Proposed Text Amendment to CR 13.018 Commercial Wind Energy Conversion Systems

Health-based Noise Standard

A Presentation to the Lincoln-Lancaster County Planning Commission

Scott E. Holmes, MS, REHS
Manager, Environmental Public Health

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Existing County 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

- 40 dB(A) measured as a 10 min Leq between 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 (10 pm to 7 am)
  - 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 action

Definition of Terms

Sound vs. Noise

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

Definition of Terms

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).
- 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

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.

Noise Annoyance Causes Health Impacts

- Physiological reactions to sound annoyance include increased heart rate and increased blood pressure which, among others, may lead to hypertension. (1) (2)

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)

Annoyance can be Measured Objectively

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

- Annoyance is subjective, but <u>can be measured objectively</u>
  - Percent of people are annoyed
  - Measurable physiological (heart rate, blood pressure), neurological (cortical stimulation), and biochemical responses (cortisol levels)

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

- The sound is 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 and higher frequency **'pulses'**
- 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)
- **Multiple turbines** can produce modulation effects in the sound
- Wind turbines generate **infrasound** below human hearing range (<20 hz)
- 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
- Most noise complaints are associated with **night-time** operations.
- Fewer noise complaints are about how loud wind turbine noise is

Wind Turbine Noise - ***It's Unique***

- It is different than other types of environmental noise, such as traffic, railway, or airport noise
- It is not comparable to ……
- It has unique characteristics, including amplitude modulation and tonality

Studies on Wind Turbine Noise and Health

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

2012 Mass DEP/DH Panel Recommendations

Land Use	Sound Pressure Levels (dBs) Nighttime levels
Industrial	70
Commercial	50
Villages, mixed usage	45
Sparsely populated areas, 8m/s wind	44
Sparsely populated areas, 6m/s wind	42
Residential areas, 8m/s wind	39
Residential areas, 6m/s wind	37

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

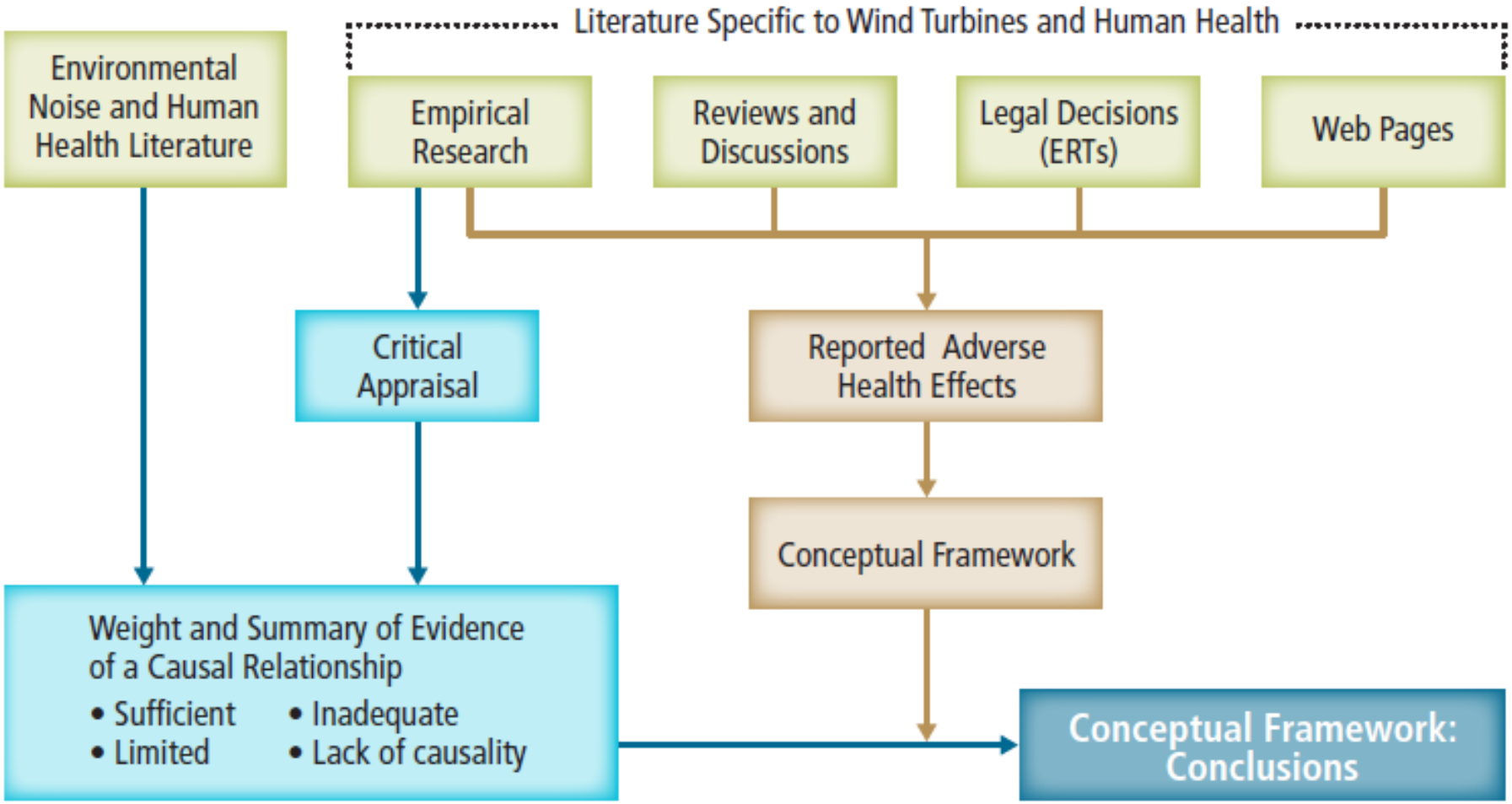

Figure 5.1

Evidence Assessment Process

Note: brown lines = potential health outcomes and mechanisms; blue lines = causal associations between wind turbine noise and health effect

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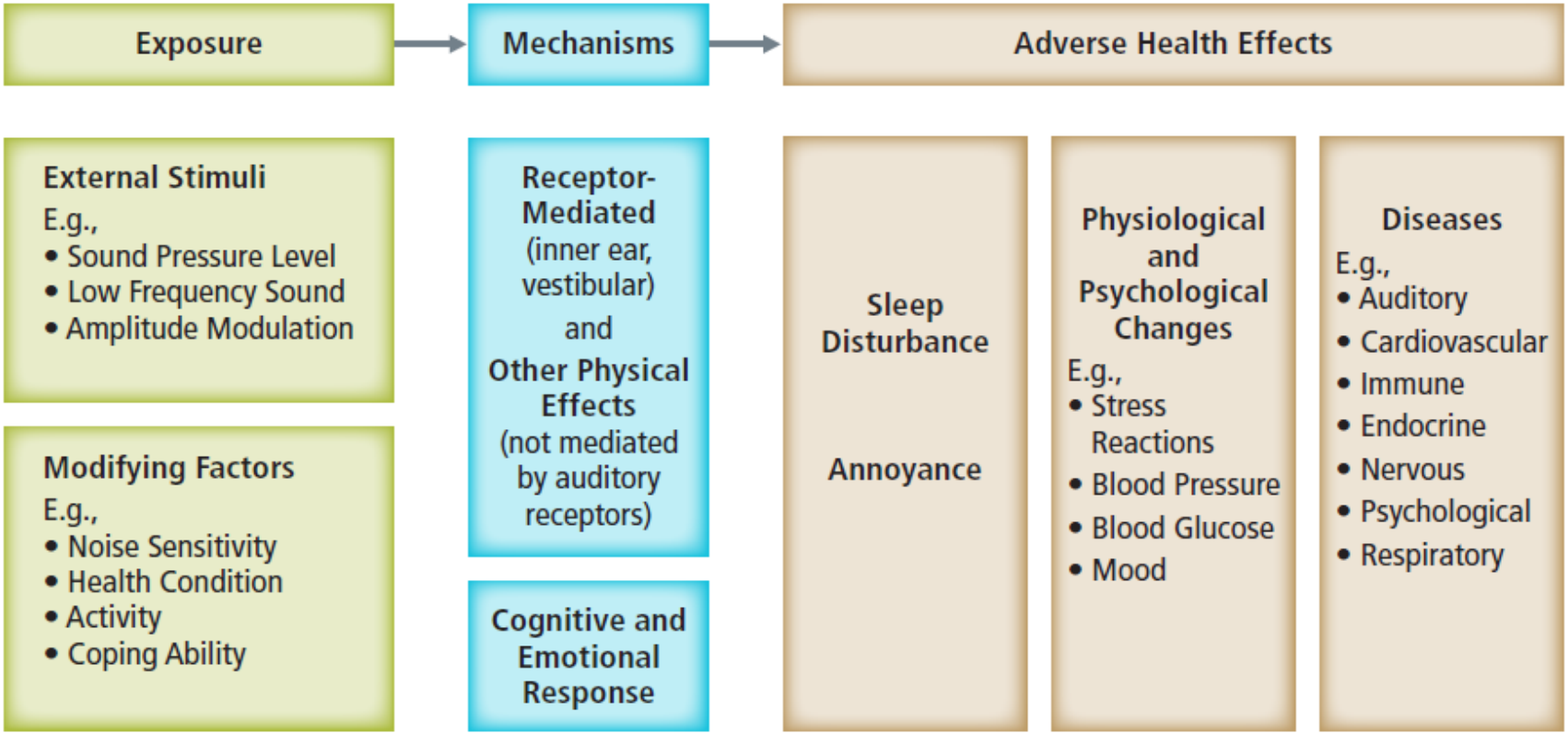

Figure 5.2

Proposed Elements of Potential Relationships Between Wind Turbine Noise and Adverse Health Effects

This framework includes proposed physical mechanisms, some of which are mediated by effects on auditory and vestibular receptors, as well as proposed effects mediated by a person's cognitive and emotional response to sound.

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.

Definition of Terms

5.6.2 Assessing Causality

Epidemiological studies cannot determine the cause of an outcome in a given individual, or even the mechanism responsible, but they can establish an association between a given exposure and the frequency of an outcome in a population … Causation can be inferred, usually based on several factors, such as the strength and consistency of the association, mechanistic plausibility, as well as the temporal sequence and biological gradient — or dose-response relationship — of the exposure and the outcome (Bradford Hill, 1965; Howick *et al.*, 2009)….

A critical appraisal guided the Panel in assessing and assigning weight to the evidence linking wind turbine noise to health effects. The Bradford Hill guidelines were used to guide Panel deliberations and to structure the summaries of evidence (Chapter 6), keeping in mind that they are not intended to be strict guidelines, and should be applied to a body of evidence rather than to individual studies. The final determination of causality was ultimately based on the Panel's judgment of the findings.

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.

Definition of Terms (cont.)

The Panel further adopted standard language to summarize the findings of causal relationships, following a framework similar to that used by the International Agency for Research on Cancer (IARC, 2006). The overall strength of evidence for a causal relationship falls into one of four categories:

- **Sufficient evidence of a causal relationship:** A *relationship was observed* between exposure to sound from wind turbines and a specific health effect in studies in which *chance, bias, and confounding factors can be ruled out with reasonable confidence*.

- **Limited evidence of a causal relationship:** *An association was found* between exposure to sound from wind turbines and a health effect for which *causal* interpretation is considered by the Panel to be *plausible*, but for which *chance, bias, and confounding factors cannot be ruled out with reasonable confidence*.

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.

Definition of Terms (cont.)

- **Inadequate evidence of a causal relationship:** The available studies are of *insufficient quality, or lack the consistency or statistical power* to permit a conclusion about the presence or absence of a causal relationship.

- **Evidence suggesting lack of causality:** *Several adequate studies* covering the full range of exposure are available that are mutually *consistent in not showing a positive association* between exposure and effect at any observed level of exposure.

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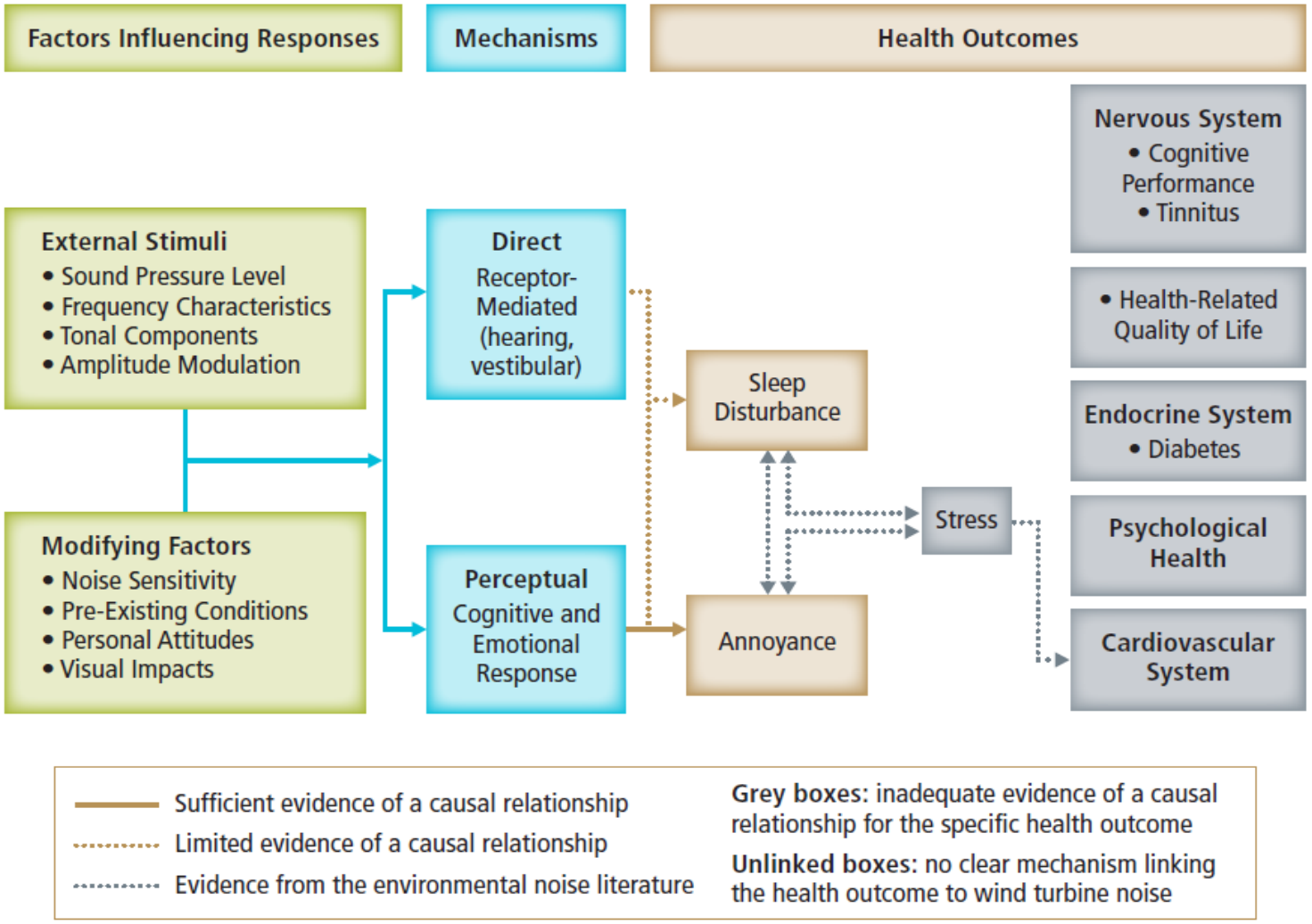


Figure 2

Summary of Evidence for Causal Pathways Between Exposure to Wind Turbine Noise and Adverse Health Effects

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.

Table 7.1

Overview of Findings with Regard to Adverse Health Effects Addressed in Empirical Population-Based Research on Exposure to Wind Turbine Noise

Condition or Symptom	Level of Evidence (IARC)	Possible Pathways	Knowledge Gaps
Annoyance	Sufficient	Direct – exposure to wind turbine noise can lead to annoyance; however, the effect may be modified by factors such as visual impact and attitudes.	• Role of visual impact and attitudes on perception of wind turbines. • Prevalence of annoyance in exposed populations, gravity of effect, and thresholds under different conditions. • Role of specific sound characteristics (amplitude modulation, low frequency noise).
Sleep Disturbance	Limited	Direct and indirect (via annoyance or stress response or both) pathways are possible; however, wind turbine noise is likely only one among many factors affecting sleep quality.	• Nature of the mechanism (direct, indirect, or both) and the relative prevalence and magnitude of the effect for each. • Impacts of specific sound characteristics (including low-frequency sound) of wind turbine noise on sleep. • Long-term effects of wind turbine noise on sleep disturbance.

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.

Canadian Academies Conclusions

- Wind turbine noise is associated with annoyance
- Annoyance has many factors
- Annoyance can lead to sleep disturbance
- 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.

Canadian Academies Conclusions

- The Panel stresses that, given the nature of the sound produced by wind turbines and the limited quality of available evidence (small sample sizes, small number of studies available, lack of comprehensive exposure measurement), the health impacts of wind turbine noise cannot be comprehensively assessed at this time. Furthermore, in noting the challenges of undertaking research on health impacts caused by multiple factors (large cohort studies, longitudinal studies, double-blind experiments), the Panel emphasizes that providing high-quality evidence would require a major research effort.

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

- ***5.3 Annoyance and Health***
- WTN annoyance was found to be statistically related to several self-reported health effects including, but not limited to, blood pressure, migraines, tinnitus, dizziness, scores on the PSQI, and perceived stress.
- WTN annoyance was found to be statistically related to measured hair cortisol, systolic and diastolic blood pressure.
- The above associations for self-reported and measured health endpoints were not dependent on the particular levels of noise, or particular distances from the turbines, and were also observed in many cases for road traffic noise annoyance.

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

Health Canada Study 2015

- ***5.3 Annoyance and Health***
- Although Health Canada has no way of knowing whether these conditions may have either pre-dated, and/or are possibly exacerbated by, exposure to wind turbines, the findings support a potential link between long term high annoyance and health.
- Findings suggest that health and well-being effects may be partially related to activities that influence community annoyance, over and above exposure to wind turbines.

Health Canada Study 2015

The following were not found to be associated with WTN exposure:

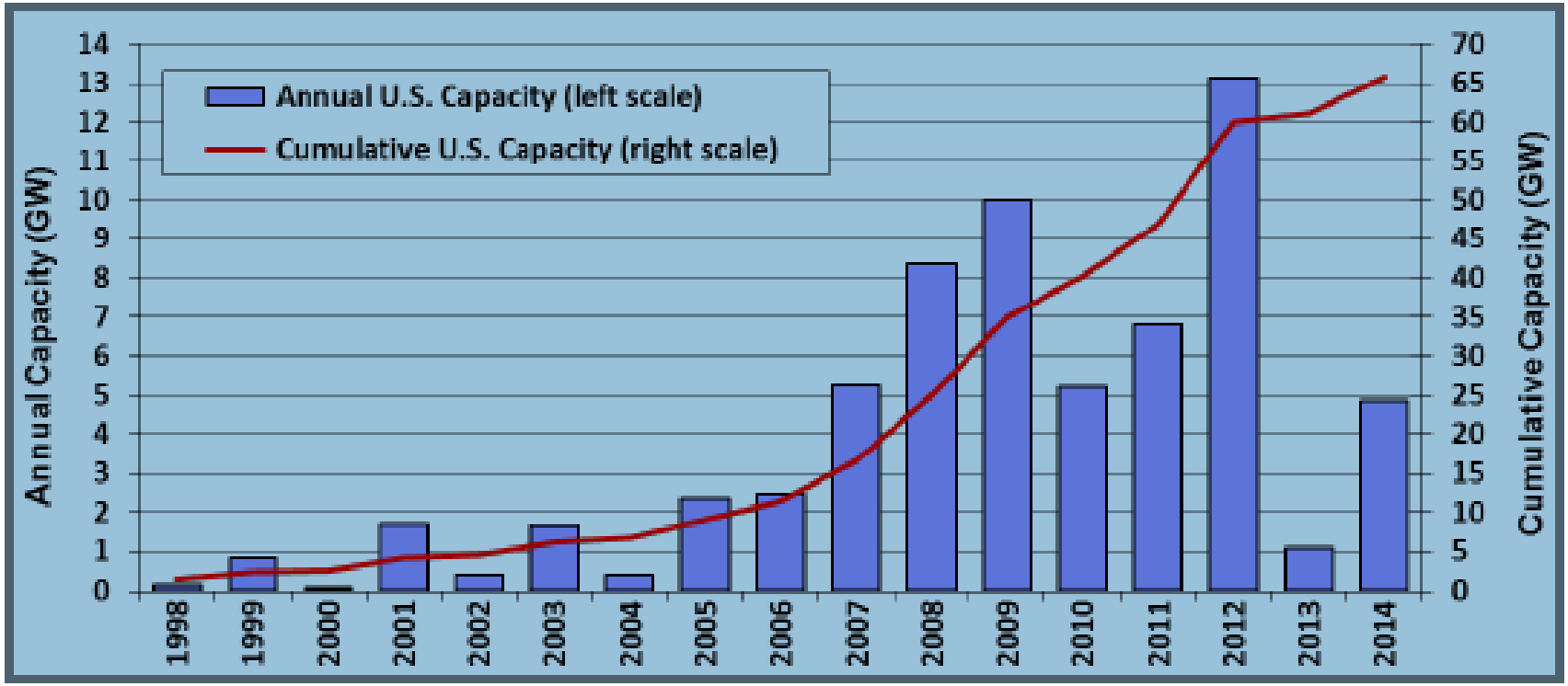
- self-reported sleep (e.g., general disturbance, use of sleep medication, diagnosed sleep disorders);
- self-reported illnesses (e.g., dizziness, tinnitus, prevalence of frequent migraines and headaches) and chronic health conditions (e.g., heart disease, high blood pressure and diabetes); and
- self-reported perceived stress and quality of life.

While some individuals reported some of the health conditions above, the prevalence was not found to change in relation to WTN levels.

The following was found to be statistically associated with increasing levels of WTN:

- annoyance towards several wind turbine features (i.e. noise, shadow flicker, blinking lights, vibrations, and visual impacts).

Wind Turbine Health Impacts are just recently being studied



Source: AWEA project database

Figure 1. Annual and cumulative growth in U.S. wind power capacity

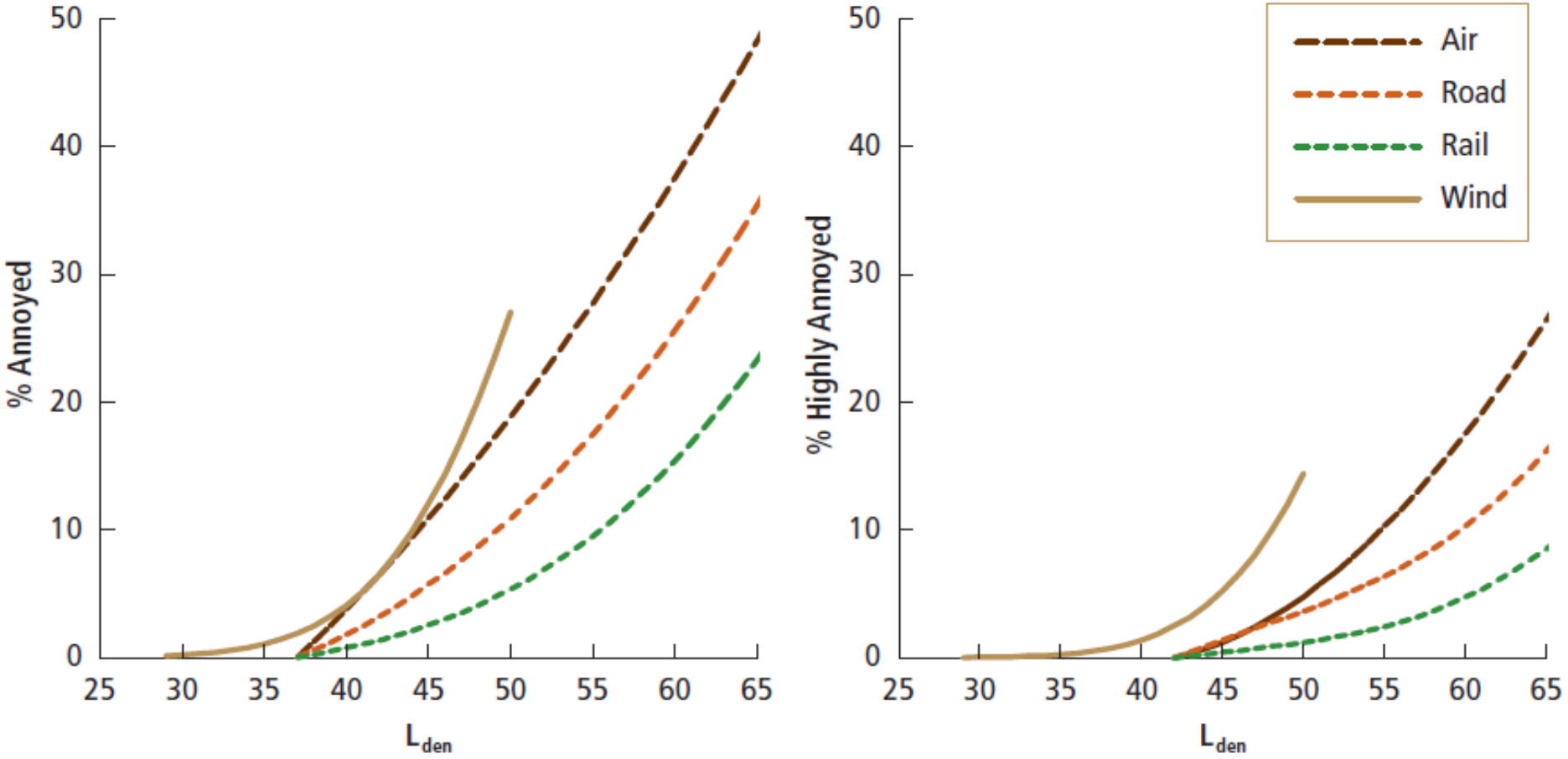


Figure 6.1

Comparison of Annoyance Due to Wind Turbine Noise and Transportation Noise

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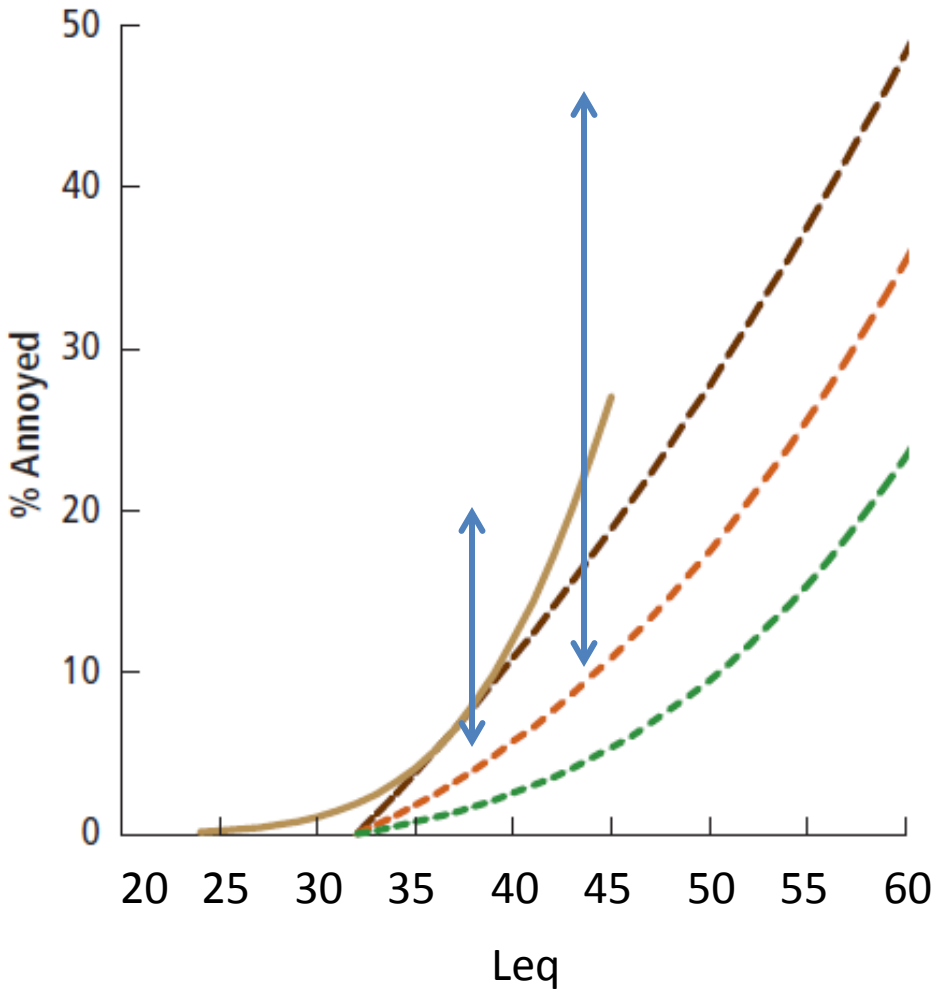

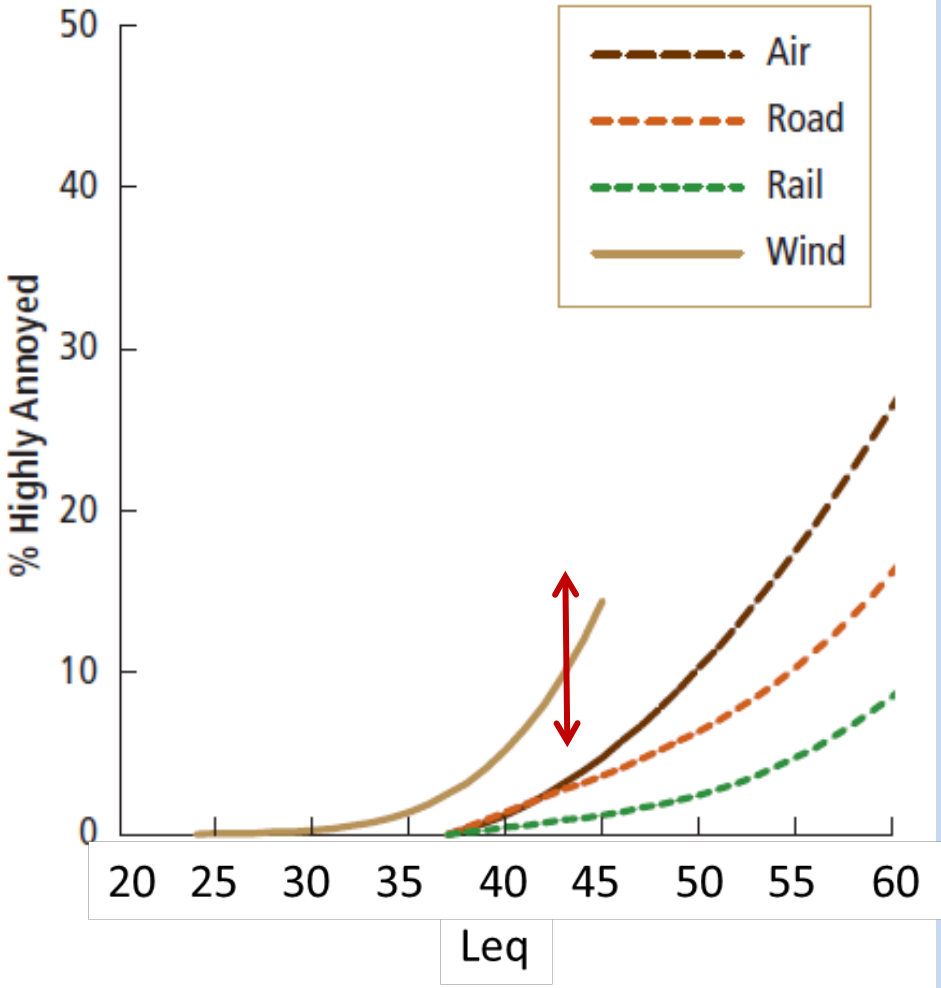

LLCHD estimates of Annoyance with Leq in dB(A)
based on Canadian Academies study Figure 6.1
using a 5dB conversion factor for Lden to Leq
- Range estimates ⇕ from Pedersen (2011)
- Range estimate ⇕ from Health Canada (2015) of very or extremely annoyed

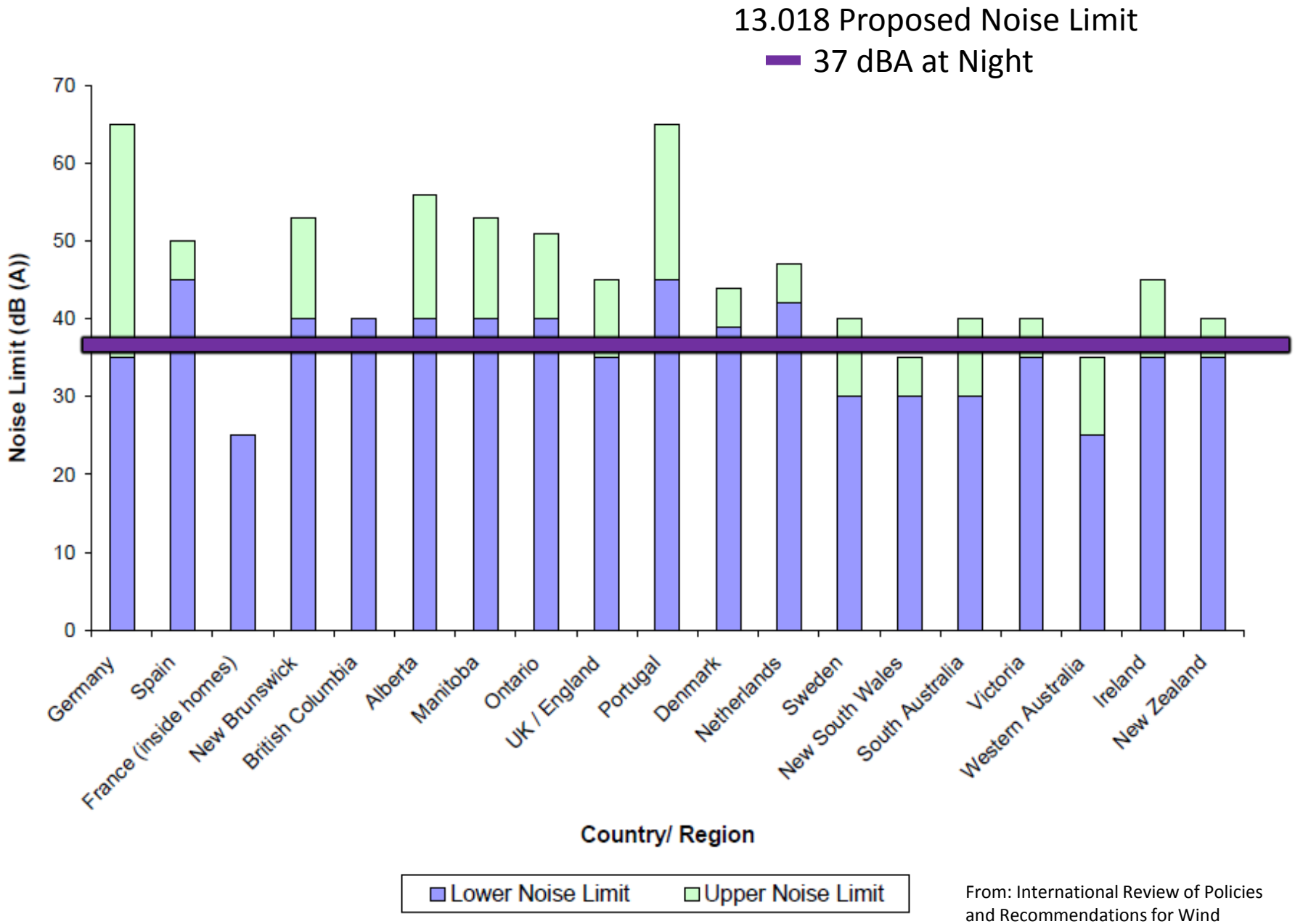

Figure 3: Country Wind Turbine Noise Limits at Residences

From: International Review of Policies and Recommendations for Wind Turbine Setbacks from Residences – MN Dept. of Commerce; 2011

LLCHD Conclusions

- The percent of annoyed people
  - Varies by site
  - Increases with noise level
  - 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 dBA Leq appears to be acceptable for >80% of people near wind turbines

LINCOLN LANCASTER COUNTY HEALTH DEPARTMENT

PUBLIC HEALTH

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LLCHD Conclusions

- Major data gaps are reason for caution and conservative noise standards for wind turbines
  - No data on the impact of wind turbine noise on children
    - Studies on other sources of noise have found correlations between noise and lower cognitive performance in children
  - No "chronic" health outcome data
    - Large industrial wind turbine facilities are a "new" phenomena
    - Chronic data (after 20 to 30 years of exposure) is not available

Proposed Noise Limits in the Text Amendment

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  - Or 3 dB(A) above background noise level (9 hour Leq)
- 37 dB(A) measured as a 10 min Leq at night
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