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Infrasound

Low frequency noise

and

Industrial Wind Turbines

An information report prepared for the

MULTI-MUNICIPAL WIND TURBINE WORKING GROUP

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Introduction

The Multi-municipal Wind Turbine Working Group was formed by municipal councillors in Grey, Bruce, and Huron Counties in Ontario in response to the growing number of complaints they were receiving from constituents concerning the installation of industrial wind turbines throughout the area. Councillors were aware of their responsibility regarding the health, safety, and well-being of their constituents. The Multi-municipal Wind Turbine Working Group was set up to share ideas on how to fulfill that responsibility. Complaints from citizens, including reports of adverse health impacts have persisted and increased as more turbines have been installed. The reported symptoms conform to those described internationally by many people living near wind turbines.

With the proliferation of recent research and the rediscovery of earlier, until now largely ignored studies, infrasound and low frequency noise (LFN) can no longer be dismissed as irrelevant. This report shows why it must be given full consideration as a contributing cause of the distress of some of those people living near wind turbine installations. It also demonstrates why the Ontario and Canadian governments must pay attention to this research, fulfill their obligation to protect the health of our citizens and amend their wind turbine regulations and policies.

Executive summary

Typically, regulating authorities have not required the measurement of infrasound (sound below 20 Hz in frequency) and low frequency (LFN) (generally sound from 200

Hz to 20 Hz) inside homes adjacent to wind turbines as a condition of their installation and operational monitoring.[1] The health risk of infrasound from wind turbines has been dismissed by the wind industry as insignificant. It has maintained that since the typical loudness and frequency of wind turbine sound within a home is not audible, it cannot have any effect on human health.

Noise measurements for most studies and environmental assessments have been limited to the measurement of *audible* sound *outside* homes-- using dBA weighted monitoring which is insensitive to infrasound frequencies. Some studies and environmental assessments have even relied on *projected* audible sound averages from computer produced models.

Such observations and projections fail to take appropriate account of the distinguishing signature of the sound from a wind turbine. Unlike the more random naturally occurring sounds (such as wind or lake waves which may themselves have an infrasound component), the sound from wind turbines displays characteristics that produce a *pattern* that the ear and audio processing in the brain recognize. Our hearing is strongly influenced by pattern recognition. (This is why we can pick out the sound of a familiar voice even in a crowded room with many people speaking).

One recognizable wind turbine pattern is a tonal signal of *sharply rising and falling pulses* in the infrasound range, (typically about 0.75 Hz, 1.5 Hz, 2.25 Hz, 3.0 Hz, and so on). It is produced by the blade passing the tower. At this frequency these pulses may be "felt or sensed" more than "heard" by the ears. Research by Dr. Alec Salt and others has demonstrated that subaudible infrasound does result in a physiological response from various systems within the body.

[1] Denmark does require a calculation of the *expected* infrasound; however it is less restrictive than limits on *audible* sound.

The second recognizable pattern is the amplitude modulation. This is the typical "swoosh" rising and falling that *is* audible. [7]

A third recognizable pattern of sound from wind turbines results from the equipment in the nacelle (such as the gearbox if the turbine has one) and ventilating fans. Although in some cases this third sound source may become predominant, it is usually of lesser effect that the first two.

We now know that *subaudible pulsating infrasound can be detected inside homes* near operating wind turbines. It can also be identified up to 10 kilometres distant. We know also that *very low levels of infrasound and LFN are registered by the nervous system and affect the body even though they cannot be heard.* The research cited in this report implicates these infrasonic pulsations as the cause of some of the most commonly reported "sensations" experienced by many people living close to wind turbines including chronic sleep disturbance, dizziness, tinnitus, heart palpitations, vibrations and pressure sensations in the head and chest etc.

Similarly, there is medical research (also cited below) which demonstrates that pulsating infrasound can be a direct cause of sleep disturbance. In clinical medicine, chronic sleep interruption and deprivation is acknowledged as a trigger of serious health problems.

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[7] It results from the blade passage frequency which acts to cause the broadband sound produced by the turbulence associated with the airfoil of the wind turbine passing through the air to rise and fall.

I. The work of Neil Kelley

1979: First report of human distress from wind turbines

The first wind turbine noise complaints in North America, reported over 35 years ago, sound strikingly familiar today. Residents living within 3 kilometres of a 2 MW wind turbine near Boone, North Carolina, described a periodic "thumping" sound accompanied by vibrations. Many said that they could "feel" more than hear the sounds. They spoke of repetitive sleep disturbance and maintained that the sounds were louder and more annoying inside their homes than outside; some became more sensitive to the impact over time.

The overlooked documents on wind turbine infrasound

In response to the complaints from Boone, the U.S. Department of Energy and the National Aeronautics and Space Administration (NASA) commissioned Dr. Neil Kelley and his colleagues at the Solar Research Institute (which later became the National Renewable Energy Laboratories of the US Department of Energy) to investigate possible causes. Over the next ten years, Kelley was able to take advantage of government and NASA facilities and funding to carry out extensive field investigations and laboratory research of a scope and thoroughness that has not been matched since. He also had access to experts at six leading American Universities as well as the co-operation and input of the wind turbine industry.[3]

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[3] In cooperation with NASA, the General Electric Company, and BREMC, Kelley and his associates at the Solar Energy Research Institute (SERI) performed a series of field measurements near the MOD-1 [turbine] during five separate sessions between 1979 and 1981. They were supported by the Pacific Northwest Laboratories and the University of Virginia, Department of Environmental Science. In addition to the measurement programs, SERI conducted ancillary experimental studies at the NASA Plumbrook Facility; the DOE Rocky Flats Wind Energy Research Center; the anechoic wind tunnel of MIT's Department of Aeronautics and Astronautics; and the subsonic wind tunnel facilities of the Department of Aerospace Engineering of the University of Colorado-Boulder (UCB). Analytical and field studies of low-frequency noise propagation in the vicinity of the turbine were conducted by a

Between 1982 and 1988, Kelley and his colleagues published five important papers:

1. N. D. Kelley, R. R. Hemphill, M. E. McKenna. **"A Methodology for Assessment of Wind Turbine Noise Generation", 1982.** (First published in J. *Solar Engineering*, Vol. 21 (1981), pp.341-356).
2. E. W. Jacobs, N. D. Kelley, H. E. McKenna, N. J. Birkenheuer. **"Wake Characteristics of the MOD-2 Wind Turbine at Medicine Bow, Wyoming". November 1984.**
3. N. D. Kelley, H. E. McKenna, R. R. Hemphill, C. I. Etter, R. I. Garrelts, N. C. Linn. **"Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control". February 1985.** (First published by the Solar Energy Research Institute, February 1985). **(262 pages)**
4. N.D. Kelley. **"A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", November 1987.**
5. N. D. Kelley, H. E. McKenna, E. W. Jacobs, R. R. Hemphill, J. Birkenheuer. **"The MOD-2 Wind Turbine: Aeroacoustical Noise Sources, Emissions, and Potential Impact"**. Solar Energy Research Institute. Prepared for the U.S. Department of Energy, **January 1988.**

His work was published in peer reviewed journals. He presented his paper "Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control" at the Fourth ASME (American Society of Mechanical Engineers) Wind Energy Symposium held in Dallas, Texas on 18-20 February 1985. In 1987 he presented his paper "A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", at the American Wind Energy Association "Windpower '87 Conference and Exposition", October 5-8, 1987 in San Francisco, California.

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multidisciplinary group at Penn State; and analytical studies of aerodynamic noise generation were performed by the Fluid Dynamics Research Laboratory of MIT's Department of Aeronautics and Astronautics. In addition a number of other organizations were active in the noise investigations: NASA Lewis Research Center--analytical modeling of noise generation by wind turbines; NASA Langley Research Center- aeroacoustical and psychophysical studies of wind turbine noise; General Electric Company Corporate Research Center--analytical and statistical studies of the MOD-l noise situation and wind turbine noise in general; Boeing Vertol Division--wind turbine aeroacoustic studies; Hamilton-Standard Corporation--analytical studies of wind turbine aeroacoustics; the Fluid Dynamics Research Laboratory of MIT's Department of Aeronautics and Astronautics and the Departments of Meteorology and Mechanical Engineering; and the Noise Control Laboratory at Penn State were retained under SERI subcontracts to develop analytical techniques for evaluating the physics of the sound generation process and the propagation aspects of the problem, respectively.

The NASA investigation by Dr. Neil Kelley and his colleagues *established a link between wind turbine generated impulsive infrasound and low frequency noise and the symptoms (including sleep disturbance)* reported by the Boone, North Carolina residents.

The first report was based on three years of detailed field research. It recorded the experiences of actual people living near turbines through their resident diaries. It involved a complete set of full spectrum acoustic measurements (not estimated computer projections limited to A-weighted sound) extended over the entire 3 year study period. It included sound and vibration measurements as well as detailed meteorological observations.

It was followed by the publication of the results of subsequent laboratory research. Human volunteers were directly exposed in the laboratory to some of the sound energy in the infrasound and low frequency noise frequencies similar to the wind turbine measurements. The individual human responses confirmed an association between infrasound/LFN and the distress experienced by the volunteers.

Kelley's key findings

(1) Wind turbines emit infrasound.

- "The modern wind turbine radiates its peak sound power (energy) in the very low frequency[4] (VLF) range, typically between 1 and 10 Hz."[5]

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[4] The audible spectrum of sound for adults is generally considered to range from 20 Hz to 20,000 Hz. Frequencies below 20 Hz are described as *infrasound*. The range from 20 Hz to 200 Hz is usually described as low frequency sound.

[5] N.D. Kelley. "A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", November 1987, p.1.

(2) Wind turbine infrasound and low frequency noise is often subaudible.

- "The detailed analysis of a series of acoustic measurements taken near several large wind turbines (100 kW and above) has identified the maximum acoustic energy as being concentrated in the low-frequency audible and subaudible ranges, usually less than 100 Hz".[6]

(3) Wind turbine infrasound and LFN is characteristically impulsive (pulsating, containing spikes or peaks and valleys).

- "Impulsive noise, such as has been found with the MOD-1, is identified with short, transient fluctuations in the radiated acoustic field which can contain considerable energy".[7]

(4) Community annoyance described by residents

- "Residents living in affected houses reported periodic "thumping" sounds accompanied by vibrations".
- Many said that they could "feel" more than hear the sounds.
- They spoke of repetitive sleep disturbance.
- "These field measurements and model results allowed us to conclude the following: The annoyance was real and not imagined". [8]

(5) Community annoyance is related to impulsiveness

- "These measurements have also shown any reported community annoyance associated with turbine operations has often been related to the degree of coherent impulsiveness present and the subsequent harmonic coupling of acoustic energy to residential structures".[9]

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[6] N. D. Kelley, R. R. Hemphill, M. E. McKenna. "A Methodology for Assessment of Wind Turbine Noise Generation", 1982, p.1.
[7] *Ibid.*, p.113.
[8] Kelley *et al.* 1985 p. III.
[9] Kelley *et al.*, 1982, *op. cit.* p.112.

(6) Wind turbine disturbance is detected more *inside* houses than outside.

- "Residents reported the sounds were louder and more annoying inside their homes than outside".
- "Experience with wind turbines has shown that it is possible, under the right circumstances, for low-frequency (LF) acoustic noise radiated from the turbine rotor to interact with residential structures of nearby communities and annoy the occupants". [10]
- "An extensive investigation . . . revealed that this annoyance was the result of a coupling of the turbine's impulsive LF acoustic energy into the structures of some of the surrounding homes. This often created an annoyance environment that was frequently confined to within the home itself".[11]
- "The strong resonant behavior of the indoor pressure field when excited by an external impulsive excitation, all point to a complex resonance condition between the volume of air in the rooms and the vibration (displacement) of the walls and floors surrounding it".[12]
- "We found that the periodic loading by the MOD-1 [wind turbine]impulses excited a range of structural resonances within the homes measured". [13]

(7) Sound measurements and residents' reactions (diarized) were compared

- "These results, limited as they are, seem to confirm that people do indeed react to a low frequency noise environment and A-weighted measurements are not an adequate indicator of annoyance when low frequencies are dominant". [14]

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[10] *Ibid. p. 112.*
[11] Kelley, 1987, p.1.
[12] Kelley *et al*, 1982, p. 116. Kelley also cites Hubbard, H, & Shepherd, K. "The Helmholtz Resonance Behavior of Single and Multiple Rooms". NASA/CR-178173, Hampton, VA: NASA Langley Research Center (September 1986).
[13] Kelley, 1987, p. 1.
[14] Kelley, 1987, p.6.

(8) A structural pattern differentiates turbine emissions from background noise

- "The acoustic pressure patterns radiated from large wind turbines have a definite structure as compared with the natural, wind-induced background".[15] [IWT emissions are different from background noise.]
- "The acoustic pressure patterns radiated from large wind turbines have a definite structure as compared with the natural, wind-induced background". [16]

(9) Human body resonances associated with annoyance

- "We hypothesize one of the causal factors related to the annoyance associated with the pulsating pressure fields in the rooms measured is a coupling with human body resonances which in turn are responsible for creating the sensation of a whole-body vibration. This perception is more noticeable indoors due to the increased reverberation time and dynamic overpressures from the interaction between the structural and air volume resonances. [17]

- "There is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5, 12, and 17-25 Hz, resulting in a sensation of whole-body vibration".[18]

(11) A-weighted measurements inadequately indicate low frequency annoyance

- "A-weighted measurements are not an adequate indicator of annoyance when low frequencies are dominant".[19]

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[15] *Ibid.*
[16] *Ibid.* p. 119.
[17] "From the meager information available from our measurements, we have crudely estimated the perception levels for the body resonance frequencies as 60 dB for 5 Hz, 55 dB for 12 Hz, and 48 dB for the 17-25 Hz band, or +5, 0, and + 10 dB above the existing background for the respective frequencies. Such a process as proposed would explain the perceived annoyance within homes when no perceptable sounds could be heard outdoors". *Ibid.*, p. 119.
[18] *Ibid.* p. 120. See also "Vibrations of 0.5 Hz to 80 Hz have significant effects on the human body", p. 17.
[19] Kelley, 1987, p.6.

Industry denies wind turbine infrasound emissions

For nearly three decades Kelley's work has been overlooked or intentionally sidestepped. The industry has continued to deny that wind turbines emit infrasound or that it affects nearby residents. In 2009 Robert Hornung of CanWEA misadvised the Ontario Ministry of the Environment:

> "No peer-reviewed study has ever established a link between infrasound from turbines and human health. . .".[20]

In responding to the recent re-discovery of Kelley's research by the public, Australian Clean Energy Council policy director Russell Marsh said the study was not relevant to modern turbines. "This is the equivalent of taking a study about Ataris and applying it to the latest iPads," Mr. Marsh said.

However, the latest much larger wind turbines have been found to emit even more infrasound.

In 2011, Henrik Møller and Christian Pedersen of Aalborg University, Denmark, pointed out that as turbines increase in size, the relative amount of low-frequency noise is greater.

> "It is thus beyond any doubt that the low-frequency part of the spectrum plays an important role in the noise at the neighbors. . . . It must be anticipated that the problems with low-frequency noise will increase with even larger turbines."[21]

[20] Letter from Robert Hornung, Canwea to Marcia Wallace, Ministry of the Environment dated July 24, 2009.

[21] "The relative amount of low-frequency noise is higher for large turbines (2.3–3.6 MW) than for small turbines (below 2 MW), and the difference is statistically significant." Moller, H., Pedersen, C.F., "Low-frequency noise from large wind turbines". J. Acoust. Soc. Am. 129 (6), June 2011.

In 2013, acoustician Richard James noted

> "... the shifting of the acoustic energy to lower frequencies that has occurred as wind turbines have increased in size from the 1.5 MW models common in 2008 to the 2.5 MW and higher models currently being installed".[22]

He added:

> "Studies by Dr. Neil Kelley demonstrated that low levels of pulsating tonal infrasound caused adverse reactions in test subjects. This research is generally denied by the wind industry and its acoustical experts. In a recent interview, Dr. Kelley now retired from a managerial position at the National Renewable Energy Laboratory (NREL), re-confirmed that the studies he conducted in the 1980's apply to the modern upwind wind turbine designs in use today. He challenged acousticians to install infrasound measurement instruments inside homes if they doubted his opinion".[23]

In the United Kingdom, *"ETSU-R-97"*, a noise guideline document put together in 1997 by the wind industry "noise working group", excludes any reference to the NASA research or to low-frequency noise. It relies exclusively on the dB(A) weighting (found to be irrelevant ten years earlier as a consequence of the NASA research). It assumes that, in all cases, the sound pressure levels inside neighbouring homes are substantially less than what is recorded outside those homes and it neglected the NASA research which showed that inside a house annoyance might be increased when low frequencies are dominant. It excludes testing inside homes for noise of any

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[22] James, Richard R. "Opening Statement at hearing re: BluEarth Project, Bull Creek, Alberta". Proceeding Number 1955, 18th November, 2013.
[23] James, R. "Wind Turbine Infra and Low-Frequency Sound: Warning Signs That Were Not Heard". 2012. Bulletin of Science, Technology & Society 32(2) 108-127. DOI: 10.1177/0270467611421845.

frequency.[24] Ontario wind turbine regulations require only dB(A) measurements and do not require LFN or infrasound measurements or noise monitoring inside homes.

The wind industry has opposed all attempts to change standards to include the measurement of low-frequency noise and infrasound or to set controls for low-frequency noise and infrasound inside homes. It has rejected requirements for turbine operators to cooperate in meaningful noise testing by shutting turbines on and off in order to distinguish between the noise generated by turbines and environmental noise. It has refused to provide operational data, such as wind speed and power output data. Instead it has lobbied for higher noise limits to permit larger turbines.

The industry is still determined to keep infrasound measurements out of REA approvals by lobbying environment ministries:

> "CanWEA takes issue with the requirement for infrasound monitoring. . ."
>
> "Studies across the world have shown that turbines do not produce infrasound at levels anywhere near those that can have an impact on humans. . . . CanWEA submits that the proposed requirement for infrasound or low frequency noise monitoring as a condition of the REA be removed". [25]

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[24] ETSU-R-97 also establishes methods which allow for the placement of monitoring equipment in locations where high background levels can be recorded prior to construction and subsequently, noise level criteria can be met by simply shifting the location of the monitoring equipment into the open away from trees or bushes—lowering the background levels to allow for wind turbine noise.

[25] CanWEA EBR Posting 010-6516 (Proposed Ministry of the Environment Regulations to Implement the Green Energy and Green Economy Act. 2009) – CanWEA's Supplemental Submission dated July 24, 2009, EBR Comment ID 123788. Signed Robert Hornung President.

Similarly in 2012, the multi-national Denmark-based wind turbine manufacturer, Vestas lobbied the Australian government proposing the removal of the requirement to measure low frequency noise from the Draft Guidelines:

> "Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise and is generally less than that of other industrial and environmental sources."
>
> "It is therefore unnecessary to require the prediction and monitoring of low frequency noise emissions from wind turbines".[26]

II. Recent verification of Kelley's work

A test of good science is the ability to repeat the experiment and obtain the same results. In recent years, a number of researchers have carried out studies that relied on full spectrum noise measurements instead of simple A-weighted ones. They have also recognized the importance of placing monitoring equipment *inside* homes rather than only outside. They have identified the pulsating feature of infrasound from wind turbines as a characteristic that allows it to be distinguished from the naturally occurring background infrasound. They have been able to measure infrasound output from turbines and relate it to symptoms experienced by some people living nearby. The harmful effect of wind turbine infrasound on human health—especially its potential to disturb sleep in some individuals—has been investigated; similarly, the negative effect on human health from sleep deprivation has been well documented. The following sections summarize these findings and review three preliminary studies carried out between 2011 and 2015 which validate Dr. Kelley's work. They are followed by a survey of medical research on the adverse effects of infrasound.

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[26] Vestas Australian Wind Technology PTY Ltd, letter to New South Wales NSW Department of Planning and Infrastructure dated 14 March 2012.

Malcolm Swinbanks 2012

Swinbanks demonstrated the perception of infrasound at significantly lower levels than has hitherto been acknowledged.

- "Conventional assessments of the perception of infrasound based on mean (rms derived) sound energy levels underestimate the importance of the associated crest factor of very low frequency sound pressure variations".

The results of simulations were compared to independently reported effects which have been observed in laboratory testing by other researchers. [27]

Richard James 2012

In 2012, Richard James published a short article entitled "Wind Turbine Infra and Low-Frequency Sound: Warning Signs That Were Not Heard".[28]

- "There is sufficient research and history to link the sensitivity of some people to inaudible amplitude-modulated infra and low-frequency noise to the type of symptoms described by those living near industrial wind turbines".

- "This information should have served as a warning sign. Experts, some well known in the field of acoustics, have defended the wind industry position through white papers, reports, and

[27] Swinbanks, M. "The Audibility of Low Frequency Wind Turbine Noise". *Fourth International Meeting on Wind Turbine Noise*, Rome Italy, 12-14 April 2011 Inter.Noise USA, 2012.
[28] James R. *Op cit.*

testimony in hearings, and through committees that are establishing guidelines for siting industrial-scale wind turbines.

- "The acoustics profession and individual acousticians should have recognized the early reports of symptoms by people living near wind turbines as a new example of an old problem. Instead of advocating caution in locating wind turbines near people, the rush for renewable energy took precedence. The position or belief that there was little or no possibility inaudible infrasound and very low–frequency noise could be causing the reported problems has delayed further research and the safe implementation of industrial wind turbines.

- "It is the author's opinion that had past experience and information, which was available prior to the widespread implementation of the modern upwind industrial-scale wind turbine, been incorporated into the government and industry guidelines and regulations used to siting wind turbine utilities, many of the complaints and AHEs (adverse health effects) currently reported would have been avoided".[29]

In a newspaper interview he stated:

- "Instead, they have large spikes of (peaks or crests) that are as much as 100 to 1,000 times higher in pressure than the pressure in the valleys between the spikes," said James. "While the average sound pressure level of the tones may not appear to be very significant, it is the peaks of the pressure waves that are significant. . . . Information of this type shows that modern upwind industrial-scale wind turbines can produce significant levels of infrasound and that the sounds produced are a complex mix of tones with rapid modulation patterns. These sounds will likely be more easily perceived than steady pure tones in a laboratory. The potential for dynamically modulated infra and low-frequency sounds to cause AHEs (adverse health effects) has been known for other types of noise sources. There is sufficient infrasound and very low–

[29] *Ibid.*, p. 125.

frequency noise produced by modern wind turbines to warrant caution when locating turbines in communities proximate to residential properties based on the potential for AHEs." [30]

III. Three preliminary studies replicating Kelley's findings

1. The Falmouth Study, December 2011

This investigation is also known as the "Bruce McPherson Infrasound & Low Frequency Noise Study" in honour of the philanthropist who created the private grant "to determine why there were so many strong complaints about the loss of well-being and hardships experienced by people living near large industrial wind turbines operating in Falmouth, Massachusetts".

The chief investigators, Stephen Ambrose and Robert Rand, set out to confirm or deny the presence of infrasonic and low frequency noise emissions (ILFN) from the "WIND 1", a municipally-owned Vestas V82 industrial wind turbine.

However to the surprise of the acousticians, almost immediately upon entering the study area, they themselves succumbed to the same adverse health symptoms that had been described by the people living near large industrial wind turbine sites in the area.

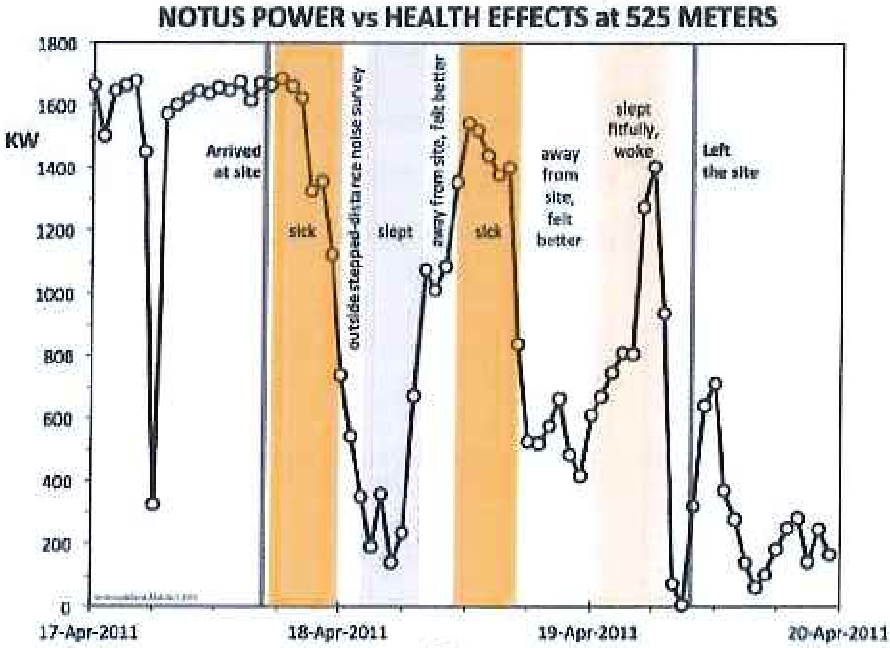
> "The onset of adverse health effects was swift, within twenty minutes, and persisted for some time after leaving the study area. The dBA and dBC levels and modulations did not correlate to the health effects experienced. However, the strength and modulation of the un-weighted and dBG-weighted levels increased indoors consistent with worsened health effects experienced indoors. The dBG weighted level appeared to be controlled by in-flow turbulence and exceeded

[30] Rick James. Quoted in *Times News*, Glencoe, Pa, Nov. 17, 2014.

physiological thresholds for response to low-frequency and infrasonic acoustic energy as theorized by Salt".[31]

It took the investigators about a week to recover from the adverse health effects experienced during the study, with lingering recurring nausea and vertigo for almost seven weeks for one of them.

The graph below presents the daily time-history variations in IWT output, observations and physiological symptoms experienced. There is a strong correlation between IWT power output and physiological symptoms.[32]



[31] Ambrose, S, & Rand, R. "The Bruce McPherson Infrasound and Low Frequency Noise Study Adverse Health Effects Produced By Large Industrial Wind Turbines Confirmed", 2011, p.2.
[32] Ambrose, S, Rand, R, Krogh, C. "Falmouth, Massachusetts wind turbine infrasound and low frequency noise measurements", Proceedings of *Inter-Noise 2012*, New York, NY, August 19-22, 2012.

Interestingly, when Ambrose and Rand conducted the Bruce McPherson Study, they were as yet unaware of Kelley's work at the DOE.[33]

The study confirmed Kelley's observation that the LFN causing health problems was inaudible;[34] that sleep disturbance resulted from it;[35] and that infrasound was measured inside the house. The study also affirmed Dr. Kelley's hypothesis of subsequent harmonic coupling of acoustic energy to residential structures.[36] It also re-iterated Kelley's observation that low frequency noise from wind turbines is impulsive:

> "The house envelope blocked most of the frequency content above 10 Hz, and amplified the remaining low frequency pulsations, much like a drum. The acoustic pressure swung from positive (compressed) to negative (rarified) 0.2 Pa peak-to-peak. . . . This increase in modulation indoors was consistent with the stronger adverse health effects Indoors" [37]

> "Our instrumentation reported the Crest Factor at 11-12 dB outdoors and indoors. This suggests that the RMS measurements reported on our graphs are well below the peak levels detectable by the human ear".[38]

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[33] Robert Rand. Personal communication (email) 8 July, 2015.
[34] "The wind turbine tone at 22.9 Hz was not audible yet the modulated amplitudes regularly exceeded vestibular detection thresholds". (Ambrose *et al.*, 2011, p.3)
[35] "Sleep was disturbed during the study when the wind turbine operated with hub height wind speeds above 10 m/s". (*Ibid.*)
[36] "The coherence values indicate that the very-low-frequency energy found below 10 Hz was very strongly coupled into the house interior, consistent with the indoors pressure amplification". (*Ibid., p.40)*
"The 'Indoors' graph shows the house envelope filtered and amplified very low frequency content of the wind turbine sound. What is apparent is that the negative pressure swings (vacuum) are more pronounced indoors compared to outdoors". (*Ibid.)*
[37] *Ibid.*, p. 42.
[38] *Ibid.*, p. 43.

The observation that sensitization occurs as exposure continues may be explained in the fact that

> "It is generally accepted that human response and cumulative effects increase with the quantity and the peak level of intrusive noises. Peak noise events are additive".[39]

Ambrose and Rand emphasized that "the infrasonic and low-frequency pulsations are hidden by the A-weighting filtering normally used by noise consultants to assess noise levels; yet, these pulsations are clearly visible in the linear, un-weighted time history in Pascal". [Pascal is the unit for sound pressure (Pa)][40]

> "The research is more than just suggestive. Our experiencing of the adverse health effects reported by others confirms that industrial wind turbines can produce real discomfort and adverse health impacts. Further research could confirm that these ill effects are caused by pressure pulsations exceeding vestibular thresholds, unrelated to the audible frequency spectrum but are instead related to the response of the vestibular system to the low frequency noise emissions. The vestibular system appears to be stimulated by responding to these pressure pulsations rather than by motion or disease, especially at low ambient sound levels.
>
> "The acoustic energy from the wind turbine was found to be: 1) Greater than or uniquely distinguishable from the ambient background levels, and 2) Capable of exceeding human detection thresholds". [41]

The investigators concluded:

[39] *Ibid.*, p. 45.
[40] *Ibid.*, p. 43.
[41] *Ibid.*, p. 3.

"This research revealed that persons without a pre-existing sleep deprivation condition, not tied to the location nor invested in the property, can experience within a few minutes the same debilitating health effects described and testified to by neighbors living near the wind turbines. The debilitating health effects were judged to be visceral (proceeding from instinct, not intellect) and related to as yet unidentified discordant physical inputs or stimulation to the vestibular system. Health effects moderated when dBG levels fell well below the 60 dBG guideline when the wind turbine was OFF".[42]

2. Shirley, Brown County, Wisconsin, 2012

The investigation of the Shirley wind project was carried out co-operatively by four different acoustic firms. They concluded:

"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. It should be addressed beyond the present practice of showing that wind turbine levels are magnitudes below the threshold of hearing at low frequencies"[43]

"This cooperative effort has made a good start in quantifying low frequency and infrasound from wind turbines. Unequivocal measurements at the closest residence R2 [Residence 2] are detailed . . . showing that wind turbine noise is present outside and inside the residence. Any mechanical device has a unique frequency spectrum, and a wind turbine is simply a very large fan and the blade passing frequency is easily calculated by RPM/60 x the number of blades, and for this case; 14 RPM/60 x 3 = 0.7 Hz. The next six harmonics are 1.4, 2.1, 2.8, 3.5, 4.2 & 4.9

[42] *Ibid.*, pp. 46-47.

[43] Walker, B., Hessler, G., Hessler, D, Rand, R. & Schomer, P. "A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin". Report Number 122412-1, Issued: December 24, 2012, p. 167.

Hz and are clearly evident . . . . Note also there is higher infrasound and LFN inside the residence in the range of 15 to 30 Hz that is attributable to the natural flexibility of typical home construction walls.[44]

Robert Rand reported ill effects (headache and/or nausea while testing and severe effects for 3+ days after testing.

Dr. Paul Schomer was one of the investigating acousticians on the Shirley project. In his report which was attached as Appendix D to the main Wisconsin report, he outlined the implications of the measurements of the Shirley Wind Farm:

- "At most locations where these health problems occurred, the wind turbines were generally not audible. That is, these health problems are devoid of noise problems and concomitant noise annoyance issues".

- "Residents of the nearest house reported that their baby son, now 2 years old, would wake up 4 times a night screaming. This totally stopped upon their leaving the vicinity of the wind turbines, and he now sleeps 8 hours and awakens happy. The fact that these residents largely report wind turbines as inaudible, and the reported effects on a baby seem to rule out the illness being caused by extreme annoyance as some have suggested".

- "In Implications, it is inferred from the resident observations that the important effects result from very low frequency infrasound, about 3 Hz or lower".

- "The measurements support the hypothesis developed in that the primary frequencies are very low, in the range of several tenths of a Hertz up to several Hertz. The coherence analysis shows

[44] *Ibid.*, p.6.

that only the very low frequencies appear throughout the house and are clearly related to the blade passage frequency of the turbine".[45]

- "The house is acting like a cavity and indeed at 5Hz and below, where the wave length is 200 ft or greater, the house is small compared to the wave length". [46]

- "Currently the wind turbine industry presents only A-weighted octave band data down to 31 Hz, or frequently 63 Hz, as a minimum. They have stated that the wind turbines do not produce low frequency sound energies. The measurements at Shirley have clearly shown that low frequency infrasound is clearly present and relevant. A-weighting is inadequate and inappropriate for description of this infrasound. . . . The International Electro-technical Commission (IEC) Wind Turbine measurement standard needs to include both infrasonic measurements and a standard for the instruments by which they are measured."

On October 14, 2014, the Brown County Board of Health declared the Shirley Wind Turbine Development "a Human Health Hazard for all people (residents, workers, visitors, and sensitive passersby) who are exposed to Infrasound/Low Frequency Noise and other emissions potentially harmful to human health."[47]

3. Cooper: Cape Bridgewater 2014

Acoustician Steve Cooper's study "The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm" (26 November 2014)[48] was similar to Kelley's project at

[45] *Ibid.*, Appendix D by Schomer and Associates Inc.
[46] Walker *et al.*, p.7.
[47] Brown County Code 38.01 , Brown County Ordinances, Chapter 38, relating to Public Health Nuisance (section (b) Human Health Hazard): "a substance, activity or condition that is known to have the potential to cause acute or chronic illness or death if exposure to the substance, activity or condition if not abated".
[48] Cooper, S. "The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm, 44.5100.R7:MSC". Prepared for Energy Pacific (Vic) Pty Ltd, Melbourne, Vic., 26 November, 2014.

Boone in that he had been called in by the turbine operator, Pacific Hydro, to investigate noise complaints at three houses without restriction and with the co-operation of the wind turbine operator and the local residents. Monitoring both inside and outside of homes was completed over nine weeks using both internal and external locations, including a number of nights inside peoples' homes. The wind turbines were shut down for part of the time in order to carry out maintenance work on cables. It determined "the actual physical parameters involved in the measurement, interpretation and assessment of wind farm noise (audible and infrasound) on persons" in 235 pages with 6 technical annexures (491 pages). It identified infrasound "as a standard and normal part of the emissions of a wind farm. The character of the infrasonic emissions is identified as being measurably different from 'ordinary' wind; that is, infrasound generated by/from turbines consists of trains of pressure pulses and must be measured through narrow-band analysis and interpreted accordingly. Standard measures with third-octave bands and G-weighting are found to be not valid identifiers/measures of wind turbine affected wind noise".[49]

Using the diarized residents' one to two hourly observations when they felt well and when they didn't, the study identified 'sensation' (including headache, pressure in the head, ears or chest, ringing in the ears, heart racing, or a sensation of heaviness) as the major form of disturbance from the wind farm.

It also found a trend between high levels of disturbance (severity of "sensation") and changes in the operating power of the wind farm.

The study identified that the infrasound inside the houses was subaudible. Using narrow band analysis in the infrasound region "the measurement results clearly show a *periodic pattern in the infrasound* (the wind turbine signature) whilst the natural

[49] Letter from Bob Thorne to Steve Cooper, 21 January, 2014.

environment for infrasound has no such periodic patterns".[50] Cooper called this the WTS (Wind Turbine Signature) which is not present when the turbines are shut down. Like Kelley, he observed that the WTS is characterized by modulation. By including narrowband analysis in the description of the acoustic environment, the study confirms that the infrasound obtained in a wind farm affected environment is different to that in a natural acoustic environment.

- "When placed in the concept of a dB(WTS) curve, there is agreement with the infrasound components of the turbine perception nominated by Kelly in 1982".[51]

- "In medical studies, the dB(A) level measurement inside dwellings is of no assistance in such studies. . . . The use of dB(A) for the assessment of large industrial wind turbines does not address low frequency noise (LFN) or infrasound due to the filter characteristics of the A-weighting curve".[52]

- "Investigations into the infrasound issue associated with the wind turbines also require consideration of the noise levels inside buildings. In some cases the internal noise levels are higher than external, whilst for other sites the internal levels are marginally below that recorded externally – but not to the extent as the reduction in dB(A) values".[53]

He found as Kelley had, from testing inside buildings that

- "Due to building elements having an attenuation at low-frequencies much lower than that of high frequencies, the external spectra from outside a dwelling changes in its spectral shape when measured inside a dwelling, such that where there is a broadband noise outside then

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[50] *Ibid.*, p. 215.
[51] *Ibid.*, p. v.
[52] *Ibid.*, p. 220.
[53] *Ibid.*

inside the dwelling the noise becomes predominantly a low frequency noise by the elimination of mid and high frequency components".[54]

Monitoring during the shutdown period

". . . permitted the opportunity to obtain noise data of the natural environment under various wind conditions, which would not be available during normal operations because of the operation of the turbines. The residents' observations during the shutdown periods identify there was no appreciable impact in terms of noise, vibration or sensation inside the buildings or the external yard area".[55]

The shutdown also allowed Cooper to make the same differentiation Kelley had between the characteristics of the infrasound emitted by the wind turbine (called the Wind Turbine Signature-- WTS) and the naturally occurring background infrasound.

"Utilizing the Cape Bridgewater narrow band results superimposed onto the 1/3 octave band results shows there is a difference between the natural environment and a wind farm affected environment in the infrasound region. Therefore one cannot claim that infrasound levels in the natural environment are similar to that of wind farm affected environments."[56]

The unique infrasound 'wind turbine signature', was found to be present in the homes, and linked it to the diarized 'sensations' felt by the residents.

"When placed in the concept of a dB(WTS) curve, there is agreement with the infrasound components of the turbine perception nominated by Kelley in 1982".[57]

[54] *Ibid.*, p. 46.
[55] *Ibid.*, p. 53.
[56] *Ibid.*, p. 197.
[57] *Ibid.*, p v.

In February, 2015, Dr. Paul Schomer wrote of the Bridgewater report:

> "This study finds that these 6 people sense the operation of the turbine(s) via other pathways than hearing or seeing, and that the adverse reactions to the operations of the wind turbine(s) correlates directly with the power output of the wind turbine(s) and fairly large changes in power output.
>
> Attempts may be made to obfuscate these simple points with such arguments as it cannot be proved that infra-sound is the cause of the discomfort. But that again is a specious argument. The important point here is that something is coming from the wind turbines to affect these people and that something increases or decreases as the power output of the turbine increases or decreases. Denying infra-sound as the agent accomplishes nothing. It really does not matter what the pathway is, whether it is infra-sound or some new form of rays or electro-magnetic field coming off the turbine blades. If the turbines are the cause, then the windfarm is responsible and needs to fix it. Anyone who truly doubts the results should want to replicate this study using independent acoustical consultants at some other wind farm, such as Shirley Wisconsin, USA, where there are residents who are self-selected as being very or extremely sensitive to wind turbine acoustic emissions".[58]

> "Some may ask, this is only 6 people, why is it so important? The answer is that up until now windfarm operators have said there are no known cause and effect relations between windfarm emissions and the response of people living in the vicinity of the windfarm other than those related to visual and/or audible stimuli, and these lead to some flicker which is treated, and 'some annoyance with noise.' This study proves that there are other pathways that affect some people, at least 6. The windfarm operator simply cannot say there are no known effects and no known people affected. One person affected is a lot more than none; the existence of just one cause-and-effect

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[58] Schomer, P. "The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm
Prepared for Energy Pacific by Steve Cooper, The Acoustic Group
A Review of this Study and Where It Is Leading". 10 February, 2015.

pathway is a lot more than none. It only takes one example to prove that a broad assertion is not true, and that is the case here. Windfarms will be in the position where they must say: 'We may affect some people.' And regulators charged with protecting the health and welfare of the citizenry will not be able to say they know of no adverse effects. Rather, if they choose to support the windfarm, they will do so knowing that they may not be protecting the health and welfare of all the citizenry".[59]

Stephen Ambrose observed that the correlation of human response journal entries with scientific waveform analysis in the Bridgewater study clearly shows hearing is not limited to audible sounds and that it goes far beyond the 1980s Neil Kelley et al. studies that identified operating wind-turbines can produce airborne transmissions that humans detect as "sensations".[60]

IV. Medical evidence on chronic infrasound exposure

World Health Organization: concerns about low frequency noise exposure

The 1999 World Health Organization (WHO) report "Guidelines for Community Noise" makes the following observations:

- "It should be noted that a large proportion of low-frequency component in a noise may increase considerably the adverse effects on health".[61]

- "The evidence on low frequency noise is sufficiently strong to warrant immediate concern". [62]

[59] Schomer, P. "Further comments on the Cape Bridgewater Wind Farm Study--Muddying the waters The Cooper report on the Cape Bridgewater Wind Farm. 2015.
[60] Stephen Ambrose letter to Steve Cooper dated January 22, 2015.
[61] Berglund, B, Lindvall, T, and Schwela, D, Ed. "Guidelines for Community Noise". World Health Organization, Geneva, 2000, p. xiv.
[62] *Ibid.,* p.35.

- "It should be noted that low-frequency noise . . . can disturb rest and sleep even at low sound pressure levels".[63]

- "Other primary physiological effects can also be induced by noise during sleep, including increased blood pressure; increased heart rate; ... vasoconstriction; ...cardiac arrhythmia".[64]

- "Special attention should also be given to the following considerations: . . .
  e. Sources with low-frequency components. [Sleep] disturbances may occur even though the sound pressure level during exposure is below 30 dBA".[65]

- "After prolonged exposure, susceptible individuals in the general population may develop permanent effects, such as hypertension and ischaemic heart disease. . .".[66]

- "For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended."

- " When prominent low frequency components are present, noise measures based on A-weighting are inappropriate."

The DEFRA Report, 2003

"A Review of Published Research on Low Frequency Noise and its Effects" by Leventhall *et al.* published by DEFRA in 2003, stated:

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[63] *Ibid.*, p. xii.
[64] *Ibid.*, p. x.
[65] *Ibid.*, p. 28.
[66] *Ibid.* p. x. See Babisch 1998 a; Babisch 1998b; Babisch et al. 1999; and Thompson, 1996.

- "The effects of infrasound or low frequency noise are of particular concern because of its pervasiveness due to numerous sources, efficient propagation, and reduced efficiency of many structures (dwellings, walls, and hearing protection) in attenuating low frequency noise compared with other noise".[67]

- "Exposure to low frequency noise in the home at night causes loss of sleep". [68]

In the 2003 DEFRA report he noted:

- "It is possible that body organs resonate within the low frequency range. Complainants of low frequency noise sometimes report a feeling of vibrations through their body".[69]

Citing the work of Inukai *et al.*, (2000) and Nakamura and Inukai, (1998), Leventhall noted that there are

> "four main subjective factors in response to low frequency noise: auditory perception, pressure on the eardrum, perception through the chest and more general feeling of vibration".[70]

His report concluded:

- "There is no doubt that some humans exposed to infrasound experience abnormal ear, CNS, and resonance induced symptoms that are real and stressful. If this is not recognised by investigators or their treating physicians, and properly addressed with understanding and

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[67] Leventhall, G, Pelmear, P, & Benton, S. "A Review of Published Research on Low Frequency Noise and its Effects Report for Defra". Published by the Department for Environment, Food and Rural Affairs, (DEFRA), May, 2003, p. 54.
[68] Leventhall *et al* DEFRA review, p. 54.
[69] Leventhall, G, Brown, F, and Kyriakides, K. " Somatic responses to low frequency noise". *Proc ICA*, Madrid, 1977.
[70] Leventhall *et al* DEFRA review, p. 32.

sympathy, a psychological reaction will follow and the patient's problems will be compounded".[71]

Vibrations of 0.5 Hz to 80 Hz have significant effects on the human body

As pointed out by Professor Alan Hedge, of Cornell University,

> "every object (or mass) has a resonant frequency. When an object is vibrated at its resonance frequency, the maximum amplitude of its vibration will be greater than the original amplitude (i.e. the vibration is amplified). Vibrations in the frequency range of 0.5 Hz to 80 Hz have significant effects on the human body".

> "Individual body members and organs have their own resonant frequencies and do not vibrate as a single mass, with its own natural frequency. This causes amplification or attenuation of input vibrations by certain parts of the body due to their own resonant frequencies. Vibrations between 2.5 and 5 Hz generate strong resonance in the vertebra of the neck and lumbar region with amplification of up to 240%. Vibrations between 4 and 6 Hz set up resonances in the trunk with amplification of up to 200%. Vibrations between 20 and 30 Hz set up the strongest resonance between the head and shoulders with amplification of up to 350%.
> Whole body vibration may create chronic stresses and sometimes even permanent damage to the affected organs or body parts".

ISO 2631 (International Organization for Standardization) Human Response to Whole Body Vibration (WVB) (parts 1, 2, and 4) sets limits to the maximum possible exposure allowed for whole-body vibration including 'severe discomfort boundaries' for 8-hour, 2-hour and 30-minute WBV exposures in the 0.1 Hz to 0.63 Hz range.

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[71] *Ibid.*, p.60.

"The exposure limit is the lowest for frequencies between 4-8 Hz because the human body is most sensitive to WBV at these frequencies. Suspected health effects of whole body vibration include: blurred vision; decrease in manual coordination; drowsiness (even with proper rest); low back pain/injury; insomnia".[72]

In 2006 Leventhall commented that "fluctuating audible sounds or amplitude modulations are the routine characteristic of IWTs and may be disturbing and stressful to exposed individuals".[73]

At a public hearing in Wisconsin in 2009[74], Leventhall stated that he was happy to accept the symptoms reported by individuals living near wind turbines including 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, "as they have been known to me for many years as the symptoms of extreme psychological stress from environmental noise, particularly low frequency noise".[75]

How sleep disturbance undermines health

In a 2014 article in the Lancet, Basner *et al.* confirmed:

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[72] Hedge, A. "Notes for students", Department of Department of Design and Environmental Analysis, Cornell University. (http://ergo.human.cornell.edu/studentdownloads/dea3500pdfs/whole-bodyvi), p.2-3.

[73] Leventhall, G. "Infrasound from wind turbines: Fact, fiction or deception?" *Canadian Acoustics, 34*, 29-36, 2006.

[74] Leventhall, G. "Wind turbine syndrome: An appraisal *Hearing before the Public Service Commission of Wisconsin*", 2009.

[75] However, in spite of these earlier statements, Professor Leventhall has subsequently appeared as an expert witness in various court proceedings for wind developers. Leventhall's evidence asserting that the nocebo effect was causing the reported symptoms was most recently heard in the Bull Creek case before the Alberta Utilities Commission in November, 2013. Rick James has observed: "The studies and reports by acousticians not affiliated with or sponsored by the wind industry warrant substantially more weight because they are less subject to issues of 'group think' or confirmation bias".

- "Evidence of the non-auditory effects of environmental noise exposure on public health is growing. Observational and experimental studies have shown that noise exposure leads to annoyance, disturbs sleep and causes daytime sleepiness, affects patient outcomes and staff performance in hospitals, increases the occurrence of hypertension and cardiovascular disease, and impairs cognitive performance in schoolchildren".[76]

  "Sleep disturbance is thought to be the most deleterious non-auditory effect of environmental noise exposure . . . because undisturbed sleep of a sufficient length is needed for daytime alertness and performance, quality of life, and health. Human beings perceive, evaluate, and react to environmental sounds, even while asleep".[77]

  "Taken together, the present review provides evidence that noise not only causes annoyance, sleep disturbance, or reductions in quality of life, but also contributes to a higher prevalence of the most important cardiovascular risk factor arterial hypertension and the incidence of cardiovascular diseases. The evidence supporting such contention is based on an established rationale supported by experimental laboratory and observational field studies, and a number of epidemiological studies. Meta-analyses have been carried out to derive exposure–response relationships that can be used for quantitative health impact assessments. Noise-induced sleep disturbance constitutes an important mechanism on the pathway from chronic noise exposure to the development of adverse health effects. [78]

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[76] Basner, M, Babisch, W, Davis, A, Brink, M, Clark, C, Janssen, S, Stansfeld, S. "Auditory and non-auditory effects of noise on health. *Lancet* 2014; 383: 1325–32

[77] Basner, *et al.* "Cardiovascular effects of environmental noise exposure". *Noise literature review 2011-2014,* 835.

[78] Münzel, T, Gori, T, Babisch, W, and Basner, M. "Cardiovascular effects of environmental noise exposure". *European Heart Journal* (2014) 35, 829–836.

How subaudible infrasound is perceived in humans

In 2004, H. Møller and C. S. Pedersen[79] of the Department of Acoustics, Aalborg University wrote and article on "Hearing at Low and Infrasonic Frequencies":

- "The ear is the primary organ for sensing infrasound . . . the perceived character of a sound that changes with decreasing frequency. Pure tones become gradually less continuous, the tonal sensation ceases around 20 Hz, and below 10 Hz it is possible to perceive the single cycles of the sound. A sensation of pressure at the eardrums also occurs. The dynamic range of the auditory system decreases with decreasing frequency".

- "The hearing becomes gradually less sensitive for decreasing frequency, but there is no specific frequency at which the hearing stops. Despite the general understanding that infrasound is inaudible, humans can perceive sound also below 20 Hz. This applies to all humans with a normal hearing organ, and not just to a few persons. The perceived character of the sound changes gradually with frequency. For pure tones the tonal character and the sensation of pitch decrease with decreasing frequency, and they both cease around 20 Hz. Below this frequency tones are perceived as discontinuous. From around 10 Hz and lower it is possible to follow and count the single cycles of the tone, and the perception changes into a sensation of pressure at the ears. At levels 20-25 dB above threshold it is possible to feel vibrations in various parts of the body, e.g. the lumbar, buttock, thigh and calf regions".[80]

- "A feeling of pressure may occur in the upper part of the chest and the throat region. Spontaneous reactions from subjects and visitors in the author's laboratory as well as their own

[79] Møller, H & Pedersen, C. "Hearing at Low and Infrasonic Frequencies". Department of Acoustics, Aalborg University, 2004, P. 54.
[80] *Ibid.* pp. 54-55.

experience suggest that vibrotactile sensations and a feeling of pressure may also occur in the upper part of the chest and in the throat region".[81]

- "It has also been shown that the hearing threshold may have a microstructure that causes a person to be especially sensitive at certain frequencies. These two phenomena may explain observations from case studies, where individuals seem to be annoyed by sound that is far below the normal threshold of hearing".

- "In addition to direct detection, infrasound may be detected through amplitude modulation of sound at higher frequencies. This modulation is caused by the movement of the eardrum and middle-ear bones induced by the infrasound, which results in changes of transmission properties. . . . a sound, which is inaudible to some people, may be loud to others. There is a reasonable agreement between data also below this frequency, and contours have been proposed down to 2 Hz".[82]

- "Under certain atmospheric conditions, e.g., temperature inversion, the noise may be more annoying and—in particular the low-frequency part—propagate much further than usually assumed". [83]

In a 7-year study that collected acoustic data at a number of the homes, so that cumulative acoustic exposures for some study participants could then be estimated, Robert Thorne concluded:[84]

[81] Møller & Pedersen *op. cit.* p. 50
[82] *Ibid.* p. 55.
[83] Møller, H, Pedersen, C. "Low-frequency wind-turbine noise". *J. Acoust. Soc. Am.*, Vol. 129, No. 6, June 2011, p. 3743.
[84] Thorne, R. "Wind Farm Noise and Human Perception A Review". Noise Measurement Services, Pty. Ltd, Queensland, Australia, 2013, p. 92.

- "The findings suggest that the individuals living near the wind farms of this study have a degraded Health-Related Quality of Life through annoyance and sleep disruption and that their health is significantly and seriously adversely affected (harmed) by noise. Based on the results of the study it is argued that, when exposed to wind farm noise and wind turbine generated air pressure variations, some individuals will more likely than not be so affected that there is a known risk of serious harm (also termed 'significant adverse effect') to health."

Nissenbaum & Hanning

In 2012, two medical doctors[85] published in a peer reviewed journal, the findings of their stratified cross-sectional study involving the health effects of persons living within 1100 meters of the Vinylhaven and Mars Hill Wind Turbine Projects in Aroostook County, Maine, which consists of 28 wind turbines.[86] They also presented their research at the 10th International Congress on Noise as a Public Health Problem (ICBEN) 2011, London, UK. They concluded:

> "The noise emissions of IWTs disturbed the sleep and caused daytime sleepiness and impaired mental health in residents living within 1.4 km of the two IWT installations studied. Industrial wind turbine noise is a further source of environmental noise, with the potential to harm human health. Current regulations seem to be insufficient to adequately protect the human population living close to IWTs. Our research suggests that adverse effects are observed at distances even beyond 1 km. Further research is needed to determine at what distances risks become negligable, as well as to better estimate the portion of the population suffering
> from adverse effects at a given distance".

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[85] Michael Nissenbaum MD, Northern Maine Medical Center, Fort Kent, Maine, USA and Christopher Hanning, MB, BS, MD, University Hospitals of Leicester, Leicester, UK.
[86] Nissenbaum, M, Aramini, J, Hanning, D. "Effects of industrial wind turbine noise on sleep and health". *Noise and Health International Journal*, September-October 2012.

In a sworn affidavit before the Court of Queen's Bench Judicial Centre of Saskatoon, Saskatchewan, Dr Nissenbaum stated:

"It is my professional opinion that there is a high probability of significant adverse health effects for those whose residence is located within 1100 meters of a 1.5 MW turbine installation based upon the experiences of the subject group of individuals living in Mars Hill, Maine. It is my professional opinion, based on the basic medical principle of having the exposure to a substance proven noxious at a given dose before risking an additional exposure, that significant risk of adverse health effects are likely to occur in a significant subset of people out to at least 2000 meters away from an industrial wind turbine installation. These health concerns include:

- Sleep disturbances/sleep deprivation and the multiple illnesses that cascade from chronic sleep disturbance.
- These include cardiovascular diseases mediated by chronically increased levels of stress hormones, weight changed, and metabolic disturbances including the continuum of impaired glucose tolerance up to diabetes.
- Psychological stresses which can result in additional effects including cardiovascular disease, chronic depression, anger, and other psychiatric symptomatology.
- Increased headaches.
- Unintentional adverse changes in weight.
- Auditory and vestibular system disturbances.
- Increased requirement for and use of prescription medication".

Summing up by a medical doctor and sleep specialist

Dr. Christopher Hanning BSc, MB, BS, MRCS, LRCP, FRCA, MD has served as Director of the Sleep Clinic and Laboratory at Leicester General Hospital, one of the largest sleep disorders clinics in the UK.[87] In 2013 he presented the following evidence under oath to the Alberta Utilities Commission Hearing for the Bull Creek wind development.

His opening statement provides an appropriate summary of the medical evidence[88]:

> "I do not think that there is any dispute that adequate sleep is essential for human health and well being. There is a vast literature on the effects of sleep loss on brain function, the heart and circulation, metabolism to name but a few. Anything that causes sleep loss will lead to ill health.
>
> "I do not think that there is any dispute either that wind turbine noise emissions can disturb sleep and that this is the principle reason for requiring a separation distance between turbines and homes. The separation distance is determined either as an actual minimum distance or by reference to a calculated noise level that has been deemed to be acceptable. The acceptable noise level is derived from a variety of sources, in particular studies of the effects of traffic noise. It must be remembered that the acceptable noise levels used in regulations and guidelines relating to wind turbines have only been derived from theoretical considerations and not from experiment at actual wind turbine sites with actual people. Until recently, there has been no experimental verification that the recommended noise levels are in fact safe and have no discernable impact on human sleep.

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[87] He has served as first Honorary Secretary of the British Sleep Society; Chairman of the Primary Care Sleep Group; Examiner Part II (Primary) FRCA Examination; Regional Adviser to the Royal College of Anaesthetists; Member, Royal College of Anaesthetists Advisory Appointments Committee Panel; Member, Royal College of Anaesthetists Hospital Accreditation Panel; Chairman, Independent Research Ethics Committee, PPD Pharmaco; Medical Adviser, UK Narcolepsy Association; and Chairman and Panellist, General Medical Council, Fitness to Practice Panels.

[88] Opening Statement of Dr Christopher Hanning BSc, MB, BS, MRCS, LRCP, FRCA, MD. Alberta Utilities Commission Hearing for development of wind power plant and associated substation in the Provost area ("Bull Creek"). Proceeding Number 1955 18th November 2013.

"In my expert opinion, there is now more than sufficient evidence to conclude that wind turbine noise impairs the sleep and health of residents living at distances greater than those proposed in the project under consideration. There is a real risk to the sleep and health of any resident living within 1.5km of a turbine. I base this opinion on three main strands of evidence.

"First, the anecdotal evidence. Dr Phillips has dealt with this so I will not deal with further with it except to state that I find it convincing. Secondly, the various general surveys taken around wind turbine installations including those of Pedersen and van den Berg in Europe and more recently by Morris and Schneider in Australia, all of which point to problems with sleep but did not use any specific test instruments for sleep quality. Again, I find the weight of evidence convincing as it all points in the same direction.

Thirdly, those studies that have used control groups and specific test instruments for sleep. Dr Shepherd's peer-reviewed study used the WHO Quality of Life test instrument which includes elements related to sleep and shows unequivocally that those living within about 1.4km of the turbines had a lower quality of life than those living several kilometres away. Dr Nissenbaum's peer-reviewed study, to which I contributed and am an author, showed convincingly that those living within about 1.5km of wind turbines had worse sleep than those living several kilometres away. This study looked at two different wind turbine facilities.

"Dr Bigelow's study, sponsored by the Ontario Government at 8 wind turbine sites, used similar sleep specific test instruments to the Nissenbaum study. The results are very similar and confirm that the closer one lives to a wind turbine installation, the more likely you are to have poor sleep. This study is complete and the results have been presented as a poster. Dr Ollson has, most unfairly, characterised this as a student study. It is not. The poster presents the results of the largest study thus far to examine the effects of wind turbine noise on sleep using test instruments specific for sleep conducted by experienced investigators who consulted widely in designing the study including with myself. BluEarth's [the developer's] witnesses claim that there is insufficient evidence to prove a causal link between wind turbine noise and sleep disruption. The only study of wind turbine noise and well being which does not demonstrate harm is that of Mroczek. The study group included subjects not exposed to turbine noise and the conclusions are not justified by the data. Every other study shows harm. There is no single, well conducted, controlled and reliable piece of original research which shows that wind turbines do not cause harm at the distances proposed here. Not one.

"With respect to causality, affected subjects improve when exposure ceases and relapse when exposure restarts. This is prima facie evidence of causality. The studies of Pedersen as well as those of Nissenbaum and Bigelow show a clear dose-response relationship. This too is prima facie evidence of causality.

"I am not a lawyer but my work with the United Kingdom General Medical Council gives me a good understanding of standards of proof. In a situation such as this where the consequence of the wrong decision is highly likely to be harm to the nearby residents, the civil standard of proof is appropriate, the balance of probabilities. In my expert opinion, the scientific evidence more than meets this evidentiary test.

"Wind turbine noise from turbines of the size proposed in the project under consideration has a high risk of disturbing the sleep and impairing the health of those living within 1.5km. There are at least 25 occupied properties meeting this criterion and I advise that the proposal be refused to safeguard the occupants".

Conclusion

Based on the information presented above, infrasound generated by wind turbines must be considered a potential direct cause of the adverse health reactions widely reported from wind turbine host communities.

Now that so many indicators point to infrasound as a potential agent of adverse health effects, it is critical to re-examine the approach to this aspect of wind turbine operation, revise regulations, and immediately implement protective public health measures based on the precautionary principle.

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ABOUT THE AUTHOR

Keith Stelling is an independent researcher and writer with many articles on health issues published in Canada and the United Kingdom.

After graduating from McMaster University with an Honours B.A. and M.A., he completed three years of post graduate studies at the School of Phytotherapy in England, obtaining the Diploma in Phytotherapy and becoming the first Canadian member of the National Institute of Medical Herbalists of Great Britain and the College of Practitioners of Phytotherapy (England). After returning to Ontario he taught courses, ran his own practice and founded and edited the Canadian Journal of Herbalism. He also served as a peer reviewer on the editorial board of the British Journal of Phytotherapy, and as a member of the Government of Canada Second Expert Advisory Committee on Herbs and Botanical Preparations, presented to the House of Commons Standing Committee on Health, and contributed a number of monographs to the Canadian Pharmacists Association and the Canadian Medical Association guide to botanical medicine (Chandler F, editor. 2000. "Herbs: Everyday Reference for Health Professionals").

After retiring to rural Bruce County, he became aware of the health and environmental issues associated with nearby wind turbines and has spent the last nine years researching these concerns. He was appointed a citizen member of the Multi-municipal Wind Turbine Working Group comprised of elected municipal councillors from Bruce, Grey, and Huron Counties. He was a founding member of Wind Concerns Ontario and in 2008 he formed a local conservation group, "The Friends of Arran Lake" with the aim of preventing the significant wildlife habitat in his neighbourhood from being degraded by a wind turbine development.

His research papers include:

Stelling, Keith (2012). **"Questions arising from the Auditor General's 2011 Report on Renewable Energy Initiatives"**. With comprehensive and detailed evidence gathered independently from inside the Ministry of Energy– much of it previously unavailable to the public– the Auditor General's Report unambiguously challenges both the rationale and implementation of the Green Energy Act. The Act has been promoted as a mechanism for cutting greenhouse gas emissions, increasing job opportunities, and creating a competitive business environment. However the Auditor General's investigators found little evidence that these objectives have been or would be realized.
Download original document: "Questions arising from the Auditor General's 2011 Report on Renewable Energy Initiatives"

Stelling, Keith (2012). **"Is the Ontario Ministry of Natural Resources undermining our environmental legislation?"** Recent issuing of "Overall Benefit Permits" by the Ontario Ministry of Natural Resources allowing renewable energy companies to damage and destroy habitat of endangered species raises concerns that the MNR is not fulfilling its obligations under the Endangered Species Act (2007).
Download original document: "Is the Ontario Ministry of Natural Resources undermining our environmental legislation?"

Stelling, Keith and Petrie, Scott (2011). **"Threats from industrial wind turbines to Ontario's wildlife and biodiversity"**. Industrial wind turbines do not have a benign environmental foot print as has been claimed. Co-authored with biologist Dr. Scott Petrie, Executive Director, Long Point Waterfowl and Adjunct Professor, University of Western Ontario, it lists the adverse environmental effects from industrial wind turbines including habitat fragmentation and habitat loss, wildlife disturbance and life history disruption; bird and bat abundance declines; disruption of ecological links resulting in habitat abandonment by some species; loss of population vigour and overall density resulting from reduced

survival or reduced breeding productivity-- a particular concern for declining populations. The cumulative effects of multiple on- and off-shore wind developments have not been considered. Download original document: "Threats from industrial wind turbines to Ontario's wildlife and biodiversity"

Stelling, Keith (2010). **"What went wrong with Ontario's energy policy? Comparing spin and reality".** By referring to the economic experience of those European countries that have vigorously promoted wind energy over the last two decades, this report demonstrates that the decisions of the Ontario government did not take into consideration the reality of introducing large scale industrial wind energy onto the grid. In fact, the government's enthusiasm to embrace what it claimed to be cheap, "clean", environmentally benign electricity at the same time as diminishing CO2 emissions appears to have ignored all the realistic warnings from electricity production professionals it received. (*Predictions of rising electricity costs and job losses have become reality with Ontario having the highest electricity costs in North America).* Download original document: "What went wrong with Ontario's energy policy?"

Stelling, Keith and Krogh, Carmen (2009). **"Summary of Recent Research on Adverse Health Effects of Wind Turbines".** Authorities and politicians in Ontario have been repeatedly warned that industrial wind turbines are having an adverse effect on the health of those living nearby. Health complaints are not peculiar to this province but are consistent throughout the world wherever large industrial wind turbines have been installed. Contrary to the claims of the industry, there is a growing body of peer-reviewed research substantiating these health claims. This report attempts to catalogue the most recent. *A generally acknowledged major concern about wind turbine disturbance centres around the low frequency noise projected from this heavy industrial machinery. Until recently measurements of this type of noise have seldom been carried out near wind turbines. There is already ample scientific evidence that low frequency noise is a cause of sleep disturbance in humans.* The evidence also suggests that long term exposure normally leads to serious health problems. *Research on animals indicates that basic survival functions such as hunting, self protection and reproduction are interrupted by low frequency noise exposure.* Download original document: "Adverse Health Effects of Wind Turbines"

Stelling, Keith (2009). Submission to the Standing Committee on General Government of the Ontario Legislature; **"A question based formula for revising Bill 150, The Green Energy and Green Economy Act".**

Stelling, Keith (2008). **"Arran Lake Wetlands Complex: a study of a sensitive wildlife habitat under threat".** An 82 page study of an important migratory stopover, which is also a functional natural heritage system, and is comprised of three provincially significant ANSIs (designated areas of natural and scientific interest); illustrated with photographs of the area; listing 21 species at risk and how they would be threatened by a proposed wind turbine development.

Stelling, Keith (2007) **"Calculating the Real Cost of Industrial Wind Power"**
An information update for Ontario Electricity Consumers Studies challenging the assumption upon which the ecological value of commercial wind power is based: that it does not reduce carbon emissions because it requires fossil-fuelled back up; that wind energy is not cheap but very expensive and will raise consumer electricity costs to economically destructive levels. Download original document: "Calculating the Real Cost of Industrial Wind Power"

LolP 2. Une enquete au Canada par Keith Stelling. La suite.

L' acousticien Robert Rand a subi le syndrome eolien de plein fouet en demeurant une nuit dans la residence qui est à 500 m de l'eolienne et l'auteur en tire les conclusions suivantes :

Les turbines des eoliennes peuvent produire des malaises certains et des consequences serieuses pour la Sante.

Toute personne etrangere aux riverains peut penetrer dans la maison impactee par les eoliennes et eprouver au bout de quelques minutes les memes symptomes decrits par les riverains.

Les symptomes ressentis par Rand etaient instinctifs et non elabores à partir de l'intellect. Ils resultaient de la stimulation causee à l'oreille interne aussi appellee vestibule de l'oreille.

La sensation penible diminuant quand le bruit se situait bien en dessous de 60dBG.(ponderation G) quand la turbine cessait de marcher.

Maintenant l'auteur evoque l'enquete de Shirley Wind Farm dans le Wisconsin egalement enterprise par Rand et un collegue en 2012.

Les eoliennes emettent un spectre sonore complet qui comprend les infrasons. C'est-à-dire 3Hz et bien en dessous. Si l 'on considere que le seuil d'audition est à 20 Hz en effet c'est inaudible mais cela peut quand meme stimuler l' oreille interne.

On peut meme calculer la frequence au passage de la pale avec la formule RPM (rotation par minute) . RPM/60 x nombre de pales. Pour Shirley Wind Farm cela donne : 14RPM/60x3= 0.7 Hz. Il parle des 6 prochaines harmonies :1.4,2.1,2.8,3.5,4.2&4.9.

A l'interieur de cette maison investiguee il se trouve aussi des infrasons plus eleves ainsi que des sons de basse frequence de 15 Hz à 30 Hz qui eux proviennent de la flexibilite naturelle des murs.

En fait tout vibre dans ce logis suite aux frequences emises.

C'est un probleme de frequences qui cree les malaises et jamais un probleme de bruit.

On en vient à une autre enquete : Cape Bridgewater Wind farm 2014 :

L'acousticien Cooper note que les infrasons enregistres presentent un « pattern « un modele identique qui se repete par periode. C'est ce qu'il appelle la signature de l'eolienne. WTS.wind turbine signature.

Le Professeur Alan Hedge de Cornell University apporte son analyse des phenomenes vibratoires observes par certains riverains pres des eoliennes :

Chaque objet ou chaque masse a une frequence, une resonnance. Quand on fait vibrer un objet à sa fréquence propre, l'amplitude maximale de sa vibration sera superieure à son amplitude originelle. La vibration est amplifiée. Les fréquences du type 0.3Hz à 80Hz ont un effet conséquent sur le corps humain.

Les différents éléments du corps humain et les organes ont une fréquence distinctive. Elle leur est propre. Ils ne vibrent pas en une seule masse avec une fréquence particulière. Cela cause une amplification ou une atténuation de la vibration par certaines parties du corps à cause de leurs fréquences particulières. Les vibrations entre 2.5 et ,5Hz génèrent une résonnance forte dans les vertèbres du cou et la région lombaire avec une amplification qui peut atteindre 240%. Les vibrations entre 4 et 6 Hz provoquent une résonnance dans le tronc avec une amplification de 200%. Les vibrations entre 20 et 30 Hz sont les plus prononcées : elles causent une résonnance entre la tête et les épaules qui va jusqu' à une amplification de 350%. La vibration du corps dans son ensemble peut créer une gêne chronique et parfois la détérioration de certains organes ou parties du corps.

ISO 2631 est le standard international qui limite l' exposition du corps humain aux fréquences. (WBV . Whole body vibration de 0.1 Hz à 0.63 Hz). On peut expérimenter dans ces zones une vision trouble, un manque de coordination, étourdissement, Insomnie, douleur lombaire, même avec un temps de repos.

La suite de l'enquête compilee par Keith Stelling sera disponible prochainement. Ne manquez pas la troisième et dernière partie.

Le collectif....

Les bruits de basses frequences et les eoliennes. Une enquete au Canada par Keith Stelling.

Abrégé de Infrasound and low frequencies in industrial wind turbines .2015.

La maison hantée par les infrasons....

Les riverains s'etant plaints en.masse des symptômes inquiétants qu' ils découvrent après l'installation du parc éolien à côté de leurs résidences, les élus soucieux de la santé générale font venir l'acousticien Robert Rand et quelques autres. Nous sommes au Canada et dans la province de l'Ontario. Le mantra des lobbies éoliens restant toujours le même : Puisque ces prétendus infrasons ne sont pas audibles, ils ne peuvent pas avoir d'effet sur la santé.

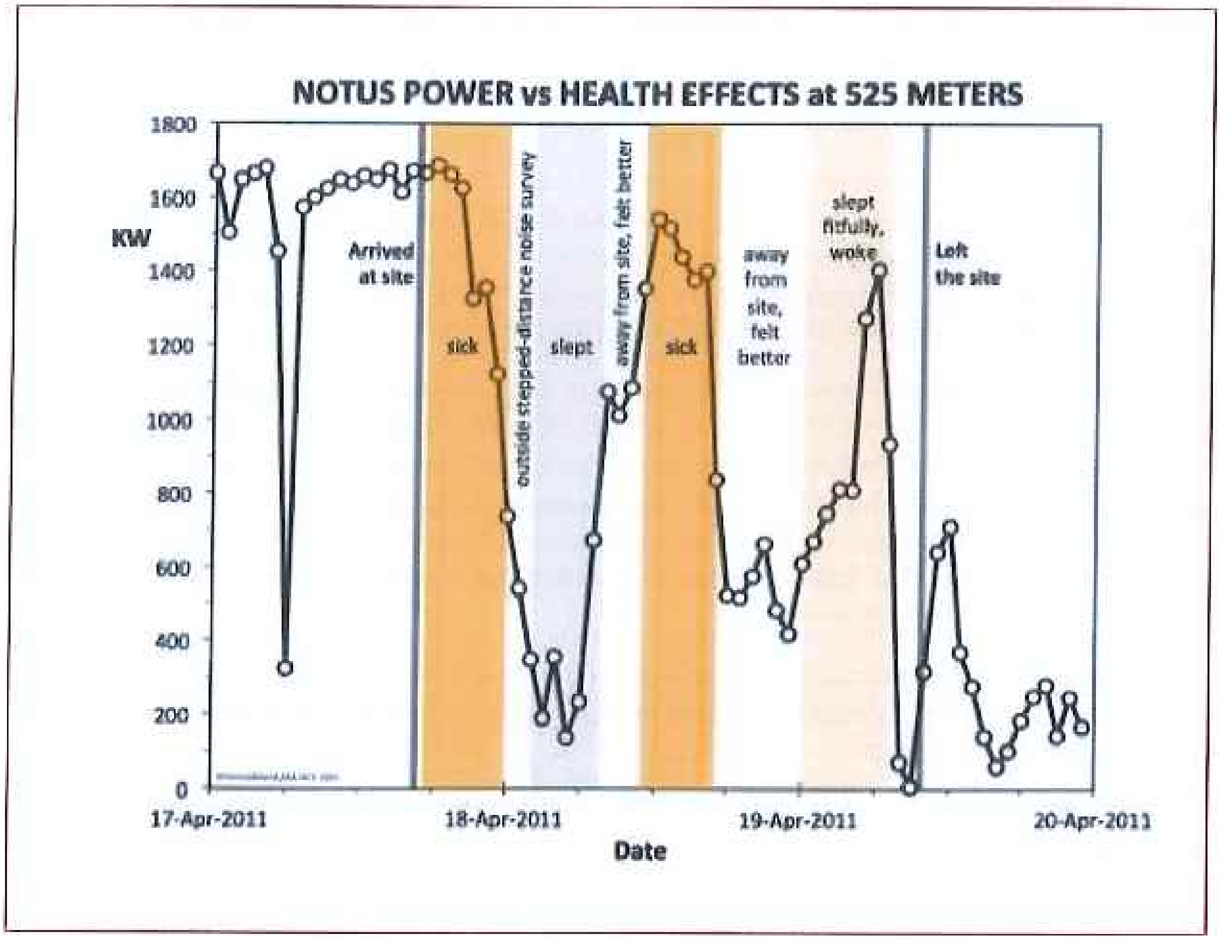
Les turbines des éoliennes produisent un signal sonore pulsé qui monte et qui descend et se situe dans la gamme infrasonique (0.75 Hz, 1.5 Hz, 2.25 Hz, 3.0 Hz) et ainsi de suite. Ceci est produit par la pale qui passe la tour.Ces pulsions peuvent être senties et non pas perçues par l'oreille. On a déjà démontré que les infrasons inaudibles produisent une réponse physiologique des différents systèmes à l'intérieur du corps humain.La seconde caractéristique du son éolien c' est la modulation d'amplitude. Elle est audible. Enfin la troisième caractéristique est le bruit émanant de la boîte de vitesse et de l'action des ventilateurs.

Le système nerveux perçoit les infrasons. Voilà pourquoi les symptômes habituels du syndrome eolien apparaissent chez les habitants : acouphènes, troubles du sommeil, palpitations, pression sur la poitrine, vomissements etc

En 2008 la norme pour les turbines était de 1.5MW, maintenant elle atteint 4MW or il faut bien savoir que plus la turbine monte en puissance et plus elle produit d'infrasons et plus les symptômes vont s'aggraver.(Christian Pedersen, Université d'Aalborg au Danemark)

Le graphique qui suit illustre bien la corrélation entre l'émission infrasonique et le malaise physiologique éprouvé par un acousticien chevronne qui accepte le challenge du parc éolien. La maison est à 525 m environ d'une turbine.

Suivons bien son parcours avec ce graphique :



Le 17 avril 2011 Robert Rand arrive sur le site. Le 18 avril il tombe malade.(sick) alors il sort pour mesurer avec son équipement la distance du son puis il dort quand même (slept)Mais rechute alors il sort dehors et cela va mieux.. Il revient se coucher mais son sommeil est agité. Enfin il quitte les lieux, bien content sans aucun doute. Le pic infrasonique est à son maximum quand le malheureux se sent mal.

Voici une analyse plus détaillée de ce qui se passe par l'acousticien lui-même : » L'enveloppe de la maison bloquait la plupart des fréquences au dessus de 10 Hz et amplifiait les basses fréquences pulsées qui restaient, ceci à la manière d'un tambour. La pression acoustique variait du positif (compression) au négatif (rarification) de 0.2 Pa (Pascal) de crête en crête. Cet accroissement de la modulation à l'intérieur de la maison cadrait bien avec le summum des malaises à l'intérieur. Nos instruments mesuraient 11-12 dB à l'intérieur et à l' extérieur en période de crête. Le RMS (rotation en m par seconde) mesuré sur le graphique est bien en dessous du niveau sonore détectable par l'oreille.

Robert Rand ajoute encore ;*

La fréquence de la turbine à 22.9 Hz était inaudible mais les amplitudes modulées dépassaient le seuil vestibulaire de l'oreille. (L'oreille humaine à un vestibule ou un couloir). Mon sommeil était interrompu quand la vitesse du vent était supérieure à 10m/s. Les valeurs de cohérence indiquent que l'énergie de tres basse fréquence en dessous de 10 Hz était fortement en phase avec l'intérieur de la maison et l' amplification de la pression interne.

Le graphique montre, poursuit il ,que l'enveloppe de la maison filtrait et amplifiait les très basses fréquences produites par les turbines. Les oscillations de pression en négatif (le vide) sont plus prononcées à l' interieur de la maison que dehors.

Les pulsations infrasoniques et de tres basses frequences sont cachees si les acousticiens utilisent la ponderation A et rien qu'elle. (Anti eoliens, exigeons des acousticiens une ponderation autre que A ! dans leurs mesures du bruit) Cependant ces pulsations apparaissent en toutes lettres dans le deroulement temporel et lineaire en Pascal qui est l'unite de mesure de la pression sonore.

L'enquete se poursuit..ne ratez pas la suite tres prochaine ment....

Le collectif 86, 87,16 a votre service.

Les eoliennes de Keith Stelling au Canada.

Troisième et dernière partie.

Une compilation.des découvertes récentes du monde entier.

Si vous avez manque les chapitres précédents, Robert Rand , l'intrépide acousticien visite une résidence à 500 m du parc eolien et subit le syndrome eolien à l'instant où il franchit le seuil.

Ce n'est pas tant le bruit des turbines qui est en cause mais bien les basses fréquences émises par elles.Le corps humain réagit mal aux basses fréquences parce qu'il a la sienne propre. Non Messieurs les lobbyistes, le corps humain n'est pas en fer blanc ! La suite est un tour d'horizon des données scientifiques internationales sur les parcs éoliens et les mises en garde ou les méfaits sanitaires rencontrés.

Le chercheur Basnet et d' autres écrivent dans The Lancet, le premier bulletin médical en Angleterre et en 2014 ,que les preuves s'accumulent maintenant de la nocivité des expositions au bruit de caractère inaudible. (Entre 0.1 et 20 Hz) pour la santé publique.Cela cause de la détresse,un sommeil troublé, de la somnolence de jour, et affecte le rétablissement pour les malades. Il y a risques d'hypertension et de maladies cardiovasculaires, et de retard cognitif pour l'enfant scolarise.

Les troubles du sommeil à partir de l'exposition aux bruits environmentaux inaudibles sont les plus dangereux parce qu'un sommeil suffisant est essentiel pour les tâches du lendemain, la performance,la qualite de la vie et la Sante. Les dormeurs perçoivent, evaluent et reagissent au bruit.

Ce sont des recherches en laboratoire et des observations scientifiques qui le démontrent ainsi que des études épidémiologiques.Dr Pedersen de l' université d'Aalborg, au département d' acousti que écrit que l'on entend moins pour les fréquences qui décroissent mais il n'y a pas de fréquence spécifique où l'on cesserait . Malgré le fait que l'infrason est inaudible , l'humain peut percevoir le son sous 20 Hz. Cela va pour tous les humains. Le caractère du son perçu change graduellement avec la fréquence. Pour une tonalité pure, celle çi et son volume décroissent au fur et à mesure que la fréquence diminue. Les deux éléments cessent autour de 20 Hz. En dessous de ce seuil, la tonalité apparaît comme discontinue. A partir de 10 Hz et plus bas encore il est possible de suivre et de compter les cycles différents de la tonalité et la perception se change en sensation de pression dans les oreilles. A des niveaux de 20-25 dB et au dessus du seuil on peut ressentir des vibrations dans différentes parties du corps : région lombaire, fesses, cuisses et talons.

On peut ressentir une sensation de pression dans la poitrine et la gorge. Le seuil de l'audition peut avoir une microstructure qui fait qu'une personne pourra être sensible à certaines fréquences. Cela peut expliquer que certaines personnes sont ennuyées par des sons bien inférieurs au seuil de l'audition. En plus de la détection infrasonique par appareils, celui çi peut être appréhendé par une modulation d'amplitude sonore avec de plus hautes fréquences. Cette modulation est causée par le mouvement dans le tympan et les os de l'oreille intermédiaire, ceci provoqué par l'infrason et qui se traduit par des changements des propriétés de la transmission. Un son inaudible pour les uns peut être fort pour les autres.

Suivant des conditions atmosphériques spéciales comme un changement de température, le bruit peut être plus agaçant et en particulier pour les basses fréquences, se propage plus loin qu'on pourrait le croire. Le Dr Hanning pointe le doigt vers la recherche basée sur des considérations théoriques et à partir de études sur le traffic routier et non sur des expérimentations au pied des éoliennes et avec des humains. La faille est considérable. Donc les limites du bruit sont douteuses et qui plus est, il n'y a pas d'étude à ce jour pour discerner les effets sur le sommeil humain.

Quand on vous demande de prouver le lien de cause à effet entre les turbines et les troubles du sommeil, on ne voit qu' une chose : les symptomes disparaissent quand on s' eloigne du parc eolien. La qualite du sommeil est bien superieure chez les residents à plusieurs kms du parc eolien que ceux qui vivront à 1.5 kms des turbines.

Fin de l'enquete par Keith Stelling. Infrasounds and low frequencies in industrial wind turbines. 2015