Wind Turbines and Health : A Review of Evidence

Ray Copes, MD, MSc
Karen Rideout, MSc

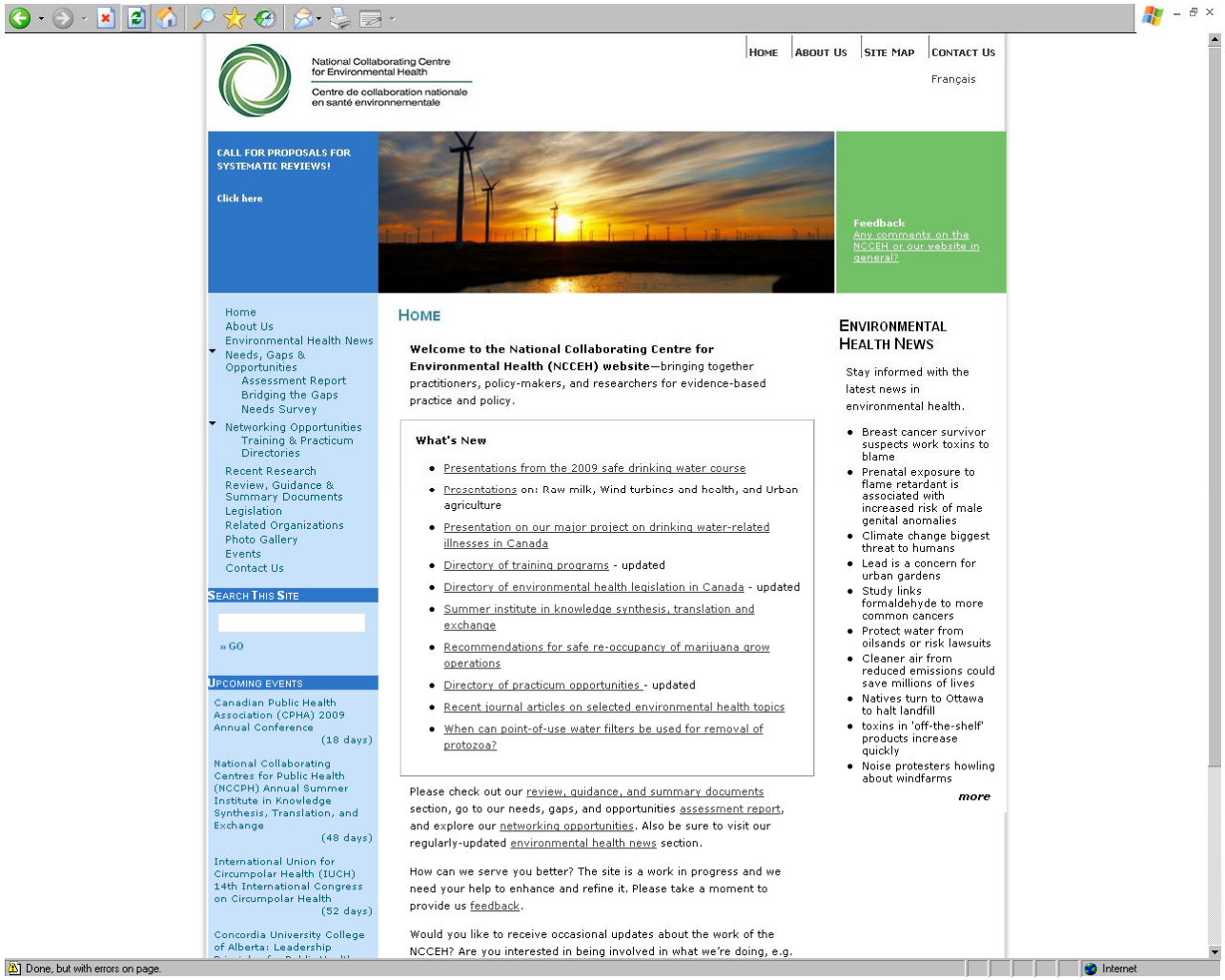
National Collaborating Centre for Environmental Health

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

Function of the NCCs

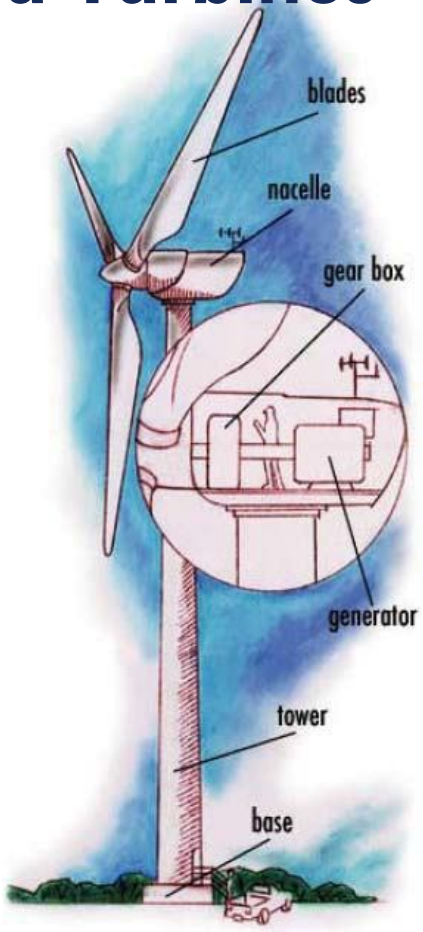
- Synthesizing, translating, & exchanging knowledge
- Identifying gaps in knowledge
- Building networks & capacity


National Collaborating Centre for Environmental Health
Centre de collaboration nationale en santé environnementale
HOME | ABOUT US | SITE MAP | CONTACT US
Français
CALL FOR PROPOSALS FOR SYSTEMATIC REVIEWS!
Click here
Feedback
Any comments on the NCCEH or our website in general?
Home
About Us
Environmental Health News
Needs, Gaps & Opportunities
Assessment Report
Bridging the Gaps
Needs Survey
Networking Opportunities
Training & Practicum Directories
Recent Research
Review, Guidance & Summary Documents
Legislation
Related Organizations
Photo Gallery
Events
Contact Us
SEARCH THIS SITE
» GO
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)
International Union for Circumpolar Health (IUCH) 14th International Congress on Circumpolar Health (52 days)
Concordia University College of Alberta: Leadership
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.
How can we serve you better? The site is a work in progress and we need your help to enhance and refine it. Please take a moment to provide us feedback.
Would you like to receive occasional updates about the work of the NCCEH? Are you interested in being involved in what we're doing, e.g.
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
Done, but with errors on page.
Internet

Wind Turbines

- Are wind turbines or any of the hazards associated with them new?
- What do we know about health effects?
- Why review health effects of wind turbines?
- Is Ontario 'special'?
- What literature is available?

Wind Turbines

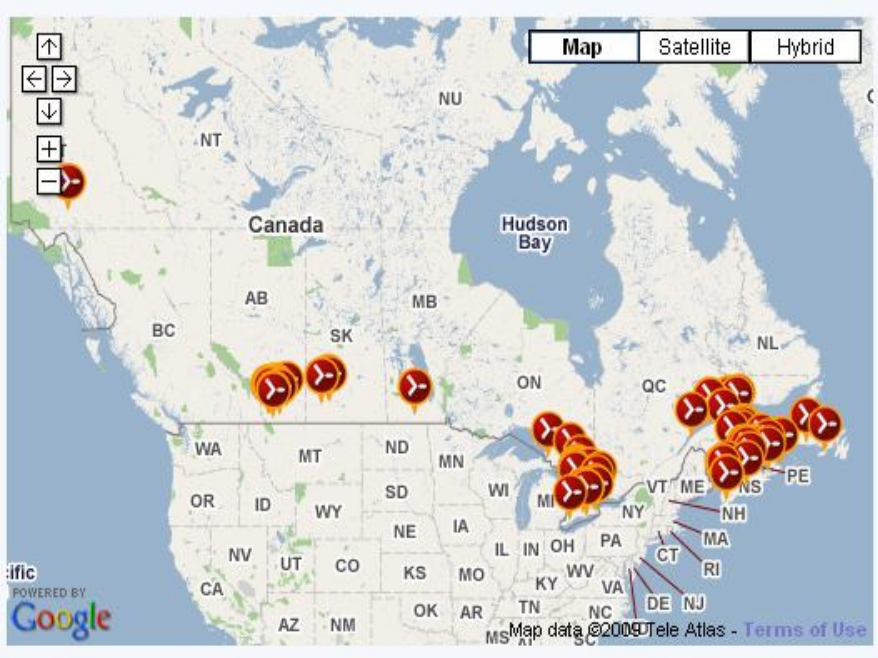


- HEIGHT: 80m
- BLADE LENGTH: 40m
- WIND SPEED:

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


© NEG Micon

Wind Turbines in Canada



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

Source: CanWEA

Public Health Concerns

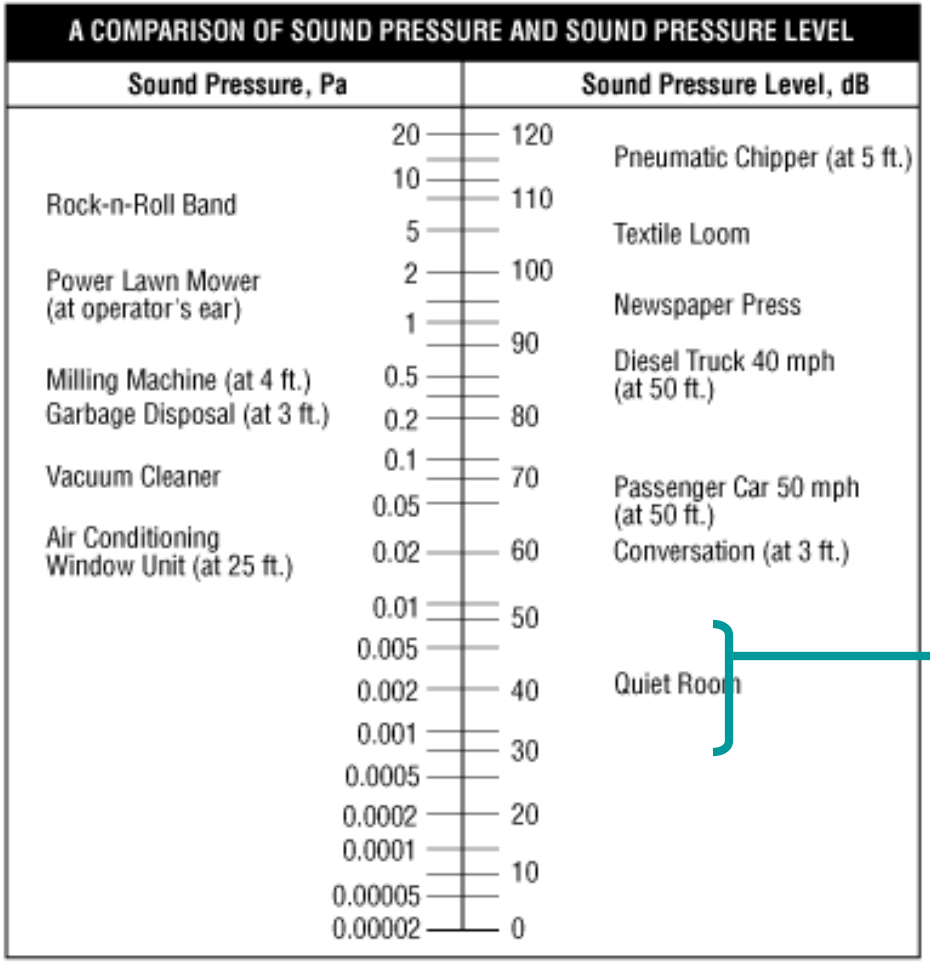
Photo: Edenfield, Lancashire, UK
www.geograph.org.uk

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

Sound

- Sound produced by wind turbines is aerodynamic or mechanical in nature
- "Infrasound" and low frequency noise 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

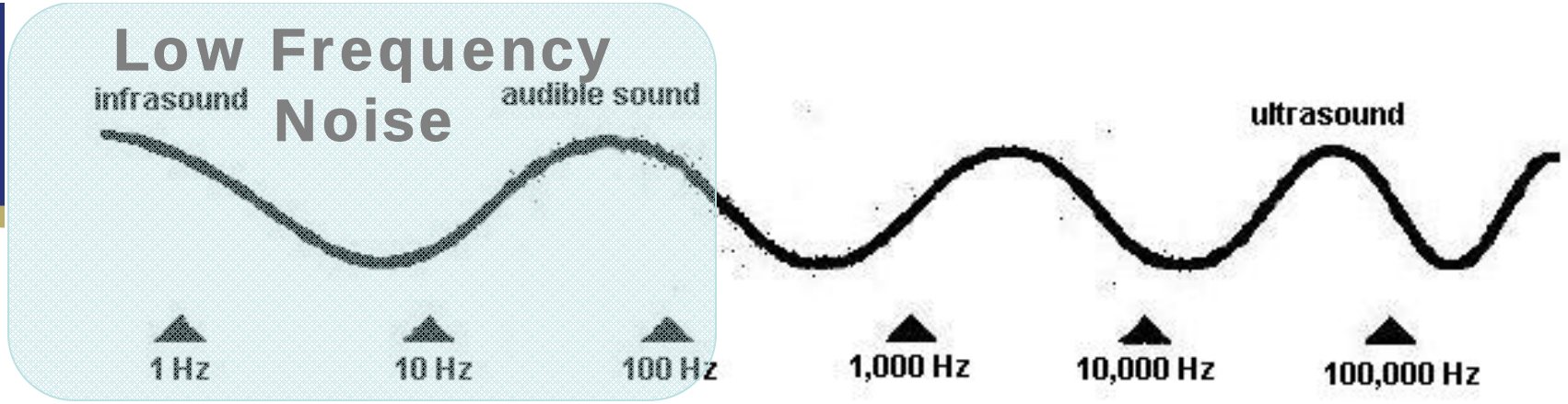
Low frequency noise (LFN):

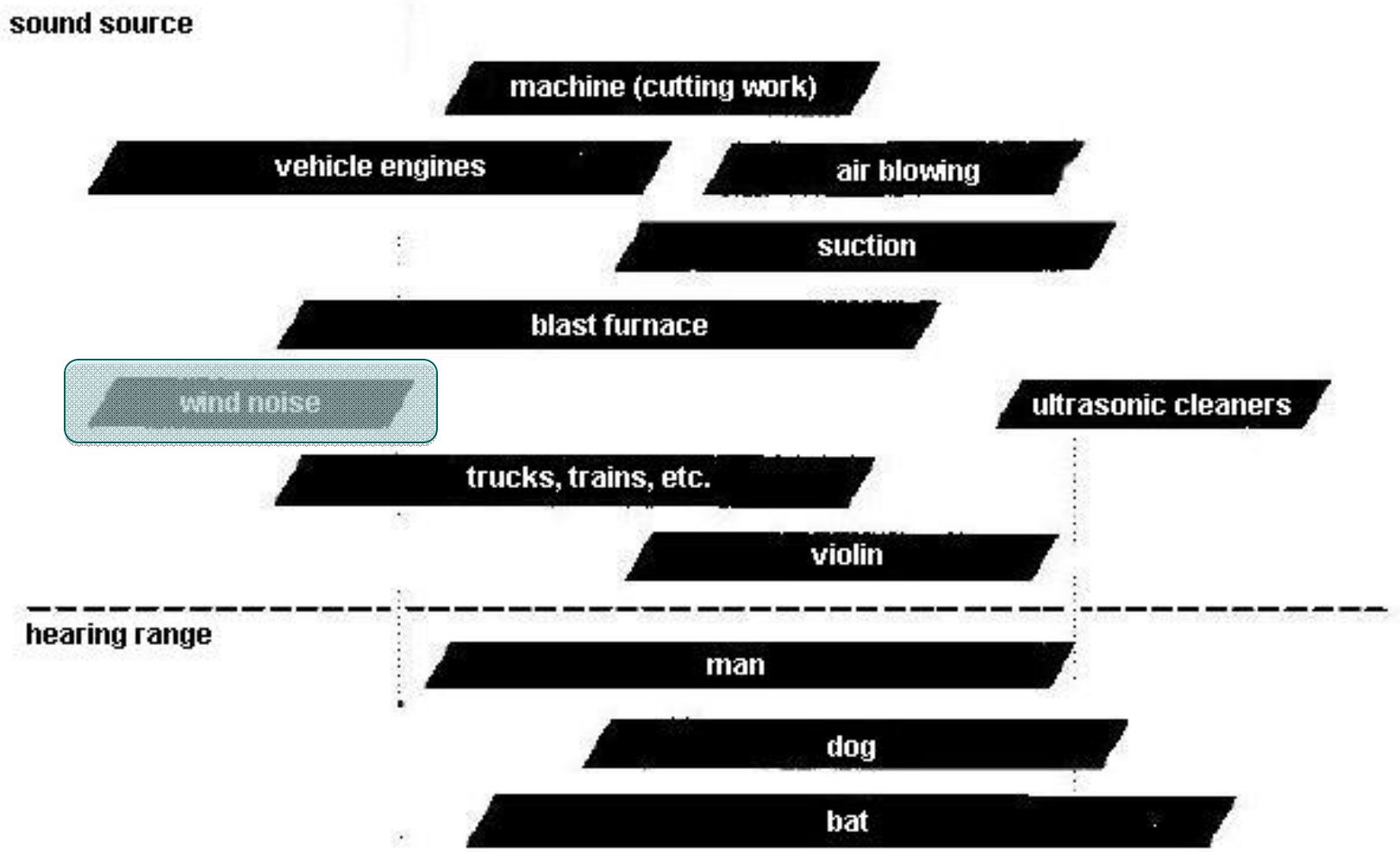
- LFN is sound in the frequencies < 200 Hz
- Infrasound < 20 Hz
- LFN at low levels (<100 dBA) is ubiquitous in the environment
- LFN at higher levels is common in some night clubs

Sensitivity:

- Infrasound is sound in the frequencies below 20 Hertz
- Human hearing is most sensitive between 1000 and 20,000 Hertz
- Frequencies below 20Hz can be audible at high enough intensities

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 from any cause may lead to health effects

Detection vs. Annoyance –Survey of residents living 'close' (>30dBA) to turbines of > 500kW in Sweden Pedersen and Waye 2007 Occup. Environ. Med

- Proportion of respondents who noticed sound increased almost linearly with increasing SPL
- At <32.5 dB(A) less than 30% noticed sound from wind turbines at 37.5-40, 76% noticed, at >40, 90% noticed.
- The relationship between annoyance and SPL was non-linear.
- At less than 37.5 dB(A) 3-4% expressed annoyance, at 37.5 -40, 6% were annoyed, at SPL > 40, 15% were annoyed
- Why is this relationship different?

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

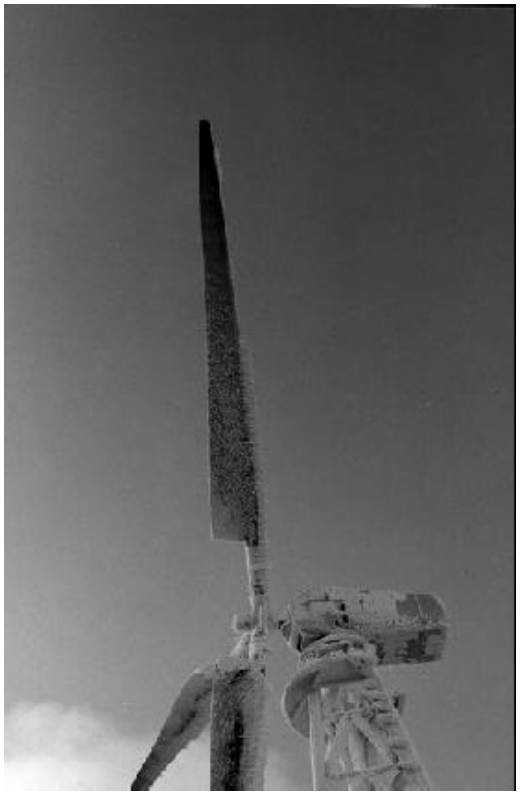
- Visual impacts are a major concern for those living near wind farms
- Perception of visual impact affects noise perception (Pederson & Larsmann 2008)
- Not a risk to health, but a legitimate concern

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} [redacted]

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

How can Risks be Mitigated?

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 (quiet areas) 53	
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

Setbacks mostly based on sound levels

- 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

What Influences Annoyance?

- In Swedish study- no relation to age, gender, employment.
- Living in a rural area, living in an area with low subjectively rated background noise, being noise sensitive, having a negative attitude towards wind turbines in general or their visual impact on the landscape were associated with annoyance.
- Are they 'inside' or 'outside' my territory
- Characteristics of wind turbine noise (not steady or random) may also affect annoyance

Can regulated setback distances ever be effective in mitigating annoyance?

Why the Controversy?

- Are there any unique hazards associated with wind turbines?
- Are wind turbines 'riskier' than other means of power generation?
- Is this new technology or a new source of risk that requires 'precaution' or more study before we proceed?
- Are regulators failing to meet a usual or target standard of risk reduction?
- Is it 'NIMBY"?

What is 'NIMBY'? from Wolsink Renewable and Sustainable Energy Reviews 11 2007

- A positive attitude towards the application of wind power, combined with an intention to oppose the construction of any wind power scheme in one's own neighbourhood.
- The not in any backyard variant, which means opposition to the application of wind power in the neighbourhood because the technology of wind power as such is rejected. This attitude is mainly based on concerns about landscape values.
- A positive attitude towards wind farms, which turns into a negative attitude as a result of the discussion surrounding the proposed construction of a wind farm.
- Resistance created by the fact that some construction plans themselves are faulty, without a rejection of the technology itself.

Opposition to wind farm projects can be due to any of the above, but only the first is truly NIMBY

- According to Wolsink, although selfishness may be the assumed motive behind opposition to wind power developments, feelings about fairness and equity may be a more accurate descriptor.
- Relative success with siting in Denmark and Germany is contrasted with 'failures' in the Netherlands and Sweden.
- May be linked to local versus central decision making on project siting

Conclusions

- Ice Throw: Generally very low risk outside noise setback distances
- Safety: Follow OHS regulations and good manufacturing practices
- Sound, flicker, aesthetics may affect annoyance + stress
- Health *concerns* are valid and must be addressed.
- Any effects on health more likely related to annoyance/sleep disturbance than to direct effect of SPLs at residence.
- Some evidence of weather effects

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

- Based on best available evidence, any identified risks can be addressed through siting (setbacks) and operating practices.
- 'Successful' siting appears to be related to other factors related to terrain and 'process'.

QUESTIONS?