

Wind Turbine Noise: Annoyance and Health



Zoning Board of
Appeals, McLean
County, Illinois

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Topic Outline

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1. Professional background
2. Relevant noise regulations, guidelines
3. Nuisance, annoyance, and adverse health effects (AHEs)*
4. Evidence that noise generated by industrial wind turbines leads to AHEs*

*See Punch, J.L. & James, R.R. (2016). Wind turbine noise and human health: a four-decade history of evidence that wind turbines pose risks (provided as handout).



Professional Background

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- Educational background
 - BA, Wake Forest University, Psychology
 - MS, Vanderbilt University, Hearing and Speech Sciences
 - PhD, Northwestern University, Audiology
- Clinically certified (ASHA), Audiology
- Retired from MSU faculty (2011)
- 50 years experience as audiology clinician, researcher, teacher, and administrator in academic, professional association, hospital, and industrial settings (last 27 years at MSU)
- Numerous research publications and conference presentations, including several recent papers on wind turbine noise
- Legal consultant as expert witness on matters of health in variety of cases in multiple states
- (Details in CV)

Nuisance, Annoyance, and Health

- A **nuisance** (dictionary definition) is the unreasonable, unwarranted, or unlawful use of one's property in a manner that either substantially interferes with the enjoyment or use of another individual's property, or an act or omission that obstructs, damages, or inconveniences the rights of the community.
- **Annoyance** (dictionary definition) refers to an unpleasant mental state characterized by irritation, frustration, distraction, or anger; if maintained, it can lead to a deterioration of health and well-being, and even to violence.
- **Health** (World Health Organization, or WHO, definition) is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” Scientific studies have shown wind turbine noise to be annoying to a substantial percentage of the population; the WHO considers noise-induced annoyance to lead to a deterioration of health.

Noise Guidelines: U.S. and International

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- **U. S. Environmental Protection Agency (EPA)**
 - Noise Control Act (1972) and Quiet Communities Act (1978)
 - ✦ Not updated
 - ✦ EPA directly links noise and stress-related illnesses and other adverse health effects (high blood pressure, speech interference, hearing loss, sleep disruption, and lost productivity)
 - ✦ Exposure to constant or high levels of noise can cause numerous AHEs
- **ISO 1996-1 and ANSI S12.9 Part 4 Standards**
 - Recommend 15-dB penalty for new noise sources in quiet, rural communities
 - Recommend reduction in allowable limits for noises with low-frequency content; not directly applicable to wind turbines
- **Hessler & Schomer (2013) have jointly recommended permissible levels of 40 dBA Leq or less for wind turbines to protect against substantial annoyance and AHEs.**

Noise Guidelines: World Health Organization Nighttime Noise Guidelines (2009)

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Leq(night- time, outside)

Health Effects

<30 dBA

No substantial biological effects

30-40 dBA

Affects sleep: body movements, awakening, self-reported sleep disturbance, arousals; vulnerable groups more susceptible

40-55 dBA

AHEs observed (with vulnerable groups more severely affected)



World Health Organization

The above levels are long-term averages and are not specific to wind turbine noise, which contains more low-frequency noise than most other industrial and transportation sources, on which these levels are based. Long-term average sound levels are correlated to cardiovascular dysfunction.

Sleep Disturbance: WHO Recommendations

- Short-term sounds specified as L_{Amax} are linked to sleep disturbance and AHEs. Sleep awakenings occur when levels exceed 40 dBA(f,max,outside).
- “Where the noise consists of a small number of discrete events, the A-weighted maximum level (L_{Amax}) will be a better indicator of the disturbance to sleep and other activities.” (Berglund et al, 1999)
- WHO (2009) mentions “ L_{Amax} ” 93 times; the term is essentially ignored by the wind industry.

Source: World Health Organization (2009). *Nighttime Noise Guidelines for Europe*.

Noise Regulations: Illinois Pollution Control Board (IPCB)

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Section 900.101 Definitions

Noise pollution: the emission of sound that unreasonably interferes with the enjoyment of life or with any lawful business or activity.

Section 900.102 Prohibition of Noise Pollution

- No person shall cause or allow the emission of sound beyond the boundaries of his property, as property is defined in Section 25 of the Illinois Environmental Protection Act, so as to cause noise pollution in Illinois, or so as to violate any provision of this Chapter.
- *The IPCB deals only with annoyance, not health effects, and emphasizes control of octave-band noise levels from 31.5 Hz to 8,000 Hz.*
- *Schomer states that IPCB numeric limits were never designed, and are not protective from, wind turbine noise.*
- *The IPCB does not consider infrasound, which is a major component of wind turbine noise.*

How do octave-band noise levels equate to dBA values?

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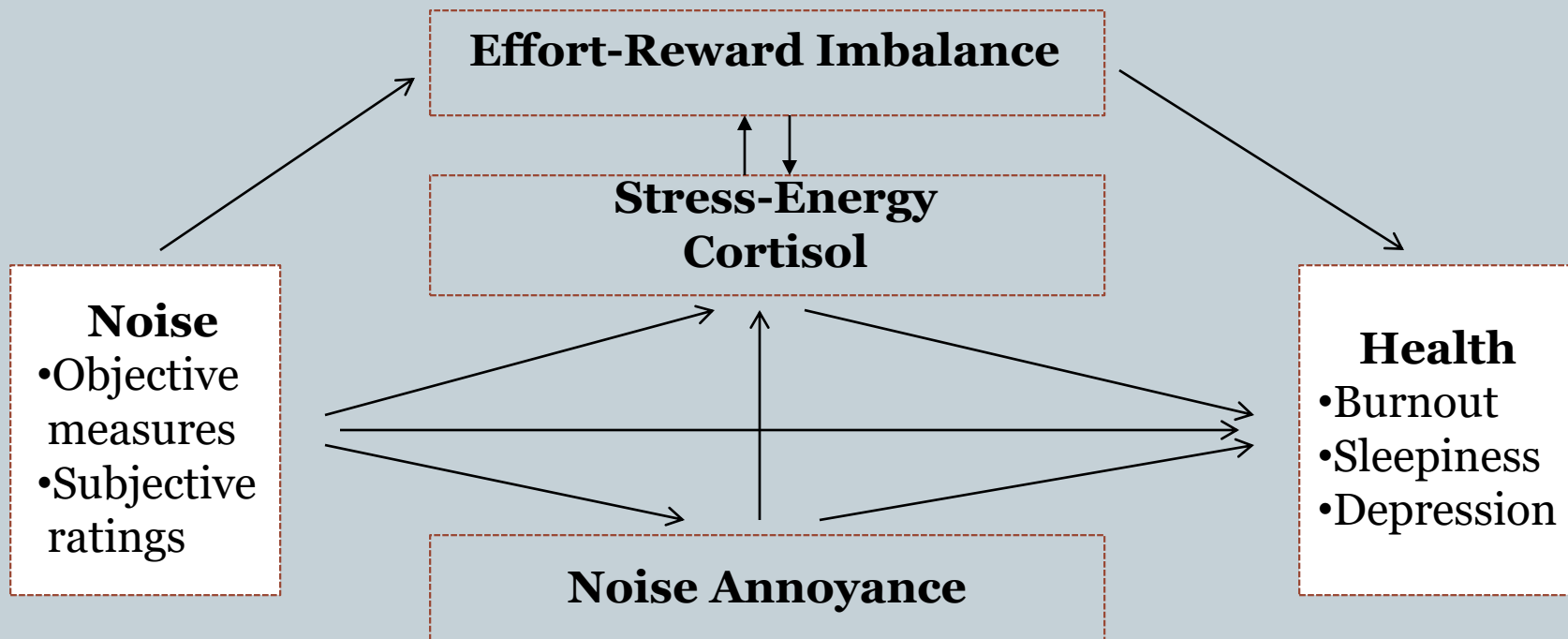
- Equivalent dBA values can be calculated from octave-band levels.
- The equivalent dBA level for IPCB's permissible octave-band data is **51.2 dBA**.
- Using octave-band levels at 1,000 Hz in DNV-GL's Table 5-1, several receptors can readily be identified where dBA levels will exceed 40 dBA.
- These values are higher than the **38-40 dBA** recommended by WHO and by Schomer and colleagues.

Noise Annoyance

- ***Industrial wind turbines produce pulsed, amplitude-modulated, tonal sounds that are unpredictable, uncontrollable (by receptors), and that disturb sleep.***
- *Amplitude-modulated* and *impulsive* noises are more easily perceived and more annoying than constant-level noise (Sutherland & Burke, 1979; Bradley, 1994).
- *Tonal sounds* are more annoying than sounds containing energy across a broad range of frequencies (Moorhouse et al, 2005; Bray, 2007; Swinbanks, 2012).
- Sounds that are *unpredictable* and *uncontrollable* increase noise annoyance (Geen & McCown, 1984; Hatfield et al, 2002).
- *Nighttime noise* is more annoying than daytime noise (Berger et al, 2015; Berglund et al, 1999; WHO, 2009).
- *Rural noise* is more annoying than urban noise (Pedersen & Waye, 2007).

Relationships Linking Annoyance and Health

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Sjödin et al (2012). Noise and stress effects on preschool personnel.
Noise & Health, 14, 166-178.

Research Linking Annoyance and Low-Frequency Noise from Wind Turbines

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- Kelley et al (1982)
- Kelley et al (1985)
- Kelley (1987)
- Leventhall (DEFRA, 2004)
- van den Berg (2004)
- Pedersen & Waye (2007)
- Pedersen et al (2009)
- Janssen et al (2010)
- Harrison (2011)
- Shepherd et al (2011)
- Walker et al (2012)
- Palmer (2013)
- Cooper (2014)
- Schomer et al (2015)
- Cooper & Chan (2017)

Annoyance from Wind Turbines

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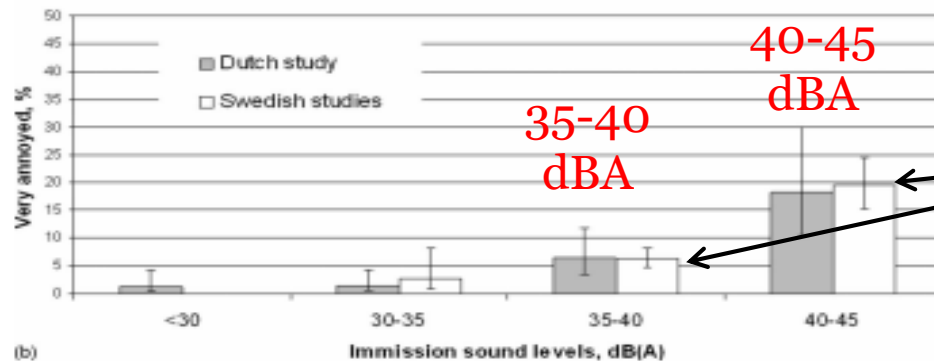
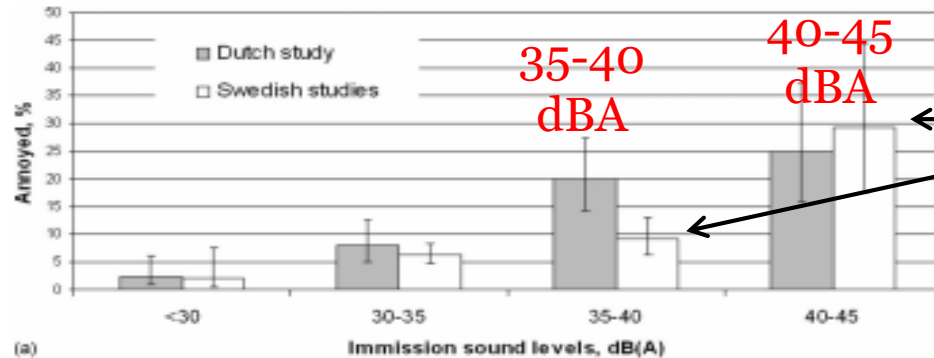
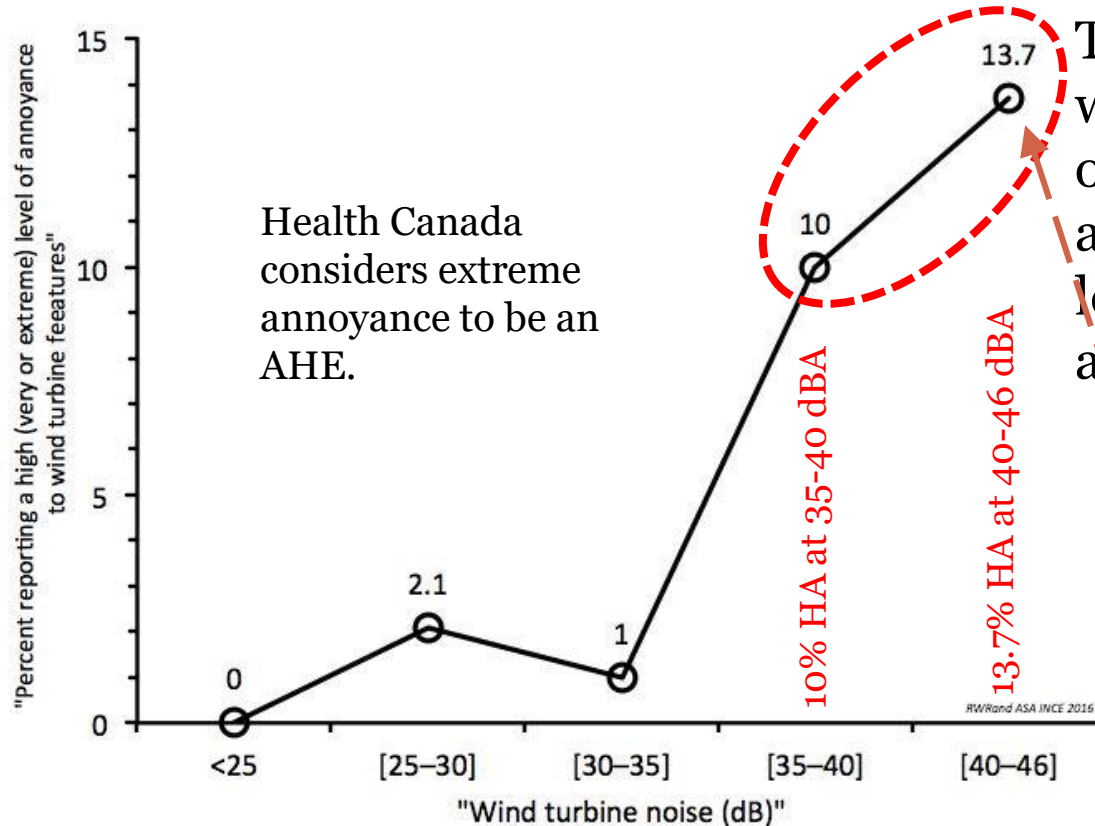


FIG. 2. Proportions of respondents annoyed (a) and very annoyed (b) by wind turbine noise outside their dwellings in four sound level intervals in the Dutch study (only respondents who did not benefit economically, n=586) and the Swedish studies (n=1095), with 95% confidence intervals.

Source: Pedersen, E. et al (2009). Response to noise from modern wind farms in The Netherlands. *Journal of the Acoustical Society of America*, 126, 634-643.

Annoyance from Wind Turbine Noise: Health Canada (2016)

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Health Canada considers extreme annoyance to be an AHE.

The proposed project will expose at least 1 out of 10 people in project area who are exposed to levels >35 dBA to high annoyance and AHEs.

Some receptors will be exposed to levels above 40 dBA, and to higher annoyance levels.

Data source: "Exposure to wind turbine noise: Perceptual responses and reported health effects", TABLE IV. Perception of community noise and related variables, Variable "Reporting a high (very or extreme) level of annoyance to wind turbine features: Noise", D.S. Michaud et al, Health Canada, J. Acoust. Soc. Am. 139 (3), March 2016.

World Health Organization (WHO): Health Risks of Noise



World Health Organization

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DIRECT EFFECTS

- Annoyance responses
- Hearing impairment
- Startle and defense reactions
- Ear pain, ear discomfort
- Speech interference
- Sleep disturbance
- Cardiovascular effects
- Performance reduction

INDIRECT EFFECTS

- Social handicap
- Reduced productivity
- Decreased performance in learning
- Absenteeism in the workplace and school
- Increased drug use
- Accidents

Common Complaints about Wind Turbine Noise

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1. Sleep disturbance
2. Headache
3. Dizziness, vertigo, unsteadiness, motion sickness, nausea
4. Tinnitus
5. Ear pressure or pain
6. External auditory canal sensation
7. Memory and concentration deficits
8. Irritability, anger
9. Fatigue, loss of motivation

Sleep Disturbance: Most Well-Documented Symptom*

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- Leventhall (2003)
- Minnesota Department of Health (2009)
- Pedersen (2009, 2011)
- Masotti & Hodgetts (2011)
- Shepherd & Billington (2011)
- Shepherd et al (2011)
- Thorne (2011, 2013)
- Krogh et al (2012)
- Nissenbaum et al (2012)
- Jeffery et al (2013)
- Nissenbaum (2013)
- Paller et al (2013)
- Palmer (2013)
- Taylor (2013)
- Kasprzak (2014)

*See Punch & James, 2016.

Research Linking Sleep Disturbance and Quality of Life (QoL) to Low-Frequency Noise

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- Waye et al (2003); LF/traffic noise and cortisol levels
- van den Berg (2004)*
- Pedersen & Waye (2007)*
- Pierpont (2009)*
- World Health Organization (2009)
- Hanning (2010)*
- Pedersen (2011)*
- Shepherd et al (2011)*
- Nissenbaum et al (2012)*
- Jeffery et al (2013)*
- Paller et al (2013)*

*Study dealt specifically with low-frequency noise from wind turbines.

Adverse Effects of Sleep Disturbance on Health: National Institutes of Health (NIH)

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- Hypertension
- Negative effects on memory, temperament, heart rate, heart health, and hormones
- Reduced capacity to learn new information, concentrate, and recall information
- Lowered immunity to disease, weight gain; negative effects on childhood growth and development, muscle growth and tissue repair in children and adults
- Negative effects on puberty and fertility



Lab test confirms that inaudible wind turbine sound causes adverse impacts on people

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- Inaudible sound pulsations occurring at infrasonic rates emitted by wind turbines have been shown to cause perceptible sensations in a landmark laboratory experiment by Steven Cooper and Chris Chan, presented at the 2017 Acoustical Society of America Conference in New Orleans.
- Wind turbine sound emissions consisting of dynamically modulated pressure pulsations at infrasound rates synchronized to the blade pass frequency have been shown to cause sensations and other adverse effects under controlled, visually blinded laboratory conditions.
- Alternative explanations, such as the so-called “Nocebo Effect,” are no longer acceptable as counter arguments because direct cause and effect has been established.

How can sounds we can't hear hurt us?

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- We know that things we can't see, touch, taste, or smell can definitely hurt us. Why, then, can't we believe that things we can't hear can also hurt us? (Salt & Lichtenhan, 2011)
- Cooper's research has shown, under controlled laboratory conditions, that wind turbine noise sound emissions cause identifiable sensations and other adverse effects in some people.
- These effects are consistent with complaints of people who live near wind turbine projects similar to the proposed Bright Stalk Wind Farm.



Conclusions

1. Annoyance can lead to health issues, based on the WHO (2009) definition of health.
2. Anecdotal and peer-reviewed scientific studies demonstrate direct and indirect associations between audible and inaudible wind turbine noise and a variety of AHEs.
3. Infrasound, at levels below the threshold of audibility, has been shown to relate directly to negative sensations and AHEs (i.e., What we can't hear can hurt us).
4. The IPCB regulations fail to account for infrasound, given their lack of attention to frequencies below 31.5 Hz.
5. The IPCB regulations do not adequately protect the health and well-being of community residents, whether participating or non-participating.
6. A preliminary analysis of the octave-band levels modeled by DNV-GL for the Bright Stalk project will undoubtedly expose a number of McLean County residents to extreme annoyance and AHEs.