

Wind turbines and health. What's the evidence?

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CIPHI NS/PEI Annual Educational Session
March 13, 2009 | Fall River, NS



National Collaborating Centre
for Environmental Health

Centre de collaboration nationale
en santé environnementale



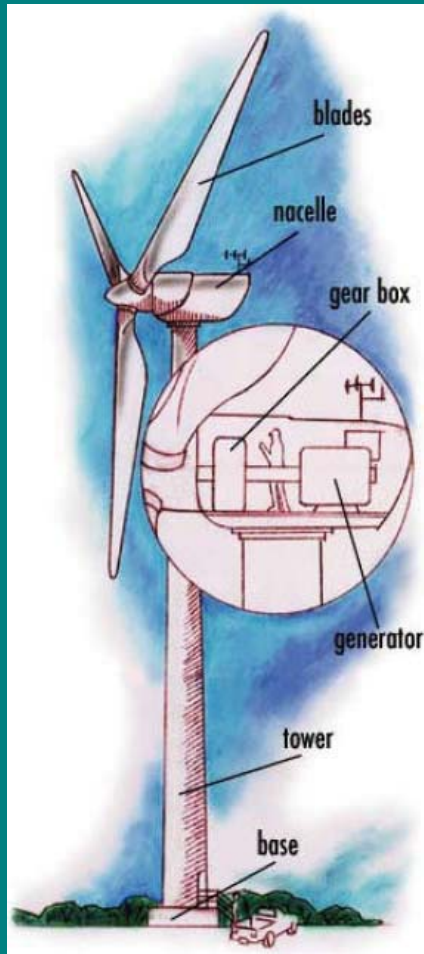
BC Centre for Disease Control
An Agency of the Provincial Health Services Authority

outline

- What are wind turbines?
- Where are wind turbines?
- The health issues
- Setbacks
- Gaps
- Risk communication



wind farms



- 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



wind turbines in Canada



- 90 wind farms in Canada; 2369 MW (1% of energy needs)
- NS
 - 18 wind farms
 - 59 MW in place
 - NS Renewable Energy Standards require 5% of electricity from renewables by 2010, 10% by 2013 (requires additional 210 MW by 2010, 510 MW by 2013)
- PEI
 - 6 wind farms
 - 72 MW in place
 - Target of 500 MW by 2013

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

sound

- Sound produced by wind turbines is aerodynamic or mechanical in nature
- “Infrasound” most controversial in terms of health
- Uneven nature of wind turbines (“swoosh swoosh”) perceived as more annoying than steady “white noise”



A COMPARISON OF SOUND PRESSURE AND SOUND PRESSURE LEVEL

Sound Pressure, Pa		Sound Pressure Level, dB	
	20	120	
	10		Pneumatic Chipper (at 5 ft.)
Rock-n-Roll Band	5	110	
	2	100	Textile Loom
Power Lawn Mower (at operator's ear)	1		Newspaper Press
	0.5	90	
Milling Machine (at 4 ft.)	0.2	80	Diesel Truck 40 mph (at 50 ft.)
Garbage Disposal (at 3 ft.)	0.1		
Vacuum Cleaner	0.05	70	
	0.02	60	Passenger Car 50 mph (at 50 ft.)
Air Conditioning Window Unit (at 25 ft.)	0.01	50	Conversation (at 3 ft.)
	0.005		
	0.002	40	Quiet Room
	0.001	30	
	0.0005		
	0.0002	20	
	0.0001	10	
	0.00005		
	0.00002	0	

**Wind farm
sound at
350m**

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

infrasound

audible sound

ultrasound

1 Hz

10 Hz

100 Hz

1,000 Hz

10,000 Hz

100,000 Hz

sound source

machine (cutting work)

vehicle engines

air blowing

suction

blast furnace

ultrasonic cleaners

trucks, trains, etc.

violin

hearing range

man

dog

bat



health concerns re 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)
- 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 EMF
 - IARC 2B: Possibly carcinogenic
 - Weak association with childhood leukemia
- EMF concerns not specific to wind energy – all electric transmission
- Buried transmission lines have effectively no electrical charge at the surface



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)
 - Buildings SE of turbines most impacted
 - Recommendation of 10× turbine diameter setback



shadow flicker

- Lasts a very short period of time (approx. 30 min) when conditions are present
- Most pronounced at distances from wind turbines less than 300 m (1,000 feet)
- Can cause dizziness and disorientation when inner ear and visual cues disagree — people with migraine may be more susceptible
- 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
- UK study recommends <3Hz (Max 3/sec; 60 rpm)
- 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

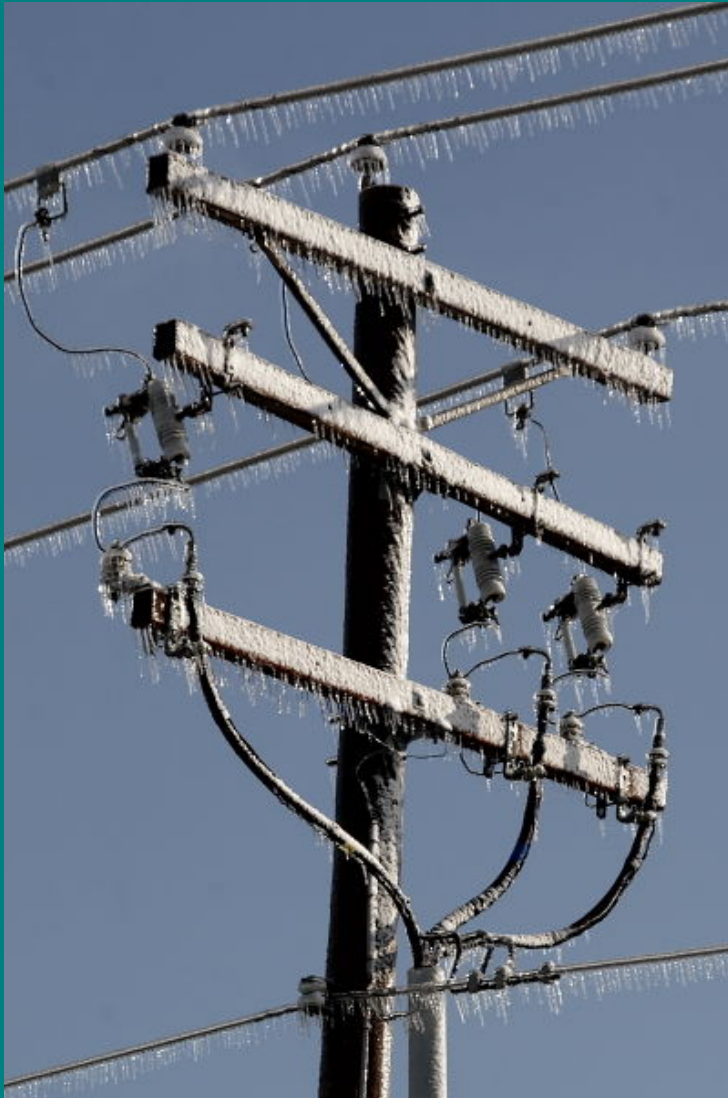
icing

- Glaze ice:

- Liquid precipitation or fog/cloud contacts cold surfaces ($<0^{\circ}\text{C}$)
- 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 Atlantic region**

- 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

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 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
 - No injuries documented in Ontario as a result of turbine failure
- 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}

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 species
- Migratory species
- Endangered species

Concerns:

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



wind farm setbacks

- Shadow flicker:
 - Recommendation of 10× turbine diameter setback (NZ Meridien Energy)
- Sound:
 - ON Ministry of Environment (NPC-232) :
40 dBA in rural areas, 45 dBA in others
 - At common setback distances, infrasound is at such low levels that it is inaudible with no evidence of health risk
- 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

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.

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

Thank you!

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