Review of

Wind Turbine Health Impact Study: Report of Independent Expert Panel

as prepared for
Massachusetts Department of Environmental Protection
Massachusetts Department of Public Health

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Background

As a leading expert on the biological response to low frequency noise exposure, I was requested to provide a review of the Jan 2012 Report of Independent Expert Panel, prepared for the Massachusetts Department of Environmental Protection (MassDEP) and Department of Public Health (MDPH), titled "Wind Turbine Health Impact Study".

Disclaimer

a) *The author of this review is not party to anti-technology sentiments;*
b) *Wind turbines are considered by this author as welcome additions to modern technological society;*
c) *The review provided herein has one, and only one, agenda - that of pure scientific inquiry;*
d) *In no way can or should this review be construed as a document arguing for or against the implementation of wind turbines;*
e) *There are no commercial, financial or professional agreements (contractual or otherwise) between the author of this review and any persons or parties involved in the wind turbine sector or persons or parties who stand against the implementation of wind turbines;*
f) *This review was provided* pro bono*.*

Goal

To provide a review of the aforementioned Report, within the author's area of expertise and therefore, exclusively focused on the infrasound and low frequency noise health issues claimed to be associated with wind turbines (WT) operations.

Panel Charge

The Panel who authored the Report was charged with several tasks, the first of which is succinctly stated as follows:

"Identify and characterize attributes of concern (eg noise, infrasound, vibrations) (...) and identify any scientifically documented or potential connection between health impacts associated with [land-based] wind energy turbines" (p.vi).

While identification and characterization of the attributes of concern might be a fairly easy task to accomplish, finding scientifically documented connections between health impacts and WT operations is almost an impossible task - not because such health impacts are non-existent, but rather because scientifically sound studies on this subject are sparse, for reasons that will be discussed ahead.

A second charge of this Panel was:

"Evaluate and discuss information (...) on the nature and type of health complaints commonly reported by individuals who reside near existing wind farms".

Noise annoyance seems to be the most consistent parameter associated with the acoustical phenomena purportedly emanated by WT. Sleep disturbances and decreased quality of life are also outcomes that have been assessed in populations living in the vicinity of WT. While noise annoyance, sleep disturbances and decreased quality of life go hand in hand with health deterioration, these parameters do not constitute objective clinical data.

This is an unfortunate situation for this Panel since it limits the evaluation and discussion to subjective parameters, known to vary in accordance with psychosocial factors. Negative or positive health impacts due to any situation usually require confirmation, or at least corroboration from clinical data. Questionnaires with self-reported symptoms provide a type of subjective data that is usually considered insufficient to clearly establish a positive or negative health effect.

Why Annoyance?

Despite the lack of scientific objectivity, assessing annoyance levels seems to be the preferential method to evaluate the health effects of individuals living in the vicinity of WT. There may be several reasons for this:

1. In 1977, the U.S. Office of Noise Assessment established the relationship between noise exposure level and the proportion of the community that is highly annoyed by noise[1]. Through direct measurement based on numerous studies of large populations, the annoyance parameter was determined to be useful as a noise predictor. Annoyance rapidly achieved importance because it quickly replaced the term "nuisance". In terms of legal jargon, "nuisance" can imply liability, while annoyance usually does not.

2. Annoyance is easily evaluated through appropriate questionnaires. No clinical physician is required in order to assess levels of annoyance among a noise-exposed population. Acousticians are therefore qualified to assess the "health effects" (i.e. annoyance), while no objective clinical data is actually gathered.

3. Grants evaluating annoyance among a noise-exposed populations are generally reviewed by public health experts and epidemiologists, and only rarely by clinical

[1] Office of Noise Abatement and Control. (1977). *The urban noise survey*. Environmental Protection Agency: Washington D.C.

physicians. Claiming that health effects are being ascertained merely through questionnaires evaluating (subjective) levels of noise annoyance would indeed surprise any clinician.

As a consequence of these situations, health effects due to the proximity of WT to residential areas are, essentially, unknown to peer-reviewed science - not because they are inexistent, but because they are not the object of scientific study.

Loaded dice

In a way, this Panel was charged with the task of rolling loaded dice. Peer-reviewed studies investigating the impact on human health of WT noise exposure practically do not exist. Those that claim to study just that, fail when objective clinical outcomes are non-existent end-points. Hence the Panel's charge, more than difficult is quite near impossible.

Literature survey

As stated by the Panel: "Because peer-reviewed literature (...) was relatively limited, we also examined several non-peer reviewed papers, reports and books that discussed health effects of wind turbines" (p.15).

As a result, 8 studies were reviewed, 4 of which were peer-reviewed:

	Authors	**Parameter(s)**
Peer-reviewed	Pederson *et al.* 2004	Annoyance questionniare + dBA
	Pederson *et al.* 2007	Annoyance questionniare + dBA
	Pederson *et al.* 2009	Mailed surveys + dBA
	Shepard *et al.* 2011	Quality of life questionnaire
Non-Peer-Reviewed	Van den Berg *et al.* 2008	General health questionnaire + dBA
	Phipps 2007	Survey
	Pierpont 2009	Survey
	Nissenbaum *et al.* 2011	Questionnaire + sleep disturbances

All these studies purport to study health effects through questionnaires, surveys and queries. None provide corroborating clinical evidence. Moreover, of the 8 studies, 4 can be considered to be authored by the same team.

It would seem that a precious and scientifically useful source of information was overlooked - scientific conferences. Perhaps it would have been helpful to the Panel if scientific/ research papers included in conference proceedings had not been excluded.

Although papers presented at conferences are not considered to be peer-reviewed, they are subjected to scientific scrutiny and might have provided the Panel with a broader background, potentially useful for carrying out its charge. The Wind Turbine Noise

Conference and the International Conference on the Biological Effects of Noise are but two examples of such sources.

Standing with these 8 studies and with the aforementioned charge is not a position one would eagerly seek to be in.

Human hearing threshold and the dBA unit

Classically speaking, the impact of acoustical phenomena on humans has been limited to the segment of the acoustical spectrum where the combination of pressure and frequency allow the acoustical phenomenon to be perceived by humans.

This limitation is what justifies the use of the dBA unit when assessing noise among human populations. The A-weighting system simulates human hearing, measuring the loudness of acoustical phenomena.

The continued use of this same dBA unit to acoustically assess environments that are suspected of being ILFN-rich is, however, scientifically indefensible. Hence, studies purporting to characterize acoustical environments suspected of being rich in ILF components, but presented entirely in dBA units are not scientifically valid.

As stated by the World Health Organization:

> *Noise measurements based solely on LAeq values do not adequately characterize most noise environments and do not adequately assess the health impacts of noise on human well-being. (…) If the noise included a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably. When prominent low-frequency components are present, measures based on A-weighting are inappropriate. However, the difference between dBC (or dBLin) and dBA will give crude information about the presence of low-frequency components in noise. If the difference is more than 10 dB, it is recommended that a frequency analysis of the noise be performed.*[2]

Wrong assumptions and flawed study designs

The use of the dBA unit and the focus on human hearing threshold values are justified however, by the assumption that acoustical phenomena are only harmful if perceived by the human being.

[2] World Health Organization. (1999). *Guidelines for community noise*. Berglund, B., Lindvall, T. and Schwela, D.H. (eds). World Health Organization, Geneva.

- *Can acoustical phenomena that are not perceived by the human auditory system be detrimental to human health?*

Once this question is set forth, results of studies where subjective parameters are the sole outcome become moot.

- *Does an agent of disease have to be perceived by the host for it to have a pathogenic effect on the host?*

- *Does an agent of disease have to cause annoyance in order for it to have a pathogenic effect on the host?*

Clearly the answer is no.

Nevertheless, where acoustical phenomena are concerned, this is an established assumption of a vast number of researchers and scientists who study "health effects" of noise exposure. The idea "*what you can't hear won't hurt you"* is responsible for numerous biased study designs which, in turn, have been leading to inconclusive or invalid results (even if peer-reviewed). This has been true for noise studies whether or not they involve WT, and further justifies the use of the dBA unit.

This wrong assumption which permeates the area of science studying the health effects of noise exposure justifies ignoring that noise-exposure effects are cumulative. As a result, noise-exposure histories (including fetal exposures) which could provide crucial information for establishing dose-responses are not obtained.

Lessons from ILFN-rich occupational environments.

Scientists with expertise in Environmental, Public or Occupational Health are well aware that excessive exposure to physical agents is often first seen in occupational environments. The health effects observed in workers have often been later observed in populations exposed to the same physical agent, but continuously and at a lower level.

> *"The workplace is a unique environment. (...) Environmentally induced diseases have (...) not uncommonly first been seen in working populations. The appearance of these illnesses may provide a warning to the general population of the toxicity of environmental substances".*[3]

After several readings of this Report, it would seem that the Panel has, at times, misunderstood the distinction between noise and vibration where human health is concerned (p. ES-5, 45, 54).

[3] Baker DB, Landrigan PJ. (1990). Occupationally related disorders. *Environmental Medicine*, **74**, 441-60.

Noise versus vibration within the context of human health

Infrasound and low frequency noise are airborne acoustical phenomena. Infrasound is internationally classified as *non-ionizing radiation*.

Vibration is considered to be the transmission of mechanical vibrations when the human is in *direct physical contact with the vibrating structure*, such as a jackhammer (hand-arm vibration) or a vibrating platform (whole body vibration).

Airborne acoustical phenomena (which may or may not be audible to humans) can cause vibration in structures existing along its propagation pathway, depending on numerous variables. Similarly, a vibrating structure can originate the emanation of airborne pressure waves (which may or may not be audible to humans).

Vibroacoustic disease (VAD) *does not* "require a very clear coupling to large vibration sources such as jackhammers and heavy equipment" (p. 45). The physical agent of disease responsible for the development of VAD is *airborne* acoustical phenomena, and *not* vibrations (as defined within the scope of human health effects).

Lessons learned with VAD bring the possibility of objective clinical data being gathered among populations residing in the vicinity of WT. Moreover, if the agent of disease responsible for the development of VAD in occupational environments had been more thoroughly explored (and understood) perhaps the "Panel's efforts (...) to examine the biological plausibility or basis for the health effects of turbines" (p.ES-3) would have been greatly improved.

An organic response to ILFN exposure has been consistently identified in ILFN-exposed workers, animal models, and dwellers in ILFN-rich environments (not generated by WT): abnormal proliferation of collagen in the absence of an inflammatory process[4]. This feature, however, cannot be evaluated through questionnaires.

Moreover, to design a study that adequately assesses the ILFN-induced pathology potentially being developed among populations living in the vicinity of WT requires knowledge not only in acoustics and clinical medicine, but also histology and cellular mechanics. Clearly, not an easy task

[4] Alves-Pereira M, Castelo Branco NAA. (2007). Vibroacoustic disease: Biological effects of infrasound and low frequency noise explained by mechanotransduction cellular signaling. *Progress Biophysics & Molecular Biology*, **93,** 256-79.

Commentary on the Panel's findings regarding health impacts of noise and vibration

There is, indeed, "limited evidence suggesting an association between exposure to wind turbines and annoyance" (p. ES-5, 54) because there are only 3 or 4 reported studies on the subject.

The notion of the noise annoyance parameter being "independent from the effects of seeing a wind turbine and vice-versa" clearly emphasizes the inadequacy and inappropriateness of selecting this parameter to evaluate "health effects". In terms of both field work and research grant submission procedures however, it is obviously more convenient to apply questionnaires to a study population than to provide objective medical diagnostic tests.

Regarding sleep disruptions, although a definitive predictor for severe health problems, the underlying rationale remains flawed: disruptions are caused by the audible portion of acoustical phenomena. ILFN-exposed works suffer sleep disruptions even though they are not exposed to ILFN during their sleep time. Most likely, individual cumulative effects of ILFN-exposures play a crucial role in sleep patterns.

Unsurprisingly "there is insufficient evidence that the noise from wind turbines is *directly* (...) causing health problems or disease" (p.ES-6, 55). While this is true **because no studies exist**, it *could be erroneously interpreted* as meaning that existing studies provide insufficient evidence.

By "measures of psychological distress or mental health" (p.ES-7, 56), it is meant the result of surveys and questionnaires. Given the nature of the agent of disease - airborne pressure waves - it stands to reason that organic lesions may occur before measures of psychological distress and mental health reach levels considered problematic. By the time they do, lesions will most likely be irreversible.

It is not the charge of this Panel to recommend future studies, and yet it was charged with "identifying documented best practices that could reduce potential human health impacts" (p.vi). Considering that human health impacts associated with living in the vicinity of WT are not the object of any of the 8 studies reviewed by the Panel, the usefulness of the best practices as provided by the Panel regarding noise (p.59-61) is questionable.

In conclusion

The Panel's charge is not an enviable one since it is nearly impossible to carry out. The health impacts on populations living in the vicinity of WT are, simply put, not documented.

Health impacts *are not* scientifically evaluated through questionnaires and surveys. Instead, objective clinical data are required which, in this case, do not exist.

The authorities who requested this Report (MassDEP and MDPH) will most likely not find it very useful *if their priority is the health of populations living near WT*. However, if other agendas exist, this Report may become relevant.

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Brief Biographical Background for the author of this Review:

Mariana Alves-Pereira holds a B.Sc. in Physics (State University of New York at Stony Brook), a M.Sc. in Biomedical Engineering (Drexel University) and a Ph.D. in Environmental Sciences (New University of Lisbon).She joined the multidisciplinary research team investigating the biological response to infrasound and low frequency noise in 1988, and has been the team's Assistant Coordinator since 1999. Recipient of three scientific awards, and author and co-author of over 50 scientific publications (including peer-reviewed and conference presentations), Dr. Alves-Pereira is currently Associate Professor at Lusofona University teaching Biophysics and Biomaterials in health science programs (nursing and radiology), as well as Physics and Hygiene in workplace safety & health Programs.

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