A second disclaimer. Readers should understand that Wind Turbine Syndrome is not the same as Vibroacoustic Disease.\textsuperscript{10} I say this because the two are often equated in the popular media. The proposed mechanisms are different, and the noise amplitudes are probably different as well.

Wind Turbine Syndrome, I propose, is mediated by the vestibular system—by disturbed sensory input to eyes, inner ears, and stretch and pressure receptors in a variety of body locations. These feed back neurologically onto a person’s sense of position and motion in space, which is in turn connected in multiple ways to brain functions as disparate as spatial memory and anxiety. Several lines of evidence suggest that the amplitude (power or intensity) of low frequency noise and vibration needed to create these effects may be even lower than the auditory threshold at the same low frequencies. Re-stating this, it appears that even low frequency noise or vibration too weak to be heard can still stimulate the human vestibular system, opening the door for the symptoms I call Wind Turbine Syndrome. I am happy to report there is now direct experimental evidence of such vestibular sensitivity in normal humans.\textsuperscript{11}

Vibroacoustic Disease, on the other hand, is hypothesized to be caused by direct tissue damage to a variety of organs, creating thickening of supporting structures and other pathological changes.\textsuperscript{12} The suspected agent is high amplitude (high power or intensity) low frequency noise. Given my research protocol, described above, my study is of course unable to demonstrate whether wind turbine exposure causes the types of pathologies


\textsuperscript{12} Castelo Branco and Alves-Pereira 2004.
found in Vibroacoustic Disease, although there are similarities that may be worthy of further clinical investigation, especially with regard to asthma and lower respiratory infections.

Moving on, I have been asked if Wind Turbine Syndrome could be caused by magnetic or electric fields. I have no reason to think so. There has been extensive epidemiologic research since 1979 on magnetic fields and health, comparing people who live close to high power lines or work in electrical utilities or work in other industries where magnetic field exposure is likely to be high, to people who do not. This substantial body of research has produced no good evidence that magnetic field exposure causes cancer in children or adults, cardiac or psychiatric disease, dementia, or multiple sclerosis. After three decades of research, there is still no experimental evidence for a physiologic mechanism for any of the proposed effects of magnetic fields.

This makes it difficult to do epidemiologic studies, since researchers don’t know what exposure to measure, or what exposure period (e.g., last week or five years ago) might be relevant. An association has been shown between higher magnetic field exposure in utility workers and amyotrophic lateral sclerosis (ALS), a neurodegenerative disease, but this is most likely due to more frequent electric shocks in these settings, not to the magnetic


14 Ahlbom et al. 2001.


16 Ahlbom et al. 2001.

17 Ahlbom et al. 2001.
that synchronizes with the feeling of pulsation some subjects felt in their chests. Coming from several towers at once, these low frequency air pressure fluctuations may synchronize and reinforce, depending on the orientation of the towers and house and the timing of the individual turbines. Three families in this study (A, B, and F) lived in houses nearly in line with a row of turbines. For families A and B, the area’s worst storms, “nor’easters,” swept right down the line towards their houses, which were built on a hill at the level of the turbine hubs. These two families, though they were a kilometer (about 3300 feet) from the closest of the 10 turbines, moved out faster—in five months—than any of the other families, and had particularly severe symptoms.

Studies of turbine noise also show that noise carries farther than predicted by conventional industry modeling. This has to do not only with the low frequency components of the noise, which attenuate less with distance, but also with layering of the atmosphere at night, which creates cool still air at ground level and brisk, laminar airflow at turbine hub heights. Industry models do not take these factors into account. Nor do they allow for a noise source more than 30 m above the ground. (Turbine hub heights in this study were 59-90 m.) Nor do they allow for increased transmission of sound in front of and behind the blades (with less sound transmission in the plane of the blades, including under the turbines), sky reflections, or weather conditions that focus the noise transmissions.

**Vibroacoustic Disease (VAD) model**

High intensities of low frequency noise over prolonged time periods may cause marked neurologic damage, as described:

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191 van den Berg 2004b.

192 Richard James, INCE Full Member, personal communication, 5/11/08.
by the Vibroacoustic Disease (VAD) group in Portugal. This is a provocative body of research, full of interesting case descriptions and pathology studies, but compromised by absence of specified study group criteria, absence of control groups, and lack of quantification. The study group consists of 140 aircraft maintenance and repair technicians in the Portuguese Air Force, of whom 22 (15.7%) had adult-onset epilepsy, compared to a national prevalence of 0.2%. Some of the case descriptions of the subjects with epilepsy also include cognitive decline, depression, paranoia, and rage attacks. The descriptions are similar to those of retired professional football players with histories of multiple concussions. The vibroacoustic disease researchers ascribe VAD pathology to whole-body vibration induced by the noise, with the pathology of each body part induced by vibration of that part. Neurologic effects may be due to neuronal or axonal shearing, as in the multiple concussions scenario, or due to microangiopathy in the brain, meaning, effects on and occlusion of small blood vessels.

With regard to the chest, the VAD researchers have used human autopsy and biopsy and animal rearing studies to describe loss of

198 Martinho Pimenta and Castelo Branco 1999.
cilia and microvilli from epithelial surfaces of the bronchi, pleura, and pericardium. They also describe thickening of bronchial epithelial basement membrane, pericardium, and blood vessel walls by extra, organized collagen and elastin. Several of the animal-rearing studies on bronchial epithelial changes are well controlled and convincing.

Based on the vibroacoustic disease research, I hypothesize that vibratory or pulsating air pressure fluctuations in subjects' airways in the present study may induce shearing of surface cilia, thus impairing the clearance of mucus and particulates from airways. This in turn could make subjects more susceptible to lower respiratory infections and increased airway irritation and reactivity (asthma). The Eustachian tube and middle ear could be susceptible


205 Castelo Branco et al. 1999.


208 Oliveira et al. 2002.
to the same process, leading to prolonged middle ear effusions and unusual acute infections.

The increased asthma seen in subjects F1 and F3 may also have a connection to their frequent use of paracetemol (acetaminophen) for headaches during turbine exposure.209

**Community noise studies and annoyance**

Studies of community noise frequently assess a quality called *annoyance*. “Apart from ‘annoyance,’” the World Health Organization writes, “people may feel a variety of negative emotions when exposed to community noise, and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion.”210

Beyond even these negative emotions, moving out of an owned home indicates that people feel sick and under threat, judging that their survival and well-being, and that of their children, will be enhanced by moving out—even as they exhaust limited resources to do so and face unrecompensed loss of their major asset, their home.

*Sick* and *annoyed* are not the same thing. In English, *annoyance* carries an air of triviality, like a mosquito buzzing around one’s head. *Sickness* threatens survival itself.

Pedersen and Persson Waye assessed annoyance (which may be a shorthand for the above list of negative emotions, but remains different from sickness) among 351 households near wind turbines in Sweden in 2000. They used a mailed survey and compared annoyance to modeled A-weighted sound pressure levels they

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