Wind Turbines and Health

A Rapid Review of the Evidence

July, 2010

The comments in the bubbles on the sides of each page were made by

Nina Pierpont, MD, PhD, on 3/30/11

Wind Turbines and Health
– A Rapid Review of the Evidence

The purpose of this paper is to present findings from a rapid review of the evidence from current literature on the issue of wind turbines and potential impacts on human health. In particular the paper seeks to ascertain if the following statement can be supported by the evidence: *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.* This statement is supported by the 2009 expert review commissioned by the American and Canadian Wind Energy Associations (Colby et al. 2009).

Dr. Nina Pierpont:
Please define.
(read my full note on Page 15, Note 1)

Dr. Nina Pierpont:
What is a "direct pathological effect"?
(read my full note on Page 15, Note 2)

Dr. Nina Pierpont:
Suggests that this Rapid Review relies strongly or piggy-backs or takes its cue and tone from the Colby et al document, which is (as its sponsorship indicates) an industry document with obvious conflict of interest.

Dr. Nina Pierpont:
Perhaps a measured and thoughtful approach would have been more appropriate given the nature of the question and the gravity of an official scientific statement by Australia's governmental medical research funding body.

Dr. Nina Pierpont:
In the health context, we are perhaps not looking for adverse health impacts to be minimised, but to be prevented altogether.

CONTEXT

In Australia, since the legislation of the *Renewable Energy (Electricity) Act* in 2000, wind power has been gaining prominence as a viable sustainable alternative to more traditional forms of energy production. Studies have found that there is increasing population demand for 'green' energy and that people are willing to pay a premium for renewable energy (Chatham-Kent Public Health Unit, 2008; Pedersen & Persson Waye, 2007). However as with any shift in technology, the emergence of wind farms is not without controversy.

Dr. Nina Pierpont:
Same comment as for "viable sustainable."

Dr. Nina Pierpont:
A dispassionate and well-reasoned scientific document would have left these two words out. These are not established facts, and this document does not provide evidence for or against sustainability or viability.

Dr. Nina Pierpont:
Government document from
(read my full note on Page 15, Note 3)

Dr. Nina Pierpont:
This statement is not supported by this reference. The reference is also wrong; this paper (title in reference list at end of Rapid Review) was published in 2004.

Dr. Nina Pierpont:
Presents "controversy" and then "opposing viewpoints" as a central issue.
(read my full note on Page 15, Note 4)

There are two opposing viewpoints regarding wind turbines and their potential effect on human health. It is important to note that these views are frequently presented by groups or people with vested interests. For example, wind energy associations purport that there is no evidence linking wind turbines to human health concerns. Conversely, individuals or groups who oppose the development of wind farms contend that wind turbines can adversely impact the health of individuals living in proximity to wind farms.

Dr. Nina Pierpont:
See last comment, on "controversy."

Dr. Nina Pierpont:
true

Dr. Nina Pierpont:
Same comment as for "controversy." Industry documents routinely set up the health problems as a spin-off of "not liking turbines." This is inappropriate for a review of evidence from a scientific body.

Concerns regarding the adverse health impacts of wind turbines focus on the effects of infrasound, noise, electromagnetic interference, shadow flicker and blade glint pro-

duced by wind turbines. Does the evidence support these concerns?

SOUND AND NOISE FROM WIND TURBINES

Sound is composed of frequency expressed as hertz (Hz) and pressure expressed as decibels (dB). In terms of frequency sound can be categorised as audible and inaudible. Infrasound is commonly defined as sound which is inaudible to the human ear (below 16 Hz). Despite this commonly used definition, infrasound can be audible (EPHC, 2009). There is often confusion regarding the boundary between infrasound and low frequency noise (Leventhall, 2006). Human sensitivity to sound, especially to low frequency sound, is variable and people will exhibit variable levels of tolerance to different frequencies (Minnesota Department of Health, 2009).

Noise can be defined as any undesirable or unwanted sound. The perception of the noise is also influenced by the attitude of the hearer towards the sound source. This is sometimes called the nocebo effect, which is the opposite of the better known placebo effect. If people have been preconditioned to hold negative opinions about a noise source, they are more likely to be affected by it (AusWEA, 2004).

Wind turbines produce noise that can be classified into the following categories:

1. Mechanical noise which is produced from the motor or gearbox; if functioning correctly, mechanical noise from modern wind turbines should not be an issue.
2. Aerodynamic noise which is produced by wind passing over the blade of the wind turbine (Minnesota Department of Health, 2009).

As well as the general audible range of sound emissions, wind turbines also produce noise that includes a range of Special Audible Characteristics (SACs) such as amplitude modulation, impulsivity, low frequency noise and tonality (EPHC, 2009).

Table 1 compares the noise produced by a ten turbine wind farm compared to noise levels from some selected activities.

Dr. Nina Pierpont:
In a real scientific document, at this point the authors would be defining their terms
(read my full note on Page 15, Note 5)

Dr. Nina Pierpont:
This is overall a good document with some particular flaws; see comment in Reference section, at end.

Dr. Nina Pierpont:
This term means the reporting of adverse medication effects in placebo recipients in clinical trials.
(read my full note on Page 15, Note 6)

Dr. Nina Pierpont:
That's a big "if" for large pieces of inaccessible machinery operating under high forces and variable weather conditions for long periods of time.

Dr. Nina Pierpont:
True, but it is more than a swish.

Dr. Nina Pierpont:
The word "tolerance" implies that there are indeed negative things to tolerate, and perhaps that more tolerance is the socially desirable thing.

Dr. Nina Pierpont:
It can be so defined and always is in wind industry documents, but "noise" probably could also be defined in terms of the loudnesses, frequencies, rhythmicity, and harmonic patterns of the sounds.

Dr. Nina Pierpont:
Industry document.
(read my full note on Page 15, Note 7)

Dr. Nina Pierpont:
We are interested in how often and how much this is an issue, not in whether it "should" be or not.

Dr. Nina Pierpont:
Yes, and these are where the problems lie; this section needs to be further developed.

Activity	Sound pressure level (dBA)[1]
Jet aircraft at 250m	105
Noise in a busy office	60
Car travelling at 64kph at 100m	55
Wind farm (10 turbines) at 350m	**35-45**
Quiet bedroom	35
Background noise in rural area at night	20-40

Table 1: Noise levels compared to ten turbine wind farm (SDC, 2005).

Dr. Nina Pierpont:
The A-weighting filter screens out low frequency noise and infrasound.
(read my full note on Page 15, Note 8)

Dr. Nina Pierpont:
Yes, this graph found in source at http://www.sd-commission.org.uk/publications/downloads/Wind_Energy-NovRev2005.pdf

Dr. Nina Pierpont:
Only their profound and possibly willful ignorance could lead them to conclude this. However, this is only a "think tank" policy paper; the lead author appears to be an environmental lawyer.

Macintosh and Downie (2006) conclude that based on these figures "noise pollution generated by wind turbines is negligible".

One of the most common assertions regarding potential adverse noise impacts of wind turbines is concerned with low frequency noise and infrasound. It should be noted that infrasound is constantly present in the environment and is caused by various sources such as ambient air turbulence, ventilation units, ocean waves, distant explosions, volcanic eruptions, traffic, aircraft and other machinery (Rogers, Manwell & Wright, 2006). In relation to wind turbines, Leventhall (2006) concludes that there is insignificant infrasound generated by wind turbines and that there is normally little low frequency noise. A survey of all known published results of infrasound from wind turbines found that wind turbines of contemporary design, where rotor blades are in front of the tower, produce very low levels of infrasound (Jakobsen, 2005). Another recent report concludes that wind farm noise does not have significant low-frequency or infrasound components (Ministry of the Environment, 2007). As discussed in further detail below the principal human response to audible infrasound is annoyance (Rogers, 2006).

Dr. Nina Pierpont:
Both errors, as demonstrated by the material in the comment for the table, above.

Dr. Nina Pierpont:
Again, this interpretation relies on the now disproven assumption that the infrasound is insignificant if its dB level falls below the human pure tone audibility curve.

Dr. Nina Pierpont:
Same comment as last.

Dr. Nina Pierpont:
Commissioned report to Ontario, Canada government (see comment in reference section).

Dr. Nina Pierpont:
They mean Rogers et al. 2006. This is an academic engineering document (link in comment in reference section). It also presents WT infrasound as insignificant. It offers primary data on wind turbine noise only for small turbines.

1 The "A" represents a weighting of measured sound to mimic that discernable by the human ear, which does not perceive sound at low and high frequencies to be as loud as mid range frequencies (AusWEA, nd. a).

EFFECTS OF NOISE FROM WIND TURBINES ON HUMAN HEALTH

The health and well-being effects of noise on people can be classified into three broad categories:

1. subjective effects including annoyance, nuisance and dissatisfaction;
2. interference with activities such as speech, sleep and learning; and
3. physiological effects such as anxiety, tinnitus or hearing loss (Rogers, Manwell & Wright, 2006).

Several commentators argue that noise from wind turbines only produces effects in the first two categories (Rogers, 2006; Pedersen & Persson Waye, 2007).

Various studies of wind turbine effects on health have concentrated on the selfreported perception of annoyance. There are difficulties with measuring and quantifying subjective effects of noise such as annoyance. According to the World Health Organization (WHO) (1999) annoyance is an adverse health effect, though this is not universally accepted. Kalveram proposes that annoyance is not a direct health effect but an indication that a person's capacity to cope is under threat. The person has to resolve the threat or their coping capacity is undermined, leading to stress related health effects (Kalveram 2000). Some people are very annoyed at quite low levels of-noise, whilst other are not annoyed by high levels.

It has been suggested that if people are worried about their health they may become anxious, causing stress related illnesses. These are genuine health effects arising from their worry, which arises from the wind turbine, even though the turbine may not objectively be a risk to health (Chapman 2010). The measurement of health effects attributable to wind turbines is therefore very complex.

One study of wind turbine noise and annoyance found that no adverse health effects other than annoyance could be directly correlated with noise from wind turbines. The authors concluded that reported sleep difficulties, as well as feelings of uneasiness, as-

Dr. Nina Pierpont:
As mentioned in the last comment, these authors are engineers. They don't know health and physiology. *(read my full note on Page 16, Note 9)*

Dr. Nina Pierpont:
That's Pedersen and Persson Waye 2004. This research only assessed annoyance; it did not assess other symptoms, so this is a false attribution, as in the first reference to this paper on page 2.

Dr. Nina Pierpont:
That's "Rogers et al. 2006"

Dr. Nina Pierpont:
"Apart from 'annoyance,'" the World Health Organization writes (in the 1999 publication *Guidelines for Community Noise*, p. 50), "people may feel a variety of negative emotions when exposed to community noise, and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion." Whether others accept this as a negative health effect or not is irrelevant compared to the authority of the WHO.

sociated with noise annoyance could be an effect of the exposure to noise, although it could just as well be that respondents with sleeping difficulties more easily appraised the noise as annoying (Pedersen & Persson Waye, 2007).

Many factors can influence the way noise from wind turbines is perceived. The aforementioned study also found that being able to see wind turbines from one's residence increased not just the odds of perceiving the sound, but also the odds of being annoyed, suggesting a multimodal effect of the audible and visual exposure from the same source leading to an enhancement of the negative appraisal of the noise by the visual stimuli (Pedersen & Persson Waye, 2007). Another study of residents living in the vicinity of wind farms in the Netherlands found that annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study also concluded that people who benefit economically from wind turbines were less likely to report noise annoyance, despite exposure to similar sound levels as those people who were not economically benefiting (Pedersen et al, 2009).

In addition to audible noise, concerns have been raised about infrasound from wind farms and health effects. It has been noted that the effects of low frequency infrasound (less than 20Hz) on humans are not well understood (NRC, 2007).

However, as discussed above, several authors have suggested that low level frequency noise or infrasound emitted by wind turbines is minimal and of no consequence (Leventhall, 2006; Jakobsen, 2005). Further, numerous reports have concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines (DTI, 2006; CanWEA, 2009; Chatham-Kent Public Health Unit, 2008; WHO, 2004; EPHC, 2009; HGC Engineering, 2007). In summary:

- 'There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects' (Berglund & Lindvall 1995).
- Infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour (DTI, 2006).

- Findings clearly show that there is no peer-reviewed scientific evidence indicating that wind turbines have an adverse impact on human health (CanWEA, 2009).
- Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effects in humans. Subaudible, low frequency sounds and infrasound from wind turbines do not present a risk to human health (Colby, et al 2009).
- The Chatham-Kent Public Health Unit (Ontario, Canada) reviewed the current literature regarding the known health impacts of wind turbines in order to make an evidence-based decision. Their report concluded that current evidence failed to demonstrate a health concern associated with wind turbines.

'In summary, as long as the Ministry of Environment Guidelines for location criteria of wind farms are followed … there will be negligible adverse health impacts on Chatham-Kent citizens. Although opposition to wind farms on aesthetic grounds is a legitimate point of view, opposition to wind farms on the basis of potential adverse health consequences is not justified by the evidence' (Chatham-Kent Public Health Unit, 2008).

- Wind energy is associated with fewer health effects than other forms of traditional energy generation and in fact will have positive health benefits (WHO, 2004).
- 'There are, at present, very few published and scientifically-validated cases of an SACs of wind farm noise emission being problematic … the extent of reliable published material does not, at this stage, warrant inclusion of SACs … into the noise impact assessment planning stage (EPHC, 2009).
- While a great deal of discussion about infrasound in connection with wind turbine generators exists in the media there is no verifiable evidence for infrasound and production by modern turbines (HGC Engineering, 2007).

The opposing view is that noise from wind turbines produces a cluster of symptoms which has been termed Wind Turbine Syndrome (WTS). The main proponent of WTS is a US based paediatrician, Dr Pierpont, who has released a book 'Wind Turbine Syndrome: A report on a Natural Experiment, presents case studies explaining WTS symp-

toms in relation to infrasound and low frequency noise. Dr Pierpont's assertions are yet to be published in a peer-reviewed journal, and have been heavily criticised by acoustic specialists. Based on current evidence, it can be concluded that wind turbines do not pose a threat to health if planning guidelines are followed.

SHADOW FLICKER AND BLADE GLINT

Shadow flicker occurs when the sun is located behind a wind turbine casting a shadow that appears to flick on and off as the wind turbine blades rotate (Chatham-Kent Public health Unit, 2008). It is possible to use modelling software to model shadow flicker before the finalisation of a wind farm layout and siting.

Blade glint occurs when the surface of wind turbine blades reflect the sun's light and has the potential to annoy people (EPHC, 2009).

EFFECTS OF SHADOW FLICKER AND BLADE GLINT ON HUMAN HEALTH

Shadow flicker from wind turbines that interrupts sunlight at flash frequencies greater than 3Hz has the potential to provoke photosensitive seizures (Harding, Harding & Wilkins, 2008). As such it is recommended that to circumvent potential health effects of shadow flicker wind turbines should only be installed if flicker frequency remains below 2.5 Hz under all conditions (Harding, Harding & Wilkins, 2008).

According to the EPHC (2009) there is negligible risk of seizures being caused by modern wind turbines for the following reasons:

- less than 0.5% of the population are subject to epilepsy at any one time, and of these, approximately 5% are susceptible to strobing light;
- Most commonly (96% of the time), those that are susceptible to strobe lighting are affected by frequencies in excess of 8 Hz and the remainder are affected

by frequencies in excess of 2.5 Hz. Conventional horizontal axis wind turbines cause shadow flicker at frequencies of around 1 Hz or less;

- alignment of three or more conventional horizontal axis wind turbines could cause shadow flicker frequencies in excess of 2.5 Hz; however, this would require a particularly unlikely turbine configuration.

In summary, the evidence on shadow flicker does not support a health concern (Chatham-Kent Public Health Unit, 2008) as the chance of conventional horizontal axis wind turbines causing an epileptic seizure for an individual experiencing shadow flicker is less than 1 in 10 million (EPHC, 2009). As with noise, the main impact associated with shadow flicker from wind turbines is annoyance.

In regards to blade glint, manufacturers of all major wind turbine blades coat their blades with a low reflectivity treatment which prevents reflective glint from the surface of the blade. According to the Environment Protection and Heritage Council (EPHC) the risk of blade glint from modern wind turbines is considered to be very low (EPHC, 2009).

ELECTROMAGNETIC RADIATION AND INTERFERENCE

Electromagnetic radiation (EMR) is a wavelike pattern of electric and magnetic energy moving together. Types of EMR include X-rays, ultraviolet, visible light, infrared and radio waves (AusWEA, nd. b).

Electromagnetic interference (EMI) from wind turbines may affect electromagnetic or radiocommunication signals including broadcast radio and television, mobile phones and radar (EPHC, 2009).

As high and exposed sites are best from a wind resource perspective, it is not unusual for any of a range of telecommunications installations, radio and television masts, mobile phone base stations or emergency service radio masts to be located nearby.

Care must be taken to ensure that wind turbines do not passively interfere with these facilities by directly obstructing, reflecting or refracting their radio frequency EMR signals.

EFFECTS OF ELECTROMAGNETIC RADIATION AND INTERFERENCE FROM WIND TURBINES ON HUMAN HEALTH

Electromagnetic Fields (EMF) emanate from any wire carrying electricity and Australians are routinely exposed to these fields in their everyday lives. The electromagnetic fields produced by the generation and export of electricity from a wind farm do not pose a threat to public health (Windrush Energy 2004). The closeness of the electrical cables between wind turbine generators to each other, and shielding with metal armour effectively eliminate any EMF (AusWEA, nd. b).

MEASURES TO MITIGATE POTENTIAL IMPACTS OF WIND TURBINES

As with the introduction of any new technology, some communities are against wind farms being located in their area. Some factors which may increase community concern include coerced or unequal exposure, industrial, exotic and/or memorable nature of the turbine, dreaded, unknown or catastrophic consequences, substantial media attention, potential for collective action and a process which is unresponsive to the community. Voluntary exposure, for example choosing to house the turbine on community land, reduces concern (Adapted by Professor Chapman from Covello et al. methodology 1986).

One review of wind turbines and noise recommends that best practice guidelines such as those identifying potential receptors of turbine noise, following established setbacks and dispelling rumours regarding infrasound which have not been supported by research, are followed in order to mitigate any potential noise issues associated with wind turbines (Howe, 2007).

Sustainable Energy Authority Victoria (2003) also recommend that complying with

standards relating to turbine design and manufacturing, site evaluation and final siting of wind turbines will minimise any potential impacts on the surrounding area.

The recently released Draft National Wind Farm Development Guidelines (EPHC, 2009) include detailed methodologies at different stages of the planning and development process to assess such issues as noise and shadow flicker to mitigate any potential impact. Such processes include a range of measures such as high-level risk assessment, data collection, impact assessment, detailed technical studies and public consultation.

Therefore if planning guidelines are followed and communities are consulted with in a meaningful way, resistance to wind farms is likely to be reduced and annoyance and related health effects avoided.

CONCLUSION

The health effects of many forms of renewable energy generation, such as wind farms, have not been assessed to the same extent as those from traditional sources. However, renewable energy generation is associated with few adverse health effects compared with the well documented health burdens of polluting forms of electricity generation (Markandya & Wilkinson, 2007).

This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement that: *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.*

Dr. Nina Pierpont:
Except that it doesn't; another meaningless and mind-numbing assertion.

Dr. Nina Pierpont:
But if they haven't been assessed, we don't know, do we?
A key difference between the wind industry and its government proponents on one side, and me, Dr. Sarah Laurie, Dr. Robert McMurtry (Health Canada, med school former dean), Bob Thorne (Australian acoustician), and others on the other side -- is that we say little is known and therefore more research is needed, while the industry says, illogically, that little is known but nothing needs to be done. Who is being honest and who dishonest here?

REFERENCES

Dr. Nina Pierpont:
Let's count:
(read my full note on Page 17, Note 10)

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Australian Wind Energy Association (AusWEA). (nd.a) *Wind Farms and Noise,* Fact Sheet No. 6. Sustainable Energy Australia

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Dr. Nina Pierpont:
Industry (AusWEA) document
(read my full note on Page 17, Note 11)

Dr. Nina Pierpont:
Industry document, supported by Australian government, appears to be another version of the first reference, no date. http://www.w-wind.com.au/downloads/CBP6_Noise.pdf

Dr. Nina Pierpont:
Industry document

Dr. Nina Pierpont:
Industry-government source.

Dr. Nina Pierpont:
Industry-government source.

Dr. Nina Pierpont:
Industry-government source.

Dr. Nina Pierpont:
Industry (AusWEA) document supported by Australian government funds; no date. Found at http://www.goodhuewindtruth.com/uploads/BP10_EMC_EMF.pdf

Dr. Nina Pierpont:
Prepared as a book for the WHO, whose 1999 report Guidelines for Community Noise is by the same authors. This obscure reference is a run-up to the widely available WHO document. Why not reference the WHO publication?

Dr. Nina Pierpont:
Industry document prepared by hired guns specifically to refute my WTS book, which it heavily critiques in a distorted fashion before my book was published, from fragments posted on the internet. This report was published within days of my book. I am told by people in attendance that Dr. McCunney, one of the authors, admitted to an audience in Massachusetts that he signed the report without having seen or read my book. I have critiqued Dr. McCunney's presentation here http://www.windturbinesyndrome.com/news/2011/pierpont-shreds-big-wind-junk-science/

Department of Trade and Industry UK (DTI), (2006): *The measurement of low frequency noise at three UK wind farms*: URN No: 06/1412 issued by the DTI in July 2006.

Environment Protection and Heritage Council (EPHC), (2009): *National Wind Farm Development Guidelines - Public Consultation Draft*. Commonwealth of Australia, Adelaide.

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Macintosh A, Downie C. (2006): *Wind Farms: the facts and the fallacies*. The Australia Institute: Discussion Paper No. 91.

Markandya A & Wilkinson P. (2007): Electricity generation and health. *The Lancet*, 370: 979-990.

Ministry of the Environment (2007): *Acoustic consulting report prepared for the Ontario Ministry of the Environment. Wind turbine facilities noise issues*. Aiolos report number

Dr. Nina Pierpont:
Hayes McKenzie report to British government.
(read my full note on Page 17, Note 12)

Dr. Nina Pierpont:
Government document.
(read my full note on Page 17, Note 13)

Dr. Nina Pierpont:
This a reputable peer-reviewed journal article. It is theoretical and does not present any cases of wind turbine flicker actually precipitating seizures. However, I presented data on wind turbine flicker precipitating migraines in Pierpont 2009.

Dr. Nina Pierpont:
Industry document for Ontario, an aggressively pro-wind-industry government.
(read my full note on Page 17, Note 14)

Dr. Nina Pierpont:
Same reference as immediate above; reference list padding vs. careless editing

Dr. Nina Pierpont:
Peer-reviewed in a journal for whom Geoff Leventhall, industry consultant, is associate editor; see http://www.multi-science.co.uk/lowfreq.htm

Dr. Nina Pierpont:
Highly obscure reference, hardly up to challenging the WHO; found at http://www.ksri.ru/eng1/sci/conf/tran.htm
Conference put on by a Russian ship building company. Could not access the paper.

Dr. Nina Pierpont:
Wind industry consultant.

Dr. Nina Pierpont:
Opinion paper issued by a "think tank" member with a master's degree in environmental studies; no data. https://www.tai.org.au/index.php?search=wind+farms+facts+fallacies&act=search&q=node%2F19

Dr. Nina Pierpont:
Here's the abstract. Nothing about health impacts of wind turbines or their noise. http://www.ncbi.nlm.nih.gov/pubmed/17876910

Dr. Nina Pierpont:
Document prepared for the Ontario government.
(read my full note on Page 18, Note 15)

4071/2180/AR155Rev3, Queens Printer for Ontario, Ontario.

Minnesota Department of Health. (2009): *Public Health Impacts of Wind Turbines.*

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Pedersen E, van den Berg F, Bakker R & Bouma J. (2009): Response to noise from modern wind farms in the Netherlands. *The Journal of the Acoustical Society of America,* 126(2): 634-43.

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Dr. Nina Pierpont:
Government document, found at http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf
(read my full note on Page 18, Note 16)

Dr. Nina Pierpont:
US federal government document; I am in it in limited section on health.

Dr. Nina Pierpont:
Another study of annoyance and attitudes
(read my full note on Page 19, Note 17)

Dr. Nina Pierpont:
Error--publication date was 2004.
(read my full note on Page 19, Note 18)

Dr. Nina Pierpont:
Found at http://umass.edu/windenergy/OLD_SITE/publications/published/Wind_Turbine_Acoustic_Noise_Rev2006.pdf

Dr. Nina Pierpont:
Government document, found at http://www.sd-commission.org.uk/publications/downloads/Wind_Energy-NovRev2005.pdf
Source of the comparative dBA chart on page 3. Repeats industry dogma that infrasound from upwind turbines can be disregarded.

Dr. Nina Pierpont:
Government document

Dr. Nina Pierpont:
Commercial document

Dr. Nina Pierpont:
I found this here: http://www.canwea.ca/pdf/talkwind/WHO%20-%20Energy,%20sustainable%20development%20and%20health.pdf on the website of the Canadian Wind Energy Association.
(read my full note on Page 19, Note 19)

Notes

1. Please define. How was the "literature" referred to in this document discovered and selected? What were the criteria for selection of appropriate documents for this review? A real scientific document based on a literature review would be very specific on this point.

I would like to suggest that the most appropriate literature to review would be publications and presentations in which primary data is presented, and that the authors should have made a powerful effort to find all the publications and presentations which include data on actual exposed people and on actual noise and infrasound measurements.

2. What is a "direct pathological effect"? Does that mean there is evidence of tissue damage, as in the practice of pathology? Or does it refer to a more general meaning of "causing disease"? What are some examples of direct vs. indirect causation to clarify the reason for the word "direct" here?

3. Government document from Ontario,Canada, from the county where Dr. David Colby (of Colby et al. 2009) is the acting Medical Health Officer. He appears to work closely with the wind energy industry. He was first author of the Colby et al. document because the names were presented in alphabetical order; he did not have primary responsibility for the document.

4. Presents "controversy" and then "opposing viewpoints" as a central issue. This is a typical industry interpretation: that the viewpoint or opinion is the primary issue. This framework for approaching the problem does not belong in a review from a scientific body.

5. In a real scientific document, at this point the authors would be defining their terms, such as, "Sound is a continuum from high frequencies too high for most people to hear (ultrasound), through the audible frequencies, to very low frequencies too low for most people to hear (infrasound). Low frequency sound or noise (LFN) is usually defined as 20-200 or 20-500 Hz, and infrasound as below 20 Hz. The actual variability in hearing thresholds makes this boundary somewhat arbitrary. For the purposes of this discussion, we will use the term "infrasound/low frequency noise" (ILFN) to refer to sound frequencies below 200 Hz, and the term infrasound by itself when referring to the very low frequencies at 20 Hz and below."

Leventhall is a British acoustician who has been working for the wind industry in various countries for at least the last 7 years.

Just for some reference, 200 Hz is approximately G in the octave below middle C; 100 Hz is an octave below that; 400 Hz is approximately the G above middle C, next to the 440 Hz A to which an orchestra tunes. The second to lowest note on the piano, a B, is 31 Hz.

6. This term means the reporting of adverse medication effects in placebo recipients in clinical trials. Leventhall introduced this concept to the wind health debate in the Colby et al. report to refute my study. However, my case-crossover data and the revealed preference measure of home abandonment demonstrate that my data did not represent people who were blaming their pre-existing ailments on the turbines (which would be the real definition of a "nocebo" effect in the case of wind turbines).

7. Industry document. These industry documents are like a snake eating its tail. They say the same thing and repeat what the others have said and have long lists of references to similar documents, just like at the end of this document.

8. The A-weighting filter screens out low frequency noise and infrasound. The lower the sound, the more it is filtered out by A-weighting. For example, at 31

Hz (equivalent to B at the bottom of the piano range), A weighting reduces the power by a factor of 10,000 (40 dB), so only one hundredth of one percent of the original sound power at 31 Hz gets measured and contributes to the single A-weighted loudness number. At 1 Hz (very low infrasound), A-weighting reduces the sound power by more than 140 dB, which means by a factor of 10 to the 14th power or to 1/100,000,000,000,000 of the sound power present.

Because the noise from wind turbines is dominated by the low frequency components (see references below), the A-weighted measure of loudness or intensity underrepresents the noise coming from turbines.

A single number also fails to represent other qualities of the noise such as its pulsatile pattern.

The wind industry asserts repetitively that A-weighted measurements are justified because "if you can't hear it, it cannot have any other effect on the body, because the ear (it has been shown experiementally) is the most sensitive receptor for sound waves in the body." The ear is indeed the most sensitive receptor, but what happens in the cochlea in response to infrasound is active supppression of the sensation of hearing despite very active registration of the infrasound by the outer hair cells of the cochlea. In the ear are also the vestibular or balance organs, whose responses to vibration are tuned to low and infrasonic frequencies.

Professor Alec Salt at Washington University School of Medicine, a cochlear physiologist who is doing this primary experimental research, describes the research on his web page at http://oto2.wustl.edu/cochlea/wt3.html

His 2010 paper in the journal Hearing Research is described and linked to here: http://oto2.wustl.edu/cochlea/windmill.html

Professor Salt also presents measurements of wind turbine infrasound and pulsatile infrasound at http://oto2.wustl.edu/cochlea/wt1.html and a discussion of A-weighting relative to ear physiology at http://oto2.wustl.edu/cochlea/wt4.html

DR. SALT'S WEB PAGES, ABOVE, ARE HIGHLY READABLE AND RECOMMENDED.

Dr. Salt's research is featured on the home page of the branch of the US NIH (National Institutes of Health) that funds his lab: http://www.nidcd.nih.gov/news/releases/10/07_28_10.htm.

Another report of specialized measurements of low frequency sound (by German scientists) is presented at http://www.kselected.com/wp-content/uploads/2010/03/The_inaudible_noise_of_Wind_Turbines-infrasound.pdf

Pedersen and Persson Waye (2004 -- note there is an error in the references of this Rapid Review, which says this paper was published in 2007) demonstrate in their community study of annoyance relative to modeled wind turbine noise in Sweden that people were highly annoyed by wind turbine noise at sound pressure levels much lower than for other types of community noise. The A-weighted decibel level (in a measure averaged and weighted over time, L_{eq}) that corresponded to 15% of the people being highly annoyed was 38 dBA for wind turbines, 57 dBA for aircraft, 63 dBA for road traffic, and 70 dBA for railways. The curve for annoyance due to wind turbine noise had a steep slope, so that by 41 dBA, 35% of people were *highly annoyed*. Sixteen percent of respondents over 35 dBA reported that their sleep was disturbed by wind turbine noise.

Studies of community noise frequently assess a quality called *annoyance*. "Apart from 'annoyance,'" the World Health Organization writes (in the 1999 publication *Guidelines for Community Noise*, p. 50), "people may feel a variety of negative emotions when exposed to community noise, and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion."

9. As mentioned in the last comment, these authors are engineers. They don't know health and physiology. This is not a research or peer-reviewed paper. They also say:

"The primary human response to perceived infrasound is annoyance, with resulting secondary effects. Annoyance levels typically depend on other characteristics of the infrasound, including intensity, variations with time, such as impulses, loudest sound, periodicity, etc. Infrasound has three annoyance mechanisms:

- A feeling of static pressure
- Periodic masking effects in medium and higher frequencies
- Rattling of doors, windows, etc. from strong low frequency components

Human effects vary by the intensity of the perceived infrasound, which can be grouped into these approximate ranges:

- 90 dB and below: No evidence of adverse effects
- 115 dB: Fatigue, apathy, abdominal symptoms, hypertension in some humans
- 120 dB: Approximate threshold of pain at 10 Hz
- 120 – 130 dB and above: Exposure for 24 hours causes physiological damage

There is no reliable evidence that infrasound below the perception threshold produces physiological or psychological effects." (p. 9-10)

10. Let's count:

Industry or government-industry or academic-industry documents with conflict of interest. Green (for money). 19 (except 2 are the same article, so really 18)

Scientific journal article or book and relevant to question at hand; also several government reports that handle science responsibly. Pink (for our joy at finding these). 6

Scientific journal but barely relevant to matter at hand. Yellow. 2

Scientific journal but conflict of interest. Blue. 2

I do not have the trauma of trying to decide where to place my peer-reviewed book in this schema, since, though it appears in the text, it (and my first name) did not make it into the list of references.

11. Industry (AusWEA) document funded by the Australian government. http://www.w-wind.com.au/downloads/CBP6_Noise.pdf

Contact is Grant Flynn at Sustainable Energy Australia (Grant@SustainableEnergyAustralia.com.au) (by the way, this PDF is locked).

The qualitative descriptions of noise on pp. 8-11 are lifted in many cases verbatim or nearly so from BWEA and other industry websites.

12. Hayes McKenzie report to British government.

Presentation by Hayes McKenzie at http://www.hayesmckenzie.co.uk/downloads/IoA%20Meeting%2020th%20March%202007%20The%20Measurement%20of%20Low%20Frequency%20Noise%20at%203%20UK%20Wind%20Farms%20-%20MDH.pdf

Presentation relies on comparisons of LFN levels to hearing thresholds, shown to be irrelevant by Salt.

13. Government document. Discussion of noise on p. 9 repeats 2 usual industry arguments: that noise from turbines is masked by rising wind speed, and that the low frequency or infrasound components are so low as to to be negligible in terms of health or detectibility. http://www.ephc.gov.au/sites/default/files/DRAFT%20National%20Wind%20Farm%20Development%20Guidelines_JULY%202010_v2.pdf

14. Industry document for Ontario, an aggressively pro-wind-industry government. http://www.canwea.ca/images/uploads/File/CanWEA_Wind_Turbine_Sound_Study_-_Final.pdf

"While a great deal of discussion about infrasound in connection with wind turbine generators exists in the media there is no verifiable evidence for infrasound production by modern turbines." (p. 7) Outright falsification based on information available in 2007.

"There has been discussion about the appropriate weighting network for the

assessment of a wind turbine noise. While there are a variety of weighting networks in use for various technical purposes, an A-weighted spectrum provides a better indicator of the spectral makeup of a sound as perceived by the human ear than any other frequency weighting network than any other commonly in use today." (p. 8) Outdated; we know more about the ear now.

15. Document prepared for the Ontario government.

Found at http://www.nationalwind.com/facts/Ontario%20-%20Wind%20Turbing%20Noise%20Issues.pdf

Reviews van den Berg dissertation as the trigger for concerns about WT noise disturbances.

"A literature review, focussed mainly on a) Metrological [sic] effects on wind turbine noise generation; b) Assessment procedures of wind turbine noise levels and their impact; c) Particular characteristics of wind farm noise; and d) Human responses to wind farm noise levels, was conducted. It showed that - local terrain conditions can influence meteorological conditions and can affect the expected noise output of the wind turbines; assessment procedures of sound power levels and propagation models, applied in different jurisdictions are quite similar in their scope; *wind farm noise do not have significant low-frequency (infrasound) components*; and modulations effects can impact annoyance." (p. vii, emphasis added) Italicized conclusion is out of date in terms of known physiology of ear's response to infrasound.

16. Government document, found at http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf

Overall this document is good, and handles scientific and physiologic information appropriately.

P. 4: National Research Council 2007 report: the section on health is misrepresented here; it is a very brief section in a general environmental impact document. Even this brief section calls for more research on my work based on my 2006 testimony to the NYS legislature. It does not refer to any other medical research. There is no data other than my own in this report.

P. 7: The description of the function of the ear is oversimplified and outdated with respect to infrasound and cochlear function.

P. 7-8: Good discussion of the vestibular system with appropriate conclusion: "It is not known what stimulus intensities are generally required for for autonomic activation at relatively low frequencies, and it is likely that there is considerable human variability and capacity to adapt to vestibular challenges." I agree. The general and agreed-upon state of knowledge does not preclude autonomic activation by low-frequency noise or vibration in sensitive people.

P. 9: Graph is confusing, even when "isopleth" (meaning a line of equal value on a map, like an equal rainfall or temperature line) is defined. However, graph makes sense later in discussion of weighting networks.

P. 9: Good discussion of subaudible LF sound as of 2009; more is known now about the response of the cochlea.

P. 9: Good discussion of resonance and pulsatile noise, until the last line about wind turbine noise. The authors did not know, but there is now good documentation of the wind turbine noise pulsatility at low frequency/infrasound frequencies as well as audible frequencies (see presentation by Richard James INCE [member of Institute of Noise Control Engineering] at the First International Symposium on the Global Wind Industry and Adverse Health Effects, Picton, Ontario, October 29-31 2010 at http://windvigilance.com/downloads/symposium2010/swv_symposium_presentation_how_we_got_here.pdf

The penultimate slide, "New insights into modulated wind turbine infrasound/low frequency noise" shows amplitude modulated ILFN.

P. 10 Human (mammalian) reponse to LFN based on Moller and Pedersen 2004 is good but has been further developed in recent research on the ear's response to infrasound.

P. 10-11 Discussion of noise measurement; A-weighting not reliable at low frequencies but will use modified A-weighting schemes below 250 Hz (???)

P. 11-14 Contribution of multiple turbines with blades turning in the turbulence from other nearby turbines (which causes more aerodynamic noise) is another big source of error in industry noise models. This is neglected in sections (3) and (4). Overall this discussion is good, but it does ignore data available at the time about the large amounts of infrasound/low frequency noise (ILFN) measured from modern upwind wind turbines. Data on amplitude modulation of the ILFN was probably not available to these authors.

P. 14 Lack of specific study of ILFN in epidemiologic studies of noise exposure does not mean no role for ILFN, especially when the studies involve airport noise, which is dominated by ILFN. ILFN is difficult and expensive to measure, and there is no uniform, readily available metric like A-weighted measuring equipment. A-weighting filters the contribution of ILFN out of any noise measurement, yet use of A-weighting is the norm in community and industrial noise studies, creating a barrier to the study of ILFN in community health.

(Commentary curtailed b/o time.)

17. Another study of annoyance and attitudes relative to modeled wind turbine noise and visibility, as well as whether benefiting financially from turbines affected attitudes (it did). Buried in the full report at:

van den Berg GP, Pedersen E, Bouma J, Bakker R. 2008. Project WINDFARMperception: visual and acoustic impact of wind turbine farms on residents. Final report, June 3. 63 pp. Summary: http://umcg.wewi.eldoc.ub.rug.nl/FILES/root/Rapporten/2008/WINDFARMperception/WFp-final-summary.pdf.

Entire report: https://dspace.hh.se/dspace/bitstream/2082/2176/1/WFp-final.pdf

…is a description of how, in the Dutch survey study, owners of turbines lived the closest to turbines and were able to turn them off if they or their neighbors were bothered by the noise—a key difference between the Netherlands and other countries.

This survey had several questions related to health that were quite inadequate to the task of producing valid health information (these questions did not even elicit baseline population frequencies of such common ailments as migraine and tinnitus, though it asked about them; see analysis in Pierpont 2009 pp. 114-121).

18. Error--publication date was 2004. Pedersen and Persson Waye published another paper in 2007: Pedersen E, Persson Waye K. 2007. Wind turbine noise, annoyance and self-reported health and wellbeing in different living environments. Occup Environ Med 64(7): 480-86. In this paper they conclude, "Annoyance was further associated with lowered sleep quality and negative emotions. This, together with reduced restoration possibilities may adversely affect health." (Abstract)

Dr. Michael Nissenbaum in the US has conducted a controlled survey study which incorporates questions on sleep, mood, and new medication use in adults exposed to wind turbines (see http://windvigilance.com/mars_hill.aspx). In a larger study still in preparation he finds a quantitative dose-response relationship between distance from wind turbines and score on several standardized sleep quality questionnaires, indicating the types of partial awakenings associated with hypertension and cardiovascular risk in other studies (personal communication from Dr. Nissenbaum).

19. I found this here: http://www.canwea.ca/pdf/talkwind/WHO%20-%20Energy,%20sustainable%20development%20and%20health.pdf on the website of the Canadian Wind Energy Association.

It does not talk at all about noise or health impacts of living near wind farms.

Why are there no references in the Rapid Review to the WHO *Guidelines for Community Noise* (1999) http://www.who.int/docstore/peh/noise/guidelines2.html or the Night Noise Guidelines for Europe (2007) http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf?

Because . . . we in the wind industry, including the authors of the NHMRC rapid report, are not actually interested in the turbine noise and health problem, but only in propaganda and repetition of a party line that aggressively denies health problems, even at the expense of distortion of science and misrepresentation of sources.