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Noise Issues And The Siting Of Facilities

Even when noise regulatory limits are satisfied, community annoyance can still be a concern.

BY CHRISTOPHER J. BAJDEK

Based on the efforts of organizations like the American Wind Energy Association (AWEA), public support in the U.S. for wind energy projects is growing. However, despite the many benefits provided by wind energy, there will be some members of the community who oppose the construction of a facility in their area.

Along with the potential visual and avian impacts of wind farms, opponents also frequently cite noise as a major concern.

Since the 1970s, technological advances in materials and blade design have led to the increased efficiency and performance of wind turbines, making wind an increasingly economically viable source of renewable energy for the future. With these advancements in technology, wind turbines have also become quieter. But, they are not silent.

Although wind turbines are quieter than they were 25 years ago, affected communities may not accept the argument that turbine noise is covered up (masked) by the wind. And while it may be demonstrated that a proposed wind farm will not exceed regulatory noise limits, facility noise may be sufficient to cause adverse community reaction once the wind farm goes online.

This article reviews the basics of sound and decibels for the uninitiated, discusses some actual measurement results from a case study, provides an overview of recent research into community reaction to noise, and outlines some methods for dealing with the noise issue.

Sound and decibels

Loudness is a subjective quantity that enables a listener to order the magnitude of different sounds on a scale from "soft" to "loud." Although the perceived loudness of a sound is based somewhat on its frequency and duration, chiefly it depends upon the sound pressure level. The sound pressure level is a measure of the sound pressure at a point relative to a standard reference value expressed in decibels (dB).

The quietest sounds that we can detect have sound pressure levels of about 0 dB, while sound pressure levels above 120 dB are painful to hear. Many sounds in our daily environment have sound pressure levels on the order of 30 to 100 dB. The average sound pressure level of a whisper at a one-meter distance is about 40 dB, while the sound pressure level of a normal voice at the same distance is about 60 dB. A shout 1 meter away has a sound pressure level of about 85 dB.

The human ear does not respond equally to identical noise levels at different frequencies. Therefore, to correlate the amplitude of a sound with its level as perceived by people, the sound energy spectrum is adjusted, or "weighted."

The weighting system most commonly used to correlate with people's response to noise is "A-weighting" (or the "A-filter") and the resultant noise level is called the "A-weighted noise level" (dBA). Because this filter generally matches our ears' sensitivity, A-weighted sound levels are normally used to evaluate environmental noise sources.

Very-low-frequency sound, or infrasound, is generally associated with the older-technology wind turbines of the 1970s. Typically a characteristic of downwind turbines, infrasound is generated by the passage of the blade through the wake of the tower, and has been associated with the human perception of noise-induced vibration in structures.

However, with newer technology and the trend toward upwind turbines, infrasound as a community noise issue has decreased.

A case study

Harris Miller Miller & Hanson Inc. conducted compliance testing for a public utility in the Midwest after the utility began receiving noise complaints from some rural neighbors living next to a wind energy facility.

Noise measurements were conducted at a number of sites in the vicinity of the wind farm during a one-week period in each of the four seasons.

The noise measurements demonstrated that the wind farm was indeed operating within the limits for audible noise as established in the permit application for the project.

Tape recordings also were made for subsequent frequency analysis of the noise produced by the turbines. The analysis demonstrated that the wind farm was also operating within the applicable limits for low-frequency noise. These results were supported by observations made by the author and comments received during informal discussions with the homeowners.

In each case, there were no reports of rattling windows, walls or doors, nor were there any reports of vibration of wall-mounted items or items on shelves – which can be indications of an infrasound problem.

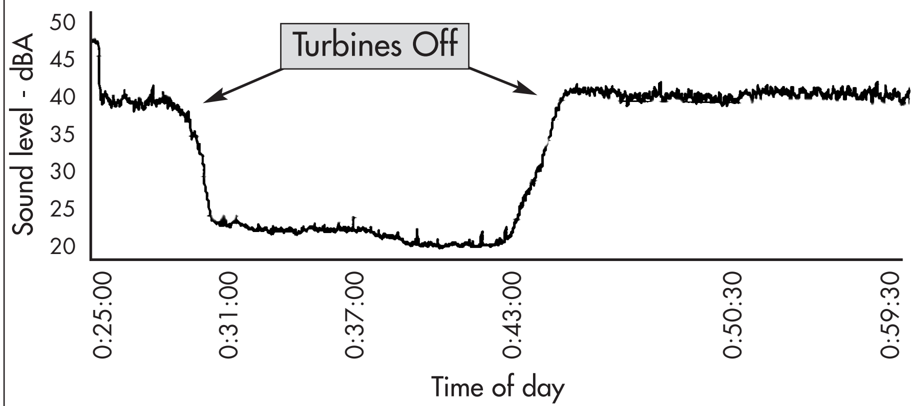
Even though the wind farm was in compliance with the applicable limits, community members filed more than 50 noise complaints over a five-month period. The majority of the complaints were at night, during periods with low background-noise levels. And, most of the complaints occurred when the affected homeowner was located downwind of the turbines.

Figure 1 shows the measured noise levels over a half-hour period at one of the sites, and illustrates the effect of turbine noise in a rural area with low background levels. Note that with the turbines "off," background noise levels were in the low 20s dBA. With the turbines "on," measured noise levels were about 40 dBA. While not particularly "loud," these significant increases in the background were very noticeable changes in the existing noise environment.

Figure 1

Measured Noise Levels Over A Half-Hour

Turbine noise can significantly affect an area with low background-sound levels.



Source: HMMH, 2002

Community reaction to noise

So what was the reason for the complaints?

Recent research suggests that for a given average noise level, a greater proportion of people would be annoyed by wind turbines than would be annoyed by noise from other sources.

To illustrate the findings of this research, first consider a community exposed to an average noise level of 40 dBA from a wind energy facility. Based upon the dose-response relationships developed by this research, roughly 25% of the people within the community would be "highly annoyed."

However, for a community exposed to the same average noise level of 40 dBA from a transportation source (either aircraft, highway or rail), the expected proportion of "highly annoyed" people would be less than 5%. Interestingly, in this research, a correlation between the attitude toward the visual impact of the wind farm and noise annoyance was found.

Other research has shown that non-auditory effects also may contribute to annoyance. In addition, there is some thought that the participation of landowners – or more precisely, their non-participation – in the development of a wind energy facility also may have an effect on community reaction to noise.

At this time, it is not clear what effect this research will have on the siting of wind farms in the U.S. At the very least, it may help call attention to the potential that noise may be more of an issue than currently believed – particularly in rural communities with low background-noise levels.

Evaluating the expected community reaction to the noise from a proposed facility has proven to be a very valuable tool to help gain community acceptance of facilities once they are constructed. Whether or not a wind farm is expected to meet the state and/or local noise ordinances or other applicable noise limits, the eventual community reaction to the noise from the facility will be what determines whether community pressure is brought to do something about the noise.

A landmark U.S. Environmental Protection Agency (EPA) report published in 1974 first introduced methodology for predicting the expected community reaction to a new noise source. Since then, the approach has been refined and applied to a wide variety of proposed and constructed industrial and entertainment facilities to assist in facility siting and design.

The degree of expected community reaction to the new noise is predicted from the expected long-term average facility noise levels in the community, the character of the noise – whether it is tonal or impulsive in nature (wind farms usually are neither) – and the community setting. Accounting for the effect of atmospheric conditions on how sound travels is also an important aspect of these evaluations.

The methodology is based on a survey of actual community reactions to a wide variety of noise sources, from industrial to transportation to entertainment. This has proven to be quite accurate when used to decide on how much and what kind of noise abatement measures should be incorporated into a facility's design. Community acceptance has been good where steps were taken to keep facility noise to levels that elicit "no reaction, although the noise is generally noticeable."

Another metric that brings added value to the discussion of community acceptance is the audibility of the operation. Residents often want to know whether they will hear the sound from the proposed wind farm, and how often they will hear it. Audibility depends on many factors, including the character of the facility noise as well as the character of the existing background sound environment.

Noise character has both frequency and time aspects, so both must be considered when estimating whether noise will be heard and how often. An advantage for wind farms is that increased wind raises ambient background noise levels as well as turbine noise levels, thereby reducing the range of differences to consider.

A new tool that's beginning to gain popularity to help people understand how a new sound will be heard in an existing setting is called "soundscape" analysis.

Soundscape demonstrations are developed starting with extremely lifelike binaural recordings (with microphones placed inside the ear) of the background environment, as well as a separate recording of an appropriate wind energy facility. Then, the two recordings are combined differently to represent what residents in different locations would hear with the proposed facility in operation. The demonstrations are played backthrough high-quality headphones for remarkably lifelike sound.

Such demonstrations are also useful to help facility designers understand residents' perspectives and to evaluate noise abatement options, such as home sound insulation.

Noise from wind farms is not usually a major impact, but if considered during siting and design, community reaction can be anticipated and managed. NP

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