13.048. Commercial Wind Energy Conversion System (CWECS)

(Resolution No. R150061, November 24, 2015; Resolution No. R110022, March 29, 2011)

- A Commercial Wind Energy Conversion System (CWECS) may be allowed in the AG District by special permit under the conditions listed below:

13.048. Commercial Wind Energy Conversion System (CWECS)

- a. In cases where CWECS wind turbines are part of a unified plan, parcels which are separated from one another only by the presence of public right-of-way may be combined into one special permit application. When a special permit covers multiple premises, the lease or easement holder may sign the application rather than the lot owner.

13.048. Commercial Wind Energy Conversion System (CWECS)

- b. Turbines shall meet all FAA requirements, including but not limited to lighting and radar interference issues. Strobe lighting shall be avoided if alternative lighting is allowed. Color and finish shall be white, gray or another nonobtrusive, non-reflective finish. There shall be no advertising, logo, or other symbols painted on the turbine other than those required by the FAA or other governing body. Each turbine shall have onsite a name plate which is clearly legible from the public right-of-way and contains contact information of the operator of the wind facility.

13.048. Commercial Wind Energy Conversion System (CWECS)

- c. Each application shall have a decommissioning plan outlining the means, procedures and cost of removing the turbine (s) and all related supporting infrastructure and a bond or equivalent enforceable resource to guarantee removal and restoration upon discontinuance, decommissioning or abandonment. Each tower shall be removed within one year of decommissioning or revocation of the special permit. Upon removal of the tower, there shall be four feet of soil between the ground level and former tower's cement base.

13.048. Commercial Wind Energy Conversion System (CWECS)

- d. Any proposed turbine which is within half mile of any non-participating dwelling shall provide shadow flicker modeling data showing the expected effect of shadow flicker on non-participating properties. Shadow flicker shall not fall upon any non-participating dwelling, or other building which is occupied by humans, for more than a total of 30 hours per any calendar year. If shadow flicker exceeds these limits, measures shall be taken to reduce the effects of shadow flicker on buildings, which may include shutting the turbine down during periods of shadow flicker. If a turbine violates this standard on a non-participating dwelling unit, constructed after the turbine is approved, then the turbine becomes a non-conforming use.

13.048. Commercial Wind Energy Conversion System (CWECS)

- e. Construction and operation shall not adversely impact identified State or Federal threatened or endangered species such as saline wetlands, or rare natural resources such as native prairie and grasslands.

13.048. Commercial Wind Energy Conversion System (CWECS)

- f. No turbine shall obstruct or impair an identified view corridor or scenic vista of public value, as mapped on the Capitol View Corridors map in the Lincoln/ Lancaster County Comprehensive Plan. The views from prominent environmental areas, such as Nine Mile Prairie and Spring Creek Prairie, shall also be protected from adverse visual or noise impacts. Any application which, upon initial review, poses a possible impact to these views will be required to be relocated or provide view shed mapping, and visual simulations from key observation points for review.

13.048. Commercial Wind Energy Conversion System (CWECS)

- g. Setbacks to the turbine base:
  - 1. For the purposes of this section, "turbine height" shall be equal to hub height plus the rotor radius.
  - 2. For a nonparticipating lot, the setback shall be 2 times the turbine height measured to the property line, or 3 ½ times the turbine height, measured to the closest exterior wall of the dwelling unit, whichever is greater, but at a minimum 1,000 feet to the property line.
  - 3. For participating dwelling units, the setback shall be 2 times the turbine height measured to the closest exterior wall of the dwelling.
  - 4. The setback to any public right-of-way or private roadway shall be no less than the turbine height.
  - 5. Setbacks to the external boundary of the special permit area shall be no less than as stated above, except that the owner of the adjacent property may sign an agreement allowing that setback to be reduced to the rotor radius plus the setback of the zoning district.

13.048. Commercial Wind Energy Conversion System (CWECS)

- h. The turbine(s) shall not impact a non-participating lot, (vacant or occupied; of any size), to the extent that, because of the location of turbine(s), the lot owner is left with less than 3 acres of land outside of the CWECS setbacks and or the noise impact area in Section (i) below, unless they are part of an agreement with the CWECS owner/operator.

13.048. Commercial Wind Energy Conversion System (CWECS)

i. Noise: No CWECS or combination of CWECS turbine(s) shall be located as to cause an exceedance of the following as measured at the closest exterior wall of any dwelling located on the property. If a turbine violates a noise standard on a dwelling unit, constructed after the turbine is approved, then the turbine becomes a nonconforming use. For both participating and nonparticipating properties:

- **1. From the hours of 7 am to 10 pm:**
  - i. Forty (40) dBA maximum 10 minute Leq or;
  - ii. Three (3) dBA maximum 10 minute Leq above background level as determined by a pre-construction noise study. The background level shall be a Leq measured over a representative 15 hour period.
- **2. From the hours of 10 pm to 7 am:**
  - i. Thirty-seven (37) dBA maximum 10 minute Leq or;
  - ii. Three (3) dBA maximum 10 minute Leq above background level as determined by a pre-construction noise study. The background level shall be a Leq measured over a representative 9 hour period.

13.048. Commercial Wind Energy Conversion System (CWECS)

- j. A professional preconstruction noise study shall be conducted which includes all property within one mile of a tower support base. The protocol and methodology for such studies shall be submitted to the Lincoln-Lancaster County Health Department for review and approval. Such studies shall include noise modeling for all four seasons and include typical and worst case scenarios for noise propagation. The complete results and full study report shall be submitted to the Lincoln-Lancaster County Health Department for review.

13.048. Commercial Wind Energy Conversion System (CWECS)

- k. Prior to the commencement of construction of any turbine, pre-construction noise monitoring may be conducted to determine ambient sound levels in accordance with procedures acceptable to the Lincoln-Lancaster County Health Department.

13.048. Commercial Wind Energy Conversion System (CWECS)

I. Prior to the commencement of construction of any turbine, the applicant shall enter into an agreement with the County Engineer regarding use of County roads during construction.

13.048. Commercial Wind Energy Conversion System (CWECS)

- m. At the discretion of the County Board, post-construction noise level measurements may be required to be performed in accordance with procedures acceptable to the Lincoln-Lancaster County Health Department.

13.048. Commercial Wind Energy Conversion System (CWECS)

- n. All noise complaints regarding the operation of any CWECS shall be referred to the County Board. The County Board shall determine if noise monitoring shall be required to determine whether a violation has occurred.

Sound, Noise & Wind Turbines

A Presentation to the Lincoln/Lancaster Planning Commission

Chris Schroeder, MCRP
Environmental Health Supervisor

October 24, 2018

LINCOLN LANCASTER COUNTY HEALTH DEPARTMENT

Definitions

- Sound is a form of energy that is transmitted by pressure variations which the human ear can detect.

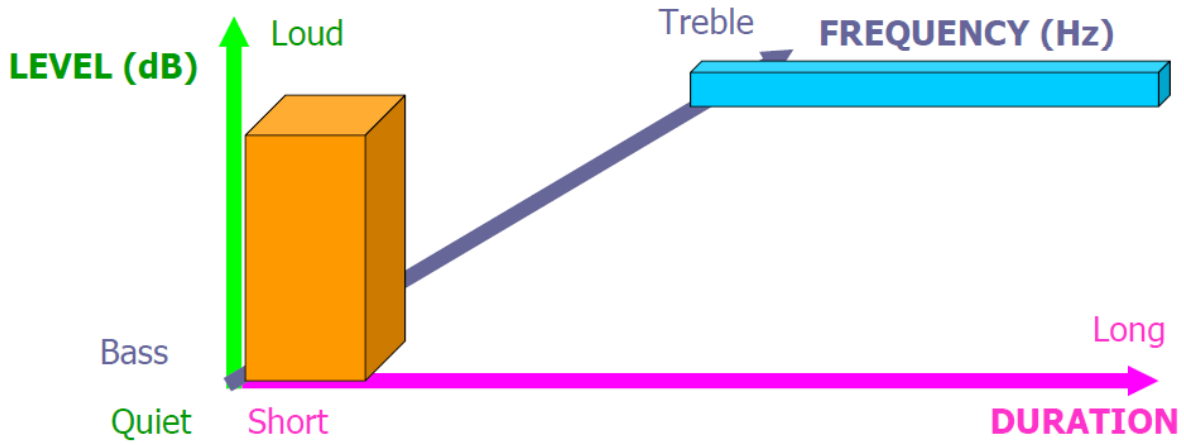
- Noise is unwanted sound - perception

Definitions

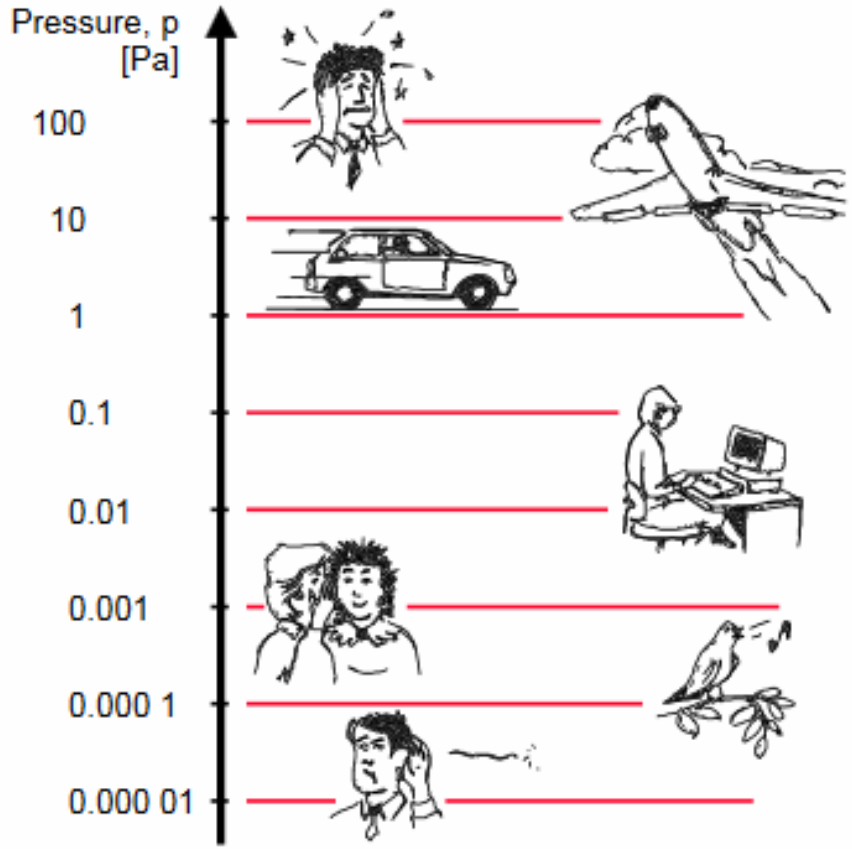
- Sound Level: the "strength" of a sound. It is measured in Decibels (dB). (how loud)
- dB(A): measurement that focuses on frequencies heard by the human ear.
- Frequency: the "pitch" of a sound. It is measured in Hertz (Hz). (how low or high)
- Leq: average noise level over a specified period of time.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

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)**



Range of Sound Pressure



Sound/ Noise Metrics

Decibels

- Measure sound pressure level (SPL)/ Logarithmic scale
- The human ear responds not linearly but logarithmically to sound pressure
- Two (2) times sound energy - increase of 3 dB
- Ten (10) times sound energy – increase of 10 dB
- One-hundred (100) times sound energy – increase of 20 dB
- One-thousand (1000) times sound energy – increase of 30 dB

Perception of dBs

Change in Sound Level (dB)	Change in Perceived Loudness
3	Just perceptible
5	Noticeable difference
10	Twice (or 1/2) as loud
15	Large change
20	Four times (or 1/4) as loud

Sound/ Noise Metrics

Frequency weighting

- A weighted – dB(A) – most common used in noise measurement – audible frequencies – human hearing
- C weighted – dB(C) - can be used for low frequency noise measurements
- G weighted – dB(G) – can be used for infrasound measurements

Sound/ Noise Metrics

Noise Measurements

- *Leq* - Equivalent continuous sound pressure level. A measure of the average sound pressure level during a period of time in dB
- Lden – level day, evening, night – 24 hr. measurement adds dB penalties to evening and night measurements
- L_{A10} - The noise level exceeded for 10% of the measurement period with 'A' frequency weighting calculated by statistical analysis
- L_{A90} - The noise level exceeded for 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis

https://www.cirrusresearch.co.uk/library/glossary-terminology/

Why do some sounds sound louder than others?

- Our hearing system does no have the same **sensitivity** at all frequencies
- The frequencies contained in the sound define its **'quality'**
- Sounds that contain few frequencies are very **'tonal'** and they are easy for the brain to focus on because they are very simple sounds.
- Sounds that contain a lot of frequencies are very **'neutral'** and the brain cannot identify the individual frequencies.
- Sounds that contain a very broad range of frequencies can effectively **'mask'** other sounds with *higher* frequencies.

What do we know about the sound generated by wind farms? (I)

- 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 elements inside the 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? (II)

- The sound changes with **distance**
  - The midrange and high frequency components tend to fall below the range of audibility fairly rapidly.
  - The low frequency (bass) components can still be noticeable at much greater distances.
- The absorption of the **ground** is not a factor for low frequency sounds
- **Multiple turbines** can yield to modulation effects in the sound at some locations.
- Turbines can influence each other when it comes to the 'smoothness' of the air surrounding them.
- Wind turbines generate acoustic waves that are below the audible range (**infrasound**).

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

- Most complaints are associated with the **'swishing pulses'.**
- Many complaints are associated with **night-time** operations.
- **Infrasound-related** complaints are problematic to assess.
  - Interfering factors
  - Equipment limitations
  - Incorrect test methodology
- It is difficult to come up with an effective **regulation** for it.
  - Weather and other factors vary between time of complaint and time of inspection.
  - Implementing **Best Practices** can be expensive.

Does sound becomes noise when it's intermittent or modulated?

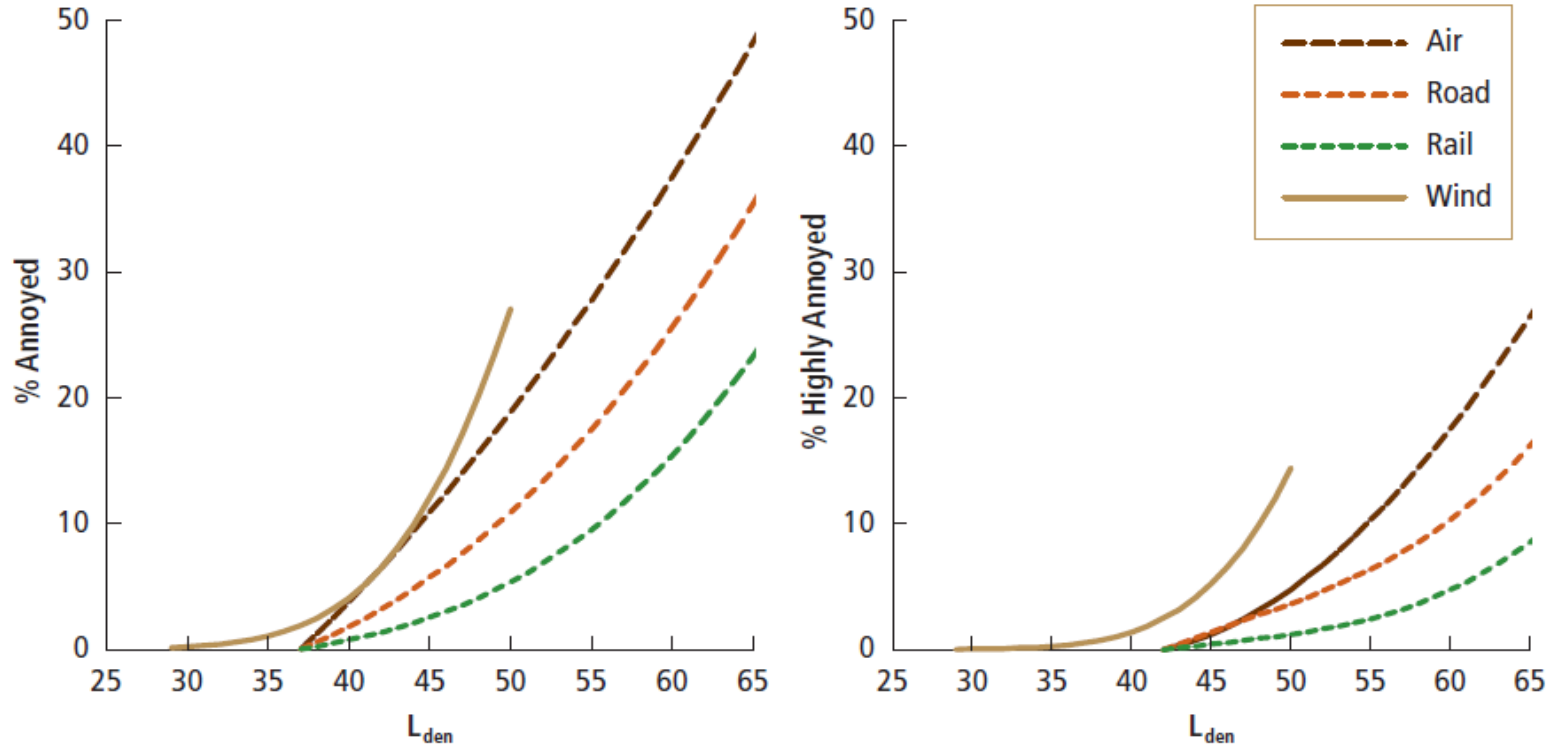
- Music is intermittent and modulated.
  - What's music to some is noise to others.
- Annoyance is **correlated** to many factors when it comes to noise…
  - The level of the sound,
  - The frequency content of the sound,
  - Opinions about the source of sound,
  - Control about the source of sound,
  - Ability to get away from the sound,
  - And **many** other factors…

WTN > Annoyance > Health

ANNOYANCE:

Noise annoyance can be defined as "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).

Council of Canadian Academies, 2015. Understanding the Evidence: Wind Turbine Noise. Ottawa(ON): The Expert Panel On Wind Turbine Noise and Human Health, Council of Canadian



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

Council of Canadian Academies, 2015. Understanding the Evidence: Wind Turbine Noise. Ottawa(ON): The Expert Panel On Wind Turbine Noise and Human Health, Council of Canadian

WTN > Annoyance > Health

- Almost all community noise codes are built around:
  - potential for hearing loss
  - projected level of annoyance (enjoyment of property)

- Annoyance is subjective, but can be measured objectively
  - Percent of people are annoyed
  - Physiological, neurological, biochemical responses

WTN > Annoyance > Health

- 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

In 2015, Health reviewed Four Key Studies on Wind Turbine Noise and Health

- 2012 - Massachusetts DEP/DH Expert Panel Review Study
- 2014 - Schmidt & Klokker; Health Effects Related to Wind Turbine Noise Exposure: A Systematic Review
- 2015 – Canadian Health Academies Expert Panel Review Study
- 2015 – Health Canada – Wind Turbine Noise and Health Epidemiological Study

2014 Schmidt & Klokker Health Effects Related to Wind Turbine Noise Exposure: A Systematic Review

- Evidence of a dose response relationship between Wind Turbine Noise and annoyance
- Evidence of a dose response relationship between Wind Turbine Noise and self-reported sleep disturbance
- Tolerable level around 35 dBA Leq

UNDERSTANDING THE EVIDENCE: WIND TURBINE NOISE

The Expert Panel on Wind Turbine Noise and Human Health

Council of Canadian Academies
Conseil des académies canadiennes

Science Advice in the Public Interest

Purpose: assess the scientific evidence on the question of wind turbine noise and human health in order to provide a foundation of knowledge to support governments, policy-makers, communities, and the industry.

Canadian Academies Conclusions

- Wind turbine noise is associated with annoyance
- Annoyance has many factors, not all of which are related to noise
- Annoyance can lead to sleep disturbance
- Sleep Disturbance can lead to annoyance
- Both Annoyance and Sleep Disturbance are associated with higher stress levels, which are associated with some health outcomes

Council of Canadian Academies, 2015. Understanding the Evidence: Wind Turbine Noise. Ottawa(ON): The Expert Panel On Wind Turbine Noise and Human Health, Council of Canadian Academies.

Health Canada Study 2015

- One of the largest epidemiological studies of wind turbine noise and potential health impacts
- 1238 residences were grouped into categories based on calculated 24 hour outdoor A-weighted Wind Turbine Noise levels:
  - less than 25 dB;
  - 25 to 30dB;
  - 30 to 35dB;
  - 35 to 40dB;
  - >40 dB*
- Everyone in the study was exposed to WTN.

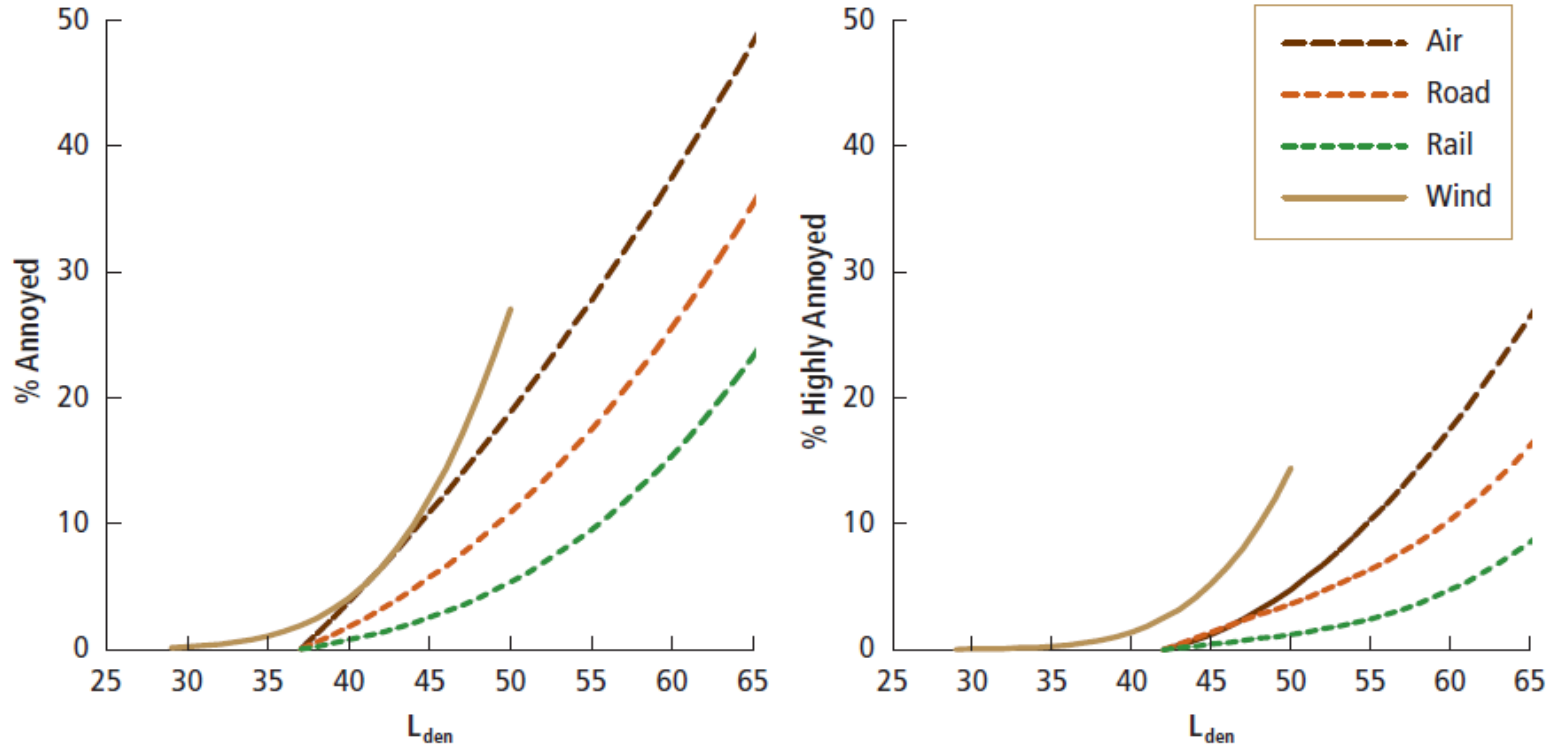
* Only 6 residences were above 45 dB.

Health Canada Study 2015

Community Annoyance Findings

- A statistically significant increase in annoyance was found when WTN levels exceeded 35 dBA.
- In Ontario, of those exposed to > 40dBA, 16.5% reported being *very or highly annoyed*
- Annoyance was significantly lower among the 110 participants who received personal benefit

Note: *Annoyance* was defined as a long-term response (approximately 12 months) of being "very or extremely annoyed" as determined by means of surveys.



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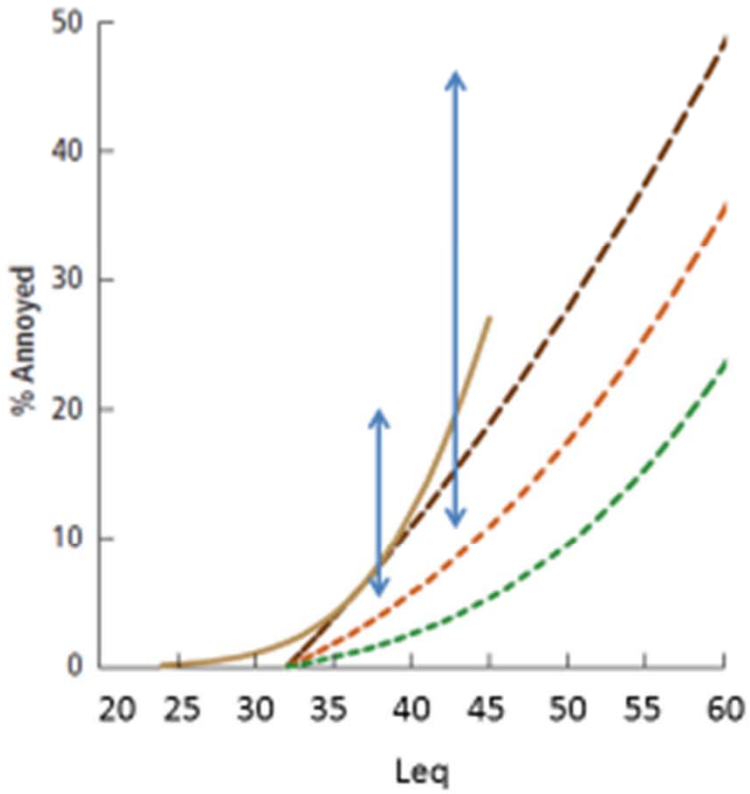

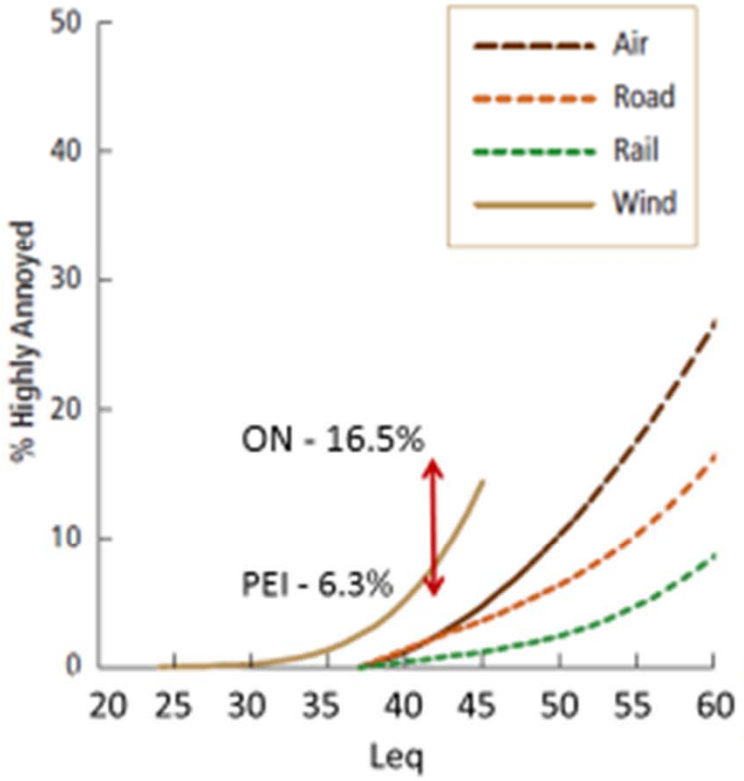

LLCHD estimates of Annoyance with Leq in dB(A) based on Canadian Academies study Figure 6.1 using a 5dB conversion factor for Lden to Leq

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

2015 LLCHD Conclusions

- The percent of annoyed people
  - Varies by site
  - Increases with louder dB(A)
  - Is associated with wind turbines being present
- Annoyance is a health issue – sleep disturbance and measurable stress responses (cortisol and blood pressure)
- 35 to 40 dB(A) Leq appears to be acceptable for >80% of people near wind turbines

In Progress

- Review NextEra/Ollson "white paper" and referenced studies
- Review additional information already requested from NextEra/Ollson
- Review other pertinent studies on wind turbine noise and health impacts

LINCOLN LANCASTER COUNTY HEALTH DEPARTMENT