Wind turbines and environmental assessment

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National Collaborating Centre for Environmental Health

Centre de collaboration nationale en santé environnementale

BC Centre for Disease Control
An Agency of the Provincial Health Services Authority

Outline

- NCC overview
- Environmental assessment
- What and where are wind turbines?
- EA with wind turbines as example

The NCCs

- One of six national collaborating centres
- Funded by the Public Health Agency of Canada (PHAC) – at arm’s length
- Each is hosted by a different institution
- Each focuses on a different aspect of public health

The NCCs

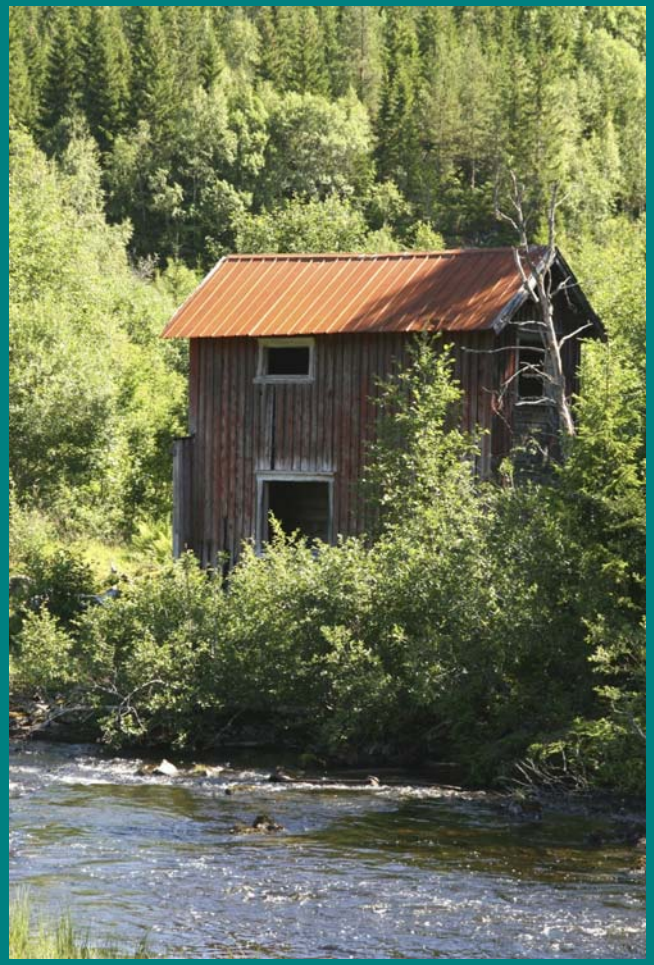
1. Environmental Health – BCCDC
2. Aboriginal Health – Univ of Northern BC
3. Infectious Diseases – International Centre for Infectious Diseases
4. Methods & Tools – McMaster Univ
5. Healthy Public Policy – Institut national de santé publique du Québec
6. Determinants of Health – St. Francis Xavier Univ

Function of the NCCs

- Synthesizing, translating, & exchanging knowledge
- Identifying gaps in knowledge
- Building networks & capacity

NCCEH - Focus

- Health risks associated with the physical environment
- Evidence-based interventions to reduce those risks



NCCEH - Scope

- Initially defined as EH services/programs currently delivered by regional & local health agencies throughout Canada
- Client group – people who deliver those services/programs or set the policy framework for delivery
- Plan to broaden definition to include environmental hazards with reasonable evidence of significant potential burden of illness

NCCEH Approach

- Defining the audience
- Listening to their needs
- Linking to what's already available
- Partnering with researchers
- Providing quality products
- Getting feedback

What We've Done

- Conducted two environmental scans
- Set up a national advisory board of practitioners, policy-makers, & researchers
- Launched a website for sharing information
- Produced review, guidance, & summary documents in collaboration with practitioners & policy-makers
- Presented a short course on drinking water in partnership with CIPHI – 2nd in May 2009
- Held a third summer institute with the other NCCs and PHAC – 4th in July 2009

www.ncceh.ca www.ccnse.ca

National Collaborating Centre for Environmental Health
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CALL FOR PROPOSALS FOR SYSTEMATIC REVIEWS!

Click here

Feedback
Any comments on the NCCEH or our website in general?

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  - Assessment Report
  - Bridging the Gaps
  - Needs Survey
- Networking Opportunities
  - Training & Practicum
  - Directories
- Recent Research
- Review, Guidance & Summary Documents
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UPCOMING EVENTS

Canadian Public Health Association (CPHA) 2009 Annual Conference
(18 days)

National Collaborating Centres for Public Health (NCCPH) Annual Summer Institute in Knowledge Synthesis, Translation, and Exchange
(48 days)

HOME

Welcome to the National Collaborating Centre for Environmental Health (NCCEH) website—bringing together practitioners, policy-makers, and researchers for evidence-based practice and policy.

What's New

- Presentations from the 2009 safe drinking water course
- Presentations on: Raw milk, Wind turbines and health, and Urban agriculture
- Presentation on our major project on drinking water-related illnesses in Canada
- Directory of training programs - updated
- Directory of environmental health legislation in Canada - updated
- Summer institute in knowledge synthesis, translation and exchange
- Recommendations for safe re-occupancy of marijuana grow operations
- Directory of practicum opportunities - updated
- Recent journal articles on selected environmental health topics
- When can point-of-use water filters be used for removal of protozoa?

Please check out our review, guidance, and summary documents section, go to our needs, gaps, and opportunities assessment report, and explore our networking opportunities. Also be sure to visit our regularly-updated environmental health news section.

ENVIRONMENTAL HEALTH NEWS

Stay informed with the latest news in environmental health.

- Breast cancer survivor suspects work toxins to blame
- Prenatal exposure to flame retardant is associated with increased risk of male genital anomalies
- Climate change biggest threat to humans
- Lead is a concern for urban gardens
- Study links formaldehyde to more common cancers
- Protect water from oilsands or risk lawsuits
- Cleaner air from reduced emissions could save millions of lives
- Natives turn to Ottawa to halt landfill
- toxins in 'off-the-shelf' products increase quickly
- Noise protesters howling about windfarms

more

Review, Guidance, & Summary Documents

- Produced in-house
- Contracted out through call for proposals
- Preference for systematic reviews

- Work with client group to identify & refine document topics
- Science/peer review as 1st stage
- User/relevance review for final documents

Documents – Posted

- Marijuana grow operations cleanup
- Effectiveness of home drinking water filters
- Cellular phone use & intracranial tumours
- Effectiveness of interventions during heat episodes
- Residential indoor radon testing
- Radon testing & remediation programs

Documents – Posted

- Effectiveness of interventions to reduce radon levels in homes
- Effectiveness of interventions to reduce UV exposures
- Cleanup of clandestine drug labs
- Conclusions of major reviews concerning environmental tobacco smoke (ETS) exposure
- Cleanup instructions for small mercury spills
- Polybrominated diphenyl ethers - What do we know

What We're Doing

- Producing additional documents
- Offering secondments & practicums
- Conducting a major project on small drinking water systems
- Enhancing our website, e.g., a listing of recent journal articles
- Developing a workshop on risk communication
- Evaluating our work through an independent process

Collaborations & Network Building

- Canadian Institute of Public Health Inspectors
- First Nations Environmental Health Innovation Network
- Canadian Public Health Association
- Conference Board of Canada
- Urban Public Health Network
- Association of Supervisors for Public Health Inspectors (Ontario)

Environmental Assessment

Environmental Assessment (EA)

- Comprehensive and systematic process, designed to identify, analyze and evaluate the environmental effects of a project in a public and participatory manner involving
  - technical experts,
  - research and analysis,
  - issue identification,
  - specification of information requirements,
  - data gathering and interpretation,
  - impact prediction,
  - development of mitigative proposals,
  - design of any required follow-up monitoring,
  - external consultations, and
  - report preparation and review

Steps in EA

- Step 1: Project Description
- Step 2: Scoping
- Step 3: Determining Significance
- Step 4: Mitigating and follow-up
- Step 5: Recommendations
- Public Participation throughout

Who decides if an EA is made?

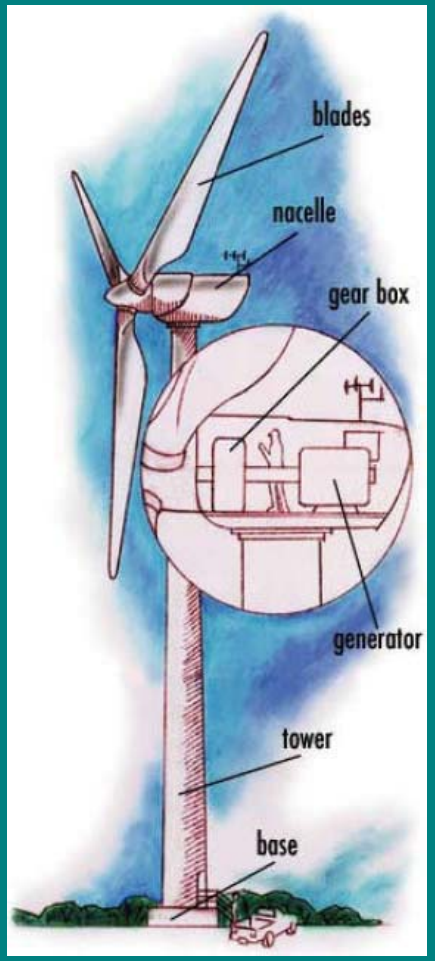
- EA administrators (MoE with provincial/territorial)
- Manager responsible for project (federal)
- Under Canadian Environment Assessment Act (CEAA), federally-funded wind turbine projects must undergo EA

Projects that tend to trigger EA

- Mining
- Agriculture
- Energy production
- Natural resource management
- Waste management
- Chemical management and production
- Manufacturing processes

Environmental Assessment: Wind Turbine Project

Wind Turbines



- HEIGHT: 80m
- BLADE LENGTH: 40m
- POWER PER TURBINE: 2 MW
- WIND SPEED:

  4–25 m/s for operation
- ROTOR SPEED: 15 rpm
- TIP SPEED: 62.8 m/s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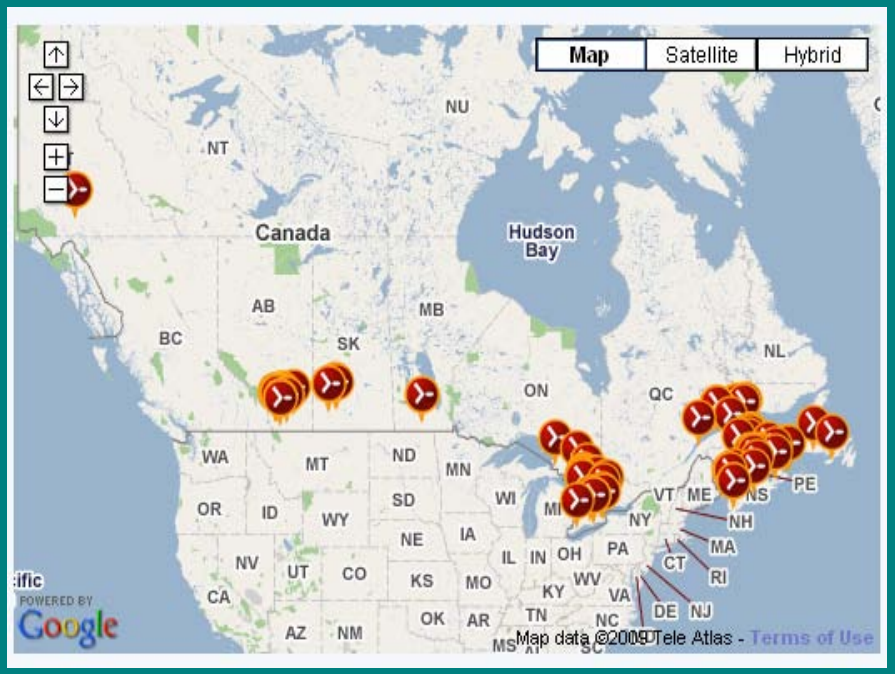
Wind Turbines in Canada



- 90 wind farms in Canada
- 2369 MW (1% of energy needs)

Source: CanWEA

1. Project Description

- Project
  - Environmental setting (e.g., rural field)
  - Stages of project's life cycle (construction to decommissioning)
  - Project activities
  - Hazards (e.g., noise)
- Human exposure
- Possible effects

2. Scoping

- Health Hazards Considered
  - Hazardous agents
  - Environmental
  - Exposure conditions (e.g., public, occupational exposure, high risk groups?)
  - Effects on physical health
  - Effects on social well-being (e.g., stress, nuisance)

Public Health Concerns

Photo: Edenfield, Lancashire, UK
www.geograph.org.uk

- Sound
  - Noise levels/intensity
  - Low frequency noise
  - Variation
- EMF exposure
- Shadow flicker
- Aesthetics
- Icing
- Structural failure
- Safety
- Environmental impacts

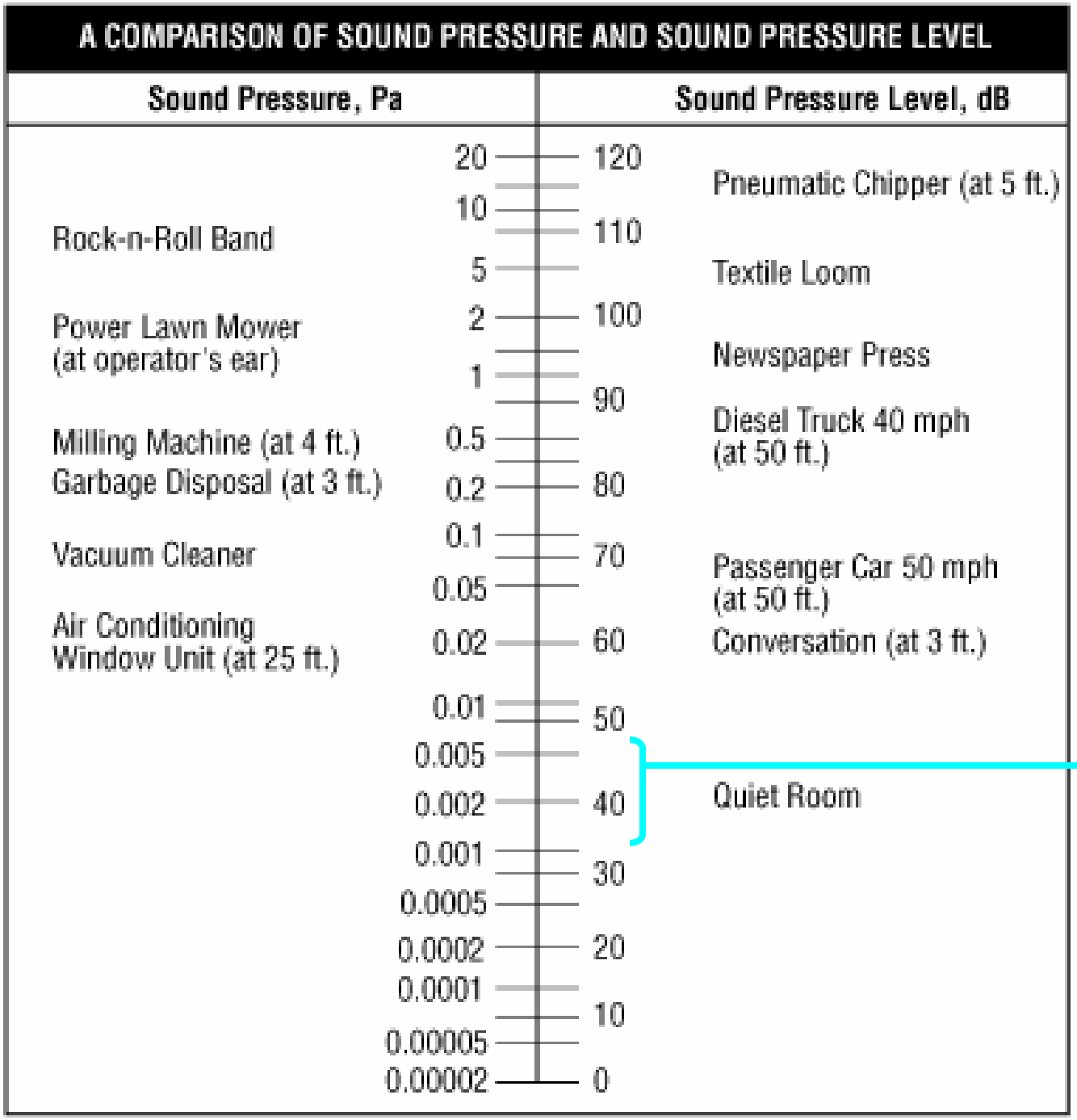
3. Determining Significance

- Environmental conditions
  - Levels of contaminants
  - Resources or species that are important
- Health and social conditions
  - Demographic characteristics of potentially affected (i.e., general public, occupational population)

Sound

- Sound produced by wind turbines is aerodynamic or mechanical in nature
- “Infrasound” most controversial in terms of health
- Aerodynamic modulation:

  Uneven nature of wind turbines (“swoosh swoosh”) perceived as more annoying than steady “white noise”



Wind farm sound at 350m

Source: CCOHS & AWEA

Low Frequency and Infrasound

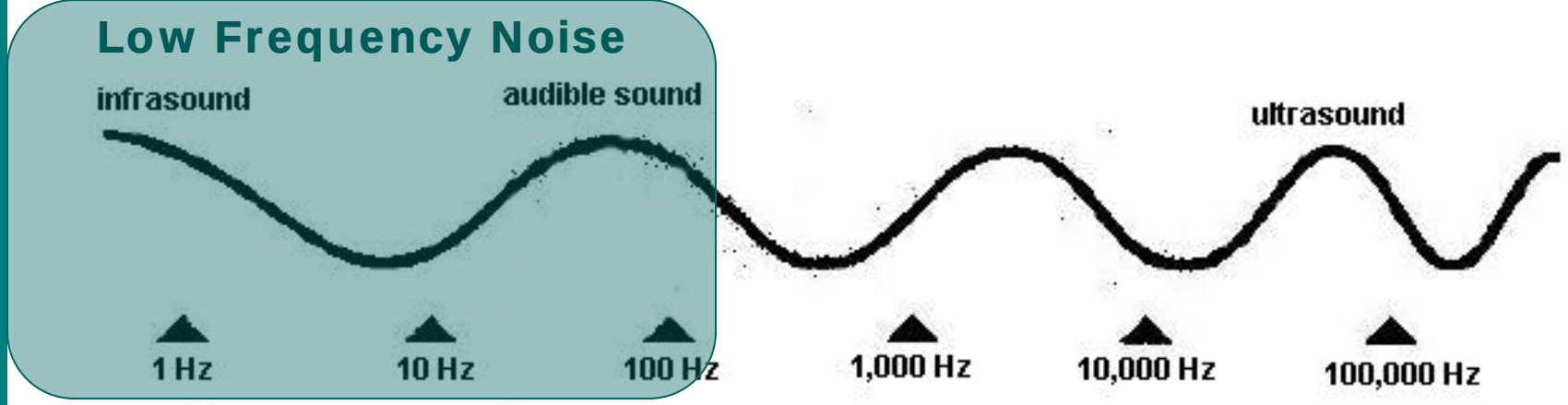
Low frequency noise (LFN):

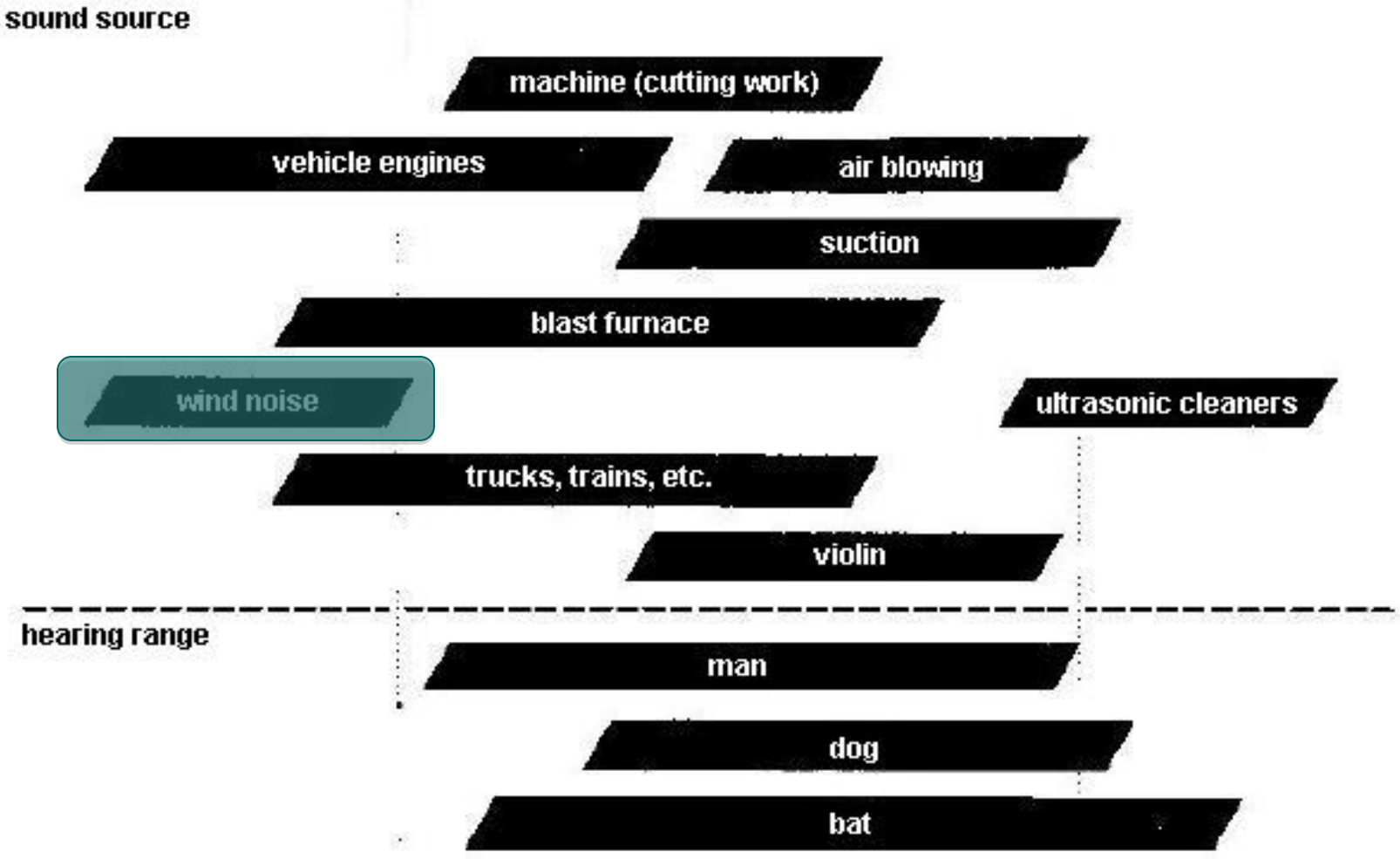
- LFN is sound in the frequencies < 200 Hz
- Infrasound < 20 Hz
- LFN at low levels (<100 dBA) is ubiquitous in the environment
- LFN at higher levels is common in some night clubs

Sensitivity:

- Infrasound is sound in the frequencies below 20 Hertz
- Human hearing is most sensitive between 1000 and 20,000 Hertz
- Human sensitivity to LFN varies

Low Frequency Noise





LFN

- Potential health effects from chronic exposure to very high levels of LFN
- Vibroacoustic disease (VAD):
  - theoretically full body pathology causing widespread homeostatic imbalances
  - related to chronic exposure to very high levels of LFN (*e.g.* airline mechanics)
- **No published data that confirm the claims of adverse health effects for low-frequency sounds of low pressure (*i.e.* below 20 Hz and 110 dB)**
- 1999 WHO report on community noise considers inaudible LFN to be of no concern
- Reports of pressure sensation in ear, “intrusive” vibration, sleep disturbance, irritation, conversation disruption

  N.B. Sleep disturbance may lead to health effects

EMF Exposure

Four potential sources from wind farms:

1. Grid connection lines
2. Wind turbine generators
3. Electrical transformers
4. Underground network cables

EMF Exposure

- No scientific consensus on health risks from magnetic fields
  - IARC 2B: Possibly carcinogenic
  - Weak association with childhood leukemia
- EMF concerns not specific to wind energy – all electric transmission
- Max EMF to be transmission lines rather than turbines

Shadow Flicker

- Occurs when turbine blades rotate in low-angle sun
  - Large moving shadows on ground
  - Intermittent light reduction indoors
- Depends on sun angle and siting (size, profile/height, direction, turbine density, distance from turbine)
  - Buildings SE of turbines most impacted

Shadow Flicker

- Lasts a very short period of time (approx. 30 min at sunrise or sunset) when conditions are present
- Most pronounced at distances from wind turbines less than 300 m (1,000 feet)
- Reports of dizziness and disorientation when inner ear and visual cues disagree
- No *evidence* of health effects
- Aesthetic or nuisance effect

Shadow Flicker & Epilepsy

- People with epilepsy are rarely light sensitive (5%)
- Sensitivity occurs at 16–25 Hz

- Epilepsy Foundation: flicker frequencies >10 Hz may trigger epileptic seizures
- Blade passage frequency of typical modern wind turbine = 0.5 to 1 Hz

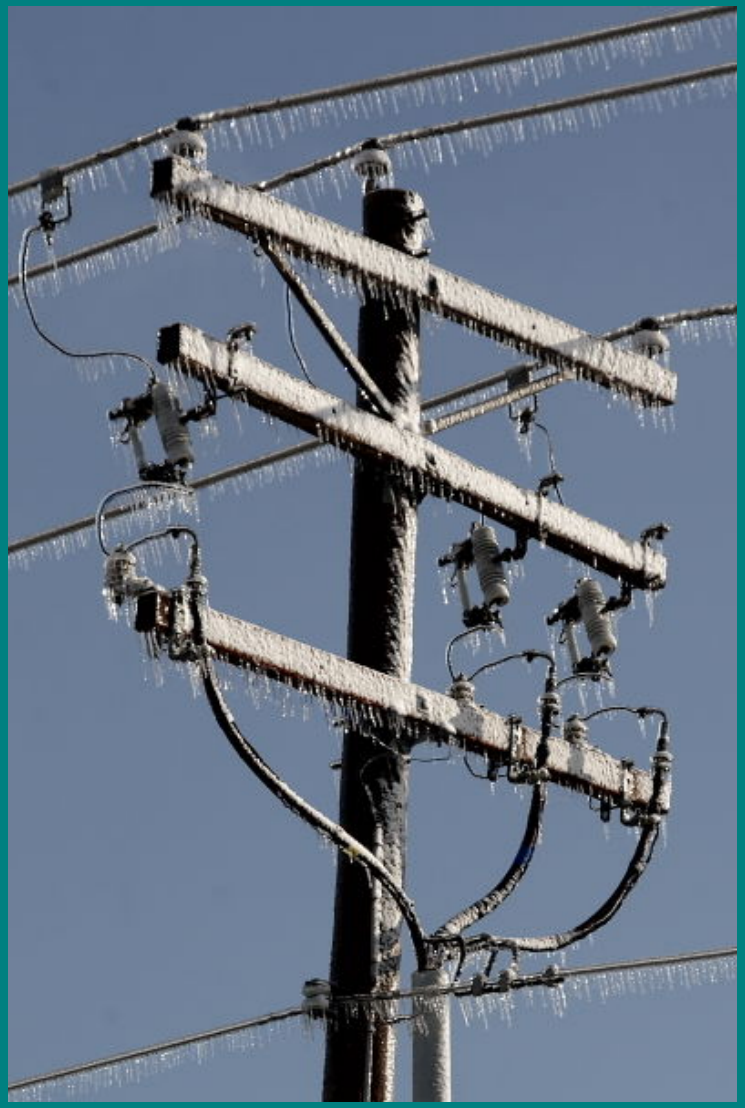
Aesthetics

PHOTOS: Wikimedia Commons

- Visual impacts are a major concern for those living near wind farms
- Perception of visual impact affects noise perception (Pederson & Larsmann 2008)
- Not a risk to health, but a legitimate concern

Icing

- Glaze ice:
  - Liquid precipitation or fog/cloud contacts cold surfaces (<0° C)
  - Smooth, hard, transparent, **highly adhesive**
  - Significant formation if temp just below freezing, high winds, and large diameter water droplets
  - Usually falls shortly after forming; **usually falls straight down**
  - Most likely form of ice in lowland coastal regions
- Rime ice:
  - Cloud contact with cold surfaces at colder temps, usually high elevation
  - White, opaque, granular
  - Adhesion less strong than glaze ice
  - Sometimes thrown, but usually breaks into smaller pieces



Glaze ice from ice storm

Rime ice from frozen fog at high elevation

PHOTOS: Wikimedia Commons

Ice Throw & Ice Shed

- Ice fall from stationary 2 MW turbines estimated at <50 m
- Ice from moving blades mostly 15–100 m from base, with mass up to 1 kg
- European studies have identified a safe distance of 200–250 m
- US study recommends 230–350 m for 1 in 10,000 to 1 in 100,000 annual strike risk
- Recommended to stop turbines in icing conditions – automatic or manual

Structural Failure

- 68,000 wind turbines have been installed worldwide over the last 25 years
- Documented blade failures:
  - Max reported distance for entire blade = 150 m
  - Max reported distance for blade fragment = 500 m
- Dutch handbook (1980–2001 data):
  - Partial or full blade failure rates range from 1 in 2,400 to 1 in 20,000 turbines per year
- Although rare, failure is extremely hazardous
- Gale force winds?

Table 4. Component reliability and failure rate h^{-1}

Component	Failure rates
Tip break	1.000×10^{-4}
Yaw bearing	1.150×10^{-5}
Blades	1.116×10^{-5}
Bolts	1.116×10^{-5}
Hub	1.116×10^{-5}
Generator	0.769×10^{-6}
Gearbox	0.630×10^{-6}
Parking brakes	2.160×10^{-6}
Tower and anchor bolts	1.000×10^{-7}

Khan M M, Iqbal M T and Khan F 2005 Reliability and condition monitoring of a wind turbine *18th Ann. Canadian Conf. Electrical and Computer Engineering (Saskatchewan, Canada)* pp 1978–81.

Cold Weather

- Ice – structural load limits include weight of iced blades
- Cold stress:
  - Steel becomes more brittle
  - Composites shrink unequally
  - Electrical damage
  - Gear damage from changes in oil viscosity
- Snow in nacelle – if no barrier present
- Most turbines designed to –20° C

Occupational Health and Safety

- Construction and maintenance work covered by existing Occupational Health and Safety guidelines for heavy equipment construction and work on tall structures

- Maintenance more difficult in icing conditions due to ice on structure and ladders – access to components is more challenging

- Maintenance is dangerous due to height, especially marine wind farms

Environmental Impacts

Wildlife:

- Resident, migratory, and endangered species

Concerns re:

- Loss of habitat and/or change in habitat/ vegetative cover
- Mortality due to collision
- Barotrauma (bats)

Weather and climate:

- Possible alterations to local weather due to increased turbulence and surface roughness
- Climate change impacts likely negligible due to benefits in reducing global CO_2 emissions & air pollutants

4. Determining Mitigation and Follow-up

- Usually required to address significant adverse effects

- Follow-up requirements may include
  - Inspection and surveillance
  - Compliance or effects monitoring
  - Impact management
  - Audit and process evaluation measures

Wind Farm Setbacks

- Ice throw:
  - Europe: 200–250 m
  - US: 230–350 m = 1 in 10,000 to 1 in 100,000 strike risk
  - Generally within noise setbacks
- Structural failure:
  - 150–500 m for blade failure
- Noise setbacks normally exceed distances recommended for safety
  - Setbacks for noise and visual perceptions are more difficult because they are subjective rather than risk-based

Noise Level Limits*

	Wind Speed (m/s)	Leq (dBA)
Quebec (not specific to wind turbines)		40 (night; Zone I) 45 (night; Zone II) 1 hr Leq
Ontario	<6 11	40 53 (quiet areas)
Alberta (Dir. 038)	6–9	40 (night; quiet rural area) **NIA** must be conducted
BC	8–11	40 (residentially zoned)

*No applicable national guideline for environmental noise.

Noise Levels

- Recommended guideline for Canada:

  Sound levels at receptor <45 dBA
  - Will not exceed room criterion for rattle in 63 Hz octave band (ANSI S12.2)
  - Will not exceed WHO recommendation of sound levels indoors <30 dBA for continuous background noise for good night's sleep (with 20 dB attenuation of dwelling)

CanWEA Proposed Setbacks

- Residential
  - Setback for sound usually >250 m – also protects against ice shed
- Roads
  - 1 blade length + 10 m
  - Risk assessment required for towers within 50–200 m of public road
- Property lines
  - 1 blade length + 10 m

Setbacks mostly based on sound levels

Gaps

- Long term exposure to low levels of LFN/ infrasound + appropriate assessment methods
- Health effects of turbine-related sleep disturbances should be investigated
- Stress-induced health effects from noise, visual impact, shadow flicker
- Dizziness and migraine from shadow flicker
- Glaze ice throw risks
- Need for specific OHS regulations

Conclusions

- Sound: Perceptions vary / No evidence of noise-induced health effects at levels emitted by wind turbines / Stress and sleep disturbance possible
- EMF & Power Cables: Lower exposure than other electricity generation / Underground cables bury electrical field
- Shadow Flicker: Can be minimized by careful siting, zoning, and screening / Not in frequency range that can induce epileptic seizures

Conclusions

- Ice Throw: Generally very low risk outside noise setback distances
- Safety: Follow OHS regulations and good manufacturing practices
- sound + flicker + aesthetics = annoyance + stress
- Minimal evidence for health *effects*.
  Health *concerns* are valid and must be addressed.
- Little evidence on infrasound
- Some evidence of weather effects

Conclusions

- Based on best available evidence, any identified risks can be addressed through siting (setbacks) and operating practices.

Risk Communication
Myths or Fact?

- Wind turbines are sources of infrasonic and low frequency acoustic energy
- Infrasonic emissions are well below all recognised threshold of perception criteria: even for sensitive receptors
- Energy in the 30-200Hz band may be audible and a small change of level in this frequency range may be perceived as an apparent larger increase of loudness
- Measured noise levels are below recognised onset levels for health effects
- Health concerns regarding wind turbines are valid

CONTEXT

- What are risks associated with generating electricity from other means?
- Dams, coal, nuclear, gas??
- Under the ‘microscope’, nothing is free of risk
- Wind power may also have weather/climate effects
-

5. Recommendations Regarding Project

- Determine whether or not a project should proceed and if so, under what conditions
- Decisions made by
  - MoE (provincial/territorial)
  - Minister responsible for project (federal) or Cabinet
  - Based on recommendations received by government officials, a board, or panel

Thank you!

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