

Wind Turbine Syndrome:  
The Health Effects of Wind Turbine Noise and Shadow Flicker

by  
Nina Pierpont, MD, PhD

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\*the following pages are excerpted from a rebuttal I wrote to a ponderous (and ludicrous) **Environmental Impact Statement** prepared by a wind energy company calling itself Noble Environmental. (This Noble company presented its weighty document to various townships in northern New York State this past spring.) For the purposes of this excerpt, I am less interested in setting Noble Environmental straight (probably hopeless) than in laying out, with clinical and scientific evidence, my case for Wind Turbine Syndrome to a (hopefully) more receptive audience — NP

## 5. Noise and Noise-related Health Issues

The noise standards adopted in the Ellenburg, Clinton, and Altona Wind Energy Facilities Ordinances are wind turbine “industry standards.” As such they make things easier on the operators of wind turbines by allowing more noise, but they do not comply with community noise standards promulgated by non-industry agencies such as the New York State Department of Environmental Conservation (NYS DEC)<sup>1</sup> or the World Health Organization (WHO).<sup>2</sup>

Compliance with NYS DEC noise standards (increasing the noise level no more than 6 dB over ambient) is anticipated to be almost non-existent near the Project: “Sound pressure increases of more than 6 dBA over existing conditions will occur at most residences within the vicinity of the Project” (DEIS p. 2-129). Though this information is included, it is discussed only with regard to the fact that legally there does not need to be compliance with this standard because NYS DEC is not the lead agency. There is no plan to mitigate these noise effects. This represents a significant alteration in noise levels judged by state agency (DEC) standards and a significant change in community character, quietness being an important part the community character which leads people to build and live in rural areas.

In Lincoln Township, WI, a University of Wisconsin survey of residents near a 22 turbine installation in 2001, 2 years after construction, documented that 44% of residents 800 ft to ¼ mile from the turbines found noise to be a problem in their households, 52% ¼ to ½ mile away, 32% ½ to 1 mile away, and 4%

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<sup>1</sup> NYS DEC, 2001. *Assessing and Mitigating Noise Impacts*.

<sup>2</sup> World Health Organization, 1999. *Guidelines for Community Noise*. Ed. by Berglund B et al. Available at [www.who.int/docstore/peh/noise/guidelines2.html](http://www.who.int/docstore/peh/noise/guidelines2.html)

1 to 2 miles away. Under certain conditions the turbines could be heard up to 2 miles away.<sup>3</sup> These numbers correspond well to measurements made by Dr. GP van den Berg of the University of Groningen in the Netherlands near a more recent 30 MW, 17 turbine installation on the Dutch-German border, where residents living 500 m (1640 ft, or 0.31 mile) and more from the turbines were reacting strongly to the noise, and residents up to 1900 m (1.2 miles) away expressed annoyance.<sup>4</sup>

In a 2005 survey of 200 adult residents within  $\frac{3}{4}$  mile of the French St. Crepin Windfarm, 83% responded. Of these, 27% considered the noise to be intolerable at night, 58% considered the noise to be disturbing, and 10% considered the noise to be disturbing by day. This is only a 6 turbine, 9 MW installation.<sup>5</sup>

Dr. van den Berg has now published his research as a book (his dissertation) which is available on-line at <http://dissertations.ub.rug.nl/faculties/science/2006/g.p.van.den.berg/>; introductory and concluding chapters are reproduced in the accompanying material. His work focuses on figuring out why noise from wind turbines carries so much farther than expected and on developing new acoustic models based on known properties of the atmosphere to improve the current poor accuracy of acoustic modeling in predicting how loudly and how far noise will carry from wind turbines. The introductory chapter provides an engaging, readable description of both the scientific and political aspects of the debate about wind turbine noise. Van den Berg's research also points to design features which could be incorporated into newer turbines which would both improve their capacity factors and reduce the annoying types of noise they make.<sup>6</sup>

The audible noise produced by wind turbines has a thumping, pulsing character, especially at night, when it is louder. The noise is louder at night because of the contrast between the still, cool air at ground level and the steady stream of wind at the level of the turbine hubs, known as a "stable atmosphere" in which there is little vertical movement of air.<sup>7</sup> This nighttime noise travels long distances. It has been documented to be disturbing to residents 1.2 miles away from wind turbines in regular rolling terrain,<sup>8</sup> and 1.5 miles away in Appalachian valleys.<sup>9</sup> Van den Berg documents how mountainous terrain can either lessen or increase the effect of a stable atmosphere in allowing sound to travel further.

At night, the WHO recommends, the level of continuous noise at the outside a dwelling should be 45 dB or less, and inside, 30 dB or less. The wind turbine noise at levels permitted by the Ellenburg, Clinton,

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<sup>3</sup> Lincoln Township Wind Turbine Survey, Agricultural Resource Center, University of Wisconsin Extension/Cooperative Extension, May 16, 2001, by David E. Kabes & Crystal Smith. See tables at end of survey. See Bittner-Mackin, E. 2003. "Excerpts from the final report of the Township of Lincoln Wind Turbine Moratorium Committee," 12-4-03; Arlin Monfils, Supervisor, Lincoln Town Board, Letter dated 2-1-00 regarding the grim realities of the windpower project to his community.

<sup>4</sup> van den Berg, GP. 2004. "Effects of the wind profile at night on wind turbine sound." *Journal of Sound and Vibration*, 277:955-970.

<sup>5</sup> French St. Crepin windplant noise survey results (2005), personal communication from J-L Butre, Ventducobage, 11-5-05.

<sup>6</sup> van den Berg, GP. 2006. "The sound of high winds: The effect of atmospheric stability on wind turbine sound and microphone noise." PhD dissertation, University of Groningen, The Netherlands. <http://irs.ub.rug.nl/ppn/294294104>

<sup>7</sup> van den Berg, GP. 2005. "The beat is getting stronger: The effect of atmospheric stability on low frequency modulated sound of wind turbines." *Journal of Low Frequency Noise, Vibration, and Active Control*, 24(1):1-24.

<sup>8</sup> van den Berg, GP. 2004. "Effects of the wind profile at night on wind turbine sound." *Journal of Sound and Vibration* 277:955-970.

<sup>9</sup> Linda Cooper, Citizens for Responsible Windpower, "Activist shares wind power concerns," *The Pendleton Times*, March 3, 2005, p. 4.

and Altona Wind Energy Facilities Ordinances are in the range of decibel levels which disturb sleep, even if permitted noise levels are not surpassed. Higher levels of noise disturb sleep and produce a host of effects on health, well-being, and productivity.<sup>10</sup> These and other health effects of excessive community noise are documented in the WHO report with reference to scientific and medical literature. These include:

- For people to understand each other easily when talking, environmental noise levels should be 35 dB or less. For vulnerable groups (hearing impaired, elderly, children in the process of reading and language acquisition, foreign language speakers, and children with developmental disabilities) even lower background levels are needed. When noise interferes with speech comprehension, problems with concentration, fatigue, uncertainty, lack of self-confidence, irritation, misunderstandings, decreased work capacity, problems in human relations, and a number of stress reactions arise.<sup>11</sup>
- Effects of noise-induced sleep disturbance include fatigue, depressed mood or well-being, decreased performance, and increased use of sedatives or sleeping pills. Measured physiologic effects of noise during sleep are increased blood pressure and heart rate, changes in breathing pattern, and cardiac arrhythmias.<sup>12</sup> Certain types of nighttime noise are especially bothersome, including noise which has impulses rather than being continuous, noise combined with physical vibration, noise with low-frequency components,<sup>13</sup> and sources in environments with low ambient background noise.<sup>14</sup> Children, the elderly, and people with preexisting illnesses, especially depression, are especially vulnerable to sleep disturbance.
- Noise has an adverse effect on performance over and above its effects on speech comprehension. The most strongly affected cognitive areas are reading, attention, problem solving, and memory. Children in school are adversely affected by noise, and it is the uncontrollability of noise, rather than its intensity, which is most critical. The effort to tune out the noise comes at the price of increased levels of stress hormones and elevation of resting blood pressure. The adverse effects are larger in children with lower school achievement.<sup>15</sup>
- What is commonly referred to as noise “annoyance” is in fact a range of negative emotions, documented in people exposed to community noise, including anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, and exhaustion.<sup>16</sup> The percentage of highly annoyed people in a population starts to increase at 42 dB, and the percentage of moderately annoyed at 37 dB.<sup>17</sup>

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<sup>10</sup> WHO, 1999. *Guidelines for Community Noise*.

<sup>11</sup> *Ibid.*, pp. 42-44.

<sup>12</sup> *Ibid.*, p. 44.

<sup>13</sup> Waye. 2004. “Effects of low frequency noise on sleep.” *Noise & Health* 6, no. 23:87-91; Waye et al. 2003. “A descriptive cross-sectional study of annoyance from low frequency noise installations in an urban environment.” *Noise & Health* 5, no. 20:35-46; Waye et al. 2001. “Low frequency noise pollution interferes with performance.” *Noise & Health* 4, no. 13:33-49; Berglund et al. 1996. “Sources and effects of low-frequency noise.” *Journal of the Acoustical Society of America* 99, no. 5:2985-3002.

<sup>14</sup> WHO, 1999. *Guidelines for Community Noise*, p. 46

<sup>15</sup> *Ibid.*, pp. 49-50

<sup>16</sup> *Ibid.*, p. 50

<sup>17</sup> *Ibid.*, p. 51

Participants in noise studies are selected from the general population and are usually adults. Vulnerable groups of people are underrepresented in studies, and if included, would show stronger effects at lower levels of noise. Vulnerable groups include the elderly, people who are sick or have chronic medical conditions, people with depression or other forms of mental illness, babies and young children in general, children with developmental disabilities, children dealing with complex cognitive tasks such as reading acquisition, and people who are blind or hearing impaired. These people may be less able to cope with the impacts of noise exposure and at greater risk for harmful effects than is documented in studies. Attention needs to be paid to them when developing noise setbacks requirements, just as laws for air pollution set ambient air quality standards to protect the most sensitive individuals.

There are additional symptoms reported by neighbors of industrial wind turbine installations. Amanda Harry, MD, a British physician, found near a 16-turbine installation in 2003 that 13 out of 14 people surveyed reported an increase in headaches, and 10 reported sleep problems and anxiety. Other symptoms included migraine, nausea, dizziness, palpitations, stress, and depression.<sup>18</sup> Dr. Harry's study is in preparation for publication.

Many individual accounts from across the world support the same set of symptoms (in submitted material and clinical interviews I have performed as part of a study in progress). Based on accounts and interviews, and in discussion with Dr. Harry, I have defined the Wind Turbine Syndrome, a complex of symptoms which start when local turbines go into operation and resolve when the turbines are off or when the person is out of the area. The symptoms include:

- Sleep problems: audible noise or physical sensations of pulsation or pressure make it hard to go to sleep and cause frequent awakening.
- Headaches which are increased in frequency or severity.
- Dizziness, unsteadiness, and nausea.
- Exhaustion, anxiety, anger, irritability, and depression.
- Problems with concentration and learning.
- Tinnitus (ringing in the ears).

Not everyone near turbines has these symptoms. This does not mean people are making them up; it means there are differences among people in susceptibility. These differences are known as risk factors. Defining risk factors and the proportion of people who get symptoms is the role of epidemiologic studies, which are in progress.

Chronic sleep disturbance is the most common symptom. Exhaustion, mood problems, and problems with concentration and learning are natural outcomes of poor sleep.

Sensitivity to low frequency noise is a potential risk factor. Some people sense low-frequency noise as pressure in the ears rather than heard as sound, or experience a feeling or vibration in the chest or throat.<sup>19</sup> Neighbors of industrial wind turbines describe the distressing sensation of having to breathe in sync with a rhythmic pulsation from the turbines which is not necessarily audible, especially at night when trying to sleep.<sup>20</sup>

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<sup>18</sup> Milner, C. 2004. "Wind farms make people sick who live up to a mile away." *Sunday Telegraph*, 1-25-04; and personal communication from Dr. Harry.

<sup>19</sup> Moller, H, and CS Pedersen. 2004. "Hearing at low and infrasonic frequencies." *Noise & Health* 6 (23):37-57.

<sup>20</sup> See, for example, Ian McCausland, "Factual information about wind turbine noise," Report on wind turbine noise filed by residents of Upper Lachlan, Australia, August 9, 2005; Karen Ervin, Letter to

Preexisting migraine disorder is emerging as a risk factor for sensitivity to Wind Turbine Syndrome. Migraine is not just a bad headache, but rather a complex neurologic phenomenon that affects the visual, hearing, and balance systems and at times motor control and consciousness itself. Many people with migraine have increased sensitivity to noise and to motion – they get carsick as youngsters, seasick, or very sick on carnival rides. Migraine-associated vertigo (which is the spinning type of dizziness, often with nausea) is a described medical entity. Migraine occurs in 12% of Americans. It is a common, familial, inherited condition.

To keep our balance and feel steady in space, we use three types of input: from our eyes, from stretch receptors in joints and muscles, and from balance organs in the inner ear. At least two of these systems have to be working, and agreeing, to maintain balance. If the systems don't agree, as in seasickness or vertigo, one feels both ill and unsteady. Wind turbines impinge on this system via the visual disturbance of the moving blades and shadows, and, I hypothesize, by low-frequency air pressure waves impinging on the balance organs of the inner ear.

Older people are may also be at increased risk for effects because of age-related problems with the function of the inner ear or the nerves and parts of the brain which receive signals from the inner ear. Many healthy people age 57 to 91 have such problems: 5% have chronic dizziness, and 24% tinnitus (ringing in the ears).<sup>21</sup> Older people often sleep less soundly and are more likely to have their sleep disturbed by noise.

People with a previous history of noise-induced hearing loss may also be at risk for effects since, when people damage their hearing through too much exposure to loud machine noise or music, the balance organs in the inner ear may also be damaged. This damage accounts for the Tullio phenomenon, in which exposure to a loud noise causes loss of balance in people with noise-induced hearing loss.

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Calvin Luther Martin, March 2, 2005; Rodger Hutzell, Jr., Letter describing wind turbine noise, February 13, 2005; David E. Kabes & Crystal Smith, "Comments on Noise," and "Comments on Health," and "Comments on Shadow Flicker," and "Comments on Sleeplessness," Lincoln Township Wind Turbine Survey, University of Wisconsin Extension/Cooperative Extension, May 15, 2001; Linda Cooper, "Activist shares wind power concerns," *Pendleton Times (Franklin, W. Va.)*, March 3, 2005, p. 4; Misty Edgecomb, "'Whoosh' spells uneasy progress: Many say wind ... turbines are noise, nuisance," *Democrat & Chronicle (NY)*, December 4, 2005; Pam Foringer, "Our Fenner wind farm story," *Malone Telegram*, Autumn 2004; "Neighbors complain of wind farm nuisances," *Albuquerque Tribune*, April 28, 2006; Seth Robson, "Noisy turbine annoys neighbours," *Stuff.CO.NZ*, August 11, 2003; Nick Churchouse, "Manawatu residents say they are being 'driven stupid' by the sound," *Dominion Post (NZ)*, November 16, 2005; "Flurry of complaints after wind change," *TVNZ.CO. NZ*, July 24, 2005; David Brierley, Letter to the editor, *Plattsburgh Press Republican*, November 1, 2004; Tom Venesky, "Waymart facility troubles residents," *ZWIRE.COM (PA)*, May 16, 2005; Gwen Burkhardt, "Wind farm illness," *Western Mail (UK)*, June 6, 2005; Kathy Webb, "And the beat goes on ... and on and on," *Hawke's Bay Today (NZ)*, February 18, 2006; "Wind turbine meeting," *Newsquest Media Group Newspapers (UK)*, July 27, 2005; Eleanor Tillinghast, "The dark side of wind power," *Malone Telegram*, February 12, 2005; Donald F. Goetz, "Promises gone with wind," *Scranton Times Tribune (PA)*, February 7, 2004.

<sup>21</sup> Sataloff, J, et al. 1987. "Tinnitus and vertigo in healthy senior citizens without a history of noise exposure." *American Journal of Otolaryngology* 8:87-89.

Dizziness (specifically vertigo) and anxiety are neurologically linked phenomena,<sup>22</sup> so the anxiety and depression seen in association with other symptoms near wind installations are not necessarily an emotional response to symptoms, but may be a neurologically linked response to the balance disturbances themselves. Sleep deprivation also causes anxiety and depression.

I estimate the proportion of the population likely to be susceptible to the symptoms of Wind Turbine Syndrome to be in the range of 20-30%, including the 12% of the American population with migraine disorder, older people with age-related problems with inner ear function, children with disabilities (especially autism spectrum disorders, of which a common attribute is auditory oversensitivity and scrambling of incoming auditory signals), and some proportion of people with noise-induced hearing loss.

Industrial wind turbines produce low-frequency as well as audible noise. Dr. Oguz Soysal, Professor and Chairman of the Dept. of Physics and Engineering at Frostburg State University in Maryland, measured sound levels over half a mile away from the 20 turbine wind farm in Meyersdale, PA, in 2005. Audible (A-weighted) dB (decibel) levels were in the 50-60 range, and audible plus low-frequency (C-weighted) dB were in the 65-70 range.<sup>23</sup> A difference of 10 dB between A and C weighting represents a significant amount of low-frequency noise by World Health Organization standards.<sup>24</sup> Dr. van den Berg measured wind turbine sound spectra 750 m (0.47 mile) from a 17 turbine installation in 2002. His graphs reveal dB levels averaging 68-90 dB in the frequency range less than 10 Hz, and over 60 dB in the 10-100 Hz frequency range.<sup>25</sup> Van den Berg states in his dissertation, "I agreed with delegate Jørgen Jakobsen, who presented a paper on low frequency wind turbine noise [Jakobsen 2004], that **even though wind turbines did produce an appreciable amount of infrasound**, the level was so far below the average human hearing threshold that it could not be a large scale problem"<sup>26</sup> (emphasis added).

Dr. van den Berg shares the perception common in both the medical and acoustic fields that if you can't hear a noise, it can't affect you, but the world's leading researchers in the health effects of low-frequency noise exposure, Nuno Castelo Branco, MD (Head of the Scientific Board, Center for Human Performance, Alverca, Portugal, and Principal Investigator for the Vibroacoustic Disease Project supported by the Portuguese Ministry of Science and Technology) and Mariana Alvez-Pereira (a biomedical engineer at the New University of Lisbon) do not agree.

This international research group, centered in Portugal and including physicians from Poland, Russia, and the United States, has published extensively on the effects of low-frequency noise on parts of the body other than the ears, particularly on the cardiovascular, pulmonary, and neurologic systems.<sup>27</sup> The

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<sup>22</sup> Balaban, CD, and JF Thayer. 2001. "Neurological bases for balance-anxiety links." *Journal of Anxiety Disorders* 15:53-79; Furman & Jacob. 2001. "A clinical taxonomy of dizziness and anxiety in the otoneurological setting." *Journal of Anxiety Disorders* 15:9-26.

<sup>23</sup> Soysal, OA. 2005. "Acoustic noise generated by wind turbines." Presented to the Lycoming County, PA, Zoning Board 12-14-05. osoysal@frostburg.edu

<sup>24</sup> WHO, 1999. *Guidelines for Community Noise*.

<sup>25</sup> van den Berg, GP. 2004. "Do wind turbines produce significant low frequency sound levels?" 11<sup>th</sup> International meeting on low frequency noise & vibration and its control, Maastricht, The Netherlands, 30 August to 1 September.

<sup>26</sup> van den Berg, GP. 2006. "Sound of high winds," p. 4-5.

<sup>27</sup> Papers submitted are a selection from many: Branco M, and M Alves-Pereira. 2004. "Vibroacoustic disease." *Noise and Health* 6 (23):3-20; Alves-Pereira M. 1999. "Noise-induced extra-aural pathology: A review and commentary." *Aviation, Space, and Environmental Medicine* 70 (3 Pt 2):A7-21; Martinho Pimenta AJ et al. 1999. "Balance disturbances in individuals with vibroacoustic disease." *Aviation, Space, and Environmental Medicine* 70, no. 3, section II:A96-99; Marciniak W, et al. 1999.

research, ongoing since the late 1980's, includes clinical, pathological, and experimental (animal model) investigations. The entity these physicians and PhD's describe, called Vibroacoustic Disease (VAD), includes fibrosis (laying down of additional fibrous thickening in the form of collagen) in the cardiovascular and pulmonary systems and seizures and cognitive changes in the brain. The disease is caused by long-term exposure to low-frequency noise (less than 500 Hz), most of which cannot be heard.

Just as we cannot detect X rays (because our eyes are not sensitive to this frequency) yet can be harmed by them, so we can be harmed by non-audible noise (pressure waves in the air), though our ears are not sensitive to them. The mechanism of this harm is the differing resonance frequencies of different parts of the human body, especially the chest and skull. Air pressure (sound) waves of certain wavelengths resonate inside these walled spaces, setting up vibrations to which the body responds by reinforcing its softer tissues with extra collagen, causing such problems as thickening of the pericardium (membrane inside which the heart beats) and cardiac valves, fibrosis of the lungs, and proliferation of glial (supporting) cells in the brain.

Vibroacoustic disease has been studied mostly in aviation workers (including pilots, flight attendants, and technicians) but is also found in other industries and community settings. One of the researchers, Mariana Alves-Pereira, a biomedical engineer, has recently compared the noise spectrum of an environment known to predispose occupants to VAD – the cockpit of a commercial jetliner – to the noise spectra of other common community settings. She finds that a variety of community settings have the low-frequency noise potential for causing VAD. She has examined noise measurements of industrial wind turbines provided to her by Amanda Harry, MD, and her collaborating acoustician, Dr. Manley in England and found the low frequency noise intensities to be in the range which can cause VAD, especially given prolonged in-home and overnight exposures. Alves-Pereira has also examined graphs of wind turbine sound pressure levels vs. frequency measured by van den Berg and considers the noise intensities at the lower frequencies to be concerning with regard to their potential for causing VAD. She is aware of the symptomatology of the d'Entremont family in Pubnico, Nova Scotia, who had to move out of their home 1000 ft. from a wind turbine, and notes the similarity of their symptoms to those of people with pathologically proven VAD. Part of our research in progress is to provide Alves-Pereira with additional wind turbine noise measurements.

Alves-Pereira has helped clarify how neighbors and town governments should be handling noise measurements related to wind turbines. An A-weighted decibel measurement misses all the low-frequency noise, since A weighting is designed to mimic the frequency response pattern of the human ear and screens out low-frequency noise. Rather than a single measurement of loudness, noise needs to be characterized by measurement of linear (unweighted) decibel levels in 1/3 octave bands across the sound frequency spectrum. Measurements should be taken inside homes, since the longer wavelengths in low-frequency noise resonate within rooms, magnifying their loudness relative to the outside. Low frequency noise also comes through walls with less attenuation than the 15 dB decrease assumed for audible noise.

Noble Environmental's analysis of noise impacts in this DEIS was technically inadequate with regard to current knowledge. Specifically:

- Ambient noise levels were not measured (Appendix H, Section 3.4, p. 3-3). Assumed rural background noise levels are too high, especially for nighttime, the critical time for noise.
- Sound intensity decreases with distance in complex ways depending on the frequency of the sound (low-frequency sound carries further and passes obstructions with less attenuation), the stability of the atmosphere (turbine noise carries further in a stable atmosphere as occurs at night),

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“Echocardiographic evaluation of 485 aeronautical workers exposed to different noise environments.”  
*Aviation, Space, and Environmental Medicine* 70 (3 Pt 2):A46-53.

and the presence of reflective surfaces (increased propagation across open or frozen lakes or in the presence of a temperature inversion providing a reflective atmospheric layer). The discussion of sound propagation on p. 3-3 of Appendix H is oversimplified and allows for underestimation of the distances to which turbine noise is predicted to be propagated.

- Modeling of sound transmission did not look at the worst case scenario of the nighttime stable atmosphere, and thus underestimated the amount of noise likely to occur at various distances from the turbine installation at night, the critical time in terms of disturbance and health effects. Dr. Leventhall, the project acoustics consultant, is aware of these more accurate models of sound propagation from wind turbines but did not require them to be used in the modeling, showing negligence in his function as a technical consultant.
- The statement on p. 3-10, “Nor would use of alternative equipment further reduce sound levels,” may apply to equipment which can be purchased right now but not to equipment which may be designed in the near future to vary blade pitch during rotation as recommended by van den Berg to reduce or eliminate the nighttime thumping which develops in stable atmosphere.<sup>28</sup> There is a rush to build because the developer stands to make a lot of money, while from the point of view of community sustainability of this type of development it would make sense to wait a few years until equipment which solves the nighttime noise problem is available.
- The measurement of wind turbine noise at Fenner Wind Farm to screen for low frequency noise occurred over a 17 minute period during the day, though van den Berg points out that to eliminate the interference of wind blowing on the microphone (which can confuse the issue of whether there is low frequency noise) it is better to measure at night under conditions of atmospheric stability (little to no wind at ground level, substantial wind at turbine hub height).
- The acoustic weighting network (or lack of a weighting network) used for the Fenner noise sample was not specified.
- Dr. Leventhall, the Project consultant, dismisses the low-frequency noise documented in this measurement [note rise in dB level on the left, low-frequency sides of the graphs] as irrelevant for two reasons: 1) Interference with microphone noise, and 2) below range of human hearing. Point (1) could be corrected by measuring at another time of day/atmospheric condition, and (2) is contradicted by the research on vibroacoustic disease. Dr. Leventhall does not go so far as to say that there is no low-frequency noise, just that it is “not unusual,” in which he is accurate. Wind turbines in general produce low-frequency noise,<sup>29</sup> which is a problem elsewhere and is likely to be a problem here, too.

In summary, this Project has substantial potential for adverse noise effects on neighboring residents for which adequate studies have not been performed nor realistic mitigation proposed. Noise impact analysis was performed in a superficial fashion ignoring current knowledge so as to bias results in favor of the developers. Realistic mitigation with current technology means adequate setback. The Academy of Medicine of France has recommended a 1.5 km (0.96 mile) setback because of noise and health issues;<sup>30</sup> ours should be at least this. Delaying the Project until the technology is available for varying of blade pitch to increase capacity factor and decrease noise would also be appropriate.

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<sup>28</sup> van den Berg, GP. 2006. “Sound of high winds.”

<sup>29</sup> Ibid., p. 4-5

<sup>30</sup> Chouard, Claude-Henri. 2006. <<Le retentissement du fonctionnement des éoliennes sur la santé de l’homme>> (“The repercussions of wind turbine functioning on human health”), Academie Nationale de Medicine (French National Academy of Medicine).



## 6. Shadow flicker

When turning with the sun behind them, turbine blades cast moving shadows across the landscape and houses, creating a strobe effect within houses which can be difficult to block out. Some people get dizzy, lose their balance, or become nauseated when they see the movement of shadows or the movement of the huge blades themselves. As with car or sea sickness, such symptoms occur when the three organs of position and movement perception (the inner ear, eyes, and stretch receptors in muscles and joints) do not agree with each other: the eyes perceive movement while the ears and stretch receptors do not. People with a personal or family history of migraine, or migraine-associated phenomena such as car sickness or vertigo, are more susceptible to these effects. The strobe effect also has the potential, like other flashing lights, to trigger seizures in people with epilepsy.

In Lincoln Township, WI, two years after installation of 22 industrial wind turbines, 33% of residents 800 ft to ¼ mile from the turbines found shadows from the blades to be a problem, 40% ¼ to ½ mile away, 18% ½ to 1 mile away, and 3% 1 to 2 miles away.<sup>31</sup>

Seventy-one houses will be subjected to shadow flicker from the Ellenburg Project (DEIS p. 2-115). No mitigation measures were proposed, but rather indefinitely deferred: “Site-specific mitigation will be proposed for residences where turbine shadow impacts are predicted.” (DEIS p. 2-117) The only realistic form of mitigation is setback, which is inadequate under Ellenburg municipal law. From the Lincoln Township data, setback of at least one mile is needed.

As for air pollution laws, which set ambient air quality standards to protect the most sensitive individuals in the population, setback requirements from turbines need to protect the motion-sensitive people in the population, including while they are driving. Dizziness and spatial disorientation is hazardous while driving, to the driver and occupants of his or her car and to the occupants of other vehicles on the road at the same time.

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<sup>31</sup> Lincoln Township Wind Turbine Survey, Agricultural Resource Center, University of Wisconsin Extension/Cooperative Extension, May 16, 2001, by David E. Kabes & Crystal Smith. See tables at end of survey. See also Arlin Monfils, Supervisor, Lincoln Town Board, Letter dated 2-1-00 regarding the grim realities of the windpower project to his community.