Industrial wind turbines can harm humans

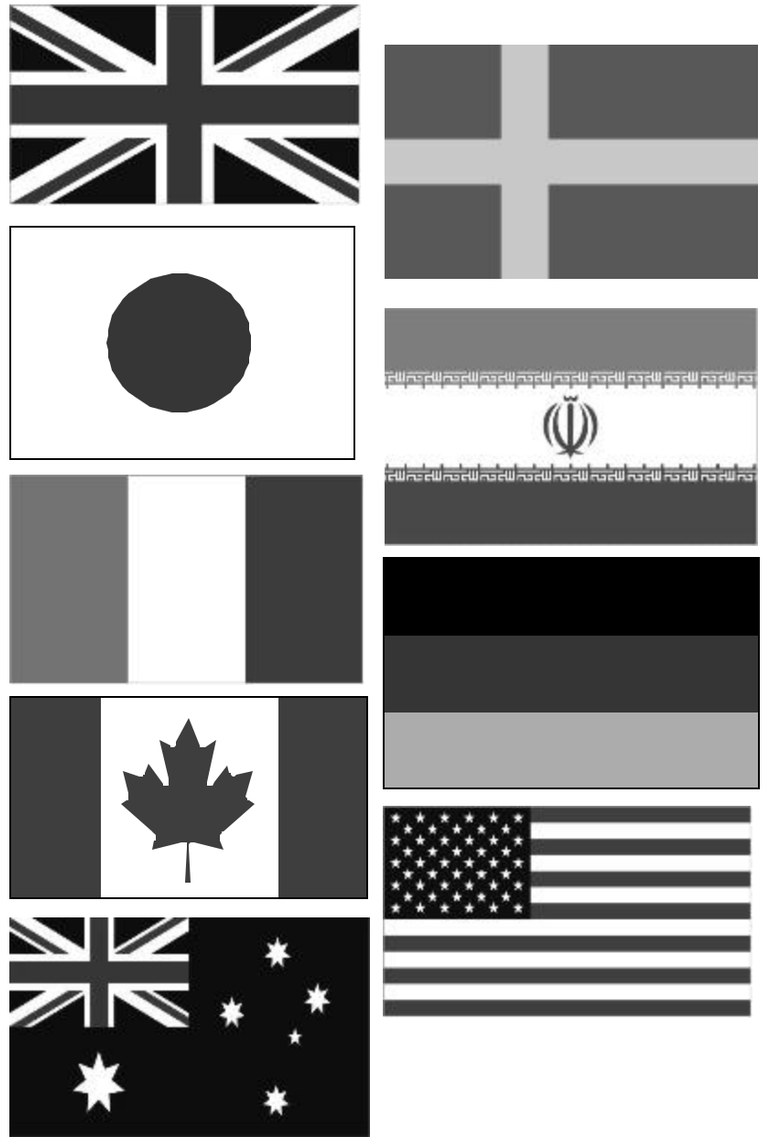
University of Waterloo

Invited Talk

Carmen Krogh, BScPharm

March 29, 2017

- Setting the stage
- Snapshot of some of the evidence
- Wrap-up / conclusions
  - *All slides referenced*
  - *Emphasis sometimes added to original quotes highlighting key points*



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

- Jeffery J. Aramini, Carmen M. Krogh, Robert W. Rand. Letter to the Editor: A critical analysis: Why “firm conclusions are not possible” *Environmental Research*, Volume 155, Online. Issue 155C, Pages 73-76. [PubMed]
- McMurtry RY, Krogh CM. Response to McCunney et al.: Wind turbines and health: An examination of a proposed case definition. Noise Health [serial online] 2016 [cited 2016 Dec 15];18:399-402.
- Robert Y McMurtry and Carmen ME Krogh, Diagnostic criteria for adverse health effects in the environs of wind turbines. JRSM Open 2014 5:1-5.
- Roy D. Jeffery, Carmen M.E. Krogh, and Brett Horner, Industrial wind turbines and adverse health effects Can J Rural Med 2014;19(1).
- Roy D. Jeffery, Carmen Krogh, and Brett Horner, Adverse health effects of industrial wind turbines Can Fam Physician 2013; 59: 473-475 (Commentary).
- Roy D. Jeffery MD FCFP, Carmen Krogh, Brett Horner CMA, Adverse health effects of industrial wind turbines, Letter to editor, Can Fam Physician. 2013 Sep;59(9):921, 923-5.

Krogh: peer reviewed publications

- Carmen M.E. Krogh, Industrial Wind Turbine Development and Loss of Social Justice? Bulletin of Science Technology & Society 2011 31: 321.
- Carmen M.E. Krogh, Lorrie Gillis, Nicholas Kouwen, and Jeffery Aramini, WindVOiCe, a Self-Reporting Survey: Adverse Health Effects, Industrial Wind Turbines, and the Need for Vigilance Monitoring Bulletin of Science Technology & Society 2011 31: 334.
- Brett Horner, Roy D. Jeffery and Carmen M. E. Krogh, Literature Reviews on Wind Turbines and Health: Are They Enough? Bulletin of Science Technology & Society 2011 31: 399.
- Stephen E. Ambrose, Robert W. Rand and Carmen M. E. Krogh, Wind Turbine Acoustic Investigation: Infrasound and Low-Frequency Noise--A Case Study, Bulletin of Science Technology & Society August 2012 DOI: 10.1177/0270467612455734,
- Robert W. Rand, Stephen E. Ambrose, and Carmen M. E. Krogh, Occupational Health and Industrial Wind Turbines: A Case Study, Bulletin of Science Technology & Society 2011 31: 359.
- Birds and Bird Habitat: What Are the Risks From Industrial Wind Turbine Exposure? Terry Sprague, M. Elizabeth Harrington, and Carmen M. E. Krogh, DOI: 10.1177/0270467611417844.

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.”
  - Instrument Decision Notice: EBR Registry Number: 011-8307011. Proponent: K2 Wind Ontario Inc. operating as K2 Wind Ontario Limited. July 23, 2013.

Ontario: models 40 dBA but approves up to 51

Wind Speed (m/s) at 10 m height	4	5	6	7	8	9	10
Sound Level Limits, dBA	40.0	40.0	40.0	43.0	45.0	49.0	51.0

Ontario

RENEWABLE ENERGY APPROVAL

NUMBER 2484-8RQUS4
Issue Date: March 16, 2012

2010: Compliance - setbacks and audible noise

Ministry of the Environment
Guelph District Office
1 Stone Road West
1st Floor
Guelph, Ontario N1G 4Y2
Tel: 519 826-4255
Fax: 519 826-4286

Ministère de l'Environnement
Bureau de district de Guelph
1, chemin Stone ouest
1er étage
Guelph (Ontario) N1G 4Y2
Tél. : 519 826-4255
Téléc. : 519 826-4286

Ontario

April 9, 2010

MEMORANDUM

TO: Jane Glassco, District Manager, Guelph District Office
and
Dave Bray, Supervisor, Guelph District Office

FROM: Cameron Hall, Senior Environmental Officer, Guelph District Office

Re: Comments - March 1, 2010 draft document, "Renewable Energy Approvals Technical Bulletin Six Required Setbacks for Wind Turbines"

- "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

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Ontario

April 9, 2010

MEMORANDUM

TO: Jane Glasseo, District Manager, Guelph District Office
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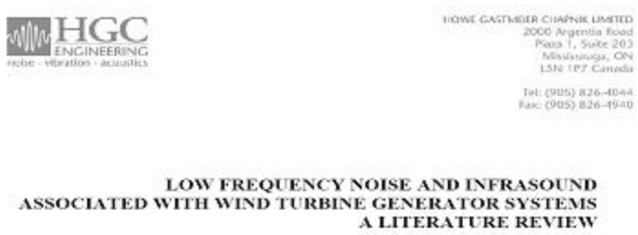
FROM: Cameron Hall, Senior Environmental Officer, Guelph District Office

Re: Comments - March 1, 2010 draft document, "Renewable Energy Approvals Technical Bulletin Six Required Setbacks for Wind Turbines"

- "… 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


HGC ENGINEERING
noise · vibration · acoustics

HOWE GASTMEIER CHAPNIK LIMITED
2000 Argentia Road
Plaza 1, Suite 203
Mississauga, ON
L5N 1P7 Canada

Tel: (905) 826-4044
Fax: (905) 826-4940

LOW FREQUENCY NOISE AND INFRASOUND
ASSOCIATED WITH WIND TURBINE GENERATOR SYSTEMS
A LITERATURE REVIEW

- "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."

  - Low frequency Noise and Infrasound Associated with Wind Turbine Generation Systems, A Literature Review, Ontario Ministry of Environment RFP December 10, 2010 [MOE consultant report]

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"

  - Case No(s): 14-065 / 14-066 / 14-067 Bryce v Ontario Ministry of Environment and Climate Change. Testimony by Brian Howe, Volume Four - January 13, 2015. pg. 189 and 257

1999: Sound and noise

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

  - Berglund, B., Lindvall, T., & Schwela, D. H., *Guidelines for Community Noise*, Geneva, Switzerland: World Health Organization, (1999)

Sound and noise

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

“Health” defined

World Health Organization (WHO)

World Health Organization

Countries

All countries which are Members of the United Nations may become members of WHO by accepting its Constitution. Other countries may be

1948: Health defined

CONSTITUTION
OF THE WORLD HEALTH ORGANIZATION[1]

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

Public Health Agency of Canada / Agence de la santé publique du Canada

Chief Public Health Officer / Administrateur en chef de la santé publique

JUL 11 2012

Canada, including both Health Canada and the Public Health Agency of Canada, continues to support the definition of health established by the WHO's constitution in 1948: Health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

Sincerely,

David Butler-Jones, MD
MHSc, CCFP, FRCPC, FACPM

Canada

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.”

  - Carmen M.E. Krogh CME, Industrial Wind Turbine Development and Loss of Social Justice? Bulletin of Science Technology & Society 2011 31: 321, DOI: 10.1177/0270467611412550.

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

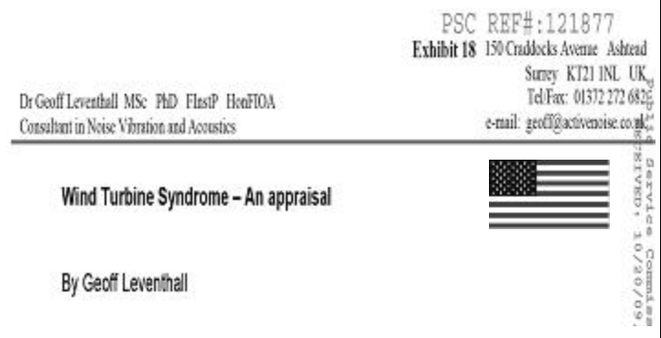

Wind Turbine Sound and Health Effects
An Expert Panel Review

Prepared by (in alphabetical order):

W. David Colby, M.D.
Robert Dobie, M.D.
Geoff Leventhall, Ph.D.
David M. Lipscomb, Ph.D.
Robert J. McCunney, M.D.
Michael T. Seilo, Ph.D.
Bo Søndergaard, M.Sc.

Prepared for:
American Wind Energy Association
and
Canadian Wind Energy Association
December 2009

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]


PSC REF#:121877
Exhibit 18
Dr Geoff Leventhall MSc PhD FInstP HonFIOA
Consultant in Noise Vibration and Acoustics
150 Craddocks Avenue Ashtead
Surrey KT21 1NL UK
Tel/Fax: 01372 272 682
e-mail: geoff@activenoise.co.uk

Wind Turbine Syndrome – An appraisal

By Geoff Leventhall

"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

1. Pierpont N. Wind turbine syndrome: a report on a natural experiment. Santa Fe, NM: K-Selected Books; 2009.

2. Colby, W. D., Dobie, R., Leventhall, G., Lipscomb, D. M., McCunney, R. J., Seilo, M. T., & Søndergaard, B. (2009). Wind turbine sound and health effects: An expert panel review 2009. Prepared for American Wind Energy Association and Canadian Wind Energy Association.

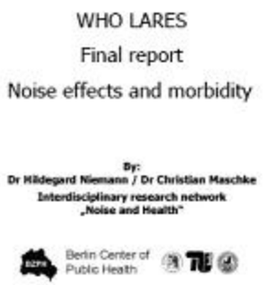
3. Leventhall, H. G. (2009, October). Wind turbine syndrome: An appraisal. Testimony before the Public Service Commission of Wisconsin (PSC Ref#121877 20).

What is annoyance?

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

- 1. The Council of Canadian Academies. Understanding the Evidence: Wind Turbine Noise, The Expert Panel on Wind Turbine Noise and Human Health. April, 2015.
- 2. Health Canada, Community Noise Annoyance, Its Your Health, (2005, September)
- 3. Michaud, D. S., Keith, S. E., & McMurchy, D., “Noise Annoyance in Canada”, Noise Health, 7, 39-47. (2005)
- 4. Pedersen, E., & Persson Waye, K., “Wind Turbine Noise, Annoyance and Self-Reported Health and Well Being in Different Living Environments”, Occupational and Environmental Medicine, 64, 480-486, (2007)
- 5. Suter, A. H., Noise and Its Effects, Washington, DC: Administrative Conference of theUnited States, (1991)
- 6. New South Wales. Parliament. Legislative Council. General Purpose Standing Committee No. 5, Rural Wind Farms (2009, December)

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."

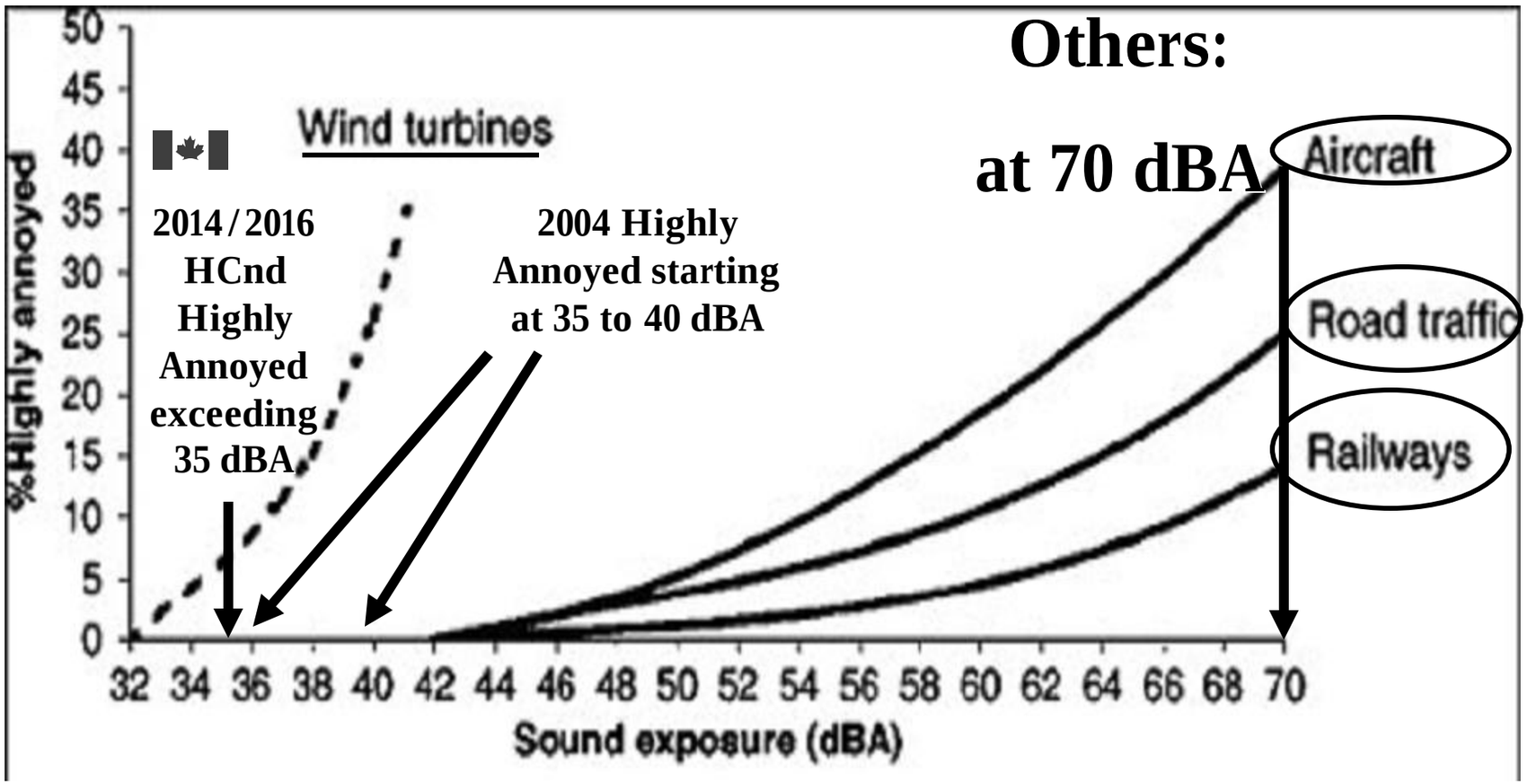
- World Health Organization LARES Final report. Noise effects and morbidity. By: Dr Hildegard Niemann / Dr Christian Maschke (2004).

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."

  - Michaud DSl, 2016. Exposure to wind turbine noise: Perceptual responses and reported health effects. Journal of the Acoustical Society of America 139 (3), March 2016:1443-1454

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



References: Wind turbines more annoying than other industrial noise

- Pedersen, E. and K. Persson Waye. 2004. Perception and annoyance due to wind turbine noise. A dose–response relationship, Journal of the Acoustical Society of America 116: 3460–3470.

- Health Canada. Environmental and Workplace Health. Wind Turbine Noise and Health Study: Summary of Results. November 6, 2014.

- Michaud DSl, 2016. Exposure to wind turbine noise: Perceptual responses and reported health effects. Journal of the Acoustical Society of America 139 (3), March 2016:1443-1454.

Visuals – flicker

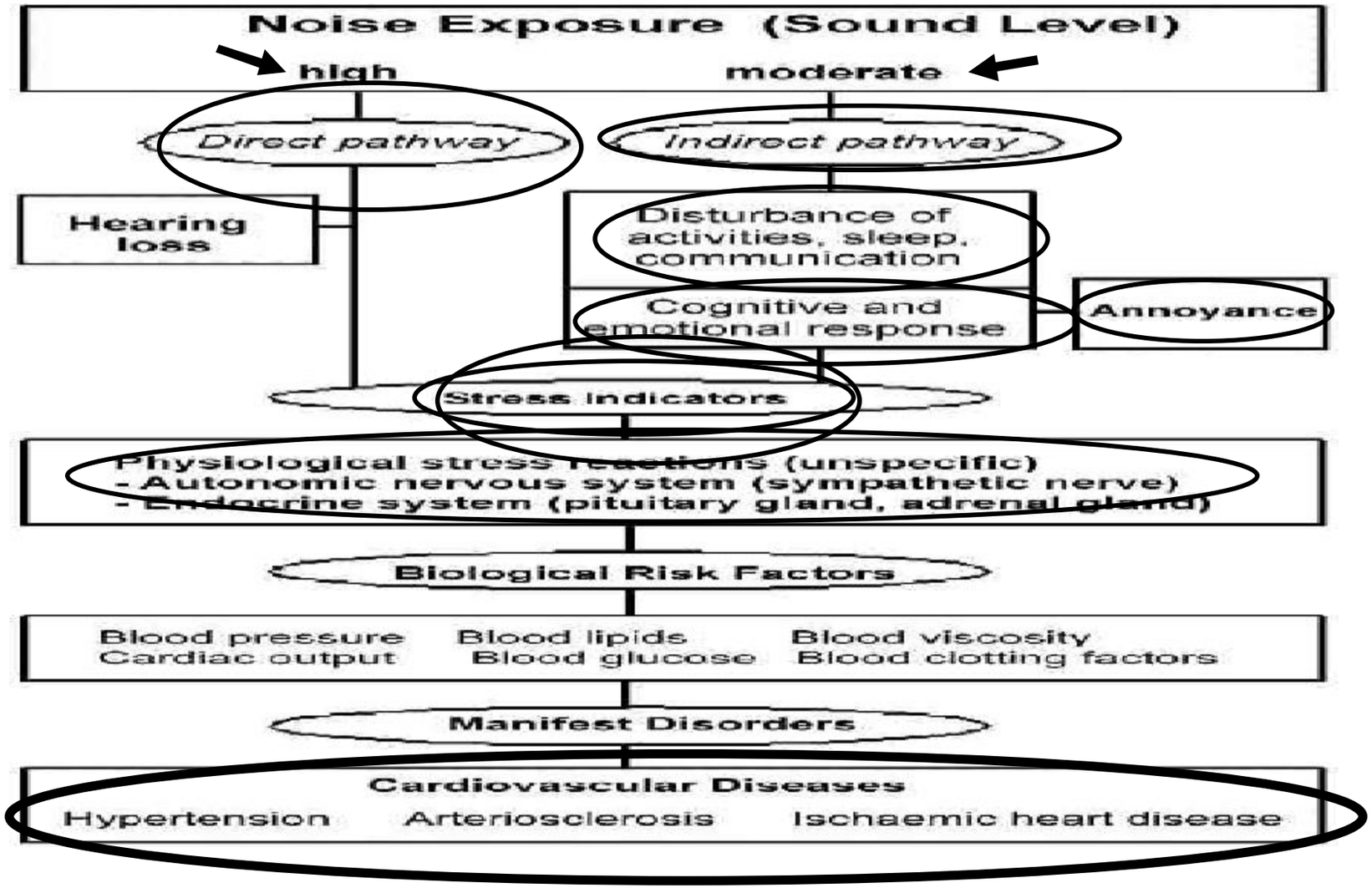
Direct and indirect impacts

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

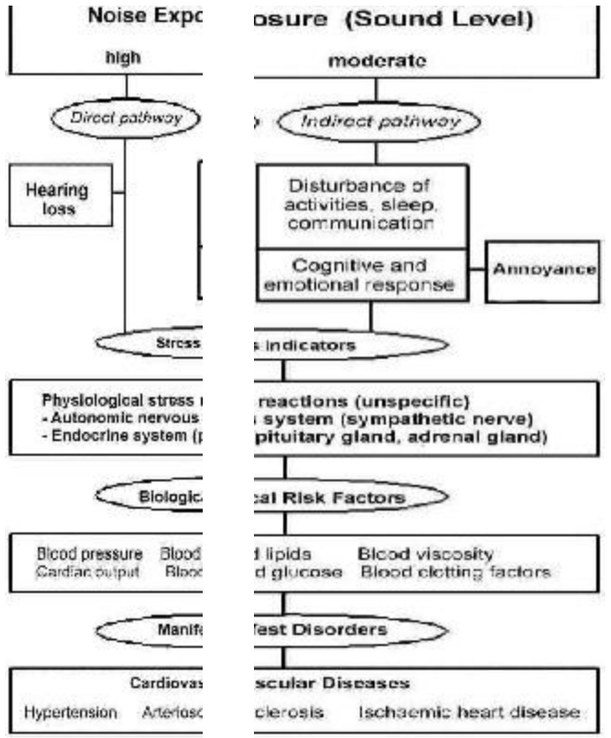
2011: Ontario Chief Medical Officer of Health author testimony

The Potential Health Impact of Wind Turbines

CMOH report only looked at direct links [2]

CMOH author agrees with schema [1]

Chief Medical Officer of Health (CMOH) Report
May 2010



- Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Transcript of Dr. G. Rachamin, Mar, 4, 2011 [1] p. 211, [2] p. 216

Green Energy and Green Economy Act, 2009, S.O. 2009, c. 12 - Bill 150

Ontario

142.2 (1) An applicant for a hearing required under section 142.1 shall state in the notice requiring the hearing,

(a) a description of how engaging in the renewable energy project in accordance with the renewable energy approval will cause,

(i) serious harm to human health, or

(ii) serious and irreversible harm to plant life, animal life or the natural environment;

An Act to enact the Green Energy Act, 2009 and to build a green economy, to repeal the Energy Conservation Leadership Act, 2006 and the Energy Efficiency Act and to amend other statutes

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%)"

  - BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation at www.bioinitiative.org December 31, 2012 Appendix 20-B Standards of Evidence for Decision making Differs Among Professions Pg 7, 8 **Appendix III** for levels of proof schema

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

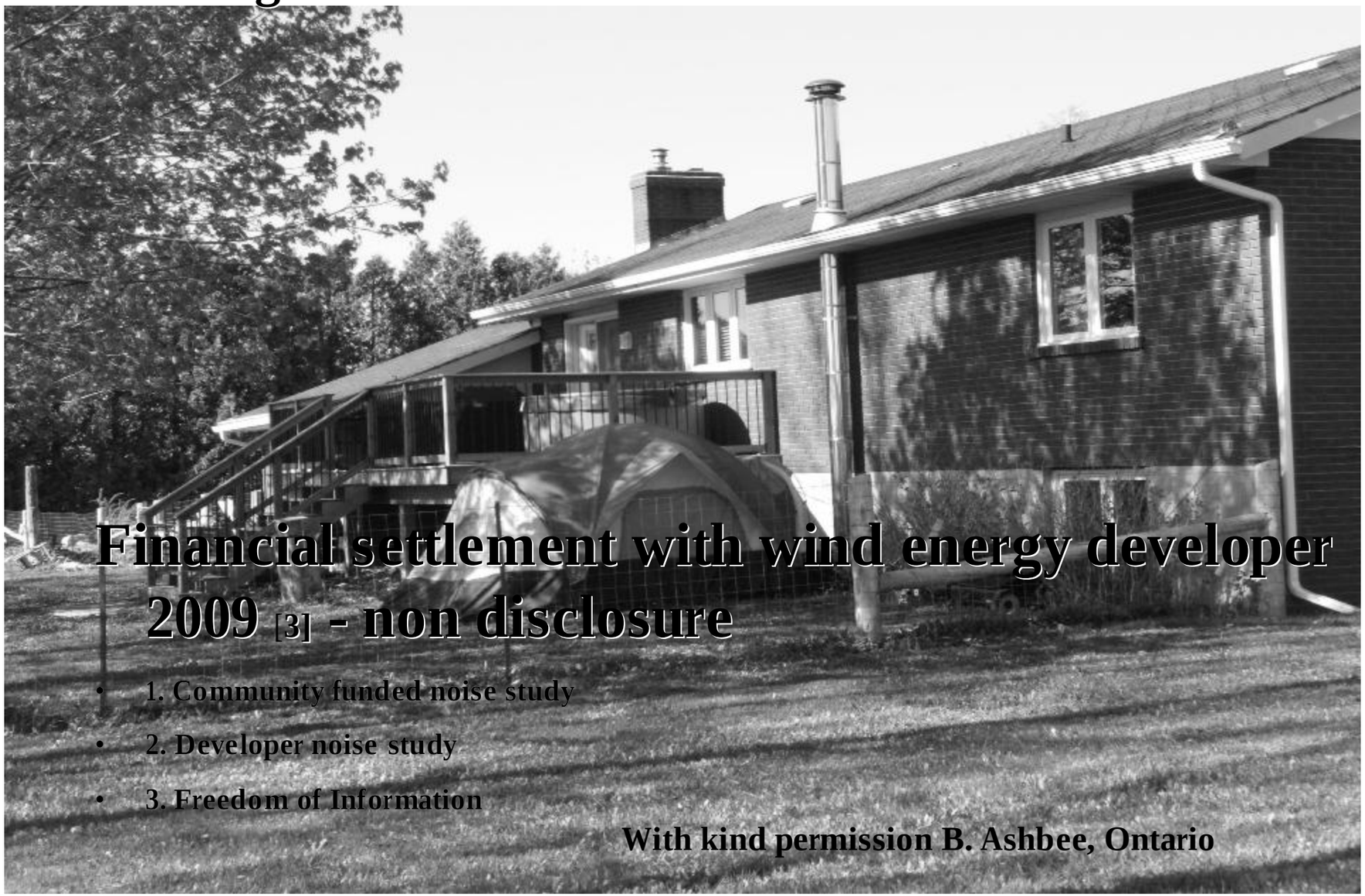
Rural families ←

Vulnerable populations

(Children, elderly and other)

Workers

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



2009: A cluster of affected families

- With kind permission: Ripley, Ontario families

Populations at risk

Rural families

Vulnerable populations ←

(Children, elderly and other)

Workers

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 …

  - Jan JE, Reiter RJ, Bax MCO, Ribary U, Freeman RD, Wasdell MB. European Journal of Paediatric Neurology 14(2010) 380-390

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)

1. Cristina Becchio, Morena Mari, Umberto Castiello, (2010). Perception of Shadows in Children with Autism Spectrum Disorders PLoS ONE | May 2010 | Volume 5 | Issue 5 | e10582.
2. Catherine Purple Cherry and Lauren Underwood. The ideal home for the autistic child: physiological rationale for design strategies. Autism Science Digest: The Journal Of Autismone, Issue 03.
3. Flavia Cortesi, Flavia Giannotti, Anna Ivanenko, Kyle Johnson (2010). Sleep in children with autistic spectrum disorder, Sleep Medicine 11 (2010) 659–664.
4. Hartmut Ising, Martin Ising (2002), Chronic cortisol increases in the first half of the night caused by road traffic noise. Noise and Health 2002,4:16:p13-21.
5. Bockelbrink A, Willich SN, Dirzus I, Reich A, Lau S, Wahn U, Keil T. (2008) Environmental noise and asthma in children: sex specific differences J Asthma. 2008 Nov;45(9):770-3.
6. Neut D, Fily A, Cuvellier JC, Vallée L (2011),. The prevalence of triggers in paediatric migraine: a questionnaire study in 102 children and adolescents. J Headache Pain. 2011 Nov 1. [Epub ahead of print].

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

7. Doreen Wagner, Velitchko Manahilov, Gunter Loffler, Gael E. Gordon, and Gordon N. Dutton, Visual Noise Selectively Degrades Vision in Migraine Investigative Ophthalmology & Visual Science, April 2010, Vol. 51, No. 4.
8. Ising H, Lange-Asschenfeldt H, Moriske HJ, Born J, Eilts M., Low frequency noise and stress: bronchitis and cortisol in children, Noise Health. 2004 Apr-Jun;6(23):21-8
9. Gilboa T.Epilepsia. 2011 Dec 9. Emotional stress-induced seizures: Another reflex epilepsy? doi: 10.1111/j.1528-1167.2011.03342.x. [Epub ahead of print].
10. Epilepsy Facts - Epilepsy Canada.
11. Hartmut Ising, Martin Ising (2002), Chronic cortisol increases in the first half of the night caused by road traffic noise. Noise and Health 2002,4:16:p13-21.
12. Neut D, Fily A, Cuvellier JC, Vallée L. The prevalence of triggers in paediatric migraine: a questionnaire study in 102 children and adolescents. J Headache Pain. 2011 Nov 1. [Epub ahead of print].

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.

- Stephen E. Ambrose, Robert W. Rand and Carmen M. E. Krogh, Wind Turbine Acoustic Investigation: Infrasound and Low-Frequency Noise--A Case Study, Bulletin of Science Technology & Society published online 17 August 2012 DOI: 10.1177/0270467612455734,
- Robert W. Rand, Stephen E. Ambrose, and Carmen M. E. Krogh, Occupational Health and Industrial Wind Turbines: A Case Study, Bulletin of Science Technology & Society 2011 31: 359DOI: 10.1177/0270467611417849.

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]

- Abbasi M, Monnazzam MR, Zakerian SA, and Yousefzadeh A, (April 2015) Effect of Wind Turbine Noise on Workers' Sleep Disorder: A Case Study of Manjil Wind Farm in Northern Iran, Fluct. Noise Lett. 14, 1550020 (2015) [15 pages] DOI: 10.1142/S0219477515500200

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."

  - Abbasi M, Monnazzam MR, Zakerian SA, and Yousefzadeh A, (April 2015) Effect of Wind Turbine Noise on Workers' Sleep Disorder: A Case Study of Manjil Wind Farm in Northern Iran, Fluct. Noise Lett. 14, 1550020 (2015) [15 pages] DOI: 10.1142/S0219477515500200

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."

- Abbasi M, Monazzam MR, Ebrahim MH, Zakerian SA, Dehghan SF, Akbarzadeh A, Assessment of noise effects of wind turbine on the general health of staff at wind farm of Manjil, Iran. Journal of Low Frequency Noise, Vibration and Active Control. 35(1) 2016 91-98, DOI: 10.1177/0263092316628714 l

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

- 1. Kelley ND, Hemphill RR and McKenna HE. A Methodology for Assessment of Wind Turbine Noise Generation. Journal of Solar Energy Engineering. May 1982, Vol. 104/119.

- 2. Kelley ND. Prepared under Task No. WE7211201. Program No. 8. Solar Energy Research Institute, Prepared for the U.S. Department of Energy. A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions. November 1987. Presented at the Windpower ’87 Conference and Exposition, October 5-8, 1987, San Francisco, California.

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.”

  - Report Number 122412-1. Issued: December 24, 2012. Revised: A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin. Prepared Cooperatively By: Channel Islands Acoustics, Camarillo, CA, Principal: Dr. Bruce Walker; Hessler Associates, Inc., Haymarket, VA, Principals: George F. and David M. Hessler; Rand Acoustics, Brunswick, ME Principal: Robert Rand; Schomer and Associates, Inc., Champaign, IL Principal: Dr. Paul Schomer

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

- The Results of an Acoustic Testing Program. Cape Bridgewater Wind Farm. 44.5100.R7.MSC. Prepared for: Energy Pacific (Vic) Pty Ltd. Melbourne, Australia. 26th November, 2014.

2015: Brain response to infrasound in general – 8 Hz

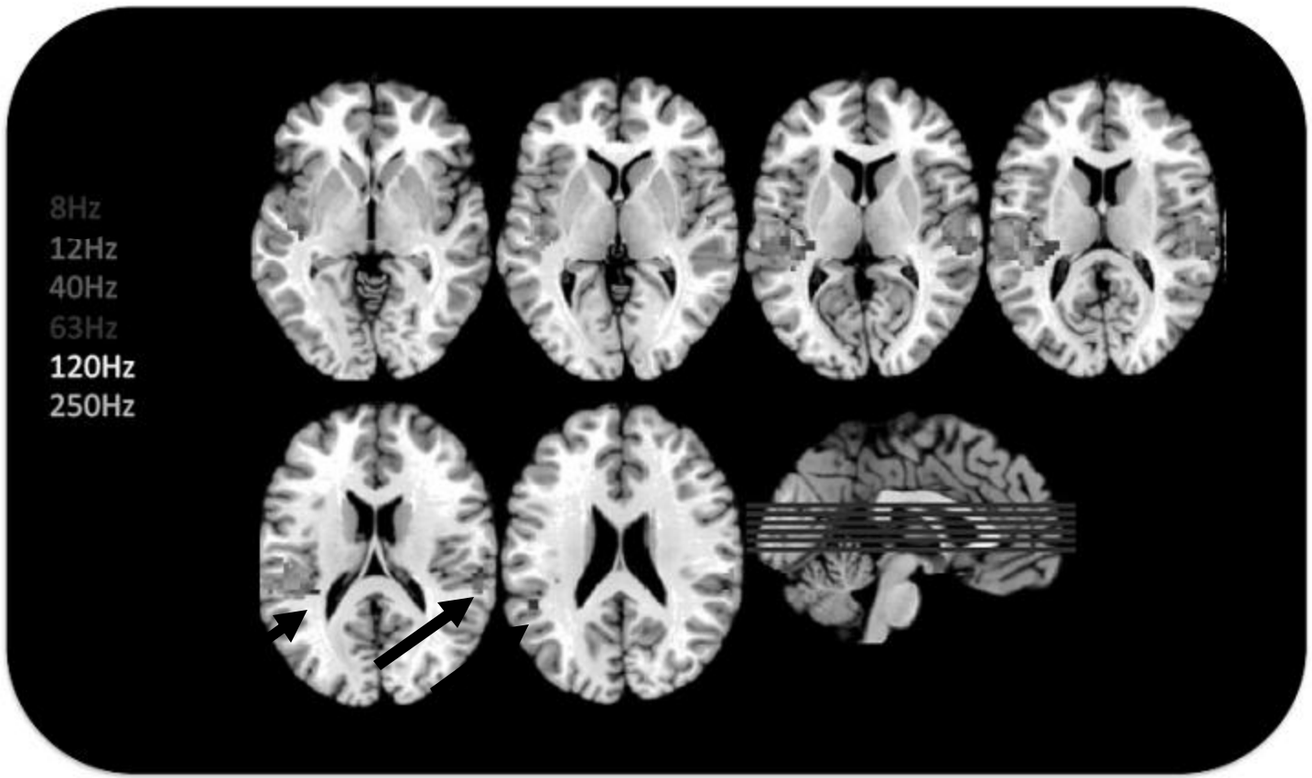


Figure 4. Slices of the brain with color-coded frequency dependent activation areas, $p < 0{,}001$

Reference: brain response to infrasound in general – 8 Hz

- Bauer M, Sander-Thömmes T, Ihlenfeld A, Kühn S, Kühler R, Koch C. Investigation of Perception at Infrasound Frequencies by Functional Magnetic Resonance Im-Aging (Fmri) and Magnetoencephalography (MEG). The 22nd International Congress on Sound and Vibration. ICSV22, Florence (Italy) 12-16 July 2015

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."

- Inagaki T and Nishi Y, Analysis of aerodynamic sound noise generated by a large-scaled wind turbine and its physiological evaluation, Int. J. Environ. Sci. Technol. (2015) 12:1933–1944 DOI 10.1007/s13762-014-0581-4

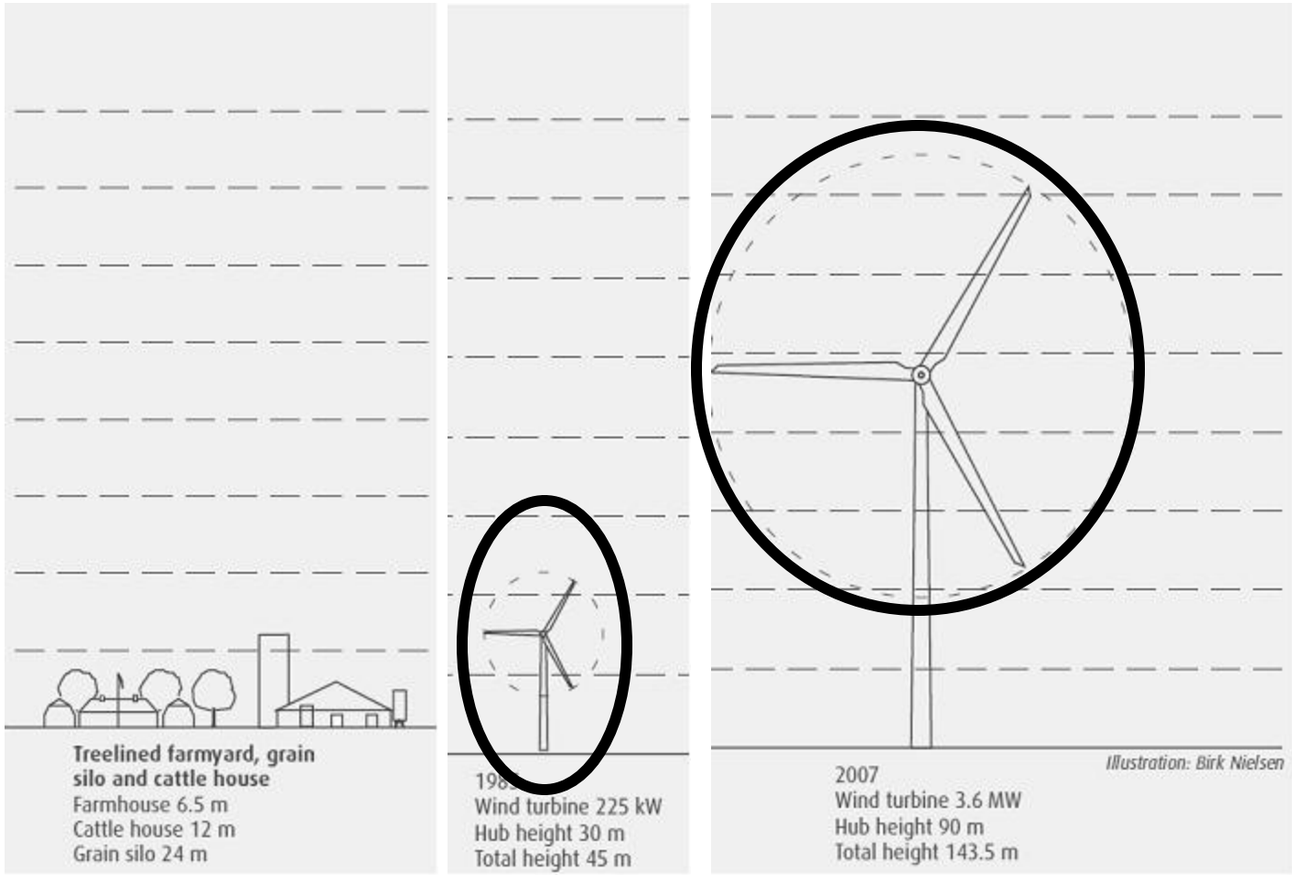
2011: Møller & Pedersen: low frequency wind turbine noise

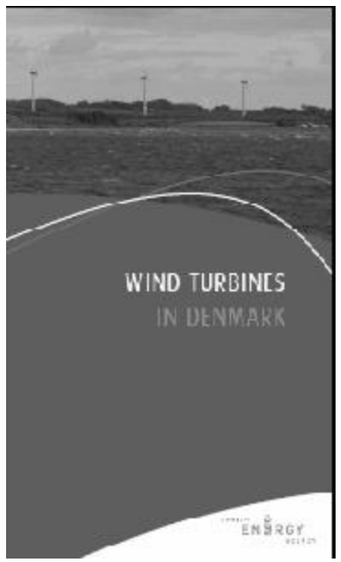
- Research indicates a variable that should be considered relates to low frequency noise in that IWTs are becoming bigger, more powerful resulting in the relative amount of low frequency noise being higher for the larger (2.3–3.6 MW) than the smaller turbines (less than 2 MW) and the difference is statistically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

- Møller H and Pedersen CS, Low-frequency noise from large wind turbines Section of Acoustics, Aalborg University, Denmark, Acoustical Society of America [DOI: 10.1121/1.3543957] J. Acoust. Soc. Am. 129 (6), June 2011 PACS number(s): 43.50.Rq, 43.28.Hr, 43.50.Cb, 43.50.Sr [ADP] Pages: 3727–3744

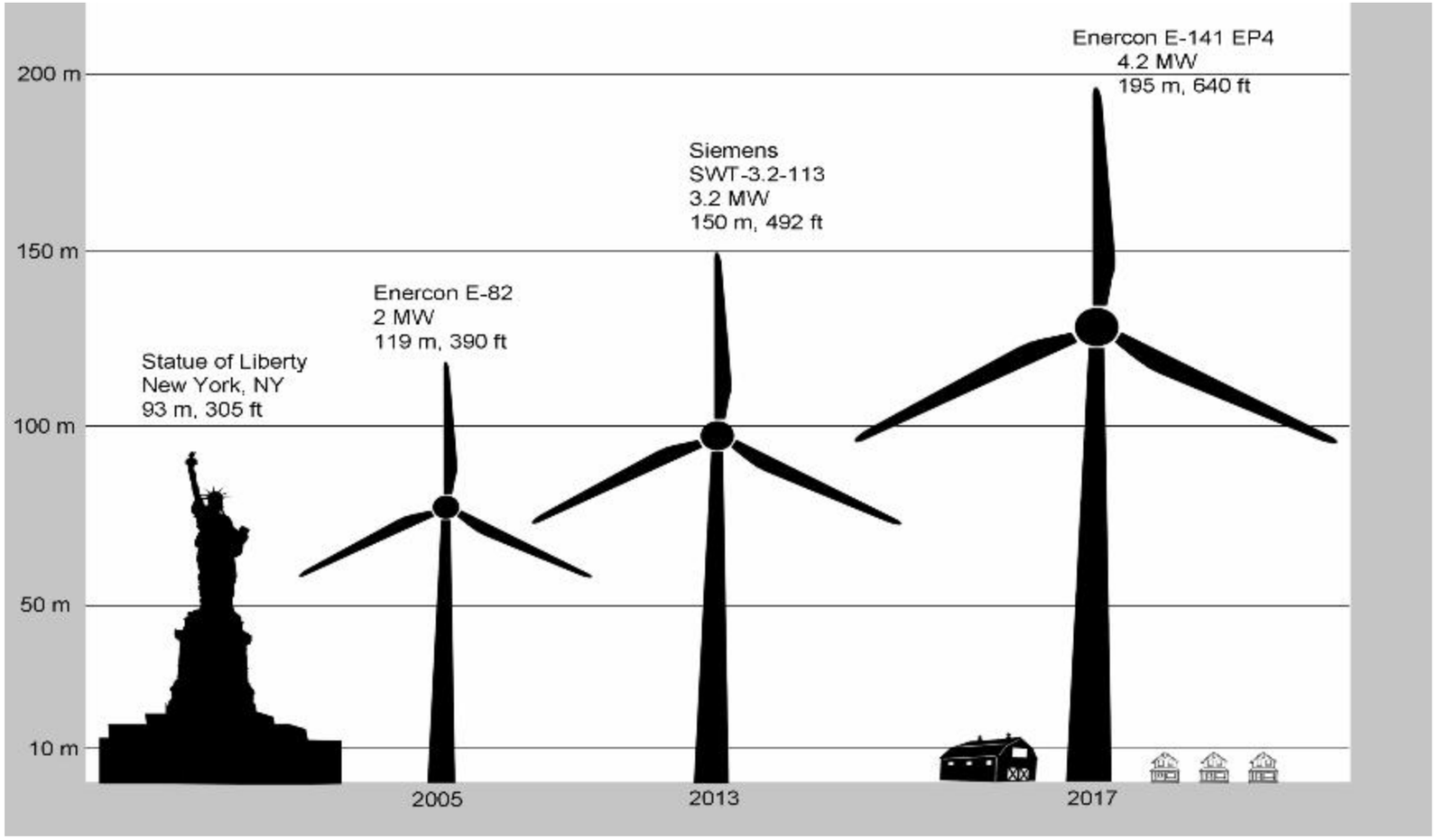
Yesterday’s and today’s industrial wind turbines

1985: Wind turbines 45 m
2007: Wind turbines 143.5 m





2017: Ontario proposed 195 m



La Gaspésie Quebec

Courtesy of Eco Awareness Society, Nova Scotia

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

- Chief Medical Officer of Health (CMOH) Report. May 2010. The Potential Health Impact of Wind Turbines.

- Rideout K, Copes R, Bos C, Wind Turbines and Health. National Collaborating Centre for Environmental Health (January 2010).

- Council of Canadian Academies (April 9, 2015) Understanding the Evidence: Wind Turbine Noise.

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

- 1. Health Canada. Environmental and Workplace Health. Health Impacts and Exposure to Sound From Wind Turbines: Updated Research Design and Sound Exposure Assessment. Summary. February 10, 2013

- 2. Michaud DS. Self-reported and Objectively Measured Outcomes Assessed in the Health Canada Wind Turbine Noise and Health Study: Results Support an Increase in Community Annoyance. Proceedings InterNoise 2015, San Francisco (August)

Other challenges

2005: Government of Canada support and fund wind energy

Exhibit 5.1
Summary of Technology Status and Federal Support

Technology Category	Status in Canada	Federal Climate Change Policy Support	Federal Climate Change Funding (PERD, TEAM, SDTC)
A. Electricity Generation and Cogeneration	Numerous new technologies are at lab-scale and pilot stages, or undergoing field demonstration	√	TEAM, SDTC, PERD
B. Renewable Energy	Wind, hydro, solar, and biomass are well established. Geothermal is at the test phase. One commercial installation exists of tidal energy, but there are no commercial installations of ocean wave technologies.	√	TEAM, SDTC, PERD

2005: Health Canada - systematic assessment / populations at risk *(Note: the next 2 slides represent this slide)*

Canada's Climate Change Plan

There is no
processes
Green

Canada

Health and Environment Framework

Setting out a vision for where Canadians live, work and play that promote the best health outcomes

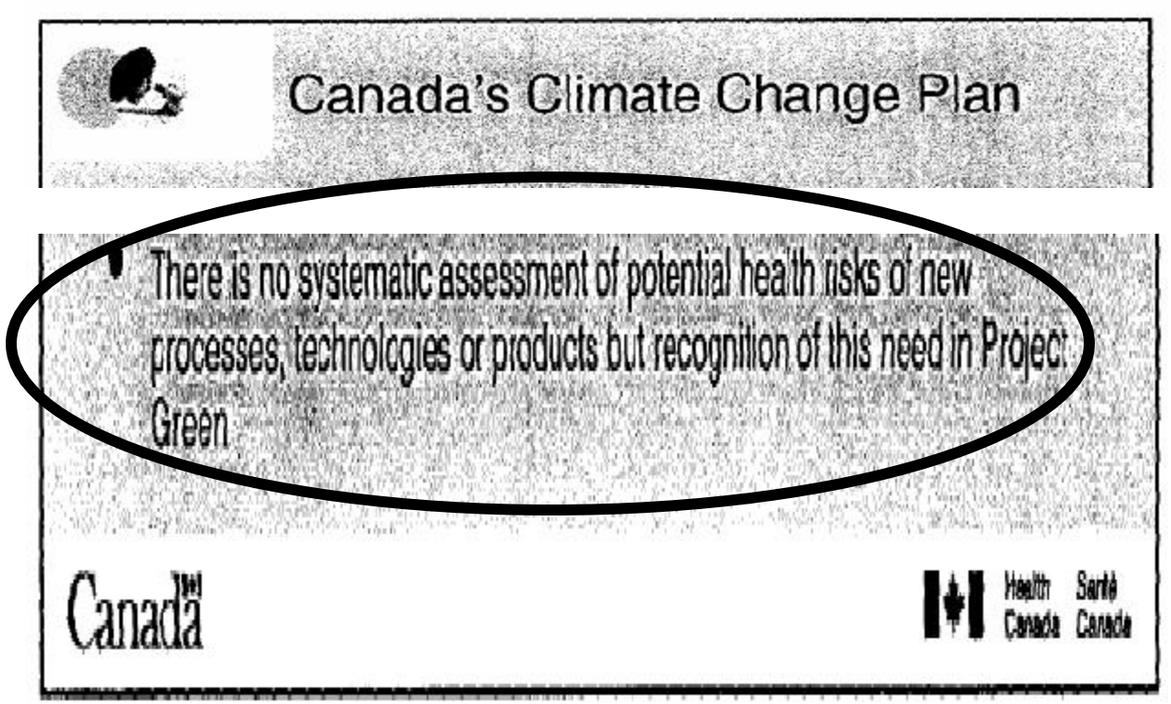
- Improving Governance
- Strengthening the evidence base
- Improving tools and management approaches
- Engaging Canadians

- *Focus on health outcomes*
- *Focus on population groups at risk*

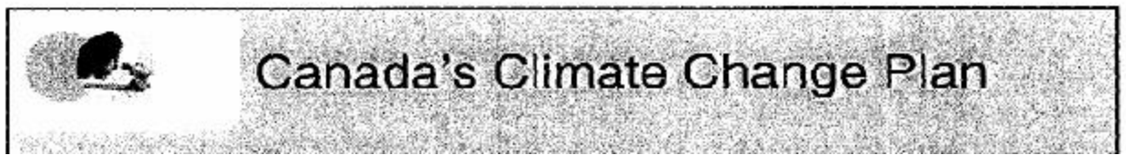
Canada

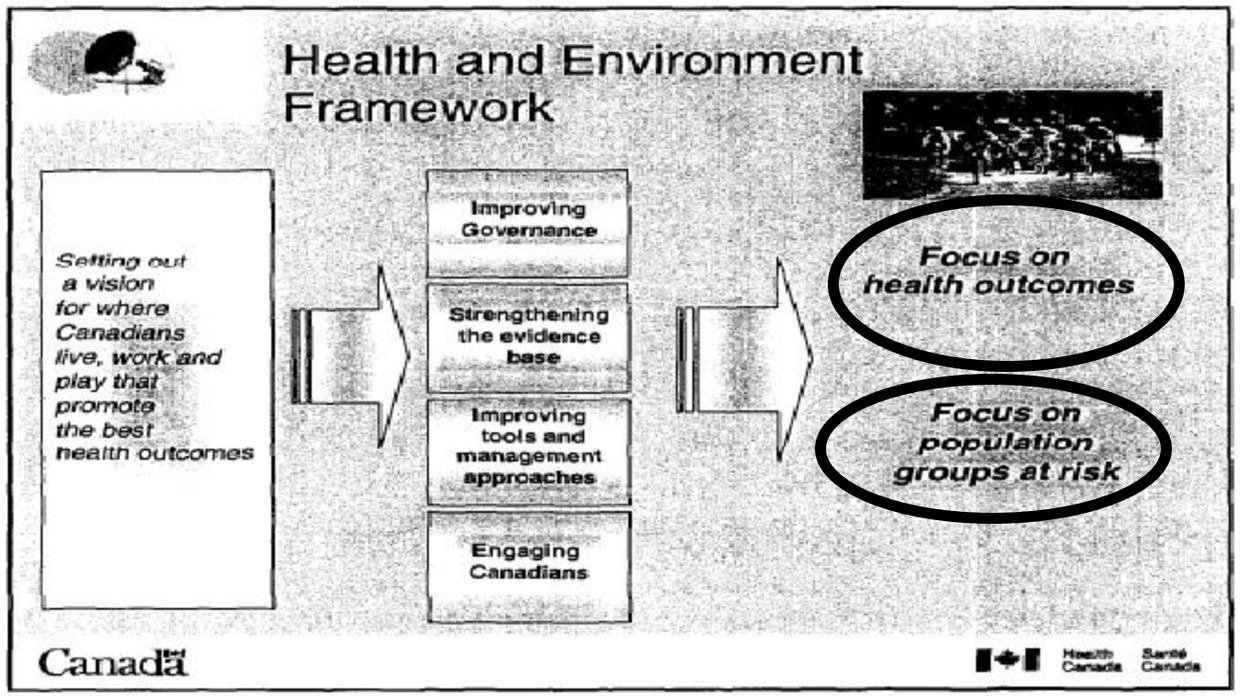
Health Canada Santé Canada

2005: Health Canada - systematic assessment / populations at risk

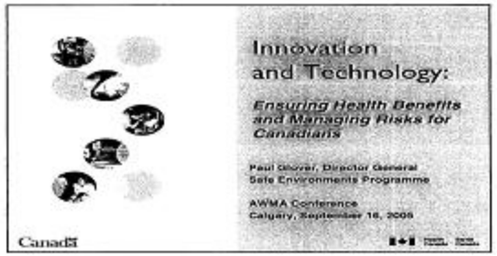


2005: Health Canada - systematic assessment / populations at risk





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.

Canada

Health Canada Santé Canada

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

Assessing and Managing the Human Health Risks of Greenhouse Gases Mitigation Measures and Technologies

Proposed Program Name

Health Risks Assessment of Climate Change Measure and Technologies Program

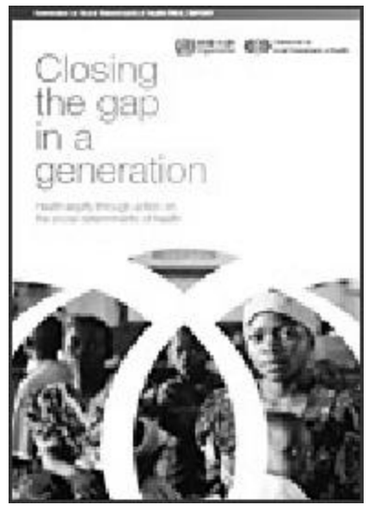
Department, or lead department if program is shared between two or more departments

Health Canada

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
  - 2. Green Energy Act, 2009. S.O. 2009
  - 3. Unwilling hosts. Wind Concerns Ontario

Industry-led : government-supported

Wind Technology Road Map

Message from Co-Chair Geoff Munro, Chief Scientist & Assistant Deputy Minister, Innovation and Energy Technology Sector, Natural Resources Canada

This Wind Technology Roadmap (WindTRM) is an industry-led, government-supported initiative that has developed a long-term vision for the Canadian wind energy industry and identified the major technology gaps and priorities to achieve a major increase in deployment of wind energy in Canada.

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."

  - World Health Organization. (1999). Guidelines for community noise. Geneva; OMS, 1999, p 94. Ilus, Berglund, B., Lindvall, T., and Schwela, D. H.

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

carmen.krogh@gmail.com