



Sound, Noise & Wind Turbines

**A Presentation to the
Lincoln-Lancaster County
Planning Commission**

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The Existing County Zoning Resolution 13.018 Commercial Wind Energy Conversion Systems Regulates Noise

- 35 dB(A) at all times measured at the property line
- A noise study may be required

Proposed Noise Limits in the Text Amendment

13.018 Commercial Wind Energy Conversion System (CWECS).

- 40 dB(A) measured as a 10 min Leq during daytime hours (7 am to 10 pm)
 - Or 3 dB(A) above background noise level (9 hour Leq)
- 37 dB(A) measured as a 10 min Leq at night
 - Or 3 dB(A) above background noise level (15 hour Leq)
- **Measured at the dwelling unit**

Proposed Text Amendment

13.018 Commercial Wind Energy Conversion System (CWECS).

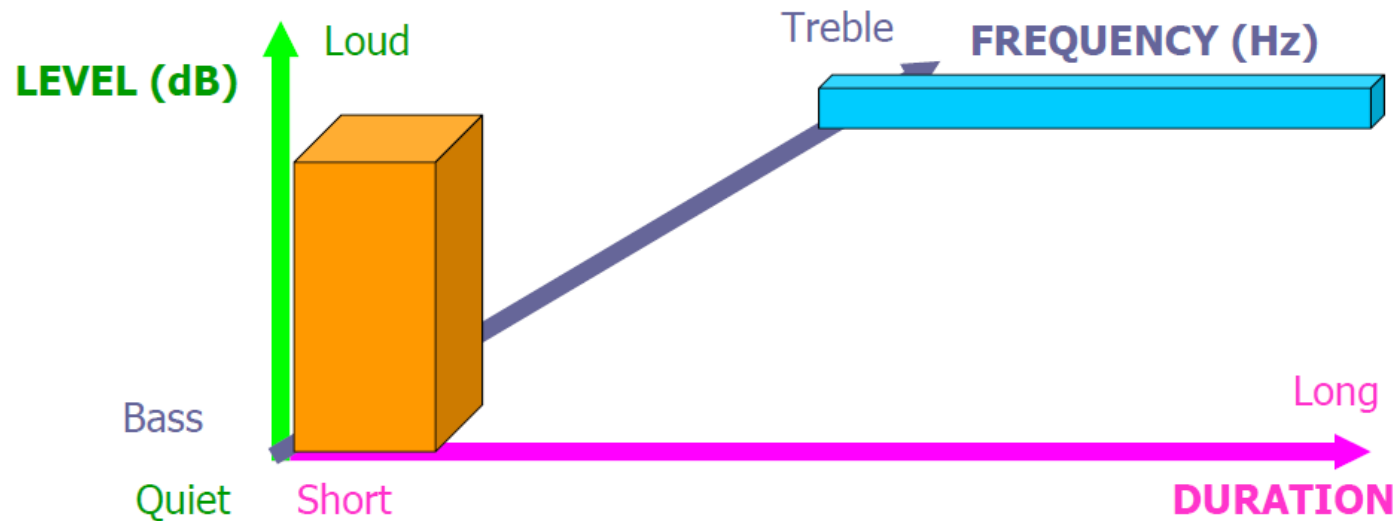
- Requires a noise study prior to construction
- Noise complaints referred to County Board to determine appropriate action

Definitions

- Sound Level: the “strength” of a sound. It is measured in Decibels (dB). (how loud)
- dB(A): measurement that focuses on frequencies heard by the human ear.
- Frequency: the “pitch” of a sound. It is measured in Hertz (Hz). (how low or high)
- Leq: average noise level over a specified period of time.

Looking at sound in 3-D

- The **DURATION** can be expressed in seconds, minutes, or even hours
- The **LEVEL** is expressed in **decibels (dB)**
- The **FREQUENCY** is expressed in **Hertz (Hz)**



Definition of Annoyance

6.1 ANNOYANCE

- Noise annoyance can be defined as “a feeling of displeasure evoked by a noise” and “any feeling of resentment, displeasure, discomfort and irritation occurring when a noise intrudes into someone’s thoughts and moods or interferes with activity” (Passchier-Vermeer & Passchier, 2006).

Annoyance is More Than Just Irritation

- Impacts may include physiological responses, central nervous system reactions, and biochemical changes. (2)
- Physiological reactions to sound annoyance include increased heart rate and increased blood pressure which, among others, may lead to hypertension. (1) (2) Hearing impairment, such as increased hearing threshold, and tinnitus are considered as another possible consequence of sound annoyance.(2) (3)

1) T. Lindvall & E. P. Radford. Measurement of annoyance due to exposure to environmental factors(1973). Academic Press Inc.

2) World Health Organisation(WHO). Burden of disease from environmental noise(2011)

3) W. Passchier-Vermeer & W.F. Passchier. Noise Exposure and public health (2000). Environmental Health Perspectives, Vol 108, Supplement 1

Sound, Noise, and Annoyance

- Annoyance is subjective, but can be measured objectively
- Annoyance is **correlated** to many factors
 - The level of the sound (how loud)
 - The frequency content of the sound (low or high)
 - Opinions about the source of sound
 - Control over the source of sound
 - Ability to get away from the sound
 - And **many** other factors...

What do we know about the **sound** generated by wind turbines?

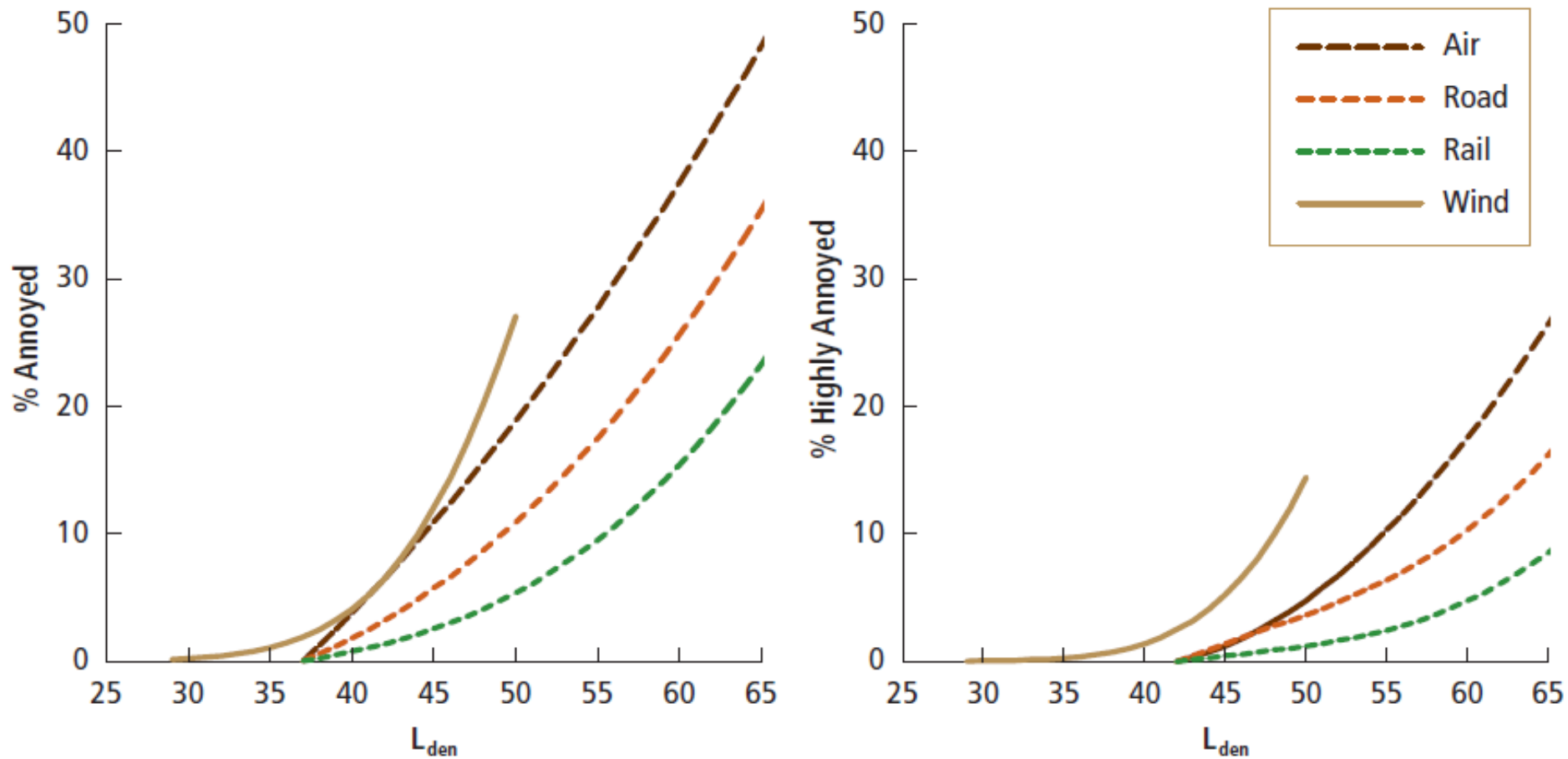
- The sound is fairly complex:
 - The blades slicing through the air can create a **‘swish’** sound with a midrange & high frequencies.
- The lack of smooth airflow can create some low frequency **‘thump’** sounds that also **‘pulses’** the higher frequencies.
- The inside the turbine nacelle can create some **‘whirr’** sounds with bass and midrange frequencies.
- All of the above tend to increase with wind speed.
- The transformer sub-station can generate some **‘hum’** tones as well as sounds from associated cooling systems.

What do we know about the **sound** generated by wind farms? (cont.)

- The sound changes with **distance** (it gets lower)
 - The midrange and high frequency components tend to fall below the range of audibility fairly rapidly.
 - The low frequency (bass or below) components can still be noticed at much greater distances.
- Sound absorption of the **ground** is not a factor for low frequency sounds
- **Multiple turbines** can produce modulation effects in the sound
- Wind turbines also generate sound (acoustic waves) that are below human hearing range (**infrasound**).
- dB(A) sound levels correlate with infra-sound levels (Health Canada, Wind Turbine Noise and Health Study, 2015)

What do we know about the noise associated with wind turbines?

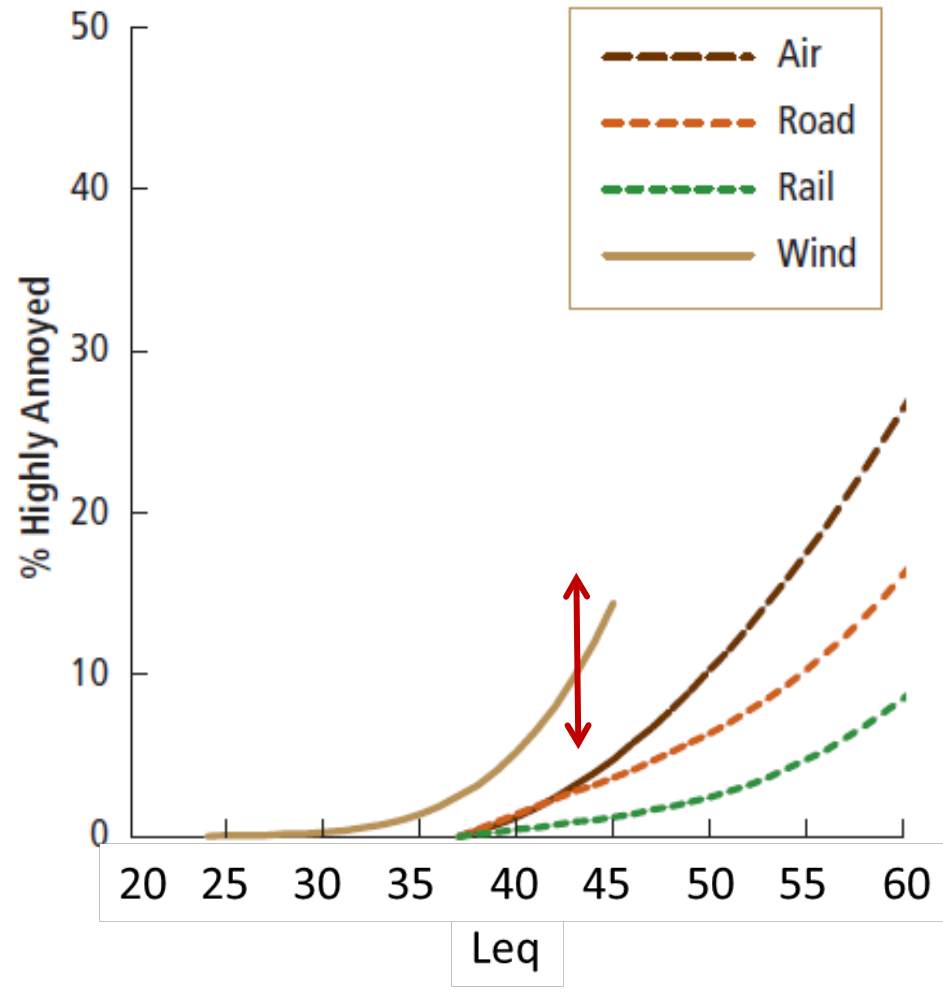
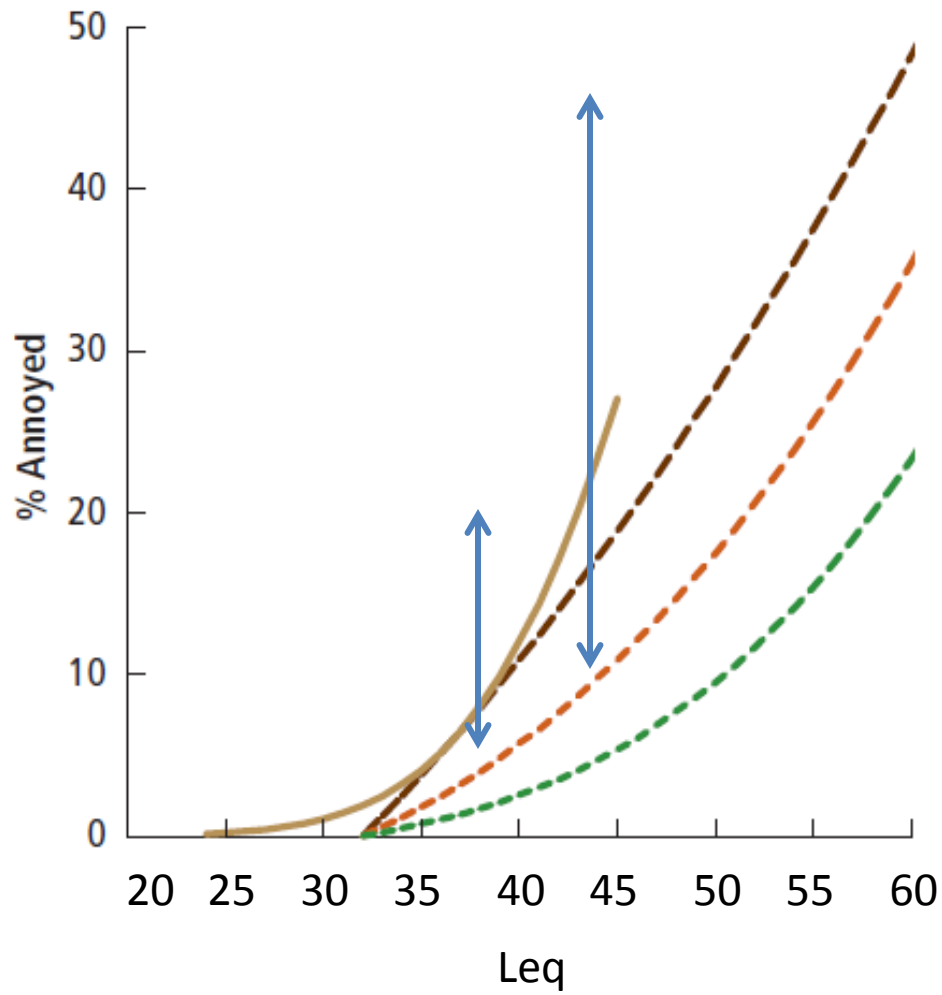
- Most noise complaints are associated with the **‘swishing pulses’**.
 - Modulation and tonality
- Many noise complaints are associated with **night-time** operations.
- No (or extremely few) noise complaints are about how loud wind turbine noise is
 - It’s not how loud, it’s how annoying.



Reproduced with permission from Janssen, S. A., Vos, H., Eisses, A. R., & Pedersen, E. (2011). A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources. *The Journal of the Acoustical Society of America*, 130, 3746-3753. Copyright 2015, Acoustical Society of America

Figure 6.1

Comparison of Annoyance Due to Wind Turbine Noise and Transportation Noise



LLCHD estimates of Annoyance with Leq in dB(A) based on Canadian Academies study Figure 6.1 using a 5dB conversion factor for Lden to Leq

- Range estimates \updownarrow from Pedersen (2011)
- Range estimate \updownarrow from Health Canada (2015) of very or extremely annoyed



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