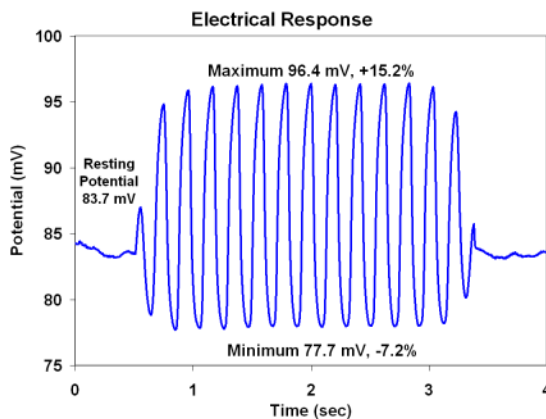
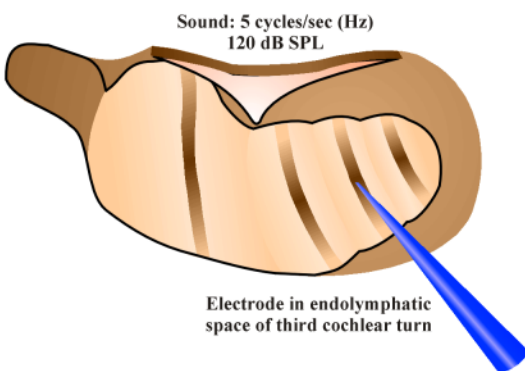


Wind Turbines can be Hazardous to Human Health

Alec N. Salt, Ph.D., [Cochlear Fluids Research Laboratory](#), Washington University in St. Louis.

Updated 4/2/2014. To keep this as readable as possible I have not included reference citations. They are typically available in our publications.

Large wind turbines generate very low frequency sounds and infrasound (below 20 Hz) when the wind driving them is turbulent. The amount of infrasound depends on many factors, including the turbine manufacturer, wind speed, power output, local topography, and the presence of nearby turbines (increasing when the wake from one turbine enters the blades of another). **The infrasound cannot be heard and is unrelated to the loudness of the sound that you hear.** Infrasound can only be measured with a sound level meter capable of detecting it (and not using the A-weighted scale). Video cameras and other recording devices are not sensitive to infrasound and do not reproduce it.



You cannot hear the infrasound at the levels generated by wind turbines, but your ears certainly detect and respond to it. The picture shows the **enormous** electrical potentials that infrasounds generate in the ear. The potentials (18.7 mV pk/pk amplitude in this case) are about 4 times the amplitude of sounds in the normal frequency range that are heard. **These measurements show that the low frequency part of the ear is extremely sensitive to infrasound.**

Our measurements show the ear is most sensitive to infrasound when other, audible sounds are at low levels or absent. That is why **homes** and **pillows** probably contribute to the problem. To clarify, maximum stimulation of the ear with infrasound

will occur inside your home, because the audible sound of the turbines is blocked by the walls of the house, but infrasound readily passes through any tiny openings. Similarly, sleeping with one ear on a pillow will block audible sound to that ear but will not block the infrasound. In either case, the infrasound will be strongly stimulating the ear even though you will not be able to hear it. The presence of sounds at higher frequencies, in the 150 Hz – 1500 Hz range at levels above 60 dB SPL, suppresses the ear's response to infrasound. It may be possible to mask the influence of infrasound with other noises but the frequency properties of the masking noise must be considered. Frequencies above about 1500 Hz will not do anything to help.

We know that the ear is being stimulated by this sound, but why would that matter if you cannot hear it?

There are several ways that infrasound could affect you even though you cannot hear it. They are:

1. **Causing Amplitude Modulation (pulsation) of heard sounds.**

We know that infrasound affects the sensory cells of the ear in a way that changes their sensitivity (like turning the volume control of the stereo up and down repeatedly). This is a biological form of amplitude modulation that **cannot be measured with a sound level meter**. The people who are measuring amplitude modulation of heard sounds with sound meters are looking at something completely different. Biological amplitude modulation can be much more powerful, with the volume cycling from going from “off” to “full”, rather than just changing a few dB. So, to investigate amplitude modulation without considering the infrasound-induced component is probably not going to explain the true nature of the problem.

Symptoms: Pulsation, annoyance, stress

2. **Stimulating “subconscious” pathways.**

We know that activity in many nerves of the ear does not result in “hearing”. If the nerves from the utricle or semi-circular canals are stimulated, you may get eye movements and changes in tension of neck muscles, but you don't hear it. The pathway of conscious hearing is very well established. It goes from the inner hair cells of the cochlea, through type I auditory nerve fibers, to the fusiform cells of the cochlear nucleus in the brain, and so on. This pathway has been well-studied. The outer hair cells of the ear (the ones that are sensitive to infrasound) do not connect to this conscious pathway. They connect to the type II nerves (which make up 5% of the nerve fibers), then to granule cells in the brain, then to cartwheel cells and to a host of other pathways in the

brain. The cartwheel cells are known to be inhibitory to hearing which may explain why the stimulation is not heard. It is known that granule cells are connected into circuits related to attention and alerting. It is not unreasonable to think that stimulation of this pathway could wake you up, and you wouldn't even hear what had actually woken you.

Symptoms: Sleep disturbance, panic, with chronic sleep deprivation leading to blood pressure elevation, memory dysfunction and more.

3. **Causing Endolymphatic Hydrops.**

The endolymph is a fluid filled compartment in the ear, like a balloon, surrounded by delicate membranes. In some conditions, such as in people with Meniere's disease, a swelling of this compartment occurs. These patients suffer from repeated vertigo spells, fluctuating low frequency hearing loss, tinnitus and a sensation of fullness or pressure in the ear. Low frequency sounds, at levels that are not damaging and do not affect hearing, have been shown to cause endolymphatic hydrops. This can occur quickly, but also recovers quickly so there are minimal consequences. This effect has been demonstrated with tones as low as 50 Hz, but has never been studied with lower sound frequencies or with infrasound. There is no reason to believe that lower frequency sounds will not generate hydrops, as we know that endolymphatic responses to infrasound are larger than those to heard sounds. As hydrops develops, endolymph moves and expands the weakest part of the balloon, which is the saccule. The saccule is the body's gravity receptor, so if it is disturbed you will feel "off balance", dizzy (subjective vertigo) and nauseous, especially if only one ear is affected (maybe the one you had on the pillow?- see above). Studies so far have only studied this for brief exposures of a few minutes. Effects are likely to increase with prolonged exposure to the sound. Furthermore, when the endolymphatic hydrops reaches a degree where the helicotrema of the cochlea is occluded, this makes the ear about 20 dB more sensitive to the low frequency sound and will undoubtedly exacerbate the problem.

Symptoms: Unsteadiness, dysequilibrium, vertigo, nausea, "seasickness", tinnitus, sensation of pressure or fullness in the ear

4. **Possibly Potentiating Noise-Induced Hearing Loss**

Animals were exposed to damaging noise, with and without low frequency sound present. When very low frequency sound was present, animals had greater hearing losses and larger areas of hair cell loss. So, if you are doing anything noisy (mowing the yard, using a chainsaw) the damage to your ears could be greater if low frequency or infrasound levels are high. It is therefore important to wear hearing protection when

pursuing noisy pastimes near sources of infrasound (that you can't even hear). As a side-note, hearing protectors, especially the over-the-ear cup type, will not protect against infrasound even though they do reduce the audible, damaging sounds you can hear.

Each of the above mechanisms is based on published data showing the phenomenon exists, thus making it a scientifically plausible process. No one has shown that any of these four mechanisms cannot occur.

However, the degree to which each phenomenon occurs in humans following prolonged exposure to the infrasound from wind turbines has not yet been demonstrated. But each now needs to be studied in more detail. The potential symptoms they could generate in people seem quite familiar though.

The Wind Turbine Industry is generally dismissive of claims that wind turbines can affect human health. For example, Scott Smith, vice president of policy for CanWEA (the Canadian Wind Energy Association), referring to the report of the Chatham-Kent Tribunal (Spring 2011) stated “The wind energy industry welcomes the tribunal’s decision, as it is consistent with the balance of expert scientific and medical information which **clearly indicates there is no direct link between wind turbines and effects on human health**” (*my emphasis added*).



This dismissive statement fails to recognize a conclusion of the Chatham-Kent tribunal, specifically “*This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree.*”

We agree that the effects of wind turbine noise on humans are largely unexplored and more research is needed. We are convinced that infrasound levels generated by some large wind turbines are unusual in the environment and that there have been no systematic long-term studies of prolonged exposure to such sounds on humans or other animals.