Industrial wind turbines can harm humans

University of Waterloo
Invited Talk

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March 29, 2017
Krogh: Personal disclosure

Health research/education
Self-funded
Air ticket/accommodation may be provided

Member of the Board - the Society for Wind Vigilance
International federation of physicians, acousticians, health, other professionals
Board members: volunteers/independent/published authors

Published author/coauthor (peer reviewed)

Krogh: peer reviewed publications


Krogh: peer reviewed publications


Wind turbines can harm humans
2011: Wind turbines can harm humans

“This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree.”

Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Environmental Review Tribunal, Decision, p 207

Ontario: 550 m setback

“The minimum setback distance of 550 metres (m) must be met in all cases and greater numbers of turbines may result in higher required setback distances applied to the nearest turbine.”

Ontario: models 40 dBA but approves up to 51

<table>
<thead>
<tr>
<th>Wind Speed (m/s) at 10 m height</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Level Limits, dBA</td>
<td>40.0</td>
<td>40.0</td>
<td>40.0</td>
<td>43.0</td>
<td>45.0</td>
<td>49.0</td>
<td>51.0</td>
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RENEWABLE ENERGY APPROVAL
NUMBER 2494-BRGUSA
Issue Date: March 16, 2012

2010: Compliance - setbacks and audible noise

“It appears compliance with the minimum setbacks and the noise study approach currently being used to approve the siting of WTGs will result or likely result in adverse effects…”

MOE memorandum, Ontario Senior Environmental Officer, April 9, 2010
2010: Audible noise recommended - 30 to 32 dBA

“… the setback distances should be calculated using a sound level limit of 30 to 32 dBA at the receptor, instead of the 40 dBA sound level limit.”

MOE memorandum, Ontario Senior Environmental Officer, April 9, 2010

2010: Setbacks and audible noise

“The audible sound from wind turbines, at the levels experienced at typical receptor distances in Ontario, is nonetheless expected to result in a non-trivial percentage of persons being highly annoyed. As with sounds from many sources, research has shown that annoyance associated with sound from wind turbines can be expected to contribute to stress related health impacts in some persons.”

2015: Annoyance - non-trivial percentage

“...two or three fairly comprehensive studies in Europe on annoyance versus sound levels ... found that in the range of about 35 to 40 dBA ... about six percent of people will be annoyed or very annoyed ... above 40 dBA, that number jumps to about 20 percent”

“...six percent is “not trivial”

1999: Sound and noise

The World Health Organization (WHO) defines noise as “unwanted sound”

Sound and noise

Sound meters can assess sound; however, unwanted sound is perceived by humans as “noise”.

“Health” defined
World Health Organization (WHO)

1948: Health defined

CONSTITUTION
OF THE WORLD HEALTH ORGANIZATION

The States Parties to this Constitution declare, in conformity with the Charter of the United Nations, that the following principles are basic to the happiness, harmonious relations and security of all peoples:

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
Canada supports definition of health

2011: Health includes social well-being

... “starting with the identification of physiological and psychological symptoms”

“culminating with frustration, grief and anger, disempowerment, loss of trust, and an overall sense of social injustice.”

“Many feel abandoned by the very procedural systems they believed would protect them.”

Commonly reported symptoms

2009: Wind turbine commonly reported symptoms

Dr. Nina Pierpont documented symptoms reported by individuals exposed to wind turbines which include: sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic episodes associated with sensations of internal pulsation or quivering when awake or asleep. [1]
2009: Wind turbine commonly reported symptoms acknowledged

Symptoms are not new and have been published previously in the context of “annoyance” and are the “well-known stress effects of exposure to noise”. [2]

“I am happy to accept these symptoms… what Pierpont describes is effects of annoyance by noise – a stress effect…” [3]

References: Wind turbine commonly reported symptoms


What is annoyance?

Annoyance is acknowledged to be an adverse health effect. 1,2,3,4,5


2004: Chronic strong annoyance

“Conclusion

The result confirms the thesis that for chronically strong annoyance a causal chain exists between the three steps health – strong annoyance – increased morbidity.”

2016: Annoyance - Health Canada Wind Turbine Noise and Health Study

“Study findings indicate that annoyance toward all features related to wind turbines, including noise, vibrations, shadow flicker, aircraft warning lights and the visual impact, increased as WTN levels increased. The observed increase in annoyance tended to occur when WTN levels exceeded 35 dB and were undiminished between 40 and 46 dB.”


2004: Wind turbines more annoying than other industrial noise (0.6 or 0.66 MW)
References: Wind turbines more annoying than other industrial noise


Visas – flicker
Direct and indirect impacts

2010: Direct causal link

“New Report From Ontario's Chief Medical Officer Of Health Says There Is No Direct Causal Link Between Wind Turbines And Adverse Health Effects”

Media Release (May 20, 2010 11:00 A.M.) Ministry of Health and Long Term Care
2009: Noise exposure in general - direct and indirect

World Health Organization, Night Noise Guidelines for Europe, 2009

2011: Ontario Chief Medical Officer of Health author testimony

CMOH report only looked at direct links [2]

CMOH author agrees with schema [1]
Proof of causality

“… the proof of causality ranks at about 95 to 99% certainty and is rarely possible for biological systems; the Precautionary Principle ranks at the about the 50% medium level, consistent with civil and some administrative law; and environmental protection has a low level of certainty (10 to 30%)”

2011: Ontario Decision - direct and indirect impacts

“... The Tribunal has found above that “serious harm to human health” includes both direct impacts (e.g., a passer-by being injured by a falling turbine blade or a person losing hearing) or indirect impacts (e.g., a person being exposed to noise and then exhibiting stress and developing other related symptoms). This approach is consistent with both the WHO definition of health and Canadian jurisprudence on the topic.”

Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Environmental Review Tribunal, Decision, p190

Populations at risk

Rural families ←

Vulnerable populations

(Children, elderly and other)

Workers
2009: Escaping wind turbine LFN \[1, 2, 3\] – 5 shut down at night

Financial settlement with wind energy developer 2009 - non-disclosure

1. Community funded noise study
2. Developer noise study
3. Freedom of Information

With kind permission B. Ashbee, Ontario

2009: A cluster of affected families

With kind permission: Ripley, Ontario families
WHO: Noise and vulnerable populations

“Who is most affected?”

Some groups are more vulnerable to noise. As children spend more time in bed than adults, they are more exposed to night noise. Chronically ill and elderly people are more sensitive to disturbance.”

World Health Organization, Europe, Noise - Facts and Figures (2012),
2010: Children - noise in general & sleep

“Animal experiments unequivocally show that sleep loss even for three or four days can adversely and permanently affect neurophysiological functions and neurogenesis.”

“This review summarises the increasing evidence … that chronic disturbances of sleep adversely affect brain development …


Children: Noise in general and pre-existing medical conditions

Autism [1,2,3]
Asthma [4,5]
Migraine [6,7]
Bronchitis [8]
Epilepsy [9,10]
Childhood asthma [11] and migraine [12] can be triggered by stress
References: Noise in general & pre-existing medical conditions (part 1)


References: Noise in general & pre-existing medical conditions (part 2)


10. Epilepsy Facts - Epilepsy Canada.


Populations at risk

Rural families
Vulnerable populations
(Children and Elderly)
Workers

2011: Worker exposure and infrasound effects

3 - 1.65 MWatt turbines – 400 & 520 m

Sleep problems, nausea, dizziness, irritability, head
ached, no appetite, concentration issues, desire to leave,
anxiety, felt miserable, performed tasks at reduced pace,
preferred outdoors to indoors.
2015: Worker exposure and infrasound effects

46 - 1.5 MW – closest about 3 km

Within 3 – 5 hours: significant sense of lethargy, progressed to difficulty in concentration, nausea, feeling distinctly unwell progressing to effects increasingly worsened, felt extremely ill, same symptoms as seasickness in a rough sea, balance and co-ordination completely compromised.

Swinbanks M. Direct experience of low-frequency noise and infrasound within a windfarm community. Paper - 6th International Meeting on Wind Turbine Noise, April 2015.

2015: Worker exposure and infrasound / low frequency noise effects

Facility: 170 wind turbines - 0.3 to 0.66 MWatt

“... sleep disorder will increase by 26% as per each 1 dB increase in equivalent sound level.” [2]

2015: Worker exposure and infrasound / low frequency noise effects

Facility: 170 wind turbines - 0.3 to 0.66 MWatt

“... for the first time in the world, examines the impact of wind turbine noise on sleep disorder of workers who are more closer to wind turbines and exposed to higher levels of noise. So despite all the good benefits of wind turbines, it can be stated that this technology has health risks for all those exposed to its sound ... further research is needed to confirm the results of this study.”


2016: Worker exposure and low frequency noise

Facility: 170 wind turbines - 0.3 to 0.66 MWatt

“... wind turbine noise has negative impacts on the health of directly exposed people. Long-term noise exposure is a psychological stressor that can cause mentally abnormal responses and adverse health effects through interactions between autonomic nervous system, neuroendocrine system, and the immune system.”

Low frequency/ Infrasound
What you can’t hear won’t harm you...

2009: Ontario guidelines and low frequency / infrasound

In regard to your question about perceptible infrasound (vibration) or low frequency noise, as stated in the Proposed REA, the Ministry of the Environment intends to develop technical guidance on the monitoring of infrasound and low frequency noise.

• Personal Correspondence: Ministry of Environment, July 20, 2009
1982 and 1987: low frequency noise

MOD-1 - 2 MW– about 3 km distance

1982: residents reported they could "feel" more than hear the sounds... “... human body resonances ... creating a sensation of a whole-body vibration" ... “This perception is more noticeable indoors...” [1]

1987: Proposed metrics “... over a range of 5-100 Hz...” [2] *

* University of Waterloo research – Professor Richard Mann

References: 1982 and 1987: low frequency noise


2012: Shirley Wind Farm and infrasound

“The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry.”


2014: Cape Bridgewater - infrasound

Approach
- Turbines “off” and “on”
- Diaries - severity ratings of noise, vibration, other disturbances
- Sensations synchronized with wind turbine operational data

Results
- “Sensations”: headache; pressure in the head, ears, or chest; ringing in the ears; heart racing; a sensation of heaviness
- Sensations not dependent on the ability to hear or see the turbines
- Sensations most related to start-up, increase or decrease in power output (about 20%), and when operating at maximum power and wind speed increased above 12 m/sec.
Reference 2014: Cape Bridgewater infrasound research


2015: Brain response to infrasound in general – 8 Hz

Figure 4. Slices of the brain with color-coded frequency dependent activation areas, p < 0.001.
Reference: brain response to infrasound in general – 8 Hz


2015: Amplitude modulation, infrasound and brain waves

0.6 MW wind turbine (average 8.9 m/s - output 0.353 MW)

To verify the physiological impact (brain waves) of AM (including infrasound with extremely low-frequency band)

Brain waves measured by EEG

General finding: Subjects cannot be relaxed comfortably when listening to the infrasound noise.

Worker exposure: “...the infrasound (e.g., low frequency and inaudible for human hearing) was considered to be an annoyance to the technicians who work in close proximity to a modern large-scale wind turbine.”

2011: Møller & Pedersen: low frequency wind turbine noise

Research indicates a variable that should be considered relates to low frequency noise in that IWTs are becoming bigger, more powerful resulting in the relative amount of low frequency noise being higher for the larger (2.3–3.6 MW) than the smaller turbines (less than 2 MW) and the difference is statistically significant.


Yesterday’s and today’s industrial wind turbines
1985: Wind turbines 45 m
2007: Wind turbines 143.5 m

2017: Ontario proposed 195 m
La Gaspésie Quebec

Germany
Michigan USA

Source: Appraisal Institute Webinar – October, 2012

Perspective visuals: Ontario

Photo courtesy of Bonny McKeough, Ontario, estimate 0.5 mile from home
Prince Edward Island

Palm Springs California
Research variables

Wind turbine variables

- Government policies
- Noise guidelines and compliance limits
- IWT trade/brand name (blades, other)
- MWatt/sound power levels
- Operational status (full/partial/off/idling/ramping up or down)
- Wind speed/direction
- Seasonal/atmospheric conditions
- Siting array (distances/upwind/downwind)
- Terrain (flat/hills/sand/soil/bedrock)
- Population densities and number of wind turbines*
People variables

Individual human responses
Noise sensitivity
Pre-existing medical conditions (cardiac, migraine, sleep, depression)
Vulnerable population groups (rural, children (all stages of development, elderly, special needs)
Occupational workers
Use of predictive computer models versus actual noise measurements
Population densities and number of wind turbines*

Knowledge gaps
Knowledge gaps acknowledged


Pre- and post-implementation knowledge gaps

- front end animal/laboratory/human studies prior to implementation
- response to consequences of chronic exposure *
- vigilance monitoring and long term surveillance
- metrics - intensity and length of time of exposure, predictability **
- response to risk of various emissions (audible and inaudible noise - low frequency/infrasound, tonal, radio/electromagnetic energy)
- response to risk of pre-existing medical conditions (cardiac, immune disorders, migraine)
- response to risk to vulnerable population groups (rural, children, elderly, those with pre-existing medical condition including special needs)
- prevalence monitoring of abandoned homes
- social-economic monitoring on rural communities and residents
- proactive remedy - causality/mechanism of action

* Annoyance pathway

**Professor Richard Mann (UofW)
Health Canada wind turbine study:
$2.1M

“... the results will not provide a definitive answer on their own.” [1]

“...this design does not permit any conclusions to be made with respect to causality.” [1]

“...results may not be generalized to areas beyond the sample as the wind turbine locations in this study were not randomly selected from all possible sites operating in Canada.” [2]

References previous slide


Other challenges

2005: Government of Canada support and fund wind energy
2005: Health Canada - systematic assessment / populations at risk (Note: the next 2 slides represent this slide)
2005: Health Canada - systematic assessment / populations at risk

2005: Health Canada proactive for most at risk

*We cannot afford to wait until the health of Canadians is affected before we act. We have the means, tools and knowledge to become proactive in protecting the health of our citizens, in particular those most at risk.*
2005: Health Canada associated health risks and uncertainty about liability

... there is uncertainty concerning the liability of the federal government with respect to future associated health risks...

To date, none of the programs established by the federal government to support climate change technologies have made provisions to incorporate health risks assessments or any other health assessment activity.

As a result, it is unclear if the recommendations … protect the Crown from future liabilities resulting from the widespread application of new technologies.

Reference: 2005: Health Canada associated health risks and uncertainty about liability
1986: Health Canada - policies and practices

“It is clear … that existing policies and practices are not sufficiently effective to ensure that Canadian men and women of all ages and backgrounds can have an equitable chance of achieving health … Conflicting interests may exist between sectors.”

2008: World Health Organization

“Different government policies, depending on their nature, can either improve or worsen health and health equity.”
Health inequity: Informed consent

Project participants (host)/non-participants (do not host) wind turbines.

Participants through a contractual agreement typically agree to accept potential risk factors such as increased noise, nuisance, and shadow-flicker [1]

Non-participants do not have an opportunity to consent to the risk of exposure [2,3]

1. Contractual agreement
3. Unwilling hosts. Wind Concerns Ontario

Industry-led : government-supported
1999: WHO comments on scientific proof

“In all cases, noise should be reduced to the lowest level achievable in a particular situation. Where there is a reasonable possibility that public health will be damaged, action should be taken to protect public health without awaiting full scientific proof.”


Conclusion
Conclusions

Authorities to acknowledge:
- Wind turbines can harm humans if sited too close to humans.
- The sound from wind turbines at typical Ontario setback distances is expected to result in adverse health effects.
- Numerous knowledge gaps remain unresolved.

Next:
- Implement prevention and precaution before exposing more humans to wind turbines.
- Provide remedy to the satisfaction of those reporting harm.

Finally:
- Establish an independent multidisciplinary approach to investigate and determine safe limits.

Thank you

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