# WINDLETTER

THE MONTHLY NEWSLETTER OF THE AMERICAN WIND ENERGY ASSOCIATION

Volume 23 Issue No. 3 – April 2004

SMALL TURBINE COLUMN:

Residential Wind Turbines and Noise

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Are residential wind systems too noisy?

When a prospective wind generator owner seeks approval for a building permit for his or her project from a local zoning committee, the permit is occasionally held up by someone with concerns about the noise that the wind system may produce. Many times, the installation in question is the first that the zoning committee has dealt with, and there is likely not another residential wind system of similar make nearby to serve as a basis from which the zoning committee can make firsthand observations.

Most concerns about noise turn out to have an historical basis. During the tax credit era of the late 1970s and early 1980s, literally dozens of wind turbine “manufacturers” churned out all manner of small turbine designs and models. Put simply, much of that equipment was junk, as was evidenced by its quick disappearance from people’s backyards. Many of these machines were very noisy clunkers. The memory of those noisy contraptions is what gives zoning committees and neighbors the jitters. (Interestingly, only three of the original 80-plus manufacturers doing business several decades ago have survived to today.)

Sound and noise is a very subjective topic with people. Sounds that are soothing to one person may drive another crazy. One person’s playful puppy may be a yapping mutt to the next-door neighbor. Fortunately, noise is measurable in relation to the background sounds in our environment. Therefore, zoning boards can choose to deal with the noise issue and neighbor concerns objectively, and not just make a decision based on pressure exerted by a concerned but uninformed or misinformed neighbor.

Sound that the human ear can perceive is measured in decibels, or dB(A), with a device known as a decibel meter. Good quality sound measuring equipment can easily exceed $10,000, and takes a trained technician to operate and interpret documented test results. This is not equipment that you can obtain from the local rental company.

People often compare various sound situations for their own perspective. The average background noise in a house is about 50 dB(A), while a car driving down a street will be measured at 60 dB(A) at a distance of 300 feet. A “quiet” vacuum cleaner will emanate sound at 70 dB(A), about the same noise level that is attributed to an expressway when standing 100 feet away from it. Nearby trees on a breezy day will measure about 55 to 60 dB(A) on a decibel meter.

The human ear can only distinguish sound differences of about 3 dB(A) or greater. This means that a sound source must be at least 3 dB(A) louder than ambient, or background environmental, sound before there is a noticeable difference between a given sound and other background noises. Most of today's residential wind turbines perform very near ambient over most of their effective operating range.

Even though the intensity of the sound coming from a wind generator may be the same as the ambient noise, the frequency may be different. Therefore, wind turbine sounds may be distinguishable from ambient noise even though they are not louder. This is not out of the ordinary. In fact, if you listened carefully, you would be able to identify all of the other components of ambient noise: dogs, traffic, kids, tractors, and even trees, to name a few.

Sound decreases with the distance from its source by the square of that distance. That is, a noise at 200 feet will have only one-fourth of the intensity as that same sound heard from 100 feet away. Therefore, any sound emitted from a wind turbine will quickly blend into the background noise with increasing distance from the tower.

Sound from a wind generator comes from two sources: the drivetrain and the blades. Utility-scale wind equipment used in wind farms has a drivetrain that includes a gearbox transmission, high-speed generator, couplings between the two, brake, mainframe, and nacelle. Some of the noise generated by utility-scale turbines comes from the high-speed transmission and generator. In contrast, most residential-sized wind generators are direct drive devices and, therefore, do not have such transmissions. Because they are direct drive, the generators used in these systems are quite slow speed when compared to wind-farm equipment. The only residential wind system on the market that does have a gearbox uses a low-speed transmission.

Most of the sound that comes from a residential-sized wind turbine is aerodynamic noise caused by the blades passing through the air. They are variable speed devices, which means that as wind speed increases, so does the speed of the blades. Therefore, the aerodynamic sound that the blades generate increases with increasing wind speed.

Aerodynamic noise is also a function of the tip speed of the blades. Tip speed ratio (TSR) is a term that refers to the speed of the tip of a wind generator blade in relation to wind speed. For example, a wind system that operates with a TSR of 10 means that when the wind speed is 25 miles per hour (mph), the tips of the blades are moving at 250 mph. Increasing tip speed results in more noise. Today's slow speed wind generators that operate at TSRs of about five to seven emit sound that is barely discernible from ambient noise with a decibel meter.

The sound that is emitted by any source should be compared to a background of all the other noises surrounding that source. This is the ambient sound of the environment. In the case of a wind generator, that background noise might include traffic or farm machinery, barking dogs, children playing, lawn mowers, and all of the other activities that we engage in that--either directly or indirectly--create sound. Even the environment itself makes a sound. As the wind blows, trees, shrubs, and cornfields make a rustling sound, and buildings may rattle as they interfere with the wind. All of these sounds increase with wind speed until a howl is created.

When testing any piece of machinery for noise emissions, two tests are usually done. The first is with the machinery turned off, so that a baseline of ambient noise can be documented. The second test is with the machinery operating. In the case of a wind turbine, tests might be done in high winds as well as relatively calm winds, with the turbine operating and shut off. Since the wind itself is also responsible for the creation of sound, ambient background noise increases with increasing windspeed, thereby effectively masking other sounds, such as from a small wind turbine.

A classic example occurred when the Clinton (Iowa) Detective Bureau responded to a noise complaint against a 10-kW Jacobs wind system belonging to a wind turbine dealer and installer. The Bureau responded by sending a trained person out to site to monitor the wind system with a decibel meter. In winds from 16 to 36 mph, and at a position only 50 feet from the wind generator, the decibel meter registered the sound of the wind generator between 55 and 59 dB(A). The detective noted that, "at this location, the sound output from the generator was observed to be partially masked by the sounds from the rustling of leaves in the trees." When the decibel meter was pointed at the trees, 300 feet away, the meter registered the tree sounds at 60 to 62 dB(A). The conclusion of the Bureau was that the wind generator sounds were "inconsequential in total noise emission."

The National Renewable Energy Laboratory (NREL) has recently completed sound testing of a number of residential-sized wind turbines and issued a report of their findings. NREL noted a "marked progress toward quieter turbines" in the past few years, as manufacturers turn their attention from achieved equipment reliability improvements. In one case, a given turbine's sound reduction was on the order of 10 to 15 dB(A) from the previous model. In fact, the sound reduction on several turbines was so great that NREL engineers concluded that "the turbine noise could not be separated from the background noise." This is generally true of most of today's residential wind equipment over a great range of operating wind speeds.

NREL engineers noted, however, that "the operating condition (of the wind turbine) has a strong influence on the noise characteristics." They found two scenarios where sound actually increased above normal operating conditions. One situation involved utility-connected equipment when the grid connection was lost, and the other involved battery-charging systems when the batteries were full.

When a utility blackout occurs with a grid-tied wind system, the wind system loses its load, the grid. The wind turbine blades "freewheel" during such an event; that is, they run faster in an unloaded situation, becoming noticeably louder. When power is restored to the utility grid and the wind system "goes back on line," the wind turbine sounds "normal" again. The solution is obvious: when a power outage occurs and the wind turbine freewheels, the owner should simply shut the wind generator off.

The second scenario involves battery-charging wind systems when the batteries are full and cannot accept more energy. This most often occurs during storms or prolonged periods of sustained high winds. Again, there is a simple situation, which involves shunting the excess wind energy to a resistive load once the batteries are full. This "dump load" maintains the load on the wind turbine, effectively keeping sound within normal operating parameters.

Anyone complaining about noise at a zoning hearing can, and sometimes does, effectively stop the installation of a residential-sized wind system. Usually, the antagonist has no up-to-date experience with the sound emissions of a small wind turbine, but instead bases their opinion on hearsay, speculation, something they may have seen on television sometime, or the ancient history of 1980s-era equipment.

However, since sound is measurable and quantifiable, zoning boards should be able to take wind generator sound out of the realm of the subjective. Hearsay and speculation are no basis for decision making.

There are several guidelines about sound that zoning committees should keep in mind at zoning hearings for residential wind systems. These include:

1. Sound drops off significantly with distance from the source. At several hundred feet away, the typical minimum distance to a neighbor's house, you are hard pressed to hear a residential wind

turbine under normal operating conditions. This has been found to be the case time and time again.

2. Today's wind turbine manufacturers have worked hard, and successfully, to take the noise out of their residential wind systems. As a result, most residential wind systems operate at or near ambient sound levels.
3. There are only a few events or circumstances that can cause a normal operating wind system to become noisy. These are power blackouts or a full battery bank. Both situations are temporary and easily remedied by the owner.
4. Test data for some turbines is available from NREL verifying residential turbine sound levels. As time goes on, NREL engineers will likely test more turbine models.
5. Requiring a certified noise test for a residential wind system is beyond the budget of any homeowner, as well as being completely unnecessary given the sound emissions of today's residential wind equipment.
6. The very best way to get a sense of the sound that a given wind turbine makes is to actually visit a site with one. It's important to visit a location with the same model turbine as is in question, as different turbines will operate differently in different wind speeds.

According to Emil Moroz, based at the University of Texas-El Paso at the time and now with GE Wind, presenting at an AWEA WINDPOWER Conference, noise "problems are compounded by the different subjective responses of individuals, which often depend more on personal attitude than actual noise level." Paul Gipe in Wind Energy Comes of Age concludes, "Wind turbines will always remain audible to those who choose to hear them."

[Editors Note: The opinions expressed in this column are those of the author and may not reflect those of AWEA staff or board.]