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Wind Industry Responds to Sound Propagation Concerns with New Technology

A recent study by the UK government suggests that up to 20% of all wind farms generate noise complaints, leaving significant risk for these projects if local stakeholders are not properly consulted and managed throughout the development phase of a project.[i] Though noise impacts should not be deal-enders for wind energy projects, they definitely can slow down the development process or stop it altogether if not adequately addressed.

As such, the issue of sound propagation has become the topic of many developments in the field of wind energy. From advanced software management tools to tweaks to blade design to wind farm modeling, the industry is responding by looking at a variety of ways to address the noise concern.

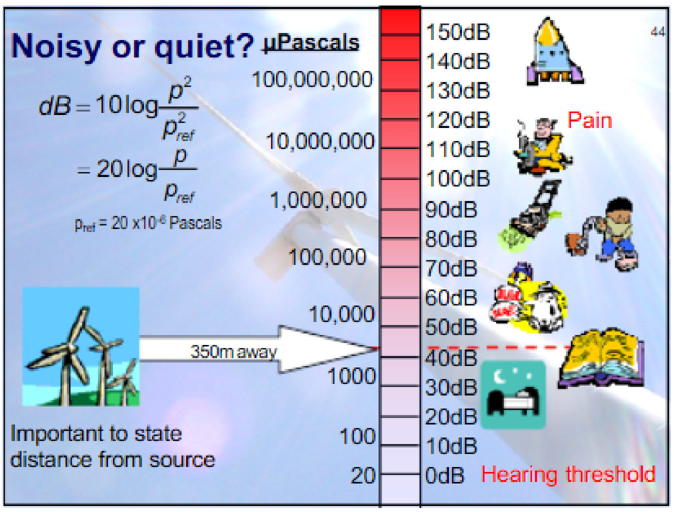
Sound Propagation and Residential Impacts of Wind Farm Noise and Vibration

Though only a small portion of those living near wind farms experience health impacts of the noise they produce, there has nevertheless been some relatively good evidence to demonstrate that those who are sensitive to the noise can experience diminished quality of life and health. One of the major complaints from residents living in close proximity to wind farms is the impact of turbine noise on sleep quality.

The World Health Organization (WHO) has found that sound levels greater than 30 decibels during sleeping periods can negatively impact the health of a child, for instance. Sound levels of 50 decibels or greater can strongly disrupt normal hormone secretion cycles, which can have a cascading impact on a child's health. And because children are more sensitive to hormone disruption, the impacts can be severe.[ii]

Dr. Nina Pierpont has also extensively studied the health effects of wind farms across a variety of locations. She has proposed the term Wind Turbine Syndrome, which describes disturbances to a person's vestibular system (inner ear), negatively impacting balance. These and many other studies are currently underway to assess the impact of turbine noise on human and ecological health.

How Wind Turbine Noise Travels to Human Ears Over Great Distances



The noise of a wind turbine from 350 meters (1,000 feet) away is similar to that of hearing someone turn the pages of a book: about 45 decibels.[iii] The intensity of a turbine's noise on the human experience is directly connected to the distance from the turbine to the observer. It is therefore crucial to always specify distance.

But the noise of a wind farm or an individual turbine is more than just the distance from the observer. Boiling the noise problem down to simplistic sound level comparisons doesn't adequately account for how turbine noise is perceived by those working and living in close proximity to these wind farms. Though distance from the origin of the noise is important, other factors including time of day and weather patterns impact how significant noise nuisance is for the residents nearby.

There are certain environmental factors that impact the degree to which noise pollution becomes a nuisance for residents living in close proximity to a wind farm. How sound is propagated is impacted, for instance, by ambient temperatures and densities and the motion of the wind.

Since sound is convected or carried by the wind, the speed with which it arrives at the observer is impacted by wind speed. In general, sound travels at approximately 340 meters per second, but when the wind is blowing in the same direction of the sound at a speed of 5 meters per second, the sound will travel at 345 meters per second.[iv]

Wind speeds often increase with height and in warmer air, which means that sound at higher altitudes travels faster than sound at lower altitudes. As a result, sound waves at high altitudes that would not have been heard by anyone are essentially bent toward the ground which increases the sound level from a wind turbine.

Temperature is a factor in the speed of wind. During the day, as solar energy heats up the surface of the planet, ambient air temperatures at lower altitudes increase while those at higher temperatures decrease (called an inverse layer), with the reverse being true at night. Cloud cover, on the other hand, stabilizes air temperatures and provides a neutralizing effect. These are called temperature gradients.

The nature and intensity of the vertical temperature gradient impacts whether sound is enhanced or attenuated. When temperatures decrease with height, sound waves are convected upwards and the sound is less observable. When temperatures at lower altitudes are higher than those above, sound is bent toward the earth and therefore is more observable. The greater the temperature gradient, the more intensely this impact is felt.

The bottom line is that when an inversion layer forms at altitudes higher than the wind turbines, the inversion layer can facilitate sound to travel greater distances by reflecting sound back toward the ground. This forms a channel for sound propagation. Because of this phenomenon (thermal inversion and the resulting sound that is bent toward the ground), many complain that turbine noise is greater at night or in the early morning hours.

However it’s not that the turbines make more noise during these periods, but rather the thermal inversion that impacts how loud the turbines seem. More research is needed to determine the atmospheric impacts turbines have on noise levels, including the issue of inversion layers.

Additionally, because there are fewer other noises to mask the sound of the turbines at night or in the early morning – such as appliances, street noise, and so forth - the sound of turbine noise seems more obvious during these periods of time than at other parts of the day.

Solutions for Addressing Residential Impacts of Wind Farm Noise

For any new wind farm development, extensive modeling needs to be conducted in order to mitigate the potential problems related to residential disturbances from turbine noise. This is especially true for regions where terrain is not flat. It is extremely difficult to calculate the wind profile over mountainous or hilly terrain due to the stability of the atmospheric factors.

Today's wind turbines are designed to minimize noise levels at or below 45 decibels at 1,000 feet (350 meters), which usually translates to noise levels of about 35 decibels at half of a mile or 1,000 meters (one of the standard distances used when determining the location of a wind farm).[v] But for many of the reasons already noted, the actual noise disturbance from a farm can sometimes be higher than was originally planned for. Some possible solutions for sound propagation problems include:

- Increasing setback distances where the prevalence of topographic or night time effects indicate sound will travel longer distances.

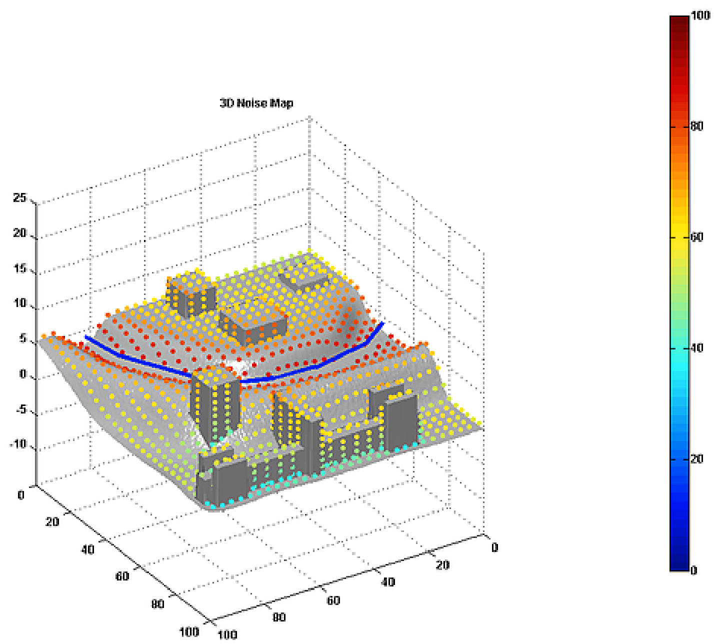
- Using noise modeling solutions before wind farm installation that take night time stable atmospheres into consideration.

- Adjusting the design of turbine blades or the structure of components within the nacelle to minimize mechanical and aerodynamic noise pollution

Wind Farm Modeling Tools for Noise Reduction

One of the most effective tools for reducing wind farm noise is to do a thorough and proper evaluation of a potential site before development begins. This type of evaluation will take local weather and temperatures, topographical elements, local residents and land-use functions, and other important factors into consideration to create a 3D noise map. This can be used to predict how much noise a wind farm will create and who will be the most effected by it.

Two of the modeling tools being used to plan wind farms are CadnaA and Harmonoise software, both of which take terrain features into account. CadnaA, which stands for Computer Aided Noise Abatement, is software that calculates, assesses, and predicts environmental noise for a variety of projects, including railways, new roads, and wind farms. Using complex calculation algorithms and object handling, the software will render a 3D visualization of noise mapping.



Harmonoise 3D noise mapping

Likewise, [Harmonoise](#) provides 3D noise mapping by using complex algorithms that predict noise propagation. This system utilizes a point to point sound propagation C library that calculates the noise level on a height map based on 3D terrain for any given source of noise.

Better Regulations to Avoid Wind Farm Noise Conflicts

Unfortunately, many of the complaints related to wind farm noise are a result of extremely lax setback guidelines that result in turbines being located too close to residential developments. These include situations where homes are located within 1,500 feet of the actual turbine. Clearly better design and stiffer regulations are necessary in order to prevent these types of conflicts.

The primary approach to ensuring proper installation of wind farms is to require that a development stay below recommended noise levels. The World Health Organization recommends a night time noise level (average) of no more than 30 decibels inside bedrooms for urban homes, and 25 decibels for rural homes.

Regulations to restrict where wind farm developments are located are being implemented in some regions. In France, for instance, the French National Academy of Medicine has called for a stop to the development of large scale wind developments that are located within 1.5 kilometers (1 mile) of residential developments or individual residences. The UK Noise Association is also recommending a separation distance of 1 kilometer.

In the US, however, separation distances are not set federally, but are rather determined by local ordinances. Unfortunately, because small town governing bodies are not equipped to deal with this kind of decision, they often provide permits without realizing the consequences and negative impacts to their residents.

More Stakeholder Engagement Needed for Better Wind Industry Outcomes

The problem of sound propagation is tangible, even if complex. The wind industry, to this point, has been responding with new innovations and strategies for ensuring their work does not negatively impact those living in close proximity of wind installations. Going forward, greater stakeholder engagement at every stage of the process is clearly needed to ensure wind achieves the best possible outcomes: renewable energy without human frustration and resentment.

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A student of all things green, Maryruth has a special interest in cleantech and green buildings. In recent years, Maryruth has worked as the senior editor of The Green Economy magazine, is a regular blogger for several green business ventures, and has contributed to the editorial content of not one, but two eco-living websites: www.ecolife.com and www.GreenYour.com. You can learn more about Maryruth's work by visiting her site, www.jadecreative.com.

Noise level comparison image via [The University of Adelaide School of Mechanical Engineering – Colin Kestell]

Sources:

[i] *Wind Energy Noise Impacts Fact Sheet*. (n.d.). Retrieved from Acoustic Ecology: http://www.acousticecology.org/docs/AEI%20Wind%20Turbine%20Noise%20FactSheet.pdf

[ii] (Wind Energy Noise Impacts Fact Sheet)

[iii] Kestell, C. (n.d.). *Wind Turbine Noise and Vibration*. Retrieved from School of Mechanical Engineering, The University of Adelaide: http://www.scribd.com/doc/82230086/Wind-Turbine-Noise-and-Vibration-HANDOUT

[iv] Tonin, R. (2012, April). *Sources of Wind Turbine noise and Sound Propagation*. Retrieved from Acoustics Australia: http://www.acoustics.asn.au/journal/2012/2012_40_1_Tonin.pdf

[v] (Wind Energy Noise Impacts Fact Sheet)