Acoustic and Visual Impacts of a 0.25 MW WTG at Huasai, Nakhon Si Thammarat in Southern Thailand

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Abstract: The main objective of this paper is to investigate the acoustic and visual impacts on local residents of an existing 0.25 MW wind turbine generator (WTG) located in Huasai district, Nakhon Si Thammarat province, Thailand. Sound pressure level (SPL) was measured at various locations within 300 m around the WTG. A survey on general attitude towards the WTG of the residents living within a 2 km vicinity was also carried out among 351 respondents using a questionnaire. The results showed that while the ambient background noise was 38-44 dB(A), the SPL produced within 300 m around the WTG, operating at the rotational speed of 26-29 rpm, was 50-55 dB(A). Inside the tower at the heights of 12 m, 24 m and 36 m above the ground and inside the nacelle, the SPLs were 73 dB(A), 81 dB(A), 84 dB(A) and 91 dB(A), respectively, during the operation of the WTG and were 66 dB(A), 73 dB(A), 77 dB(A) and 78 dB(A), respectively, during the shutdown. The SPL produced as a result of the WTG was relatively low with respect to that generated from the other nearby sources such as the diesel engines of the pumping machines used in the shrimp farm. Public attitude towards the acoustic and visual impact of the WTG was not negative. Furthermore, some respondents believed that installation of WTG farm should create jobs for the locals and the WTG farm could become a tourist attraction site.

Keywords: Acoustic, Noise Annoyance, Public Attitude, Visual Impact, Wind Turbine Generator.

1. Introduction

Different noise sources affect on people living around noise source differently e.g. noise generated by an airplane is more annoying than noise generated by road traffic [1]. The impact of wind turbines noise on people living nearby is only partly clarified. Most of the studies on acoustic and visual impacts due to wind turbine generator (WTG) were conducted in countries where a number of WTG were installed. Even though the WTGs are often installed in a rural area, they are still highly visible. People living nearby WTGs are exposed and are expected to receive visual stimuli. It was found that seeing WTG and hearing noise simultaneously increases the probability of noise annoyance [1]. Furthermore, the impact of WTG on aesthetic qualities of landscapes has been also investigated and discussed [2]. It showed that there was no negative influence of WTG on landscape scenery as observed in the landscape with low aesthetic value. It is also showed that the wind power technology has the potential to offer a variety of benefits but the important thing is the boosting of social acceptance of a technology [3]. It is also evident that social barriers and public attitude became crucial issues in taking into consideration wind farm development as shown in French, Australian, German, and Netherlands cases [4-7]. The analysis of the French legislative debate over the new energy policy showed that landscape and local acceptance have been recurring issues in the debate [4]. The evaluation of fairness using procedural justice principles has been done through empirical research using wind farm pilot study [5]. It indicated that perception of fairness do influence how people perceive the legitimacy of the outcome, and that a fairer process will increase justice acceptance (outcome fairness), outcome favorability and process fairness. The public opinion about wind power is quite positive but social acceptance at the local level represents an important challenge for the wind farm developers. The key factors affecting the wining acceptance of wind farms were identified and analyzed. The developers were eager to know how to manage social acceptance at the different stages of planning, realization, and operation [6]. The case study confirmed that the factors of social acceptance were visual impact, ownership, information, and participation. Furthermore, those aspects of acceptance directly related to the implementation, i.e. local integration of the developer, the creation of a network of support, and access to ownership of the wind farm. Likewise, the impact of WTGs on air, land, and water is far less than any other conventional power sources. However, it is becoming increasingly apparent that the deployment of a larger WTG is creating problems of wildlife, particularly bats [8]. Several recent incidents at WTG sites in North America involved the killing of dozens to hundred of bats during periods lasting just a few weeks. Hence, the operations of WTGs may be a new source of community noise and only few studies have evaluated their impacts on people living nearby. An extensive dose-response study was performed in Denmark, the Netherlands and Germany since 1993 [9]. They found only a weak correlation between A-weighted SPL and noise annoyance caused by WTG. In Thailand, development of wind power utilization has continuously and rapidly increased over the past few years. At present, the MW WTGs (0.25 MW up to 1.5 MW) were installed and still being installed at different parts of the country in conjunction with the acoustic and visual impacts of WTGs which have not been yet studied. Consequently, the objectives of this paper are to investigate the noise generated by the 0.25 MW WTG and its propagation, as well as to survey the public attitude on the WTG's impacts on people living within a 2 km vicinity based on questionnaire and personal interview.

2. Experimental

2.1 Noise measurement

Sound pressure level (SPL) was measured using the calibrated sound level meters model RION NL-21. The average A-weighted sound pressure level or equivalent sound level (Leq) was then determined. The SPL were measured at different positions within 300 m around the existing 0.25 MW WTG located in Huasai district, Nakhon Si Thammarat province, Thailand. The measuring positions were divided into two schemes i.e. the first scheme follows the IEC 61400-11 standard. Three calibrated sound

level meters were fixed (blue dots) and the sampling interval was 10 min. Another scheme was designed as polar distributed or 8 main directional distributions at radius of 10 m, 20 m, 100 m, 150 m, 200 m, and 300 m as shown in Fig. 1. Sampling interval for the later scheme was 1 hr. Experimental data were obtained in December 21-23, 2008 and January 22, 2009 during the operation and the shutdown of the WTG. The SPL inside the tower of WTG at height of 12 m, 24 m and 36 m as well as inside the nacelle were also measured while WTG was both operating and shut down. The background noise was obtained in January 22, 2009 when the WTG was shut down. For the noise disturbance, the 351 respondents living around WTG by about 2 km were asked to respond on a five-point rating scale, where: 1= do not notice, 2 = notice but not annoyed, 3 = slightly annoyed, 4 = moderately annoyed, and 5 = very annoyed. There were also diesel engines operating around the WTG which contributed the noise emission. In this connection, two conditions were conducted in this experimentation. The noise emission was measured with and without the operation of diesel engine. Furthermore, the revolution of wind turbine blade depends upon the wind speed, i.e. the more wind speed, the higher the revolution. However, the revolution speed of the wind turbine blade was relatively constant within the range of 22-29 rpm. Consequently, the measurement of noise emission from the 0.25 WTG within a few days could be representative data for the whole year period.

2.2 Visual impact and other related environmental impacts

The questionnaire was completed by a random sampling of 351 respondents who were living within a 2 km vicinity of the WTG. The respondents were first asked about their personal information. The 351 valid questionnaires were collected with a rate of 51% men and 49% women. The average ages of the respondents were in the range of 20-39 years old (30.8%), 40-59 years old (34.2%), over 60 years old (21.9%) and the rest (13.1%). The respondents were educated at primary school level (57.5%), and high school level (32.2%). The respondents were also asked for general attitude, aesthetic aspects, impacts on landscape, shadow flicker, impact on soil, underground water contamination, impact on plant growth, bird and bat deaths, health and safety, turbine blasting from lightening, turbine destruction from a heavy storm, and economic and social impacts e.g. job creation and tourist attraction.

3. Results and Discussion

3.1 Acoustic impact

The background noise around the existing 0.25 MW WTG was measured in order to investigate the noise generated by an ambient environment surrounding the wind turbine. This condition was obtained in January 22, 2009 when the wind speed was insufficient for operating the 0.25 MW WTG. The contour and surface plots of background noise are shown in Fig. 2. The background noise was in the range of 38-44 dB(A). The background noise at the locations close to the WTG were in the range of 40-44 dB(A). The field observation indicated that the splash noise occurred occasionally while turbine yawing for starting the operation. The contour and surface plots of SPL around WTG while turbine was operating were shown in Figs. 3-5. The SPL while turbine was operating was in the range of 48-68 dB(A). In Fig. 3, it can be observed that there are two peaks at the corners of the left hand side of the plot. These are due to the operation of the diesel-engine water pumps used in the shrimp farm close to the turbine site. Figs. 4-5 showed the condition that only one diesel-engine water pumping system was operating. The results from field measurements showed that the SPL around the 0.25 MW WTG within 300 m were in the range of 50-55 dB(A) while the rotor was operating at rotational speed of 26-29 rpm. The variation of directional SPL and Leq and directional variation of Leq against distance are shown in Figs. 6-8. The SPL inside the tower at 12 m, 24 m, and 36 m were 73 dB(A), 81 dB(A) dB(A), and 84 dB(A) respectively while the WTG was operating. While the WTG was shut down, the SPL were 66 dB(A), 73 dB(A), and 77 dB(A) respectively as shown in Fig 9. The SPL inside the nacelle was 91 dB(A) while the WTG was operating and it was 78 dB(A) while shut down. The correlations between SPL and wind speed is linear as also shown in Fig. 9. Fifty respondents reported to hear the noise generated by the WTG. Forty three of them revealed that they noticed but were not annoyed and 4 mentioned that they were slightly annoyed. Since, the respondents had been annoyed by the noise from the diesel-engine water pumps of the shrimp farm, it can be concluded that the noise pollution from the 0.25 MW WTG at Huasai would be relatively low with respect to the noise generated from other nearby sources.

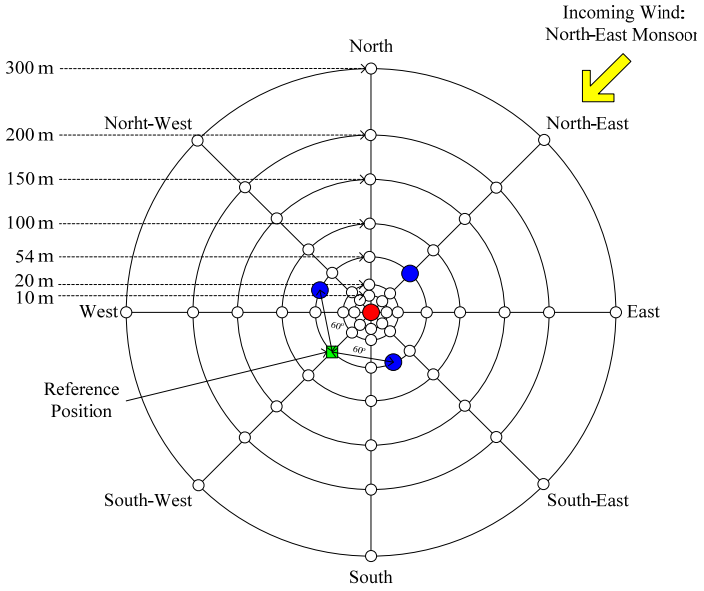

Figure 1. The 58 polar distributed measuring positions under IEC 61400-11 standard [10].

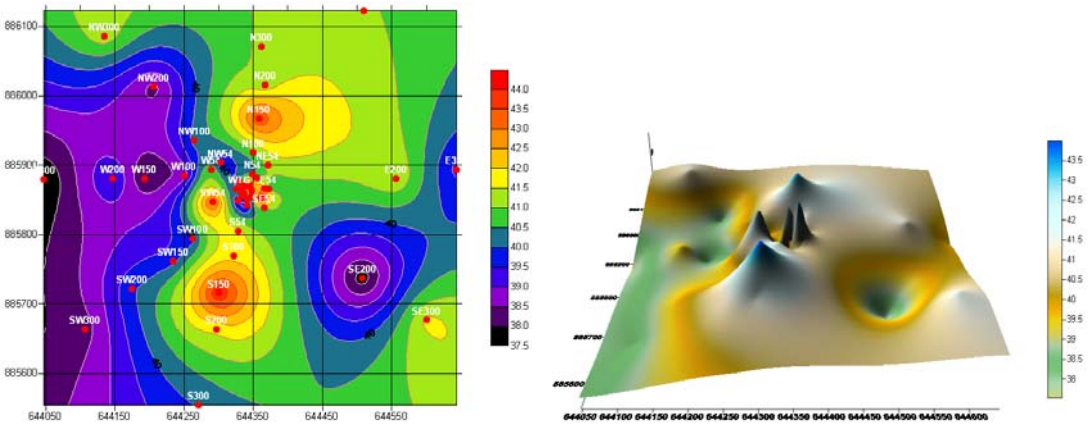

Figure 2. The contour and surface plots of background noise around WTG during shutdown (22nd January 2009).

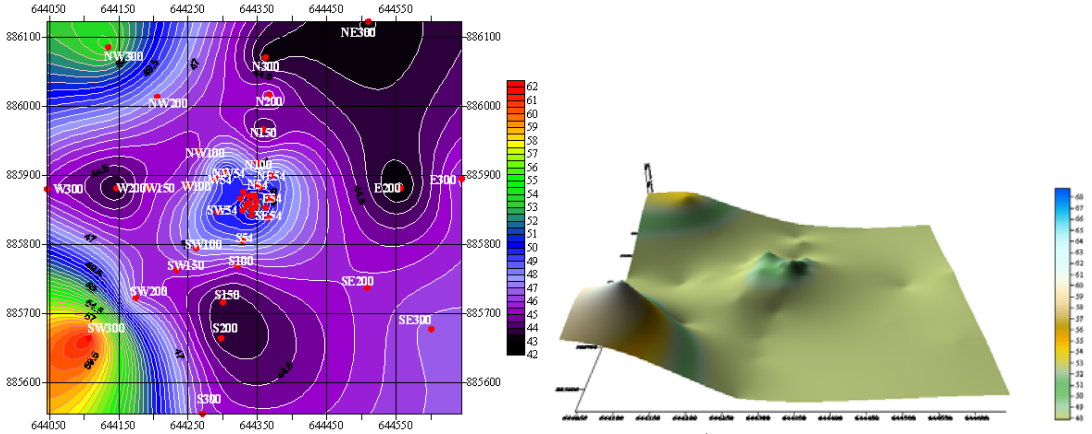

Figure 3. The contour and surface plots of SPL around WTG during operation (21st December 2008).

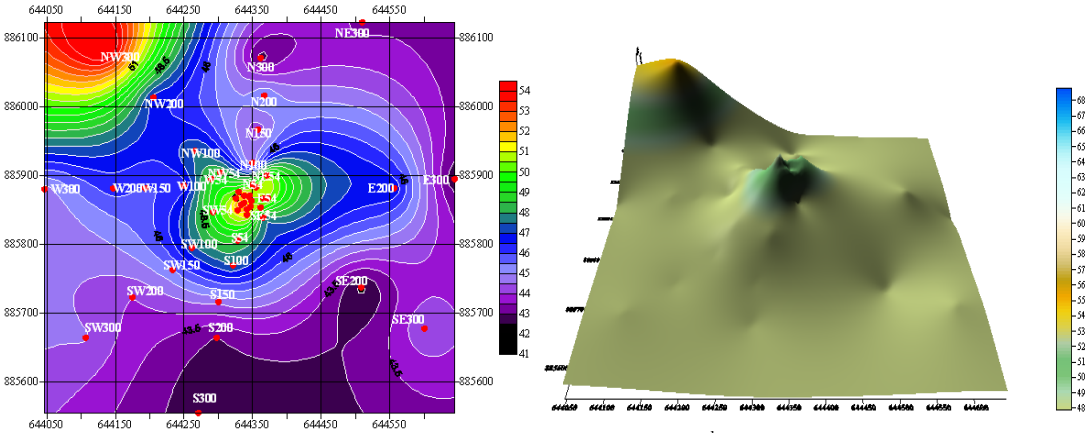

Figure 4. The contour and surface plots of SPL around WTG during operation (22nd December 2008).

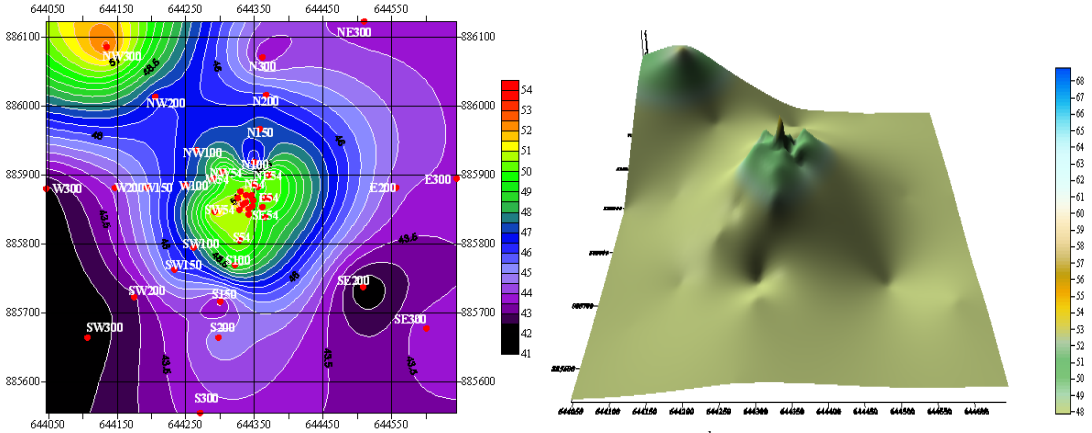

Figure 5. The contour and surface plots of SPL around WTG during operation (23rd December 2008).

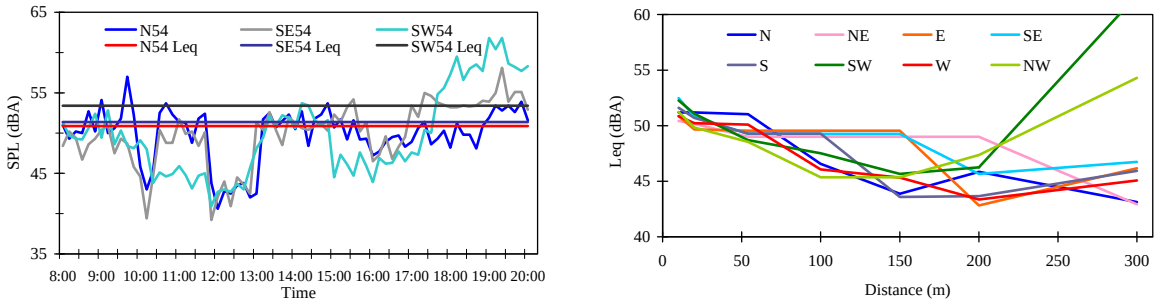

Figure 6. The variation of directional SPL and Leq at fixed receiver under the IEC 61400-11 standard (Left) and directional variation of Leq against distance (Right) (21st December 2008).

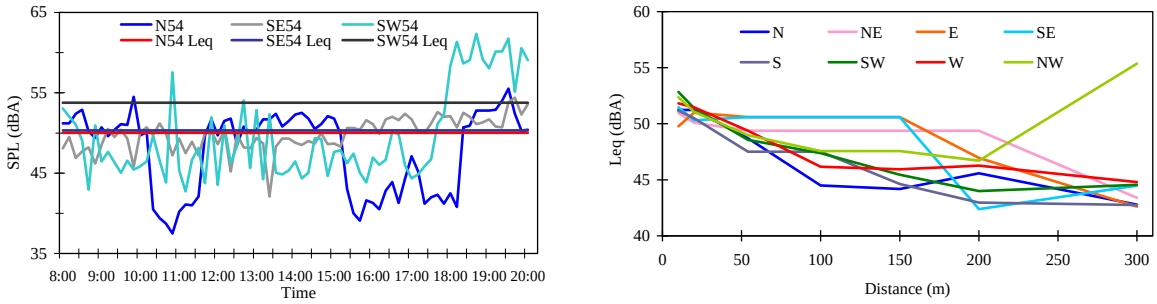

Figure 7. The variation of directional SPL and Leq at fixed receiver under the IEC 61400-11 standard (Left) and directional variation of Leq against distance (Right) (22nd December 2008).

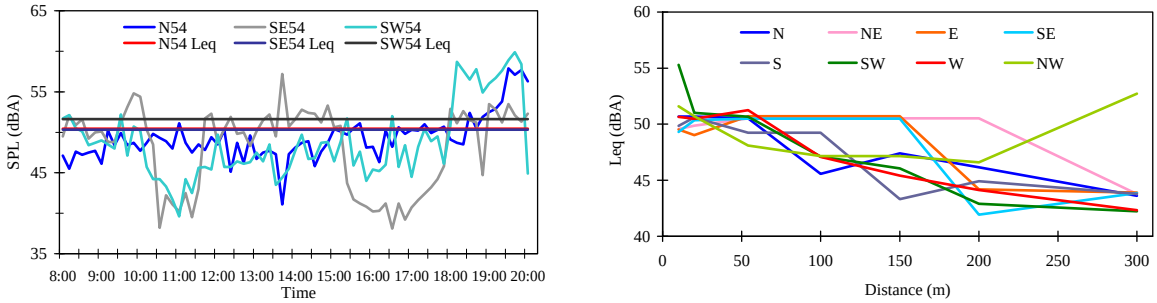

Figure 8. The variation of directional SPL and Leq at fixed receiver under the IEC 61400-11 standard (Left) and directional variation of Leq against distance (Right) (23rd December 2008).

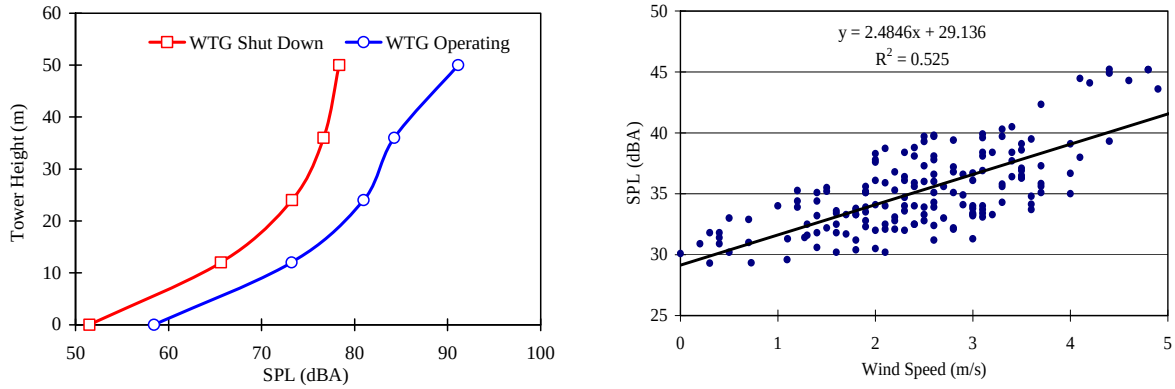

Figure 9. SPL at different heights of tower (Left) and the relationship between SPL and wind speed (Right).

3.2 Visual impact and other related environmental impacts

The questionnaire-based survey of 351 respondents showed that there was insignificant impact on the aesthetics, landscape and shadow flicker as viewed by the people living around the WTG within a radius of 2 km. Only few respondents of 2.35% and 2.6%, respectively, thought that the installation of WTG might have some impacts on soil and underground water. There was, however, no evidence for such claims yet. For the bird and bat death issue, there are 10 respondents who have seen the bird's death around the WTG site. But 341 respondents believe that the WTG may not cause the death of bird and bat. The field observation also revealed that there are little amount of bird living around the WTG. Nevertheless, some bird could live and fly near the turbine blade while turbine was operating since the operational revolution of rotor is quite slow (26-29 rpm). Some 10 respondents believe that the installation of WTG may affect the growth of plants around the WTG. One interesting point is that 92 respondents believe that there are opportunities for the turbine blasting due to a lightning strike and 58 respondents fear the turbine being destroyed in a heavy storm. And these facts showed

the lack of public dissemination of wind turbine installation and operation especially at the site close to the community. However, 78 respondents answered that the installation of WTG could create jobs for the local people. The 265 respondents were proud about the WTG installation near their habitats and believe that this will boost the tourism in the area and will augment local economy. The details of analyzed results from questionnaire were given in Table 1. Finally, some respondents need more information about the WTG installation and operation from the government agency. Therefore, the perceptions of local people on WTG installation and operation is another issue to be clarified, thus become a crucial step prior to utilization of advanced technology or investment of wind farm by private developers in southern Thailand or in any other parts of the country.

Table 1. Analyzed results from the questionnaire.

Impact of WTG	Frequency	Percentile
1. Aesthetic and Impact on Landscape	1	0.3
Impact	350	99.7
No Impact		
2. Visual Impact		
Impact	2	0.6
No Impact	349	99.4
3. Shadow Flicker		
Impact	6	1.7
No Impact	345	98.3
4. Noise Perception		
Yes	50	14.2
No	301	85.8
5. Annoyance		
- Do Not Notice	3	6.0
- Notice But Not Annoyed	43	86.0
- Slightly Annoyed	4	8.0
- Moderately Annoyed	0	0.0
- Very Annoyed	0	0.0
6. Impact of Low Frequency Noise on Livestock		
Impact	10	2.8
No Impact	341	97.2
7. Soil		
Impact	8	2.3
No Impact	343	97.7
8. Underground Water		
Impact	9	2.6
No Impact	342	97.4
9. Bird and Bat Death		
Impact	10	2.8
No Impact	341	97.2
10. Plant		
Impact	10	2.8
No Impact	341	97.2
11. Number of Patient due to Wind Turbine Vibration	0	0.0
12. Number of Patient due to Wind Turbine Noise	0	0.0
13. Opportunity of Turbine Blasting due to Lightening		
Yes	92	26.2
No	259	73.8
14. Turbine Destruction due to Heavy Storm		
Fear	58	16.5
No Fear	293	83.5
15. Job Creation		
Yes	78	22.2
No	273	77.8
16. Tourist Attraction		
Yes	265	75.5
No	86	24.5

Conclusion

The results from field measurements showed that the SPL within 300 m around the existing 0.25 MW WTG located in Huasai district, Nakhon Si Thammarat province, Thailand were in the range of 50-55 dB(A) while the rotor was operating at rotational speed of 26-29 rpm. The background noise of ambient was in the range of 38-44 dB(A). The SPLs inside the tower at 12m, 24m, and 36m heights were 73 dB(A), 81 dB(A), and 84 dB(A) respectively during the operation of the WTG. During the shutdown, the SPLs were 66 dB(A), 73 dB(A), and 77 dB(A) respectively. The SPL inside the nacelle was 91 dB(A) while the WTG was operating and it was 78 dB(A) while the WTG was shut down. Results from 351 respondents revealed that there were no significant noise and visual impacts from the 0.25 MW WTG. Positive impact of the WTG installation such as job creation and tourist attraction was mentioned by some respondents. Likewise, as the respondents also experienced the noise annoyance from the diesel-engine water pumps used in the shrimp farm around the WTG, therefore, the noise pollution from the 0.25 MW WTG during operation was relatively low comparing to the noise generated from the other nearby sources.

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