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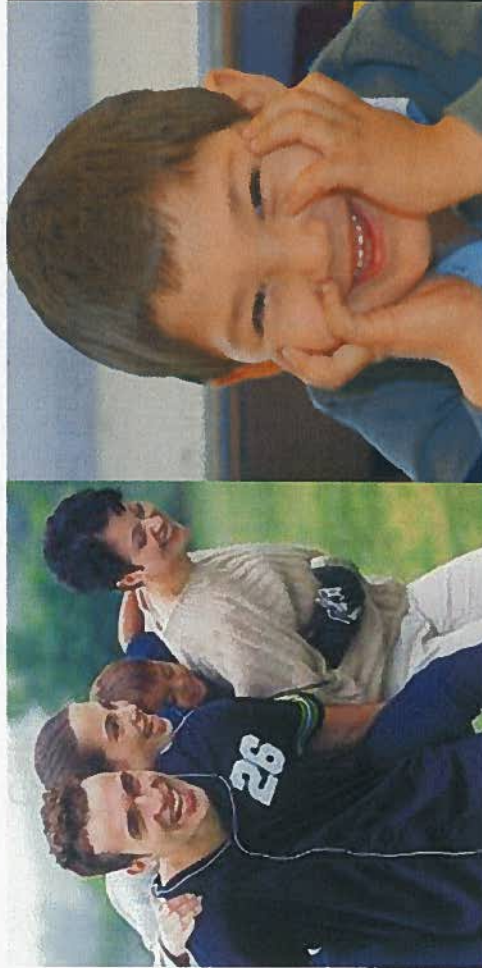
Your health and  
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# Health Canada's Wind Turbine Noise and Health Study

## Results Overview

Fall 2014



Canada

## Background – National Context

- The wind turbine industry is steadily expanding in Canada
- Currently 192 wind turbine installations in Canada
- Wind capacity currently surpassing 8.5 Gigawatts (GW) - enough to power over 2 million homes/year. By 2015 capacity is expected to reach 10 GW – a 20 fold increase over 2000 levels
- Canada's wind industry has set a vision of 20% of Canada's electricity generation by wind power by 2025
- Growing concerns about possible health effects of wind turbine noise from residents living in proximity to wind turbine installations.
  - Cited health effects include dizziness, nausea, tinnitus, sleep disturbance, migraines, increased blood pressure).



# Health Canada's (HC) Wind Turbine Noise and Health Study

- HC's ability to provide science-based advice and support decision-makers on noise impacts from wind turbines has been challenged by limited peer-reviewed scientific research in areas including low frequency noise and infrasound from wind turbines.
- In 2012, HC announced that it would undertake a research study, in collaboration with Statistics Canada (SC) and a team of external experts, to explore the relationship between wind turbine noise and the extent of health effects reported by, and objectively measured in, those living near wind turbine installations.
- The objectives of the study:
  - To investigate the prevalence of health effects or health indicators among a sample of Canadians exposed to wind turbine noise using both self-reported and objective health measures;
  - To apply statistical modeling in order to derive exposure response relationships for wind turbine noise levels and self-reported and objective health measures; and,
  - To investigate the contribution of low frequency noise from wind turbines as a potential contributing factor towards adverse community reaction.
- The overall cost of the study was approximately \$2.1M.



# Consultation on Study Design

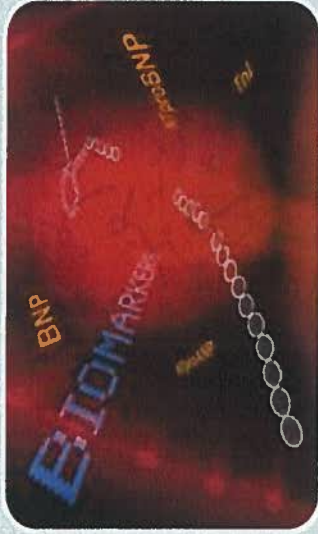
- Given significant stakeholder interest, the research design/methodology was subjected to a high level of consultation and peer review.
- In addition to a series of presentations at internationally recognized noise-related conferences, the peer review process included reviews by:
  - The HC Science Advisory Board;
  - A 27 member expert committee (Annex); and
  - The World Health Organization's (WHO) Noise Committee.
- A 60-day public consultation period for the methodology resulted in 950 submissions. In response, Health Canada made the following study enhancements:
  - Inclusion of an infrasound assessment component; and
  - Consideration for non-noise related impacts in the questionnaire survey instrument including items related to shadow flicker and blinking aircraft warning lights.
- An extensive response to the consultation feedback was prepared and published on the Health Canada website.



# Study Design – Methodology Details



Demographics  
 Quality of Life  
 Sleep Quality  
 Chronic Conditions  
 Stress & Recent Life Events  
 Perception of Outdoor noise sources  
 Housing Characteristics  
 Physical Activity  
 Community Engagement



Blood Pressure - automated Method  
 Hair Sample for Cortisol Analysis - ELISA method  
 Sleep Actimetry – wrist watch-like device worn for 7 consecutive days



Noise calculations using common internationally accepted noise modelling protocols (harmonoise/CADNA) >6 Hz  
 Sound recordings, including LFN, inside and out a number of homes on completion of the survey >6 Hz  
 Infrasound measurement – one year duration (NRCan seismologists)

H<sub>2</sub>?



# Results



## Results: Participation Rates

- Of 2004 potential dwellings identified, Statistics Canada determined that 1570 were valid addresses\*.
- 1238 of 1570 households participated.
- Overall participation rate of 78.9% - above the 70% target set by HC and Statistics Canada investigators.

\*434 locations were coded as out-of-scope because they were found to be demolished for unknown reasons, under construction, vacant for unknown reasons, an unoccupied seasonal dwelling or not a home at all. This finding is consistent for out of scope residences in rural communities.



## Self-Reported Measures from Questionnaire:

- The following were not found to be associated with wind turbine noise (WTN) exposure:
  - sleep disturbance; use of sleep medication, diagnosed sleep disorder;
  - reported illnesses (e.g., dizziness, tinnitus, migraines/headaches, increased blood pressure) and chronic health conditions (e.g., heart disease, high blood pressure and diabetes); and,
  - perceived stress and quality of life.
- While some individuals reported some of the health conditions above, the extent/prevalence was not found to change in relation to wind turbine noise exposure.





## Objectively Measured Results (Physical Measures):

Objective measures were largely consistent with self-reported results and do not support an association between evaluated health outcomes and WTN.

- Hair cortisol: no association to WTN
- Systolic blood pressure: no association to WTN
- Diastolic blood pressure: on final analysis, no association to WTN
- Resting heart rate: no association with WTN
- Sleep actigraphy: no association with WTN\*

*\*based on nightly average sleep against average WTN. Analysis by time-matched operational WTN data to be completed in 2015.*



## “Community annoyance” as a measure of well-being

**Community annoyance is defined as a long-term response (>12 months) of being very or extremely annoyed as determined by means of surveys.**

Support for community annoyance as a health indicator has emerged from:

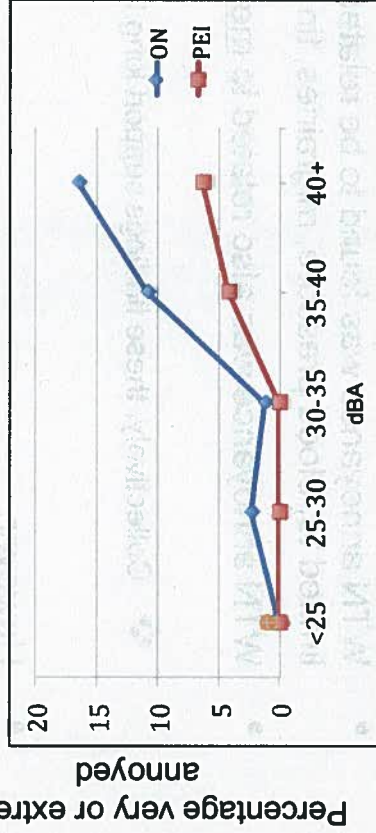
- 50+ years of community-based social and socio-acoustic research;
- precedent from U.S., European and International standard and policy setting bodies;
- an established dose-response relationship with metrics used to assess community noise impacts;
- the potential to be linked with chronic stress and other health effects;
- quantifiable impact determined by the WHO in Disability Adjusted Life Years (DALYs)
- consistent with WHO’s definition of “health”.



## Wind Turbine Noise Annoyance: Response Patterns and Provincial Differences

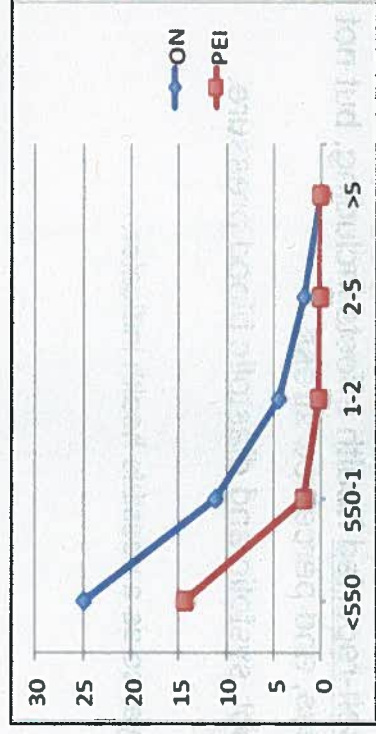
- As the wind turbine noise levels increased (which could happen for example as you get closer to the turbines), so did respondent's annoyance to wind turbine-associated features such as noise, blinking lights, shadow etc. This was a statistically significant finding.
- In comparison to aircraft, rail or road traffic noise, annoyance with WTN was found to begin at lower sound levels (i.e. ~35dBA).
- Pattern of response was similar across provinces, but the extent/prevalence of WTN annoyance was higher in the ON sample compared to PEI
- When assessed by distance, WTN annoyance in the ON sample persisted up to distances between 1-2KM; in the PEI sample this was restricted to <550m.

> investigating the reasons for provincial differences lies outside the scope of the current study.



Percentage very or extremely annoyed\*

Fitted data\*



Distance to nearest turbine (km)

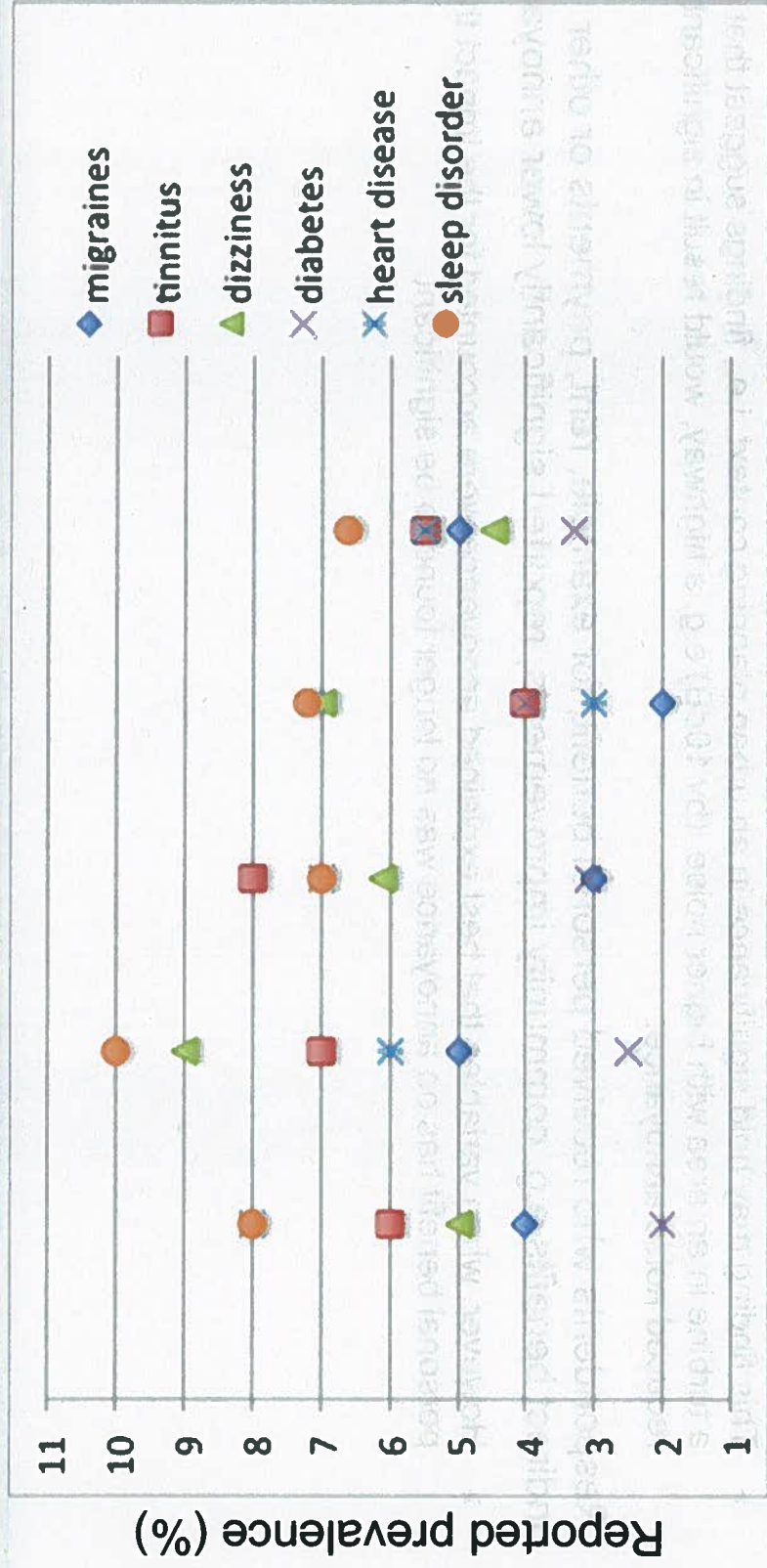


# Wind Turbine Noise (WTN) Annoyance and Health

- WTN annoyance was found to be related to several self-reported health effects including, but not limited to, blood pressure, migraines, tinnitus, dizziness, and perceived stress.
- WTN annoyance was also related to measured cortisol, systolic and diastolic blood pressure.
- ❖ Collectively, these findings support long term high annoyance as a possible health indicator.
- However,
  - These associations 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.
  - Health Canada has no way of knowing whether these conditions may have either pre-dated, and/or are possibly exacerbated by, exposure to turbines.
- Findings suggest that the extent of self-reported health effects may be partially related to activities that influence community annoyance, over and above wind turbine exposure.



# Illustration (i.e. not actual data) to demonstrate how annoyance can be associated with health effects but not WTN levels



(<25) (25-30) (30-35) (35-40) (40+)

dBA

Figure illustrates how the association between annoyance and health measures is Independent of WTN



## Additional Annoyance Findings of Interest

- WTN annoyance was highest in the summer, outdoors and during evening and night
- WTN annoyance significantly dropped in areas where modeled nighttime background noise exceeded WTN by 10dB or more.
  - This finding may hold significance in an urban planning context. i.e., findings suggest that siting a turbine in an area with higher noise (by 10dB) e.g. a highway, would result in significantly reduced noise annoyance.
- Respondents who received personal benefit, for example, rent, payments or other indirect benefits e.g. community improvements, reported significantly lower annoyance.
  - However, when variables that best explained annoyance were accounted for the impact that personal benefit has on annoyance was no longer found to be significant.



# Measured and Calculated Noise Findings

Health Canada conducted over 4000 hours of wind turbine noise measurements.

## A-weighted sound levels

- Historical use for assessing community response to noise (including WTN);
- Filters out frequencies humans are less sensitive to;
- The World Health Organization (WHO) identifies an annual outdoor average of 40 dBA as the level below which no health effects associated with sleep disturbance are expected to occur even among the most vulnerable people (WHO (2009) *Night Noise Guidelines for Europe*); and,
- The A-weighting may not be appropriate for sources that are dominated by strong low frequencies (i.e. A-weighting undermines these frequencies).

**Result:** Noise was calculated up to 46 dBA (19% of sample greater than or equal to 40dBA). Uncertainty in calculated dBA increases with distance because unknown weather conditions have stronger influence at distances beyond about 1km. +/- 4dB within 1km to about +/- 10dB by 10km.



# Calculated and Measured Low Frequency Noise (i.e. below ~200Hz)

**Low frequency noise (LFN):** Levels were found to be below proposed indoor limits for rattle perception/ annoyance.

- Produced by many sources including industrial wind turbines;
- Can pass through structures with little or no reduction in energy;
- Can interact with room to amplify indoor sound levels;
- Can induce rattles in light weight structures and increased annoyance;
- Can be estimated using C-weighting (dBC); and
- Proposed limit for sources that operate at night in rural environments is between 60 - 65dBC.

**Result:** Calculated outdoor dBC levels ranged from 24 dBC to 63 dBC. 3% of dwellings exceeded 60dBC. Levels are below proposed indoor limits for rattle perception/ annoyance.

## Infrasound (i.e. below ~20Hz)

15 Hz

- Produced by natural/man-made sources, including industrial wind turbines
- Measured over a period of 1 year at distances up to 10km from 4 wind turbines

**Result:** measurable above background at distances up to 10km from the wind turbines. Levels measured near the base of the turbine were around the threshold of audibility that has been reported for about 1% of people that have extraordinarily sensitive hearing.

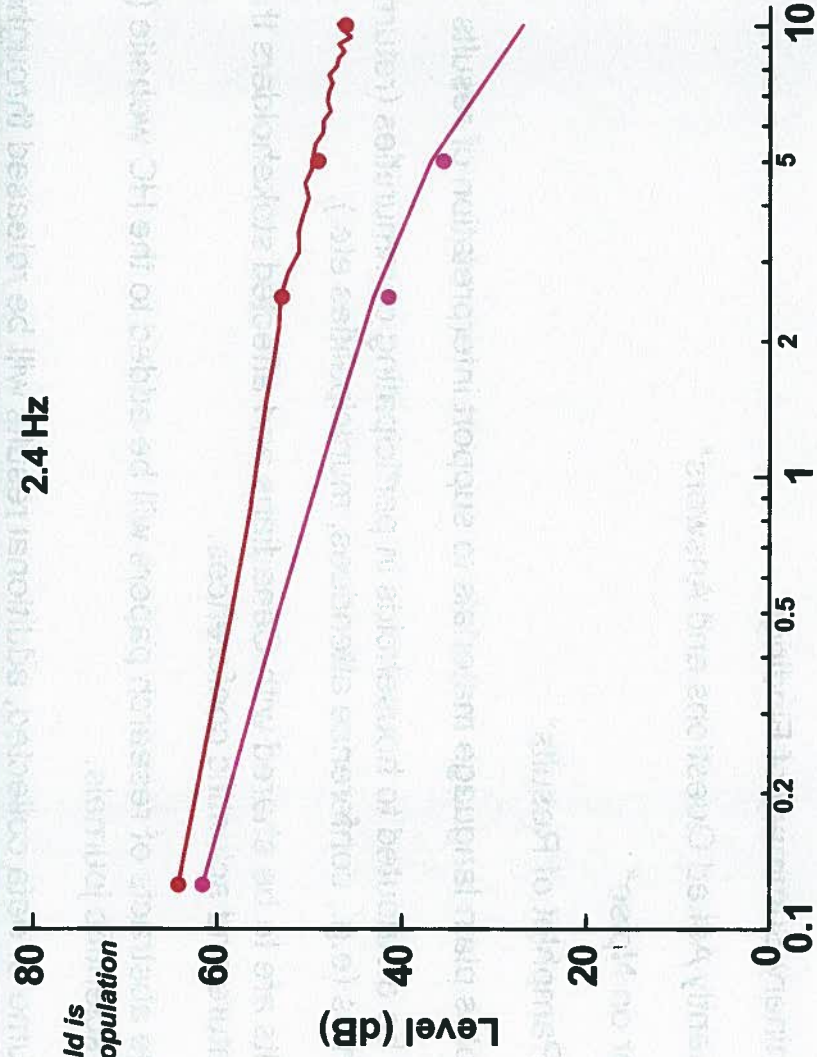




# Infrasound was measurable up to 10KM with a slow rate of decrease (relative to A-weighted sound)

2.4 Hz

The audibility threshold is around 90dB for average population



Measurements during nighttime condition (red circles) and afternoon (magenta circles). Solid lines show the predicted levels.



# Release Materials and Knowledge Transfer

- On the date of announcement Health Canada will post the following materials on the HC website:
  - News Release\*
  - Preliminary Summary of Findings
  - Frequently Asked Questions and Answers\*
  - Primer on Noise\*
  - PDF Pamphlet of Results\*

\*Denotes plain language materials to support interpretation of results

- Pamphlet will be distributed to households in participating communities (return of results) in addition to interested parties (e.g., conference attendees, municipalities etc.).
- Detailed results are to be shared with Canadians and affected stakeholders through the peer-reviewed scientific literature and scientific conferences.
- Plain language abstracts of research papers will be added to the HC website (WTN page) following publication in scientific journals.
- Given the volume of data collected, additional results will be released throughout 2015.



# Key Messages

- The Government of Canada is committed to protecting the health and well-being of Canadians.
- Health Canada's WTNHS is considered internationally to be the most comprehensive study to date.
- Results from this study:
  - are a significant contribution to the global knowledge base on wind turbine noise and health but do not provide definitive answers on their own.
  - should be considered in the context of all of the published peer reviewed scientific literature on the subject.
  - may not be generalised to areas beyond the sample as the wind turbine locations in this study were not randomly selected from all possible sites operating in Canada.
  - do not support conclusions about causality (direct cause and effect) between wind turbine noise and health.
- The Department will not be making any recommendations or policy statements in relation to the study's findings. Jurisdiction for the regulation of noise is shared across many levels of government in Canada.
- Detailed analysis and results will be shared with Canadians and the international community through the peer-reviewed scientific literature over the next several months with updates provided on the Health Canada website.



# Knowledge Transfer and Innovation Gains

The Wind Turbine Noise & Health Study represents the:

- ❑ First Canadian study, and largest internationally, to derive exposure response relationships between WTN and several annoyance endpoints;
  - *When considered together with overall science base; exposure response relationships can be used in environmental assessments and/or other guidance.*
- ❑ First study to comprehensively model shadow exposure from WTs in relation to community annoyance—established exposure response;
  - *Support for current/future domestic and international guidelines/legislation that site turbines based on shadow flicker exposure limits*
- ❑ First study to implement the use of both self-reported and objectively measured endpoints;
  - *Provides a more comprehensive assessment of the potential association between WTN and health*
- ❑ Largest study to implement hair cortisol as a measure of stress;
  - *Supports the use of this non-intrusive approach to assessing long-term stress in epidemiology studies; circumvents many of the shortcomings associated with blood and saliva sampling*
- ❑ Largest sleep actimetry study ever conducted
  - *Demonstrates the suitability of using an objectively measured evaluation of sleep quality on a large sample (has generated international interest for collaboration).*

