

# wind turbine noise

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## Is Low Frequency Noise a Problem for Wind Turbines?

Source: Neil Kelley, U.S. National Renewable Energy Laboratory

1) Because of the low rotational rates of the turbine blades, the peak acoustic energy radiated by large wind turbines is in the infrasonic range with a peak in the 8-12 Hz range. For smaller machines, this peak can extend into the low-frequency "audible" (20-20KHz) range because of high rotational speeds and multiple blades.

2) The levels of infrasound radiated by the largest wind turbines are very low in comparison to other sources of acoustic energy in this frequency range such as sonic booms, shock waves from explosions, etc. The danger of hearing damage from wind turbine low-frequency emissions is remote to non-existent. Generally there is little acoustic energy much above about 4000 Hz so ultrasound is not a problem. < 100 Hz noise can, under the right circumstances, be responsible for annoying nearby residents. Typically, except very near the source, people out of doors cannot detect the presence of low-frequency noise from a wind turbine. They can, however if the noise has an impulsive characteristic, "hear" it within homes in nearby communities again under the right set of circumstances. Often it is not clear with low-frequency noise if people are hearing or feeling it or some combination of both stimuli. Because of the impulsive nature of the acoustic low-frequency energy being emitted, there is an interaction between the incident acoustic pulses and the resonances of the homes which serve to amplify the stimulus creating vibrations as well as redistributing the energy higher into the audible frequency region. Thus the annoyance is often connected with the periodic nature of the emitted sounds rather than the frequency of the acoustic energy.

3) Impulsive noise generation is generally confined to turbines whose rotors operate downwind of the support tower (downwind machine). In this case, impulses are generated by the interaction of the aerodynamic lift created on the rotor blades and the wake vortices being shed from the tower elements. Turbines that have their rotors upstream of the tower, except in very rare circumstances, do not generate impulses since there is nothing blocking the flow upwind of the rotor. The low-frequency noise generated from an upwind turbine is primarily the result of the interaction of the aerodynamic lift on the blades and the atmospheric turbulence in the wind. Because atmospheric turbulence is a random phenomenon, the radiated low-frequency noise also exhibits a random or non-coherent characteristic. Impulsive noise generated by the tower wake/rotor interaction, on the other hand, tends to be much less random or coherent and therefore much more detectable when it interacts with an intervening resonant structure.

4) In my paper published in the AWEA WindPower '87 conference proceedings ("A Proposed Metric for Assessing the Potential of Community Annoyance from Wind

Turbine Low-Frequency Noise Emissions," SERI/TP-217-3261, Nov 1997 or Proceedings of WindPower '87, San Francisco), I discuss the development of a criteria for assessing potential annoyance. It is interesting to note that low-frequency sounds with a random characteristic are much less likely to induce human annoyance than those which are impulsive. Typically the random low-frequency noise induces annoyance only at much higher acoustic energy levels than impulsive sounds.

5) While downwind wind turbines inherently are pre-disposed for producing impulsive noise because of the wakes from tower structural elements, careful designs can reduce such emissions to below detectable levels and therefore will cause no community annoyance. The overwhelming majority of wind turbines that have been installed in Europe are of the upwind rotor design and therefore low-frequency noise has not been considered a major issue there. By contrast, the primary concern there has been the much higher frequency broadband and discrete frequency noise associated with the unsteady aerodynamic forces on the blades, often in the blade tips.