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 to other renewable energies in Japan. Although a large number of conflicts have occurred with residents in areas where wind power is used, 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 sources of power are located. In particular, it is not clear that residents' perceptions and feelings of annoyance are singularly due to 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 had coastal wind farms in their jurisdictional areas in order to clarify how frequently complaints pertaining to wind turbines arose. Moreover, interview surveys were administered to over 100 people who lived within 300 m of the turbines. The results showed the following: (1) There are 39 coastal wind farms that have over 5,000 kWh installation capacity in Japan. (2) The perception of shadow flicker was more frequent than that of the 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 due to waves can eclipse the noise of turbines. (4) According to a geographical distribution, residents living near plural turbines were likely to perceive noise and thereby get annoyed.

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

1. Introduction

The severe nuclear disaster at Fukushima Daiichi nuclear power plant caused by the huge earthquake and massive tsunami raised a wide spread debate on energy policy throughout Japan. The tsunami that hit the Tohoku area shut down 16 reactors from five nuclear plants in that area. Consequently, all of the 54 nuclear reactors including four decommissioned ones completely ceased operations on May 5, 2012, for the first time in 42 years. Obviously, this situation represents an unprecedented crisis that fundamentally changes the Japanese people's understanding of energy issues. Thus, the promotion of renewable energies is crucial in order 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 to the other types of renewable energy which included non-residential use of PV 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 quite slowly. The previous target of installing 3 GW of wind power by FY 2010 which the national government set has not yet been achieved.

One of the major reasons why wind power has not been smoothly introduced in Japan is 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 scenic impact and landscape at the proposed site 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 gave rise to noise complaints. This number of noise complaints is the highest amongst those due to other environmental components (MOE, 2011).

Moreover, the ratio of occurrence of complaints is higher according to the installation scale: 27% at 5–10MW capacity sites, 38% at 10–15MW sites, 44% at 15–20MW sites and 69% at 20–30MW sites (MOE, 2011). Also, it is mentioned that residents' perception of unpleasant sound depends on not only the wind power capacity but also psychological aspects. People who live in areas

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where they can see turbines tend to perceive more noise than those who cannot see the turbines. Moreover, a previous survey indicated that people feel that wind turbine noise is more unpleasant than the noise due to aircrafts, road traffic, and railways (Pedersen, 2004).

In recent years, some previous studies have been discussing not in my back yard (NIMBY) theory relating to public or community acceptance of wind power. The term NIMBY is often used by proponents of the facility as "a succinct way of discrediting project opponents" (Burningham, 2000). Most researchers now, however, seem to agree that this phenomenon is rather complex (Wolsink, 2000; van der Horst, 2007; Wüstenhagen et al., 2007). As Wolsink (2012) points out, the current mainstream trend in academic circles is clearly towards abandoning NIMBY explanations. Although the complexity of community acceptance of wind power has been cleared in previous studies, the mechanism is still unclear, particularly in environmental conditions such as geographical features.

Regarding offshore wind firms, enough research has not been conducted so far. Wolsink (2010) focuses near-shore wind power and concludes that the often suggested idea that siting wind farms offshore could solve the problems encountered onshore is naïve and far too simple. Actually, however, little is known if there are environmental impacts in coastal wind farms. In particular, it is not clear to what extent residents located in coastal areas can perceive turbine noises and they experience them annoyed. Therefore, this study focuses on the perceptions and the annoyance experienced by residents living near the coastal wind farms.

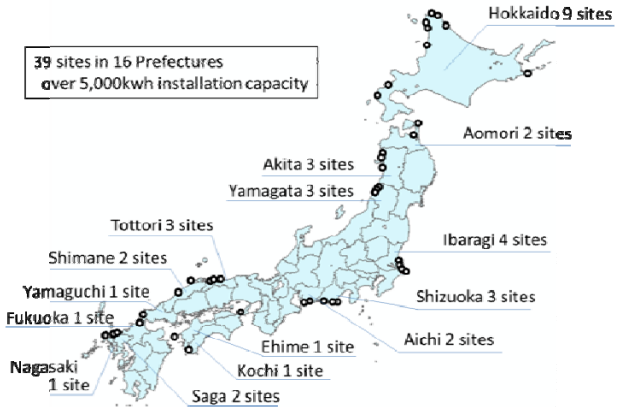

Fig. 1. Site location of coastal wind farms in Japan

2. Research framework

2-1. Definition and scope

As there is not a general definition of "coastal area" in Japan, it was defined in this study as a zone that is located within 500 m of the shoreline. Moreover, this study focused on coastal wind sites that had over 5,000 kWh installation capacity, which had a relatively high possibility of generating operational noise complaints[4].

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).

2-2. Surveys

Two types of surveys were conducted as follows;

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

(b) Individual interviews with 114 local residents in two coastal wind sites were conducted 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 potentially expected. Furthermore, while residents brought environmental complaints to the municipality at one site, there were no complains at the other site. At the interviews, residents were asked about their perceptions and

Table 1. Frequency of complaints due to coastal wind farms (No. of sites)

		occur	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		

the extent of their annoyance due to wind turbines, such as operational noise, shadow flicker, and disturbance of the scenery.

The response of most questions was rated on 5-point verbal rating scales. For instance, when respondents were asked their perception or feelings of annoyance, they answered those questions with following items; not applicable, not much applicable, unknown, somewhat applicable, applicable.

3. Results of questionnaire: occurrence of complaints owing to coastal wind farms

According to the results of the questionnaires, which were collected from 38 coastal wind farms in Japan, there was at least one complaint related to 45% (17 sites) of wind farms (Table 1). Major factors that were the 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 is an issue that might be more noticeable to residents.

Regarding noise-related complaints, eight out of nine sites caused residents complain about operational noise. There was only one site where complaints had occurred before operations started up (during the planning stage). Furthermore, all the eight sites where complaints about operational noise had occurred were near residents who were located at no more than 310 m from the sites. In contrast, there were some sites where no noise-related complaints occurred in spite of the wind sites' proximity to the residents, who were located within 50 to 350 m of the sites.

Whether or not noise-related complaints occurred depended on factors such as geographical features of the area, meteorology, and psychological aspects. According to a previous study, there was a case in which the impact on distant residents was greater than that on local residents living near the wind power site because noise perception depends on the background noise level which is often related to geographical features. This phenomenon can be applied to coastal wind farms as well, because operational noises can be eclipsed by the sound of waves. This implies that the distance of the site from the shoreline might be a significant factor in residents' perception of operational noise.

It is, however, difficult to clarify in detail through a questionnaire, residents' perceptions or feelings of annoyance that are related to turbines. In particular, the results derived from the questionnaire do not reflect the actual state of residents' sense of awareness because people do not necessarily issue a complaint about wind farms even if they do have one.

Therefore, the next section focuses on the perceptions and feelings of annoyance of residents through interviews with them.

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 annoyance. Table 2 shows an overview of these two cases. Although both sites were roughly similar in terms of installation capacity, topography, and distance from the shoreline and residents, the type of occurrence of complaints was different.

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

Fig. 2 shows residents' perceptions and feelings of annoyance related to environmental impacts due to noise and shadow flicker. As a whole, it indicates that approximately half of the

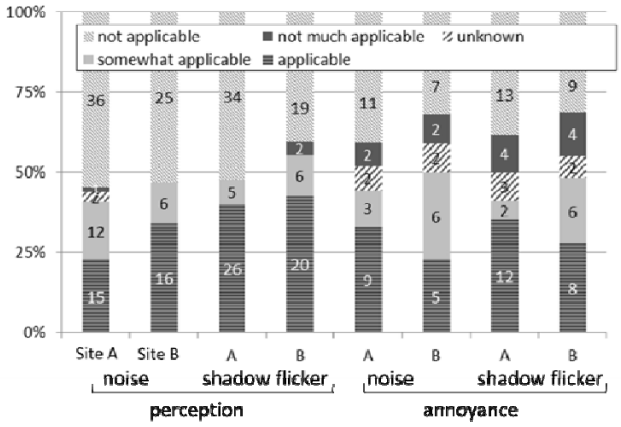

Fig. 2. Perceptions and feelings of annoyance related to environmental impacts of noise and shadow flicker from wind farms

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
closest distance from the shoreline	100 meters	60 meters
closest distance from the resident	300 meters	150 meters
occurrence of complaints (result of the questionnaire)	noise, shadow flicker	none
interviewees (coverage rate of survey scope)	66 (31% of households)	47 (34%)

respondents more or less perceived the environmental impacts of noise or shadow flicker due to turbines. The rate of perception of shadow flicker was relatively higher than that of operational noise. This result is not the same as that which is for one of the items on the questionnaire in which the number of sites wherein noise-related complaints occurred was greater than that of shadow flicker.

Focusing on this quality of annoyance, however, the total number of respondents answering that noise "annoyed" or "somewhat annoyed" them was greater than that in case of shadow flicker in both sites A and B. This implies that the rate of annoyance due to operational noise is higher than that for shadow flicker.

Residents who lived near site B perceived more and were more annoyed by the environmental impacts than those near site A. One of the major factors is the proximity of residents to the site. Actually, the distance from site A is twice as big as the distance from site B.

4-3. Awareness of wind farms

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

Also, residents did not have a negative evaluation of wind farms because 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 nearly the same between the two sites.

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

Table 3 shows the results of the multiple regression analysis. According to the results, as the residents' distance from the turbine became greater, the perception of noise they harbored subsided. In general, this was a reasonable and popular response. In contrast, regarding the distance from the shoreline, the results were reverse, in that the closer the residents were to the shoreline, the lesser were they likely to perceive noise. This implies that the sound of waves can 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 show a correlation between noise and shadow flicker perception. This implies that one environmental impact can induce the perception of another impact, or, that noise and shadow flicker are likely to occur at the same place. The results can be applied to the relation between perceptions and feelings of annoyance.

Moreover, those who had a negative image of wind farms, such as rating them "bothersome" or "demanding them to be removed" tend to be sensitive to environmental impacts. By contrast, those who had a positive image, such as rated by "familiarity" or "favorable", tended not to be annoyed by the wind turbines.

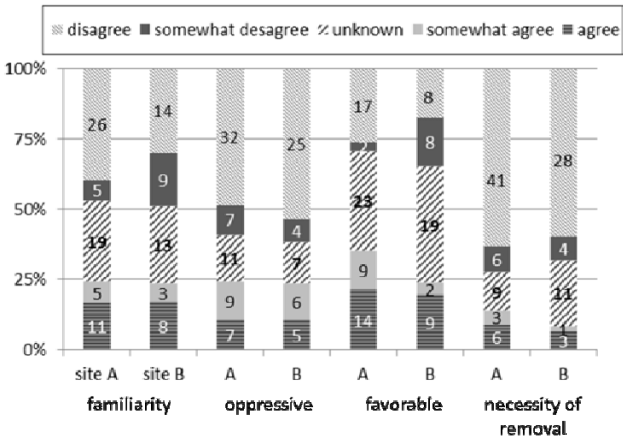

Fig. 3. Awareness of wind farms

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	

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 who lived in the area at both ends of the site did not perceive noise (see left in fig. 4). In contrast, many people who lived near the plural 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 more perceived or were annoyed than those of the south in spite of their dwelling at a distance of over 300 m. This result can be explained by the relation with shadow flicker impacts.

Focusing on shadow flicker impacts, the pattern of geographical distributions was basically similar as that of noise. It means people who lived near the plural turbines or the north-west of the site had perceived shadow flicker and had been annoyed. It was also cleared that people who perceived noise is likely to perceive shadow flicker as well. It shows a logical consistency with the result of multiple regression analysis.

A little difference was shown in the pattern, particularly in a higher occurrence of perception or annoyance in the south-east area from the site. The reason why they perceived its impact would be that they were exposed to its impacts for long hours due to angles of sunlight during sunrise.

Considering those results mentioned above, there is a possibility that shadow flicker can be a trigger for the perception of noise impact. In this respect, developers should pay more attention to areas potentially affected by shadow flicker when they propose a wind power development in the coastal area. Also, shadow flicker impacts should be considered carefully so as to be identified in the process of Environmental Impact Assessment procedure. Noise impacts should be predicted on the basis of the relation of shadow flicker impacts.

5. Conclusion

In this study, the perception and feelings of annoyance due to coastal wind farms were analyzed by the means of questionnaire and interview surveys. The results showed the following: (1) There are 39 coastal wind farms that have over 5,000 kwh installation capacity in Japan. (2) The perception of shadow flicker was more frequent than that of operational noise, while annoyance due to shadow flicker was slightly less than that due to noise. (3) The perception of noise depends on the residents' 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 plural turbines were likely to perceive noise and be annoyed.

Further studies are needed, particularly in areas with different topography such as west coast where shadow flickers would less affect residents. Also, to clarify mechanisms of the relation between cause and effect relating to annoyance, individual and contextual parameters should be considered in future detailed studies.

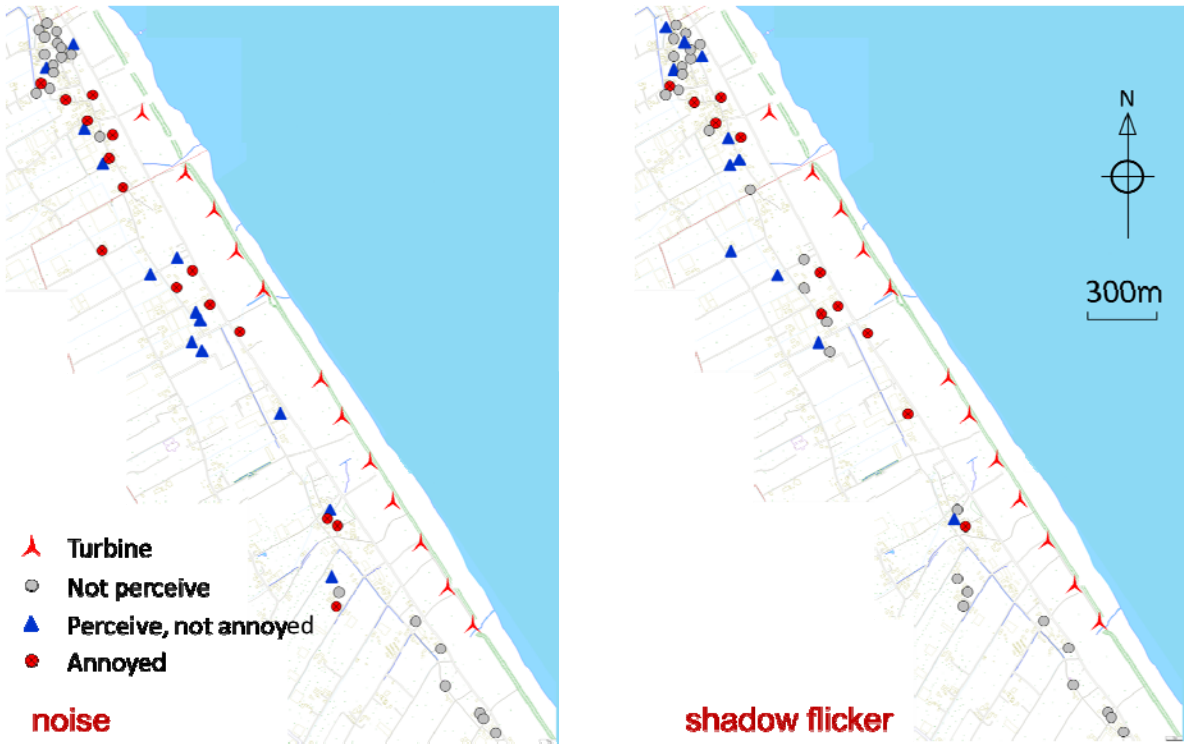

Fig. 4. Geographical distribution of perceptions and feelings of annoyance (site B : Kamisu City)

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