Approaches to assessing the effort of wind turbine noise and infrasound in Japan

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ABSTRACT

In Japan, expectations are recently rising with regard to the potential of renewable energy sources as the country needs to combat global warming and reinforce the security of energy supplies. In particular, wind power is drawing attention as a renewable source of energy with great potential.

In recent years, an increasing number of wind turbines have been installed. However, the number of complaints about noise generated by them, including infrasound, has also increased. This situation has required the Ministry of the Environment of Japan to assess the effects of wind turbines and accumulate knowledge on how to investigate, predict and assess such noise and infrasound generated by these installations. In FY2010, the Ministry initiated studies to achieve this.

One such study is being conducted by a Ministry-commissioned study group that in March 2013 submitted a report on optimal methods and approaches to the environmental impact assessment (EIA) of noise generated by wind power installations based on the best available evidence, including knowledge accumulated within and outside Japan, and taking into account Japan's topographic features and land use patterns. The Environmental Impact Assessment Law was revised and takes effect in October 2012. The revised law expands the scope to include wind turbines, among other amendments. The report stresses the need to assess the sound propagation characteristics due to topographical features, as many of the wind power plants in Japan are located on mountain ridges. It also emphasizes the importance of ex-post evaluations to assess, if any, the adverse health effects of wind turbine noise and infrasound. The report will provide a valuable resource for concerned plant operators and local governments that may be responsible for EIA. It will also serve as an important reference for compiling ordinances and handbooks that the Ministry of Economy, Trade and Industry (METI) will issue, which in turn will serve as guidelines for the EIA of future wind turbine installations under the revised law.

Moreover, the Ministry of the Environment starts implementing a three-year project entitled " Epidemiological research on the long term health imapct of wind turbine noise and law-frecency noise on humans" since FY2013.

1. INTRODUCTION

The extent to which noise and infrasound are generated by wind turbines and the propagation of these sound waves is not fully understood. Efforts have been made in Japan and abroad to study how to investigate, predict, and assess them. Since FY2008, the Ministry of the Environment of Japan has been looking into the matter in light of the differing criteria, including those related to the structure and location, while gathering other relevant information.

On the unclear cause-and-effect relationship between wind turbine noise and infrasound and health effects which is complained about, the Ministry of the Environment has been implementing a three-year project entitled “Research on the assessment of the effects of wind turbine infrasound on humans” since FY2010. This project includes fact-finding surveys in the field, public response surveys of local residents living near wind turbines, and the subjective evaluation of noise under laboratory conditions.

Since wind power plants were made subject to the EIA law in October 2012, there has been a need to provide the most recent knowledge for the organizations involved in EIA. To meet this requirement, the Ministry-commissioned study group published a report on how to investigate, predict, and assess wind turbine noise and infrasound in FY2013. The 2013 report is expected to be referred to in conducting EIAs for wind power plants.

In addition to these research, the Ministry of the Environment starts implementing a three-year project entitled “ Epidemiological research on the long term health imapct of wind turbine noise and law-frecency noise on humans” since FY2013. It contanins literature review, epidemiological survey, enviromental evalution of houses next to wind turibine, Health Impact Assessment and so on.

2. OVERVIEW OF THE RESEARCH ON THE ASSESMENT OF THE EFFECTS OF WIND TURBINE INFRASOUND ON HUMANS

In japan, Wind power was installed in earnest since the 1990s, and neighboring residents of wind power feel the anxiety of health. To solve this problem, correspondence is required in government agencies. As a result, the wind power was also the subject of assessment law in FY2012.

The three-year project entitled “Research on the assessment of the effects of wind turbine infrasound on humans” revealed several facts.

First, Distance from the wind turbine is in the range of about 1km, the noise level is distributed in the range of about 25 ~ 50dB(it is A-weighted sound pressure level). In addition, where the wind power plants are built is often a quiet environment (noise level is less than 30dB). So, neighboring residents of wind power hear enough often wind-turbine noise.

Second, frequency characteristics of the wind turbine noise is attenuated at a constant rate towards the treble from the bass. Further, there was no low-frequency components specific. In addition the low-frequency component is much lower than the level you feel in the human ear.

Third, infrasound is inaudible. However, it is considered that the components of the audio frequency range is included in the the wind turbine noise, it becomes a

problem as the environmental noise. Therefore, a laboratory experiment has been carried out on hearing the reaction of people to the sound of low frequencies. As a result, the threshold of the low-frequency sound became clear. And it A-weighted sound pressure level is high correspondence with the loudness was also revealed.

Fouth, Swish sound included in the noise of the wind turbine increase the annoyance.

3. OVERVIEW OF THE 2013 REPORT

The report reviews selected EIA cases and the current knowledge available within and outside Japan. It then proposes appropriate methods of investigation, prediction, and assessment and establishes guideline values for noise levels.

3.1 Literature Review

An expert working group of the Ministry-commissioned study group reviewed the relevant literature to summarize the best available knowledge. The working group was made up of four doctors, who specialize in epidemiology, health risk evaluation, industrial medicine, and psychiatry.

Among the literature the working group reviewed are studies included in MEDLINE, a major online database of medical literature. The group identified these studies by entering “wind turbine noise” in the search box and sorting out those dealing with its health effects on humans or animals. The group also reviewed records of lectures in academic circles, as well as relevant reports provided by experts that are not on the MEDLINE. The evaluation of these studies focused mainly on the relevance of the interpretation of the study findings in light of a number of criteria, including the type of study method, the range of health effects evaluated, and the levels of exposure.

The purpose of this literature review was to provide an answer to the question: “Could wind turbine noise have health effects (at normal levels of exposure)?” To this end, the following focuses of research are identified:

(1) What are the major health effects of exposure to wind turbine noise?

(2) Are there chronic health effects due to long-term exposure?

(3) At what level of exposure (sound pressure) do health effects, if any, arise?

(4) Could health effects arise even if the sound pressure level is below the sensory threshold?

(5) Does infrasound involve a factor or factors that modify the effects on health?

The working group evaluated the identified studies in light of the kinds of evidence presented for in each of the researches enumerated above.

This literature review has confirmed the following observations:

1) Epidemiological studies designed to assess the health effects of infrasound generated by wind power plants are limited in number; in fact, only four out of the identified studies are so designed. All are cross-sectional studies that focus on local residents living near wind turbines and employ self-administered questionnaires.

2) These studies suggest that annoyance and sleep disorders may be related to turbine noise. None of the studies, however, links any other ailments with such noise.

3) The studies confirm the relationship between wind turbine noise and annoyance. It is difficult, however, to ascertain the causality of the relationship, as noticeability of the installation and other factors may be involved.

4) Likewise, the studies confirm the relationship between wind turbine noises and sleep disorders. However, they fail to provide clear evidence that ascertains its causality.

5) The studies do not provide compelling evidence that supports a definite level of sound pressure that causes annoyance and sleep disorders (thresholds). Instead, they confirm the possibility that various factors concerning individuals affect their sensitivity.

6) A few of the identified studies confirmed changes in cardiac cells in animals when they were exposed to extremely high levels of noise. These studies fail to provide valid evidence that can be used for risk evaluation of exposure to wind turbine noise in the real world.

7) In sum, the literature review has concluded that studies have yet to provide scientific evidence that shows a cause-and-effect relationship between wind turbine noise and health effects. Some studies, however, suggest that wind turbine noise is associated with annoyance and sleep disorders. It is therefore unreasonable to rule out the possibility that the stress due to the chronic occurrence of these ailments gives rise to some kinds of health effects. Still, none of the identified studies provide reliable evidence that shows that wind turbine noise causes these health effects.

3.2 Investigation, Prediction and Assessment Methods

(i) Investigation methods

The report notes that any method for investigating wind turbine noise should consider a) the sound source characteristics (e.g., acoustic power levels of the wind turbine), b) the sound propagation characteristics (e.g., the topography of the project area and the direction and velocity of the wind), and c) information about the sound receiving points (e.g., the noise levels in residential areas with measuring points).

a. Sound source characteristics

The report notes the need to gather data on the overall values and frequency characteristics (octave band or 1/3 octave band) at particular sound power levels in order to assess the environmental impact of a wind turbine when it is running at the rated or maximum output. It also suggests gathering such information as the manufacturer, the model number of the wind turbine, and its basic specifications, including the hub height and the rotor diameter to ensure accurate predictions.

b. Sound propagation characteristics

The report states that it is important to consider the topographic and climatic conditions of the area where the wind turbine is located since many wind turbines in Japan are located on mountain ridges. It emphasizes the need for a comprehensive approach to the collection of such data for prediction purposes. The report notes that topographical features affect how wind turbine noise and infrasound are reflected, absorbed, diffracted and so on. It also points out that the wind direction and velocity, the temperature, and other climatic conditions affect the sound propagation characteristics.

c. Information about the sound receiving points

Field surveys provide an important means of identifying housing, schools, hospitals, and other types of buildings in the vicinity of the wind power plant that require special consideration with regard to environmental conservation. Digital maps provide a useful tool for the assessment of the areas surrounding the installation. The means of assessing the residual noise in the survey area may include taking measurements or estimating the noise levels based on the measurements at the nearby wind power plant, and gaining access to relevant data held by the local government concerned.

The residual noise level should preferably be the time average during the period when there is no specific noise such as aircraft noise, automobile noise, noise from nearby business establishments, and natural noise. The differences in noise levels between day and night should be taken into account. Estimating the time average noise level, however, requires meticulous work, including processing of exclusive sound. The 2013 report states that the time average noise level may be substituted for by measuring the percentile level L_A95 (L_{A95}, 10min) using time weighing (FAST) of a noise-level meter within the 10 minutes measurement time.

(ii) Prediction methods

The sound waves radiated from a noise source are propagated while being dispersed three-dimensionally. In the process, the sound waves undergo a range of changes, including attenuation over distance, reflection and absorption by the ground surface, reflection and diffraction by acoustic obstacles, the effects of the weather conditions (especially winds), and attenuation due to acoustic absorption by the air. In short, noise propagation is an extremely complex phenomenon. Practical methods that simplify these factors have been devised for actual noise prediction for EIA and other purposes. Such prediction methods for noise generated by wind power plants include

one standardized by the International Organization for Standardization (ISO) and the NEDO method in Japan. The ISO method has been widely applied within and outside Japan.

Research is underway on models for noise propagation in an outdoor environment. The 2013 report expressed expectations that these models, when their accuracy is confirmed, will be used for the propagation prediction of wind turbine noise as well. The report states that noise prediction should in principle cover the area of investigation and be conducted with regard to the geographical points where the health effects of wind turbine noise are expected, including points of investigation. According to the report, when and how long the noise prediction is made should be identified based on comprehensive analysis of the sound source characteristics and the propagation characteristics as well as the situations of the geographical points of prediction (assessment points) so that the environmental impact will be maximized.

(iii) Assessment methods

EIA in Japan builds on two major approaches: “prevention and reduction of the environmental impact” and “consistency with standards or targets.”

As far as the first approach is concerned, it is necessary to come up with two or more options after studying a wide range of environmental conservation measures, including those concerning the structure and layout of the wind power plant, environmental conservation facilities, and the method of constructing the installation. These options should then be compared and weighed with one another from time-series and parallel-period perspectives. The 2013 report states that evaluation should be made as to whether the possible adverse effects of the wind power project in question are being prevented or reduced. For this purpose, focus should be placed on whether the plant operator has adopted practical and better technologies.

“Standards or targets” in the second approach refer to those for wind turbine noise that have been identified in the environmental standards, environmental basic plans, and other environmental conservation policies of the central or local governments. The report states that the evaluation should be made as to whether the relevant standards or targets have been achieved, and whether the results of the prediction and investigation are consistent with the aims or contents of the environmental basic plans and other policies.

Under this situation, MOEJ set up Subcommittee on technical matters and is disuccusing approaches to controlling wind turbine noise and infrasound including wind turbine noise reduction technology .

(iv) Methods of follow-up investigation

The follow-up investigation should be conducted over an extended period of time, rather than a short period of time, to take measurements in each season or other representative periods of the year.

It is necessary to keep in mind that as a characteristic of the sound source, noise from a wind power plant peaks when it is running at the rated output. Measurement should be conducted with regard to the direction and velocity of the wind at nacelle height, changes in generation output, and the attenuation over the distance from the wind power plant and each assessment point. Climatic data such as the direction and

velocity of the surface wind and the air temperature and humidity should also be collected and recorded.

The proportions of the amplitude-modulated tones i.e. swish sounds and the pure tone elements constitute an important part of the evaluation of wind turbine noise. They should be fully taken into account in the follow-up investigation as well. The report states that, in principle, the area of investigation matches the area investigated during the EIA, while the points of investigation correspond to the points for which the investigation has been conducted as part of the EIA (points of prediction or assessment points).

As for evaluation time, it should be remembered that wind turbine noise greatly varies depending on the wind conditions; the turbine often repeats the process of stopping and starting operations. It is therefore necessary to measure the wind turbine noise during the time period when the turbine is running at the rated output (or when the impact of the wind turbine noise is especially great) and at the same time the effects of the background noise are kept to a minimum, notably at night. A typical procedure is to measure the 10-minute time average noise levels during which the noise is stable (the equivalent continuous A-weighted sound pressure levels over a period of 10 minutes; L_{Aeq},10min) and use them as the representative values. If the wind turbine runs at the rated output over an extended period of time and it is possible to measure the noise generated by the turbine, it may be good idea to take measurements for a ten-minute period every hour on the hour and calculate the average energy for the entire time period (e.g., at night). This is a useful way to obtain stable data.

The next step is to compare the findings of the follow-up investigation against the results of the prediction for the EIA (the composite values of the predicted levels of the residual noise and wind turbine noise in the region). This makes it possible to verify the predicted values and assess the actual situation. If it is found that the preventive and reduction measures are inadequate or that the consistency with the targets is weak, additional measures for environmental conservation will be required. The report adds that if the follow-up investigation finds that the wind turbine noise includes a pure tone element, it is necessary to make evaluations based on the criteria indicated in ISO 1996-2 and take additional measures to reduce the environmental impact.

4. Conclusion and future

This paper showed the social reaction on the wind turbine noise and proposed options for the investigation, prediction, and assessment methods and approaches in relation to wind turbine noise and infrasound in light of the basic requirements of the EIA law and other requirements of the applicable ministerial ordinances. It also presents the requirements of assessment indicators. Many problems stand in the way of assessing the environmental impact of wind power plants, especially with regard to wind turbine noise. Continuous research and investigation are necessary to solve these problems. The Ministry of the Environment will continue to pursue appropriate EIA methods by referring to the most recent studies and continune to implement research wind turbine noise by three-year project entitled “ Epidemiological research on the long term health imapct of wind turbine noise and law-frecency noise on humans” since FY2013 In this study, carried out on a large scale epidemiological

survey of people living near wind farms. And MOEJ also promote the further study also describes a method of EIA described above.