perception or feelings of annoyance, the scale included "not applicable", "not much applicable", "unknown", "somewhat applicable", or "applicable".

3. Results of questionnaires: occurrence of complaints due to coastal wind farms

The results of the questionnaires, collected from 38 coastal wind farms in Japan, revealed at least one complaint for 45% (17 sites) of wind farms (Table 1). The major topics of local residents' complaints were noise (nine sites), shadow flicker (eight sites), and bird collisions (five sites).

In general, bird collisions are likely to be key issues related to wind farm developments in mountainous areas. However, the data indicates that, in coastal areas, shadow flicker might be a more noticeable issue for residents.

Regarding noise-related complaints, eight out of nine sites generated complaints about operational noise. There was only one site where complaints occurred before operations began (during the planning stage). Furthermore, residents were located at no more than 310 m from the sites that generated complaints about operational noise. In contrast, some sites received no noise-related complaints in spite of having residents located within 50-350 m of the sites.

The emergence of noise-related complaints depended on factors such as the geographical features of the area, meteorological factor, and psychological aspects. A previous study noted a case in which the impact on distant residents was greater than that on local residents living near a wind power site. This is because noise perception depends on the background noise level, which is often related to geographical features. This phenomenon can also be applied to coastal wind farms, because operational noises can be eclipsed by the sound of waves. This implies that the distance of the site from the shoreline might significantly influence residents' perception of operational noise.

However, it is difficult to comprehensively clarify residents' perceptions or feelings of annoyance related to turbines through a questionnaire. In particular, the results derived from a questionnaire do not reflect the actual state of residents' awareness, because people may not register a complaint about wind farms even if they have one.

Therefore, the next section presents the results of interviews with residents to examine their perceptions and feelings of annoyance.

4. Results of interviews with residents: perceptions and feelings of annoyance

4-1. Overview of the cases

Two cases were selected to clarify the actual conditions of residents' perceptions and feelings of

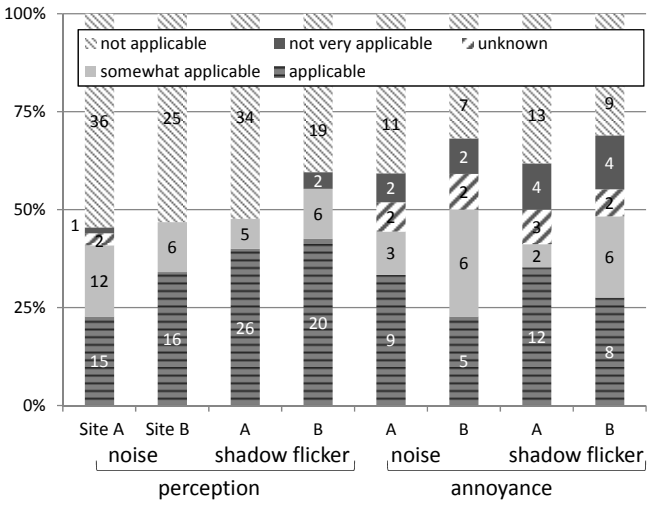

Fig. 2. Perceptions and Feelings of Annoyance related to the environmental impacts of noise and shadow flicker from wind farms

Table 2. Overview of the Cases

	Site A	Site B
site location	Kajima city, Ibaragi Prefecture	Kamisu city, Ibaragi Prefecture
installation capacitiy	20,000 kWh (2,000kWh * 10)	15,000 kWh (1,250 kWh * 12)
topography	flat	flat
distance from closest shoreline	100 meters	60 meters
distance from closest resident	300 meters	150 meters
occurrence of complaints (result of the questionnaire)	noise, shadow flicker	none
interviewees (coverage rate of survey)	66 (31% of households)	47 (34%)

annoyance. Table 2 shows an overview of these cases. Although both sites were similar in terms of installation capacity, topography, as well as distance from the shoreline and residents, the types of complaints generated by the sites were different.

4-2. Perceptions and feelings of annoyance related to environmental impacts of turbines

Fig. 2 presents residents' perceptions and feelings of annoyance related to the environmental impacts of noise and shadow flicker. The figure indicates that approximately half of the respondents perceived the environmental impacts of noise or shadow flicker caused by turbines. The rate of perception of shadow flicker was higher than that of operational noise. This result is not the same as that for an item on the questionnaire in which the number of sites at which noise-related complaints occurred was greater than that for shadow flicker.

If we focus on this aspect of annoyance, however, the number of respondents stating that the noise "annoyed" or "somewhat annoyed" them was greater than that in the case of shadow flicker at both Sites A and B. This implies that the rate of annoyance due to operational noise is higher than that for shadow flicker.

Residents living near Site B perceived greater environmental impacts and were more annoyed by them than residents near Site A. Thus, a major factor is the proximity of residents to the site; the distance to the closest resident from Site A is twice that from Site B.

4-3. Awareness of wind farms

Fig. 3 indicates residents' awareness of wind farms. According to the results, many residents either do not have a positive evaluation of wind farms or are indifferent to them. For instance, almost half of the respondents did not consider themselves familiar with wind turbines. In addition, over 25% answered "unknown" to the question regarding whether they had a favorable impression of wind farms.

Furthermore, residents did not have a negative judgment of wind farms; the majority answered that they disagreed or somewhat disagreed with the idea that wind farms are bothersome. In particular, approximately 60% of respondents answered that they disagreed that wind farms should be removed. These results were roughly the same between the two sites.

4-4. Factors related to perceptions and feelings of annoyance

Table 3 displays the results of the multiple regression analysis. According to the results, residents' distance from the wind turbine was inversely proportional to their perception of its noise. In general, this was a reasonable and popular response. In contrast, regarding the distance from the shoreline, the results were the reverse: the closer the residents were to the shoreline, the less likely they were to perceive noise. This implies that the sound of waves can

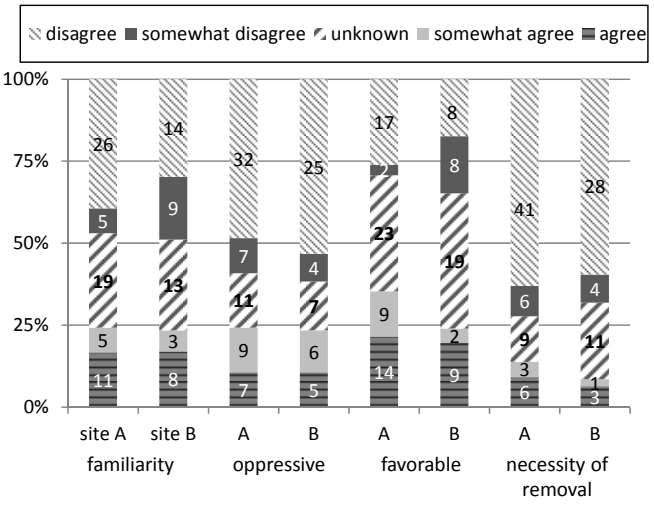

Fig. 3. Awareness of wind farms

Table 3. Factors of Perceptions and Feelings of Annoyance

	noise				shadow flicer			
	perception		annoyance		perception		annoyance	
Expl. Variable	Site A	Site B	Site A	Site B	Site A	Site B	Site A	Site B
distance from the turbine		-.268**		-.362**				
distance from the shoreline		.486***			.211*		.269**	-.759***
perception of noise	-	-			.263**	.442***		.558***
perception of shadow flicker	.235**	.381***	.421***	.485***	-	-		
oppressive			.600***					
familiarity				-.304*				-.326*
necessity of removal		.269***		.676***			.381***	
favorable							-.276*	
n	66	47	27	22	66	47	31	26
adjusted R^2	0.51	0.67	0.73	0.56	0.15	0.34	0.73	0.46

*p<.10, **p<.05, ***p<.01

eclipse the noise of turbines. The significant values are shown in Site B, which is closer to the shoreline than Site A.

Furthermore, the results suggest a correlation between noise and shadow flicker perception. This implies that one environmental impact can induce the perception of another, or, that noise and shadow flicker are likely to occur at the same place. These results can be applied to the relationship between perceptions and feelings of annoyance.

Moreover, those who perceived wind farms negatively, such as rating them "bothersome" or "demanding that they be removed", tend to be sensitive to environmental impacts. In contrast, those who had a positive image, such as rating them "favorable" or on the basis of "familiarity" tended not to be annoyed by wind turbines.

4-5. Geographical distribution of perceptions and feelings of annoyance

Fig. 4 shows the geographical distribution of perceptions and feelings of annoyance. It indicates that people living in the areas at both ends of the site did not perceive turbine noise (see left side in Fig. 4). In contrast, many people who lived near the multiple turbines perceived noise. In particular, residents who lived within 300 m of the turbines experienced annoyance. Some residents living near the north end of the site perceived greater noise or annoyance than those at the south end, despite the northern residents' dwelling at a distance of over 300 m from the turbines. This result can be explained by the relationship of noise with shadow flicker impacts.

The geographical distribution of shadow flicker impact was similar to that of noise. This means that people who lived either near the multiple turbines or at the north-west end of the site perceived shadow flicker and had been annoyed by it. It also indicated that people who perceived turbine noise were likely to perceive shadow flicker as well. This result suggests a logical consistency with the results of the multiple regression analysis.

Some inconsistency was exhibited by the pattern, particularly in the higher occurrence of perception or annoyance in residents living in the north-west area of the site. These residents may have perceived the impact of the wind turbines because they were exposed to shadow flicker for long hours, owing to the angles of sunlight during sunrise.

Based on the abovementioned results, it is possible that shadow flicker can be a trigger for the perception of noise impact. Thus, developers should pay more attention to areas potentially affected by shadow flicker when they propose a wind power development in coastal areas. In addition, shadow flicker impacts should be diligently evaluated to ensure their identification during an Environmental Impact Assessment

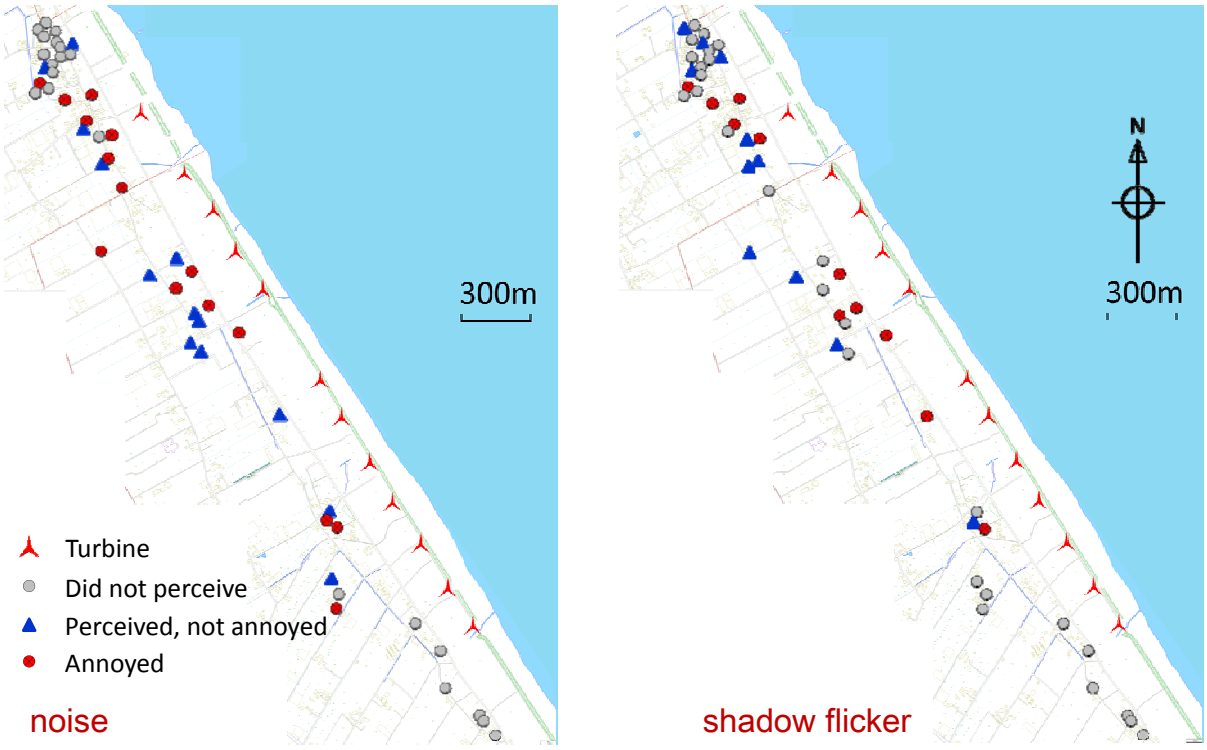

Fig. 4. Geographical distribution of perceptions and feelings of annoyance (Site B: Kamisu City)

procedure. Noise impacts should be predicted on the basis of their relation to shadow flicker impacts.

5. Conclusion

In this study, residents' perceptions and feelings of annoyance due to coastal wind farms were analyzed by means of questionnaire and interview surveys. The results indicated the following: (1) Japan contains 39 coastal wind farms that have over 5,000 kWh installation capacity. (2) The perception of shadow flicker was more frequent than that of operational noise, whereas the level of annoyance due to shadow flicker was slightly less than that due to noise. (3) Residents' perception of noise depends on their distance from the shoreline as well as from turbines, because the back–ground noise from waves can eclipse the noise of turbines. (4) According to a geographical distribution, residents living near multiple turbines were likely to perceive noise and thereby become annoyed.

Further studies are required, particularly in areas with different topographies, such as on the west coast, where shadow flicker would have a lesser impact on residents. Moreover, future studies should comprehensively clarify the cause-and-effect relationships among annoyance, individual, and contextual parameters.

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