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Environmental Impact Assessment and Management Plan on Wind Turbine Noise in South Korea

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Summary

In South Korea, a wind power plant is a target of the environmental impact assessment, but there is a no clear standard for wind turbine noise. The environmental impact assessment is essential because wind turbine noise can affect the human body, as it contains low-frequency sound. In this study, we want to look into the research cases of low-frequency sound generated by wind power plants in major countries in the same field, regulatory standards for the noise and consider measurement and assessment methods for the wind power plants, which can be applied to the environmental impact assessment in Korea. Finally, we suggest a management plan on wind turbine noise.

1. Introduction According to the Global Wind Energy Council, world wind power market in 2013 recorded a total of 318.1GW including accumulated installed capacity of 35.3GW like Fig 1. However, it decreased about 21.8% compared with the previous year because of reduced demand that was caused by the European financial crisis and global economic recession.

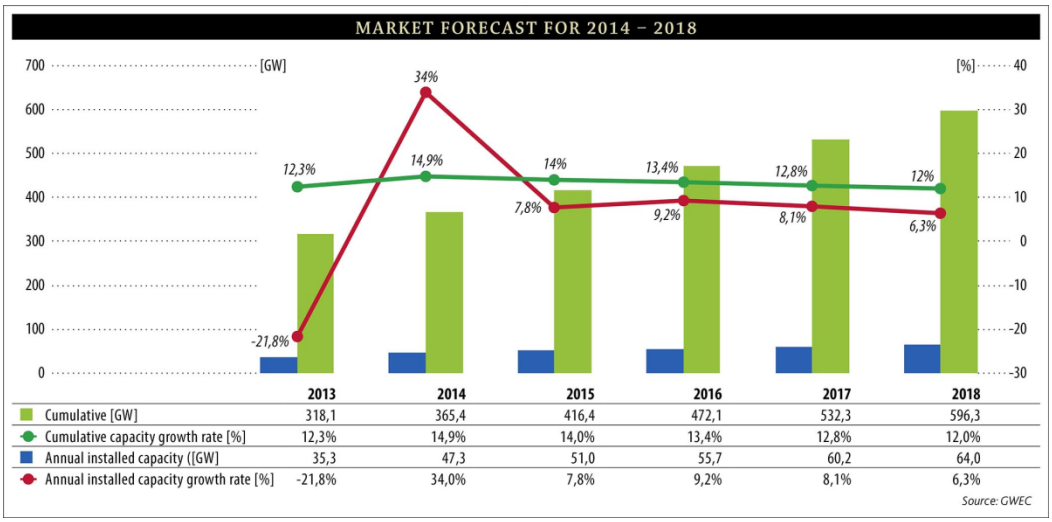


Fig 1 Market forecast for 2014-2018

Meanwhile, Asia has emerged as the first place ahead of European countries in 2013 as in Fig 2, and Chinese installation capacity came close to 100GW. On the other hand, South Korea shows a pool number which is approximately 0.5GW (accumulated). But the country has a plan to increase a capacity up to 18.2% of new renewable energy until the year 2035 in order to develop a key energy source.

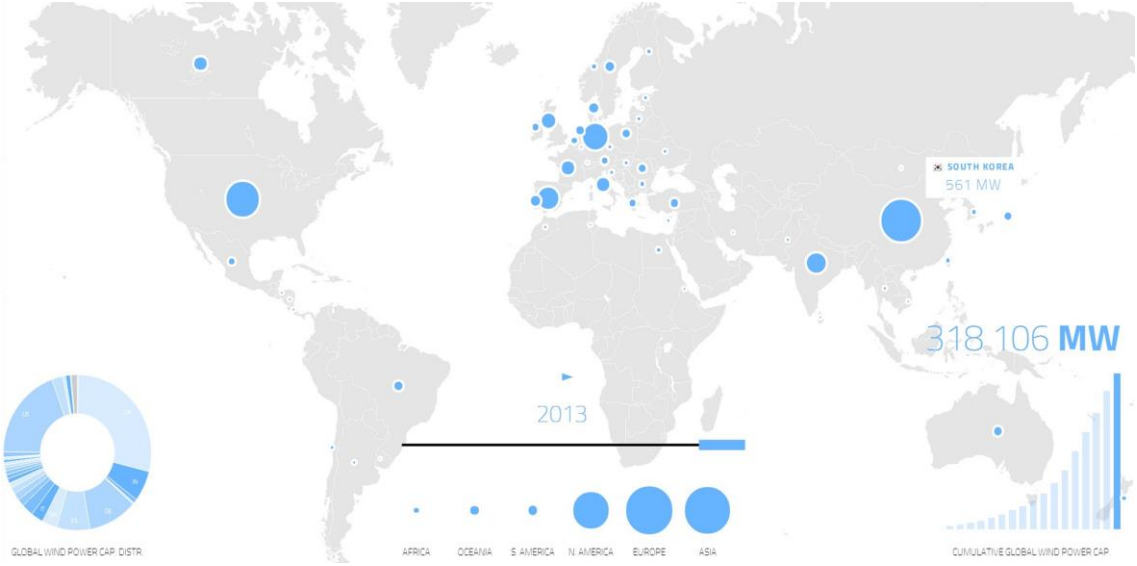


Fig 2 Interactive infographic – cumulative installed wind power capacity per country in 2013

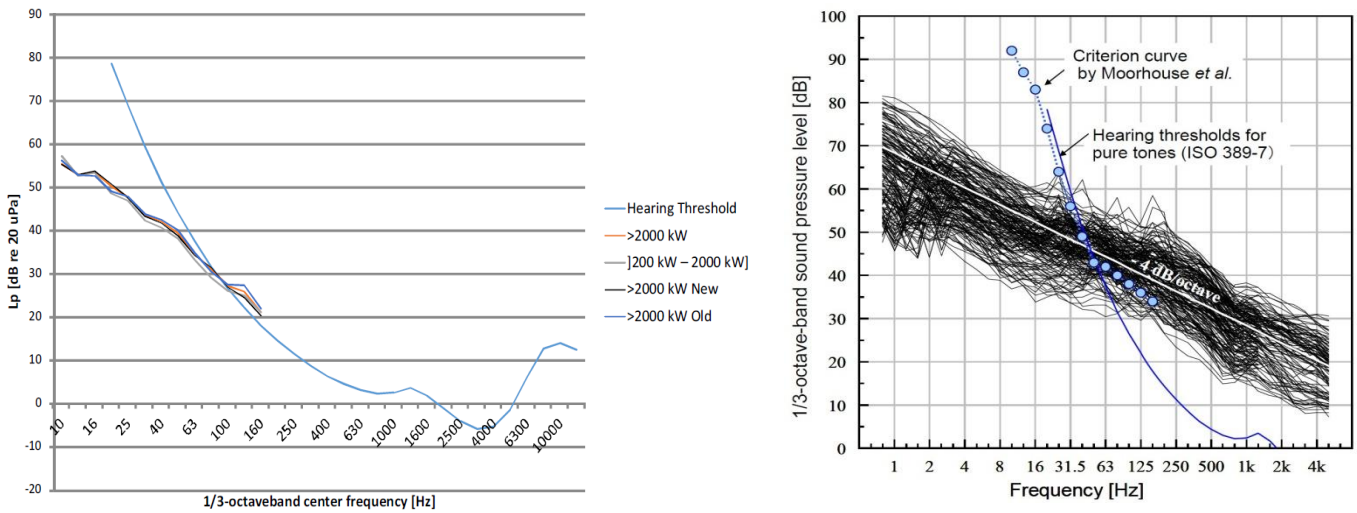
The aim of this study, to look into the research cases of low-frequency sound generated by wind power plants in major countries in the same field, regulatory standards for the noise and consider measurement and assessment methods (include management plan) for the wind power plants, which can be applied to the environmental impact assessment in Korea.

2. Preceding studies and environmental impact assessment case

2.1 Characteristics and health effects Wind turbine noise can only audible middle and high-frequency band as shown in Fig 3, in the low frequency band, is lower than the hearing threshold, a characteristic that cannot be heard.

In Denmark, the predicted result of indoor low-frequency sound the (wind speed 8m/s, outdoor noise 44dB(A) criteria), depending on the scale of wind power generation facility there was a study that compared to the audible threshold (Bo Søndergaard, 2014). Result of the comparison, the 100 Hz or more can be audible (because wind turbine noise is higher than the audible threshold) as shown in Fig 3 (a). However, in the low frequency region below 100 Hz, it cannot hear (because lower than the audible threshold).

In Japan there are cases where measured outdoor radiation noise of the wind farm, the result that the frequency analysis is the same as (b) in Fig 3 (TACHIBANA, 2014). There are approximately 4dB reduced are characteristic to each time you increase by octaves. And the following infrasound region 20 Hz not is able audible, because lower the evaluation curves of low-frequency noise provided by Moorhouse et al. (2009).



(a) indoor wind turbine noise levels **(b) Outdoor wind turbine noise levels**

Fig 3 Comparison of in and out-door wind turbine noise levels with the hearing threshold

In Australia was survey the impact on quality of life for the wind turbine noise in the target 25 adults that are resident within 1,000~3,500m from the Wind farm. The study uses the WHOQOL (World Health Organization's Quality)-Bref scale was developed to measure the quality of life, findings were as Table1. Residents near by Wind farm, showing all of the area (physical, psychological, social, living environment) a significantly lower result is quality of life than the residents and patients of a standard population (David MCBRIDE etc., 2014). However, sample size is small; it is insufficient to explain the relation between wind turbine noise and health.

Table 1 Comparison of WHOQOL scores

Group	Physical	Psychological	Social	Environmental
Wind Farm	42.43	48.67	59.67	53.63
Community	73.50	70.60	71.50	75.10
Outpatient (LIDO)	61.47	65.37	62.89	67.93
Inpatient (LIDO)	51.55	64.04	63.36	66.99

2.2 Wind turbine noise measurements Method of measuring the wind turbine noise is using standards IEC64100-11 in most countries. However, this method does not include a method for measuring low-frequency sound.

Wind turbine noise is measured at the position of (H+D/2) as shown in Fig 4. Here, H is the height from the center of the wind turbine rotor to the ground (m), D means the wind turbine rotor diameter (m). The measurement height can be seen that it is located near the floor to minimize the effects of wind. Wind speed affecting the wind turbine noise is measured at a height of 10m from the ground. This measurement method is effectively used for the sound power measurement. However, it is not suitable for measurement of (measured at a certain height) low-frequency sound or environmental noise.

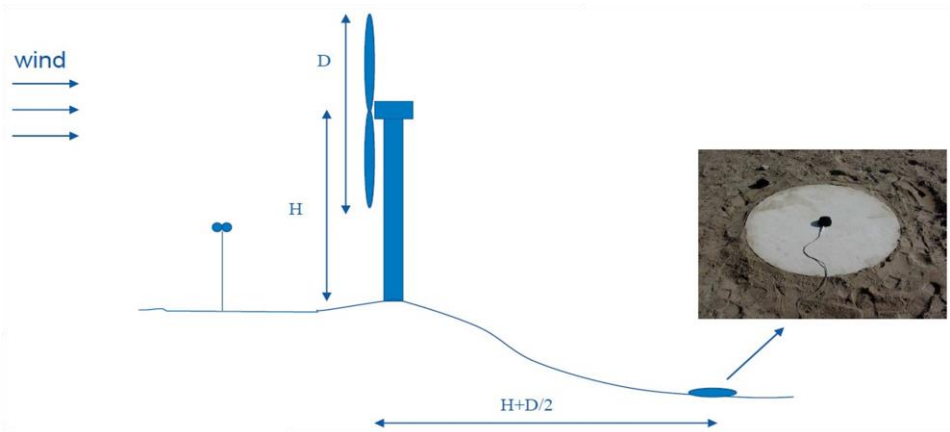


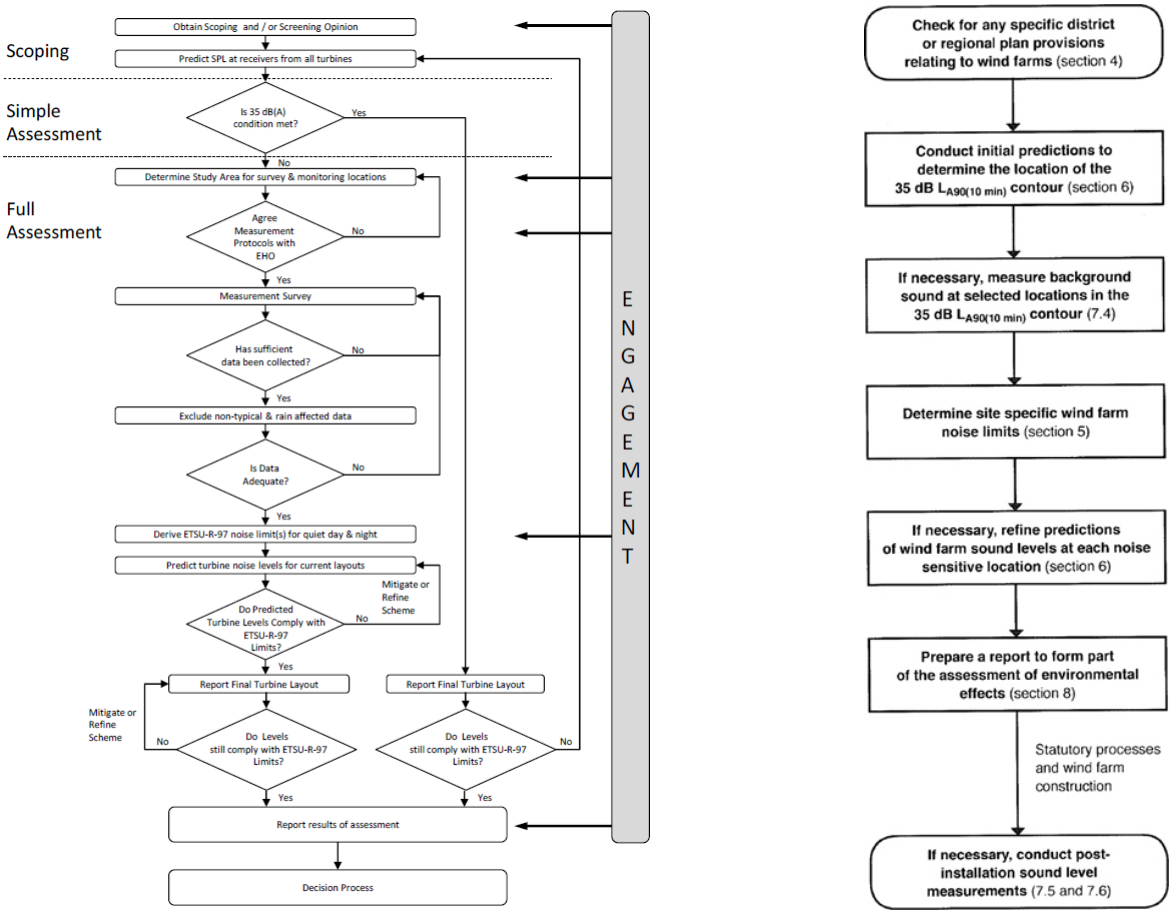
Fig 4 Measurement position of Wind turbine noise (IEC 61400-11), ref. NREL(2011)

Sound power levels from a wind turbine typically vary with the speed of a wind turbine (ICAN Acoustics, 2013)

- At 4m/sec (ref height of 10m) the sound power level could be 95dB(A)
- At 9m/sec (ref height of10m) the sound power level could be 104dB(A)

2.3 Environmental impact assessment in major countries The wind turbine noise regulations and environmental impact assessment of major countries, still has an only regulation to audible sound. For the low-frequency sound, it is reality is presents a recommendation value.

Procedures that are most often used as an evaluation standard of wind turbine noise are an ETSU-R-97(The Assessment and Rating of Noise from Wind Farms) and NZS6808. The environmental impact assessment process of wind turbine noise that is presented in both procedures is shown in Fig 5.



(a) ETSU-R-97 (b) NZS 6808

Fig 5 Wind Turbine Noise Assessment Procedure

The assessment procedure (represented graphically in Figure 4-(a)) consists of the following steps:

- Predict noise levels from all turbines (existing and proposed) at the nearest receptors;
- Determine a study area;
- Identify potentially affected properties;
- (If required) Undertake a measurement survey consisting of simultaneous measurement of background noise levels at representative properties with wind speed and direction at the proposed turbine site;
- Analyse the data to remove rain affected and atypical data, and derive the noise limits for the scheme;
- Update noise predictions & assess compliance with the noise limits for a candidate turbine, and provide design advice if compliance with the limits is considered unlikely.

The main purpose of this procedure is to set out the noise data required, and the subsequent analysis needed to allow a decision maker to make an informed decision to assess compliance with ETSU-R-97 (Institute of Acoustics, 2013).

Wind turbine noise regulatory standards of major countries are as follows.

In the UK, using according to ETSU-R-97, is not exceed 5 dB (A) above the background noise, is regulated wind turbine noise in the daytime 35~40dB, night 43dB. However, the wind speed is prescribed following a 12m/s at a height 10m.

In New Zealand in accordance with NZS6808 using $L_{A90,10min}$ is regulated wind noise based on the background noise as shown in Fig 6. The High amenity area requiring silence such as a hospital, it is understood that it is applied more enhanced regulated.

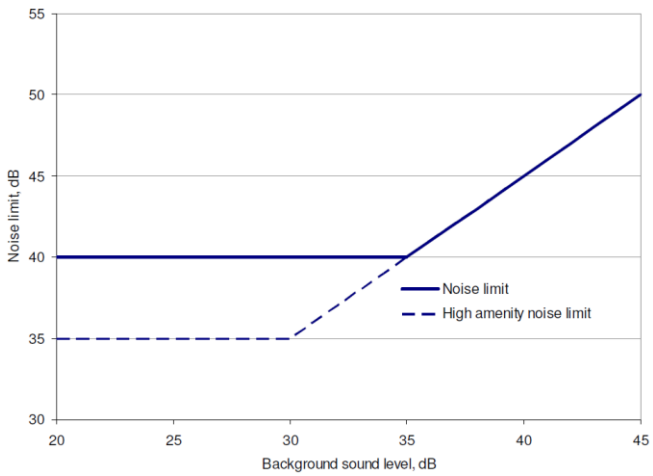


Fig 6 NZS 6808 noise limits

In Denmark, control standards of wind turbine noise in response to wind speed and regionalization are defined as follows (Danish ministry of environment, 2011).

The total noise impact from wind turbines may not exceed the following limit values:
1) At the most noise-exposed point in outdoor living area no more than 15 meters from dwellings in open countryside:
(a) 44 dB(A) at a wind speed of 8 m/s.
(b) 42 dB(A) at a wind speed of 6 m/s.
2) At the most noise-exposed point in areas with noise-sensitive land use:
(a) 39 dB(A) at a wind speed of 8 m/s.
(b) 37 dB(A) at a wind speed of 6 m/s.

The total low-frequency noise from wind turbines may not exceed 20 dB at a wind speed of 6 and 8 m/s indoors in dwellings in open countryside or indoors in areas with noise sensitive land use respectively.

On the other hand, if the wind power generation facility capacity is equal to or greater than 100MW on the basis of the Environmental impact assessment Act in Korea, will be subject to environmental impact assessment (less than 100MW is small environmental impact assessment carried out).

Noise environment impact assessment accompanying the development projects of wind power generation facilities are include below.

- Status survey – Distribution of residential area and noise· vibration (including the separation distance)
- Prediction of the effects of noise and vibration due to enforcement of wind power generation facility business (during the construction, operation at the time)
- Development of noise and vibration reduction proposal
- Post environmental impact study plan

The "Environment evaluation guidelines for onshore wind development projects" in 2014 was carried out to minimize the influence of the ecological damage and living environment. Evaluation of noise and vibration field of this guideline is to apply the ‘regulatory standards of community noise and vibration’ based on the Noise and vibration control laws (Table 2). However, it has applied the environmental standards (dB (A)) which the low frequency sound is not considered, it is impossible to prevent the health effects of the human body that are expected in response to the continuous wind noise exposure.

Table 2 Guideline values for community noise (Place of business) in Korea

[unit: dB(A)]

Specific environment	Morning, Evening (05:00~07:00, 18:00~22:00)	Day time (07:00~18:00)	Night time (22:00~05:00)
Dwelling, Conservation areas, School・Hospital・Library, etc.	50	55	45
Other areas	60	65	55

3 Environmental impact assessment and Post management plan

Major developed nations have environmental assessment guidelines and they carry out various researches on human health effects about wind turbine noise. However, South Korea does not have enough studies on wind turbine noise with the assessment guidelines. In particular, precise evaluation of the low-frequency sound, which may affect human health, is needed. Therefore, this study recommends the Environmental impact assessment and post management plan on the wind turbine noise.

3.1 Noise Limits Noise limit radiated from the wind power plant to facilities which needs calmness such as school and hospital is below 40dB(A) (excluding background noise) and that of low-frequency sound is less than Overall value of 1Hz ~ 80Hz 90dB(G). Here is, Characteristic of G is a correction on human sense (ISO 7196) specifically infrasonic sound between 1 ~ 20Hz. And a low frequency band may be different because each country has different regulations.

Wind turbine noise level when the environmental impact assessment is done, excluding the background noise, expected noise level is 40dB(A) or less. When considering the background noise, where background noise is 40dB (A) less than the 43dB (A) and less than 40dB (A) at least where the background noise can be predicted with synthetic noise exceeds 3dB (A) than the background noise.

3.2 Separation distance The environmental effect of wind turbine noise has been promoted continually research. However, a clear reduction measures has not been prepared.

In order to minimize the environmental impact on the current wind turbine noise, it is best to ensure proper separation between the wind farm and residential area. For proper separation distance, the criteria are different for each country.
In Germany, it is divided into affected noise areas less than 500m and 1000m respectively (DNR, 2005).
In the French National Academy of Medicine, it is recommended that the wind power generation facility away from residential areas 1500m or more.
Therefore, with regard to the area within the 500m are to limit the location (Table 3). And recommend the 1500m more spaced installation by taking into consideration the low-frequency characteristics (long the propagation distance).

Table 3 Separation distance from the Wind Farm

Section	Separation distance
Residential area	Within 500m : Established the Immigration measures
	Within 1500 m: Consultation of residents (existing areas)
	1,500m ~ (recommended)
Livestock and breeding facility (except the grass)	Within 500m : Established the Immigration measures
	Within 1000 m: Consultation of residents (existing areas)
	1,000m ~ (recommended)

3.3 Post management plan After the establishment of wind farm, post-environmental impact assessment and monitoring on the change of wind turbine noise level are carried out. Monitoring should be recorded quarterly because results can be different depending on season (because temperature and wind speed affect wind turbine noise).

In order to analyse the relation between accumulated wind turbine noise and impact on health as well as prepare for complaints from residents, questionnaire survey should be done and people should receive a regular medical check-up.

4.0 Conclusions

This study suggests the environmental impact assessment and management plan and low frequency sound generated from wind power facilities. In order to reflect the result on policies, however, accumulated documentation is required on human health effects and comprehensive environmental assessment guidelines for low-frequency sound of wind turbine noise (measurement, evaluation and etc.) must be prepared. Regarding complaints that occurs after the installation of wind power facilities, proactive management plan on the low-frequency sound is needed because it is difficult to solve the issue by measuring existing environmental noise.

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