National Collaborating Centre for Environmental Health
Centre de collaboration nationale en santé environnementale

JANUARY 2010

Wind Turbines and Health

Karen Rideout, Ray Copes, Constance Bos

evidence review

Summary

- **Noise and Low Frequency Sound.** The sound level associated with wind turbines at common residential setbacks is not sufficient to damage hearing, but may lead to annoyance and sleep disturbance.
- **Electromagnetic Fields (EMF).** Wind turbines are not significant sources of EMF exposure.
- **Shadow Flicker.** Shadows caused by wind turbine rotors can be annoying, but are not likely to cause epileptic seizures at normal operational speeds of 30 to 60 rpm.
- **Ice Throw and Structural Failure.** Risk of injury can be minimized with setbacks of 200 to 500 m and by implementing shutdown procedures during conditions that cause ice to form.

Introduction

Wind turbines are large towers with rotating blades that use wind to generate electricity (Figure 1); a wind farm is a collection of wind turbines. In 2009, wind farms produced 3249 MW, 1.1% of Canada's electricity consumption, with most provinces planning to significantly increase wind energy production over the next 5 to 10 years.

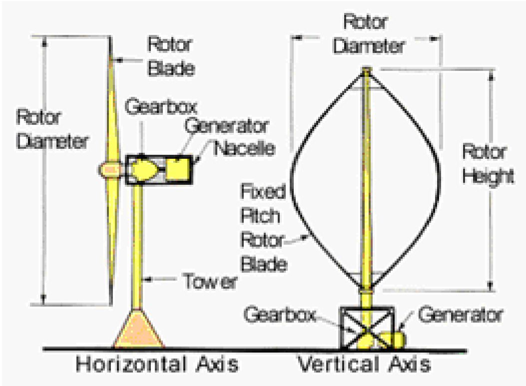

Figure 1. *Typical Wind Turbine Configuration*[1]

Wind turbines and health

A range of symptoms including dizziness, sleep disruption, and headaches have been attributed to wind turbines.[2] This document synthesizes available research relating to the potential for wind turbines to affect the health of nearby residents (Table 1).

Sound and noise

Sound from wind turbines is caused by the movement of mechanical parts near the central housing (nacelle) or the displacement of air caused by the turning blades. Wind turbines produce both broadband and tonal (distinct pitch) sound.[3] At 300 to 350 m, the sound level associated with large wind turbines is normally in the range of 35 to 50 dBA, which is comparable to indoor background sound (Figure 2)[3, 4] and not sufficiently high to damage hearing.[5]

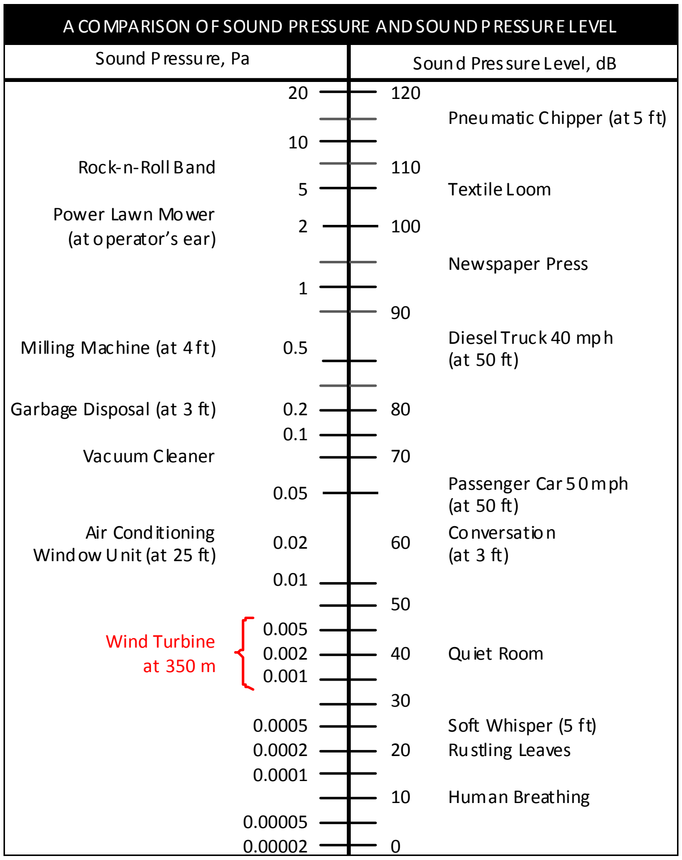

Figure 2. *A comparison of sound pressure and sound pressure level (wind turbines in relation to other sources)*

Source: Adapted with the permission of CCOHS[6] with AWEA[4] and RCMP[7]

Noise is defined as unwanted sound, and perception of noise differs among people and places. Sleep interruption has been associated with wind turbine sound among residents living less than 2.5 km from turbines, particularly when sound levels are above 45 dBA at night[8]; however, many people report noise annoyance from wind turbines at outdoor sound levels below 40 dBA.[9, 10] When aerodynamic modulation (swishing sound) occurs, wind turbine sound may be perceived as more annoying than steady sound or 'white noise'.[11] Studies in Sweden and the Netherlands have found dose–response relationships between measured dBA levels, perception of sound, and annoyance.[8, 9, 12, 13] The association between sound pressure and noticing sound is stronger than that between sound pressure and annoyance with sound.[12, 13] Annoyance with wind turbine sound is also modified by visual perception[9, 10, 12, 14], the belief that turbines are intrusive,[10, 15] and a lack of direct economic benefit.[8, 12] It is also more common in rural areas and in complex versus flat landscapes.[14]

Low frequency sound, vibration, and infrasound

Concerns have been raised about human exposure to low frequency sound from wind turbines. Low frequency sound is normally defined as that below 200 Hz, and infrasound as that below 20 Hz. Although low frequency sound can be audible[16], human hearing is most sensitive between 1000 and 20000 Hz, which is the range of human speech. Low-level low frequency sound is ubiquitous in the environment (e.g., from wind), which presents additional challenges to public health officials because it is difficult to measure and attribute specifically to wind turbines.[17-21]

The Danish limit for indoor environmental infrasound is 85 dBG[a], just below the average threshold of hearing.[19] Schust[22] provides a comprehensive review of experimental studies, reporting effects such as ear pain, vibration sensations, respiratory effects, and delayed motor response from low frequency sound above 80 dB. Low frequency and infrasonic sound from upwind[b] turbines is lower, typically 50 to 70 dB.[19, 20] A small increase in sound level at low frequency can result in a large increase in perceived loudness and may be difficult to ignore, even at relatively low sound pressure levels,[17, 23, 24], increasing the potential for annoyance (e.g., complaints occur at 55 dBA when there is a sizeable low frequency component[17]).

EMF

Electromagnetic fields (EMF) around wind farms can originate from the grid connection lines, wind turbine generators, electrical transformers, and underground network cables.[25-27] The grid connection lines are similar to other power lines and generate low levels of EMF, comparable to those generated by household appliances. Turbine generators are located inside the turbine's central housing, which is situated 60 to 100 m above ground, and results in little or no EMF at ground level.[26] Transformers generate EMF highest within the wind farm itself. The underground cables that connect the turbines effectively generate no EMF at the surface because of the close placement of phase conductors and screening of the cables.[25, 26] Thus, wind turbines are not considered a significant source of EMF exposure.

---

[a] dBG is a frequency weighting designed specifically to measure infrasound (1–20 Hz).
[b] Upwind turbines, the common modern configuration, are those with the rotor upwind of the turbine. Older "downwind" turbines produced much higher levels of low frequency and infrasound.

Shadow flicker

Shadow flicker occurs when the blades of a turbine rotate in sunny conditions, casting moving shadows on the ground that result in alternating changes in light intensity. The timing, intensity, and location of shadows are influenced by the size and shape of the turbine, landscape features, latitude, weather, and layout of the wind farm. Moving shadows have their longest reach when the wind direction is parallel to a straight line between the sun, turbine, and object and when the sun is low in the sky.[3, 28] One Swedish study found that annoyance was more closely associated with whether shadow flicker occurred when people were at home than with the amount of time shadows were visible.[29]

About 3% of people with epilepsy are photosensitive, generally to flicker frequencies between 5 and 30 Hz.[30] To ensure shadow flicker frequency does not approach this range, turbine blades should be programmed to stop when blade rotation exceeds 3 Hz (60 rpm for a three-blade turbine). Most industrial turbines operate at 30 to 60 rpm.[31] Although these moving shadows are not dangerous *per se*, they nonetheless may introduce a distraction hazard for drivers.[3]

Ice throw and ice shed

Ice may form on wind turbines, depending on the presence of low temperature, cloud cover, precipitation, and heavy fog. Ice and ice fragments can be thrown from moving turbine blades or break loose and fall to the ground.[32, 33] Ice throw (i.e., ice projected off the turbine blade) presents a potentially severe public hazard since the ice may be launched far from the turbine. In contrast, ice that sheds or drops from stationary components places service personnel near the wind farm most at risk.

Two types of ice can form on the blades of wind turbines. Glaze ice is smooth, transparent, and highly adhesive; it forms when moisture contacts surfaces colder than 0°C (e.g., ice storms at low elevation). It normally falls straight down shortly after formation. Rime ice, which is granular and opaque, forms at colder temperatures and is less adhesive. It is sometimes thrown from moving turbines, but often breaks into smaller pieces.[33-35] A European survey found that ice fragments shed from wind turbine blades ranged in size from 0.1 to 1.0 kg and were found between 15 and 100 m from the base.[33] Reports from approximately 1,000 inspections of a single wind turbine in Ontario between 1995 and 2001 identified 13 occasions of ice build-up. On each occasion, ice fragments of up to $30 \times 30 \times 5$ cm were found on the ground, mostly within 100 m of the turbine.[32]

The extent of ice formation and resulting ice throw depends on a number of factors: climate conditions, wind speed and operational range of turbines, direction of blades in relation to people or structures, turbine dimensions, terrain, and structural factors such as anti-adhesive coatings or dark coloured (heat absorbing) blades.[32, 33, 35] To minimize risk, turbines can be stopped during icy conditions, either manually or automatically, and restarted only when no ice remains on the blades.[33]

Key Gaps in Evidence

- **Health effects from long-term exposure to low levels of low frequency sound**
- **Practical measurement methods for attributing sound specifically to wind turbines**
- **Impact of wind turbine sound on sleep physiology**
- **Risk of ice throw in regions where glaze ice is common (most research has focused on rime ice)**
- **Research to measure the efficacy of currently-used setbacks to prevent injury**
- **Epidemiological data to assess health status before and after wind farm development**

Structural hazards

In documented cases of wind turbine blade failure, the maximum reported throw distance is 150 m for an entire blade, and 500 m for a blade fragment. A Dutch handbook using 1980–2001 data (Braam cited in [32]) indicated the risk of partial blade failure was 1 in 4,000 turbines per year, and the risk of full blade failure was between 1 in 2,400 and 1 in 20,000 turbines per year, depending on rotor speed. There have been instances of turbine collapse and blade failure in Europe and the US.[36, 37] Because structural failure is potentially fatal, careful monitoring is essential.[36] Other injuries and fatalities associated with wind turbines have been reported[38, 39], mostly to workers during construction and transport accidents.

Wind turbine structures are designed to withstand ice loads on the blades, but ice and snow build-up can contribute to structural failure and hamper performance.[34, 40, 41] Although most turbines are designed to withstand temperatures as low as –20 to –40°C, structural materials can be compromised by extreme cold.[41] Cold stress can cause steel and/or composite components to crack or deform, interfere with electrical equipment, or damage moving parts in the gearbox[35, 40], increasing the risk of turbine failure.

Setbacks and operating conditions

Setbacks and operational guidelines can be used in combination to address safety hazards, sound levels, land use issues, and impacts on people (see Table 2).

Table 1. *Summary of potential wind turbine hazards and mitigation options*

Hazard	Possible Sources	Evidence	Mitigation
Sound/Noise	Turbine mechanics or blade motion (aerodynamic)	• Sound levels are below health and safety limits • Annoyance and sleep disruption are common when sound levels are 30 to 45 dBA • Noise perception is associated with perception of visual impact, lack of direct economic benefit, and negative attitudes toward turbines	• Utilize setbacks and land use planning to minimize sound levels and sound propagation
Low frequency sound Infrasound	Turbine mechanics or blade motion (aerodynamic)	• Evidence of health effects at levels >80 dB • Lack of evidence regarding levels produced by wind turbines (<70 dB)	• Install turbines with rotor upwind of turbine base • Utilize setbacks to minimize sound levels
EMF	Generators Grid connection lines Transformers Underground cables	• No community exposure from turbine EMF • No EMF generated at surface from underground cables	• N/A
Shadow flicker	Blade motion when sun is low in sky	• Flicker frequency is below range likely to induce epileptic seizures • Annoyance is more likely if flicker occurs while people are at home	• Use of non-reflective and/or dark coloured blades • Maintain flash frequency below 3 Hz (60 rpm for 3-blade turbine)
Ice throw/ Ice shed	Glaze or rime ice falling from stationary turbine or thrown from moving blades	• Physical danger to people or passing vehicles • Ice tends to fall straight down; usually falls well within setbacks	• Utilize setbacks to minimize risk of injury from ice fall • Utilize operational controls to cease turbine operation during icing conditions
Structural failure	Blade or tower cracking or falling	• Physical danger to people or passing vehicles • Cases of failure rare and normally contained within 500 m of base	• Utilize setbacks to minimize risk of injury in the event of structural failure

Table 2. *Examples of Canadian wind turbine setback guidelines and regulations**

<table>
<tr><th>Reason</th><th>Setback/Guideline</th><th>Comments</th><th>Source</th></tr>
<tr><td>Sound</td><td>≤ 6 m/sec wind speed:
• 40 dBA Class 3 (rural)
• 45 dBA Class 1 (urban) & Class 2 (major centre with quiet nights)
10 m/sec wind speed:
• 51 dBA</td><td>• Proposed minimum 550-m setback to ensure noise is less than 40 dB at the receptor (defined as centre of dwelling, or 30 m from the dwelling façade in the direction of the turbine, whichever has higher noise impact)
• Distance depends on sound rating and number of turbines
• Perceptible infrasound and low frequency sound should be monitored and addressed</td><td>Ontario Ministry of the Environment (NPC-232)[42-44]</td></tr>
<tr><td>Sound</td><td><table>
<tr><th rowspan="2">SPL (dBA)</th><th colspan="3">Number of Turbines</th></tr>
<tr><th>5</th><th>10</th><th>25</th></tr>
<tr><td>102</td><td>550 m</td><td>650 m</td><td>750 m</td></tr>
<tr><td>104</td><td>600 m</td><td>700 m</td><td>850 m</td></tr>
<tr><td>105</td><td>850 m</td><td>1000 m</td><td>1,250 m</td></tr>
<tr><td>107</td><td>950 m</td><td>1,200 m</td><td>1,500 m</td></tr>
</table></td><td>• Proposed (September 2009) setbacks for compliance with MOE Noise Limits
• Based on number of turbines in wind farm (5, 10, or 25) and sound power level (SPL) rating of turbines expressed as dBA</td><td>Ontario Ministry of the Environment[44]</td></tr>
<tr><td>Sound</td><td>6–9 m/sec wind speed:
• 40 dBA (night, rural)</td><td>• Noise impact assessments must be conducted to assess impact of energy projects on nearest or most impacted residence</td><td>Alberta Directive[45]</td></tr>
<tr><td>Sound</td><td>8–11 m/sec wind speed:
• 40 dBA (residential)</td><td>• Based on wind speed at which power is constant, normally 8 to 10 m/sec. Otherwise 11 m/sec is used</td><td>British Columbia Land use operational policy, wind power projects on Crown Land[45]</td></tr>
<tr><td>Sound</td><td>• <45 dBA at receptor</td><td>• Proposed guidelines for Canada
• Designed to comply with WHO recommendation of sound levels indoors <30 dBA for continuous background noise for good night's sleep (with 20-dB attenuation by dwelling)</td><td>Keith et al.[45]</td></tr>
<tr><td>Structural failure</td><td>• 150 m to 500 m</td><td>• To minimize risks from potential blade failure</td><td>Garrad Hassan Canada Inc.[32]</td></tr>
<tr><td rowspan="2">Ice throw</td><td>• 200 m to 250 m</td><td rowspan="2">• For protection from ice throw</td><td>Morgan et al.[33]</td></tr>
<tr><td>• 230 m to 350 m</td><td>Jacques Whitford[37]</td></tr>
<tr><td>Public road safety</td><td>• 1 blade length + 10 m from public road</td><td>• Risk assessment required for towers within 50 to 200 m of public road</td><td rowspan="2">CanWEA[46]</td></tr>
<tr><td>Physical safety</td><td>• 1 blade length + 10 m from all property lines</td><td>• To minimize risk from ice or blade fragments
• Setback not necessary if all property owners agree</td></tr>
</table>

*Setbacks for wind farms in Canada are often managed through municipal by-laws, which are too numerous to list here.

Acknowledgements

We would like to thank the following individuals for their invaluable input and review of this document: Allan Torng, Hugh Davies, Mark Durkee, Neal Michelutti, and Robert Rippin. Research assistance provided by Mê-Linh Lê.

References

1. Environmental Protection Agency. Auxiliary and supplemental power fact sheet: Wind turbines. Office of Water; 2007 [cited 2010 Jan 7]. Available from http://www.epa.gov/owm/mtb/wind_final.pdf.
2. Pierpont N. Wind turbine syndrome. 2009 [cited 2009 Apr 15]. Available from: http://www.windturbinesyndrome.com/.
3. National Research Council Committee on Environmental Impacts of Wind-Energy Projects. Environmental impacts of wind-energy projects. Washington, D.C.: National Academies Press; 2007.
4. AWEA. Utility scale wind energy and sound. Washington, DC: American Wind Energy Association. 2009 [updated 2009 June 26; cited 2009 July 22]. Available from: http://www.awea.org/pubs/factsheets/Utility_Scale_Wind_Energy_Sound.pdf.
5. Colby WD, Dobie R, Leventhall G, Lipscomb DM, McCunney RJ, Seilo MT, et al. Wind turbine sound and health effects. An expert panel review: American Wind Energy Association & Canadian Wind Energy Association; 2009 [cited 2009 Dec 21]. Available from: http://www.canwea.ca/pdf/talkwind/Wind_Turbine_Sound_and_Health_Effects.pdf.
6. CCOHS. Noise - Basic information. Canadian Centre for Occupational Health and Safety. 2006 [updated 2006 Jan 9; cited 2009 July 22]. Available from: http://www.ccohs.ca/oshanswers/phys_agents/noise_basic.html.
7. RCMP. Shooting ranges and sound. Ottawa, ON: Royal Canadian Mounted Police; 2007 [cited 2009 Nov 10]. Available from: http://www.rcmp-grc.gc.ca/cfp-pcaf/information/club/snd_guide/SRAS/ShootingRangesSound.pdf.
8. van den Berg F, Pedersen E, Bouma J, Bakker R. WINDFARMperception. Visual and acoustic impact of wind turbine farms on residents. 2008 [cited 2009 Aug 27]; FP6-2005-Science-and-Society-20, Specific Support Action, Project No. 044628: Available from: http://www.wind-watch.org/documents/wp-content/uploads/wfp-final-1.pdf.
9. Pedersen E, Persson Waye K. Perception and annoyance due to wind turbine noise—a dose–response relationship. J Acoust Soc Am. 2004;116(6):3460-70.
10. Pedersen E, Persson Waye K. Wind turbines—low level noise sources interfering with restoration? Environ Res Lett. 2008;3:1-5.
11. Moorehouse A, Hayes M, von Hünerbein S, Piper B, Adams M. Research into aerodynamic modulation of wind turbine noise: Final report: University of Salford; 2007 [cited 2009 June 10]. Contract No.: NANR233. Available from: http://www.berr.gov.uk/files/file40570.pdf.
12. Pedersen E, van den Berg F, Bakker R, Bouma J. Response to noise from modern wind farms in The Netherlands. J Acoust Soc Am. 2009;126(2):634-43.
13. Pedersen E, Persson Waye K. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. Occup Environ Med. 2007;64:480-6.
14. Pedersen E, Larsman P. The impact of visual factors on noise annoyance among people living in the vicinity of wind turbines. J Env Psych. 2008;28:379-89.
15. Pedersen E, Hallberg LR-M, Waye KP. Living in the vicinity of wind turbines – A grounded theory study. Qual Res Psych 2007;4:49-63.
16. Moller H, Pedersen C. Hearing at low and infrasonic frequencies. Noise Health. 2004;6(23):37-57.
17. Berglund B, Hassmén P, Soames Job RF. Sources and effects of low-frequency noise. J Acoust Soc Am. 1996;99(5):2985-3002.
18. Guest H. Inadequate standards currently applied by local authorities to determine statutory nuisance from LF and infrasound. J Low Freq Noise Vib Active Contr. 2003;22(1):1-7.
19. Jakobsen J. Infrasound emission from wind turbines. J Low Freq Noise Vib Active Contr. 2005;24(3):145-55.
20. Leventhall G. Infrasound from wind turbines – fact, fiction or deception. Can Acoust. 2006;34(2):29-36.
21. Sienkiewicz Z. Rapporteur report: Roundup, discussion and recommendations. Prog Biophys Mol Biol. 2007;93(1-3):414-20.
22. Schust M. Effects of low freqnency noise up to 100 Hz. Noise Health. 2004;6(23):73-85.

23. Berglund B, Lindvall T. Community noise. Stockholm: Center for Sensory Research; 1995 [cited 2009 Apr 21]. Available from: www.appa-agf.net/filemanager/download/145/noise%20OMS.pdf.
24. DeGagne DC, Lapka SD. Incorporating low frequency noise legislation for the energy industry in Alberta, Canada. J Low Freq Noise Vib Active Contr. 2008;27(2):105-20.
25. Sustainable Energy Australia (SEA) Pty. Ltd. The electromagnetic compatibility and electromagnetic field implications for wind farming in Australia. Melbourne and Canberra: Australian Greenhouse Office & Australian Wind Energy Association; 2004 [cited 2009 July 21]. Available from: http://www.wind.appstate.edu/reports/BP10_EMC&EMF.pdf.
26. Hydro Tasmania. Heemskirk Wind Farm - Development proposal and environmental management plan project summary. Hobart: Department of Primary Industries, Parks, Water and Environment; 2003 [cited August 26 2009]. Available from: http://www.environment.tas.gov.au/file.aspx?id=1773.
27. Windrush Energy. The health effects of magnetic fields generated by wind turbines. Palgrave, ON: Windrush Energy; 2004 [cited 2009 Feb 17]. Available from: http://www.windrush-energy.com/update%20Jul%2024/Appendix%20D%20-%20Magnetic%20Field%20Survey/Magnetic%20Field%20Report.pdf.
28. Danish Wind Energy Association. Shadow casting from wind turbines. Frederiksberg: Danish Wind Energy Association. 2003 [updated 2003 June 8; cited 2009 June 29]. Available from: http://www.windpower.org/en/tour/env/shadow/index.htm.
29. Bolton RH. Evaluation of environmental shadow flicker analysis for "Dutch Hill Wind Power Project." Rushville, NY: Industrial Wind Action Group; 2007 [cited 2009 Aug 31]. Available from: http://www.windaction.org/?module=uploads&func=download&fileId=1136.
30. Epilepsy Foundation. Photosensitivity and epilepsy. Epilepsy Foundation. n.d. [cited 2009 April 15]. Available from: http://www.epilepsyfoundation.org/about/photosensitivity/index.cfm.
31. Harding G, Harding P, Wilkins A. Wind turbines, flicker, and photosensitive epilepsy: Characterizing the flashing that may precipitate seizures and optimizing guidelines to prevent them. Epilepsia. 2008;49(6):1095-8.
32. Garrad Hassan Canada Inc. Recommendations for risk assessments of ice throw and blade failure in Ontario. Contract report for Canadian Wind Energy Association (CanWEA); 2007 [cited 2009 Apr 22]. Contract No.: 38079/OR/01. Available from: http://www.canwea.ca/images/uploads/File/GH-RiskAssessment-38079or01a(1).pdf.
33. Morgan C, Bossanyi E, Seifert H. Assessment of safety risks arising from wind turbine icing. BOREAS IV – Wind Energy Production in Cold Climate; 1998 Mar 31 - Apr 2; Hetta, Finland: Finnish Meteorological Institute; 1998. p. 113-21.
34. Bailey BH. The potential for icing of wind turbines in the northeastern US. Windpower; 1990 Sept 25-28; Washington, DC: American Wind Energy Association; 1990. p. 286-91.
35. Lacroix A, Manwell JF. Wind energy: Cold weather issues. Amherst: Renewable Energy Research Laboratory, University of Massachusetts; 2000 [cited 2009 Apr 23]. Available from: http://www.hydro.mb.ca/regulatory_affairs/wuskwatim/presentations/exhibits_1031b.pdf.
36. Ciang CC, Lee J-R, Bang H-J. Structural health monitoring for a wind turbine system: A review of damage detection methods. Meas Sci Technol. 2008;19(12).
37. Jacques Whitford. Model wind turbine by-laws and best practices for Nova Scotia municipalities. Halifax, NS: Union of Nova Scotia Municipalities; 2008 [cited 2009 Apr 21]. Contract No.: 1031581. Available from: http://www.sustainability-unsm.ca/our-work.html.
38. Caithness Windfarm Information Forum. Summary of wind turbine accident data to June 30th 2009. 2009 [updated 2009 June 30; cited 2009 July 23]. Available from: http://www.caithnesswindfarms.co.uk/page4.htm.
39. Gipe P. Wind energy – The breath of life or the kiss of death: Contemporary wind mortality rates. Wind-Works.org. 2003 [cited 2009 July 23]. Available from: http://www.wind-works.org/articles/BreathLife.html.
40. Manitoba Hydro. Clarification of wind turbine cold weather considerations: Manitoba Hydro summary. Winnipeg: Manitoba Hydro; 2004 [cited 2009 Apr 21]. Available from: http://www.hydro.mb.ca/regulatory_affairs/wuskwatim/presentations/exhibits_1031.pdf.
41. Durstewitz M, Dobesch H, Kury G, Laakso T, Ronsten G, Säntti K. European experience with wind turbines in icing conditions. European Wind Energy Conference; 2004 Nov 22-25; London, UK. 2004.

42. Ontario Ministry of the Environment. Noise guidelines for wind farms: Interpretation for applying MOE NPC publications to wind power generation facilities. Ottawa: Ontario Ministry of the Environment; 2008 [cited 2009 Apr 21]. Available from: http://www.ene.gov.on.ca/publications/4709e.pdf.
43. Ontario Ministry of the Environment. Wind turbines – Proposed requirements and setbacks. Ottawa: Ontario Ministry of the Environment. 2009 [updated 2009 June 9; cited 2009 Aug 13]. Available from: http://www.ene.gov.on.ca/en/news/2009/060901mb2.php.
44. Ontario Ministry of the Environment. Proposed content for the renewable energy approval regulation under the Environmental Protection Act. Ottawa: Ontario Ministry of the Environment; 2009 [cited 2009 Nov 10]. Available from: http://www.ene.gov.on.ca/envision/env_reg/er/documents/2009/010-6516.pdf. Ontario Ministry of the Environment. Section 47.3 (1) Environmental Protection Act R.S.O. 1990. Development of noise setbacks for wind farms. Requirements for compliance with MOE noise limits. Ottawa: Ontario Ministry of the Environment; 2009 [cited 2009 Dec 7]. Available from: http://www.ene.gov.on.ca/en/business/green-energy/docs/WindNoiseSetbacks.pdf.
45. Keith SE, Michaud DS, Bly SHP. A proposal for evaluating the potential health effects of wind turbine noise for projects under the Canadian Environmental Assessment Act. J Low Freq Noise Vib Active Contr. 2008;27(4):253-65.
46. CanWEA. Canadian Wind Energy Association position on setbacks for large-scale wind turbines in rural areas (MOE Class 3) in Ontario. Ottawa, ON: Canadian Wind Energy Association; 2007 [cited 2009 Aug 31]. Available from: http://www.canwea.ca/images/uploads/File/FINAL-CanWEAPositionOnSetbacks-2007-09-28.pdf.

This document was produced by the National Collaborating Centre for Environmental Health at the BC Centre for Disease Control in January 2010.

Production of this document has been made possible through a financial contribution from the Public Health Agency of Canada. The views expressed herein do not necessarily represent the views of the agency.

ISBN: 978-0-9812646-4-6

400 East Tower
555 W 12th Avenue
Vancouver, B.C. V5Z 3X7

Tel.: 604-707-2445
Fax: 604-707-2444
contact@ncceh.ca

National Collaborating Centre for Environmental Health

Centre de collaboration nationale en santé environnementale

To provide feedback on this document, please visit Hwww.ncceh.ca/en/document_feedback

Hwww.ncceh.ca