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# COMMENTS FOR RESEARCH MEETING IN PITTSBURGH, 21st May, 2015 re priority directions for wind turbine noise and health research

The following comments would have been made in person had I been able to attend this meeting in Pittsburgh. I would be delighted to discuss them further with interested parties, and hope they are useful.

**What We Already Know**

- Infrasound and low frequency noise (ILFN) have a range of known, potentially serious, adverse health impacts, if the dose is excessive – physiological, tissue pathological (VAD), and psychological. Longterm exposure to excessive ILFN is causing immunosuppression, resulting predictably in chronic infections and cancers, as well as potentially fatal cardiovascular diseases, known to be associated with chronic sleep deprivation and chronic stress.
- People do not habituate to the ILFN sound energy – rather they become progressively sensitized to it. Steven Cooper's recent detailed data collection is the most comprehensive – but comprised only six subjects, however his results were consistent in that people chronically sensitized for 6 years report perceiving sensations (from ILFN) at around 50 dB (rms) with what appears to be a peak sensitivity at around 4-5 Hz (narrow band analysis)
- Amplification inside homes can occur, so measurements outside homes will not accurately represent the true exposure doses inside homes, especially at the lower sound frequencies in the infrasound range (0 – 20 Hz)
- From a public health perspective, we need noise pollution guidelines which protect sleep and which do not induce repeated physiological stress responses (annoyance) – we know that both sleep deprivation and chronic stress have serious long term health consequences
- Wind turbine noise with its capacity to produce heightened noise zones with the transient pulse pressure peaks appears to be inducing serious adrenaline surge pathology – and there is no way of preventing these occurrences other than restricting siting and operation of multiple turbines. Where these heightened noise zones are occurring inside people's homes when they are trying to sleep, the consequences especially from the larger wind turbines where there are large numbers of them, are severe, as reported by multiple residents (eg Macarthur wind development with 140 x VESTAS V 112 3 MW turbines in Victoria, Australia)
- Vibration is another possible area of risk – especially to developing embryos if exposed at a critical time in their development can result in fetal deformities. Fetal deformities, increased stillbirths, and miscarriages have already been reported by a vet in Denmark with respect to a mink farm. It is therefore possible in humans as well as animals – we just don't yet know the threshold dose or the current exposure doses. There may well also be a synergistic effect with airborne pressure pulsation effects from ILFN.

**What is now required, urgently**

1. Full spectrum acoustic testing – inside and outside homes, (including vibration as well) for sufficient duration (weeks) to cover a range of weather conditions, wind directions, and operation of the wind turbines including worst case scenario as reported by the residents, and needs to include "on off" testing, full provision of relevant data, and full cooperation of the operator. Governments must insist on this, especially if subsidies are being paid.
2. Concurrent physiological testing ***inside homes first*** including EEG, heart rate, non invasive blood pressure measurement (eg pulse transit time) and biomarkers for stress, including sequential salivary cortisol, neuro peptide Y, and some of the new markers for genetic damage from short term sleep deprivation could also be used (Emeritus Professor Alun Evans from Ireland, is a useful source of information about this recent research).
3. Carefully supervised laboratory research could then follow if and when absolutely necessary, bearing in mind that there are potential risks of injury and fatalities using infrasound generators in laboratories, so extreme care must be exercised whilst using this equipment.
4. Dr Bob Thorne's health indicator data collection from his study at two Victorian Wind Developments provides a useful collection of standardized questionnaires which have international and national norms for comparison. These could be utilized internationally.

**Who to test / investigate?**

It is my strong view that those who report the ***most serious symptoms*** and those with the ***longest chronic exposures who report symptoms and sensations***, must be the priority to investigate, to determine exposure doses at which they are demonstrating a physiological response. The priority must be to investigate the ***sleep disturbance first,*** because of the overwhelming importance of sleep for the maintenance of good physical and mental health. ***Children should not be excluded*** from observation of the impacts on them – indeed they are a priority to protect, especially children with special needs including neurodevelopmental issues, and conditions such as epilepsy where sleep disturbance could significantly increase the risk of seizures. ***Wind turbine host families*** should be offered the opportunity to be involved in such research, and nondisclosure clauses in any agreements with developers must be declared null and void so they can participate in such research.

In my view **it is not a priority to investigate people who do not report an adverse impact**. That will not tell us anything new and is a waste of precious resources – we already know that some people are not affected at doses where others are severely adversely impacted, because this is reported by families all the time, and we already have some clues as to who is susceptible, thanks to Dr Pierpont's research and the research of others including Dallos (size of the helicotrema plays a part in sensitivity to LFN). So too does certain medication – eg narcotic analgesia also appears to increase sensitivity to ILFN. Nussbaum also established individual variation in 1985.

**Objectives of the research**

1. Establish direct causation of sleep disturbance and specific symptoms and sensations, often referred to as "annoyance" symptoms by engineers / acousticians with expertise in low frequency noise problems. In other words, establish which frequencies, and which "doses" of sound energy are inducing the symptoms/sensations, particularly the sleep disturbance
2. Establish thresholds of perception including where sleep disturbance is triggered in chronically sensitized people. Their exposure dose (both measured acutely, and calculated with respect to the months/years of exposure) must be established.

3. Establish the exposure doses of people when they are reporting severe acute impacts both inside and outside – development of a portable dosimeter device is a priority especially for those who have already had an adrenaline surge episode of either an acute hypertensive crisis or a Tako tsubo event or who are experiencing pressure bolt sensations.

**Priority locations**

There are reports of adverse impacts thought to be from excessive ILFN at the following in Australia, for example

1. Residential homes
2. Schools
3. Aged care facilities
4. Jails

In the case of jails there is the international convention against Torture to consider – jail inmates cannot escape the adverse impacts by removing themselves, and I suspect Australia is not alone in allowing the siting of ILFN emitting industrial developments not far from jails. Jail cells make perfect infrasound resonators, (Kelley 1982 comments about the impacts being worse in small rooms).

**Noise sources other than wind turbines:**

Wind turbines are not the only sources of excessive impulsive ILFN. In Australia other locations include gas fired power stations, coal fired power stations, underground coal mine extractor fans, open cut coal mines – diesel machinery. It would be preferable to ensure that the adverse health impacts from different noise sources are investigated – the above adverse health effects are of course not confined to wind turbines.

***Finally, numerous international human rights conventions and covenants generally include the proviso that member states should ensure their citizens can attain the best possible mental and physical health. It is not possible to comply with the provisions of these UN Conventions and Covenants unless noise pollution (including from infrasound and low frequency noise and vibration) is regulated so that the regulations are effective to protect health, and in particular sleep.***

I hope these comments are helpful, and look forward to helping progress the research agenda by sharing the Waubra Foundation's knowledge of the impacts and the relevant research.

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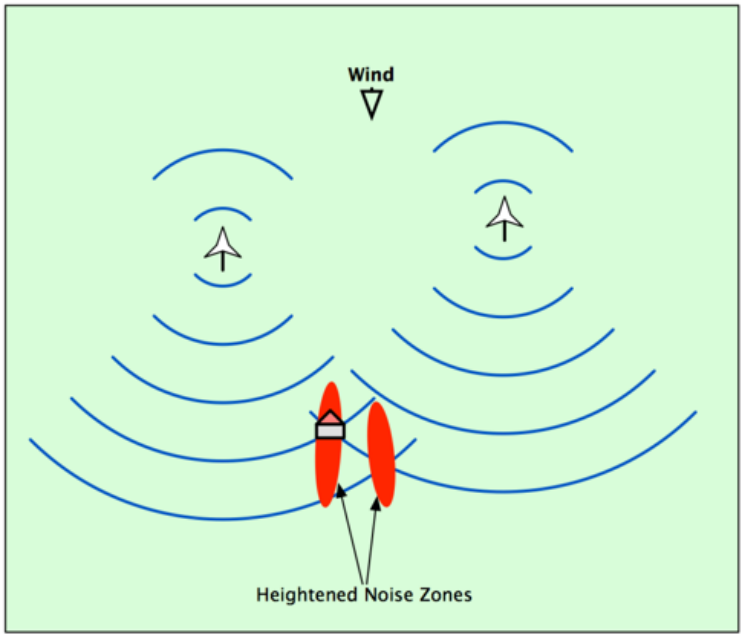
## References

Diagram of Heightened Noise Zone, reproduced with thanks from Dr Bruce Rapley's book (Bakker, H.H.C. and B.I. Rapley, *Sound, Noise, Flicker and the Human Perception of Wind Farm Activity*. Palmerston North: Atkinson & Rapley Consulting (2010)
).




## Existing evidence of direct causation of sleep deprivation, body vibration and other annoyance symptoms – the Kelley / NASA research from the 1980's

Hubbard, H "*Noise Induced House Vibrations and Human Perception*" 1982
http://waubrafoundation.org.au/resources/hubbard-h-1982-noise-induced-house-vibrations-human-perception/

Kelley N et al "*A Methodology for Assessment of Wind Turbine Noise Generation*" 1982
http://waubrafoundation.org.au/resources/kelley-et-al-methodology-for-assessment-wind-turbine-noise-generation-1982/

Kelley N et al "*Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact and* ***Control"*** 1985 Prepared for the US Department of Energy
http://waubrafoundation.org.au/resources/kelley-et-al-1985-acoustic-noise-associated-with-mod-1-wind-turbine/

Kelley, N "*Problem with Low Frequency Noise from Wind Turbines Scientifically Identified*" 1987 Presented to the American Wind Energy Association Conference, 1987, California
http://waubrafoundation.org.au/resources/1987-problem-with-low-frequency-noise-from-wind-turbines-scientifically-identified/

See also the timeline:
http://cdn.knightlab.com/libs/timeline/latest/embed/index.html?source=0Ak2bgr7C0nhPdGR3S1lEekU3T3p4ZDhUNDdRV2Y2ZkE&font=Bevan-PotanoSans&maptype=toner&lang=en&height=650

## Acceptance of direct causation of annoyance symptoms from low frequency noise - Leventhall

Professor Geoff Leventhall's comments to the NHMRC Workshop in June 2011 that "noise annoyance" symptoms are the same as "wind turbine syndrome" symptoms, and are a stress effect (from audible noise): http://waubrafoundation.org.au/resources/leventhall-g-comments-nhmrc-june-2011-wind-turbine-syndrome-symptoms-same-as-noise-annoyance/

Leventhall G, (assisted by Benton, Pelmear) 2003 Report for UK Department of Food and Rural Affairs: *"A Review of Published Research on Low Frequency Noise and Its Effects"* *http://waubrafoundation.org.au/resources/review-published-research-low-frequency-noise-leventhall/*

## Longterm harm from chronic exposure to excessive ILFN

There is very little data relating specifically to the consequences of chronic exposure to wind turbines. Of the available evidence relating to chronic ILFN exposure data, the most detailed research is the body of research including clinical reports, post mortems, and animal research by the Portuguese team of scientists led by ***medical practitioner, occupational physician and clinical pathologist*** **Dr Nuno Castelo Branco**, and **Professor Mariana Alves Pereira**, ***physicist, biomedical engineer and environmental scientist***, who together with their team have investigated and described what happens with chronic (mostly occupational) exposure to ILFN. (see http://waubrafoundation.org.au/resources/vibroacoustic-disease-biological-effects-infrasound-alves-periera-castelo-branco/ and http://waubrafoundation.org.au/resources/alves-pereira-castelo-branco-vad-need-for-new-attitude-towards-noise/ to start with.

With respect to wind turbines specifically, **there is no longitudinal data**, however useful clinical information can also be gleaned from some Europeans chronically exposed to ILFN from wind turbines over many years, such as from Germany http://waubrafoundation.org.au/resources/juttas-story-windwahn/ and from Portugal, presented in this video by Professor Alves Pereira: http://waubrafoundation.org.au/resources/low-frequency-noise-presentation/ .

There are also discreet population groups where there is health data detailing significantly increased rates of heart disease and cancer, and clinical histories from local residents consistent with chronic exposure to excessive ILFN (eg from a coal fired power station) with consequent sensitization to ILFN, but very little full spectrum acoustic exposure data to confirm actual exposures. However the acoustic and health data which does exist is compelling, and suggests that the few known clinical cases of ILFN related health damage are the tip of the iceberg for those communities, and that the true incidence of health damage from chronic exposure to excessive ILFN is much higher.

One such community is Lithgow in NSW, Australia, long known by locals to have a low frequency noise problem, however no full spectrum acoustic data was available until recently (The Acoustic Group Report (S Cooper) for Centennial Coal April 2015).

Health problems for the Lithgow community have previously been attributed to air and water pollution alone, (http://www.smh.com.au/environment/health-fears-for-lithgow-residents-amid-coal-boom-20100605-xlr8.html ) with noise issues seemingly ignored by the health and noise

pollution regulatory authorities despite longstanding knowledge of those authorities that environmental noise could cause a range of health problems including sleep disturbance and neurophysiological stress, mental health disorders, cardiovascular disorders, children's learning difficulties and "annoyance". (http://waubrafoundation.org.au/resources/health-effects-environmental-noise-other-than-hearing-loss/ )

*This example in Lithgow NSW Australia is indicative of the suspected under reporting related to the lack of reliable full spectrum acoustic data, health data suggesting a serious problem, and lack of awareness of the medical profession generally about the many health problems which are directly related to excessive ILFN exposure which compounds the problems for the residents.*

## Experimental evidence related to ILFN exposure
**(generally acute exposure with higher doses)**

Stepanov, K *"Health Risk Factors of Low Frequency Noise Oscillation below 20 Hz"* http://waubrafoundation.org.au/wp-content/uploads/2015/04/stepanov-dr-vladimir.pdf
National Institute of Environmental Health Sciences, USA 2001 "*Infrasound, Brief Review of Toxicological Literature"* http://waubrafoundation.org.au/resources/infrasound-brief-review-toxicological-literature/

## Cardiovascular Diseases resulting from Chronic Sleep Deprivation & Chronic Stress

Effects of chronic sleep deprivation – see WHO Night Noise Guidelines for Europe 2009
http://waubrafoundation.org.au/resources/who-night-noise-guidelines-for-europe/

Capuccio et al "*Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies"* European Heart Journal Feb 2011
http://waubrafoundation.org.au/resources/sleep-duration-predicts-cardiovascular-outcomes/

McEwen, B "*Protective and Damaging Effects of Stress Mediators*" New England Journal of Medicine 1998, 338 171–179

Vitiliano, P et al *"A Path Model of Chronic Stress, the Metabolic Syndrome, and Coronary Heart Disease*" 2002 Psychosomatic Medicine 64: 414-435 http://www.uned.es/psico-doctorado-envejecimiento/articulos/Rupert/Vitaliano_etal_2002.pdf

## Sensitisation to ILFN with Progressive Exposure

Noted by Kelley et al in 1985 and specifically referenced on page 199 of the following report:
Kelley N et al "*Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact and Control"* 1985 Prepared for the US Department of Energy
http://waubrafoundation.org.au/resources/kelley-et-al-1985-acoustic-noise-associated-with-mod-1-wind-turbine/

Cooper, S "*The Results of An Acoustic Testing Program at Cape Bridgewater Wind Farm*", December 2014 for Pacific Hydro http://waubrafoundation.org.au/resources/cooper-s-acoustic-group-results-cape-bridgewater-acoustic-investigation/

See also the Waubra Foundation summary of the Cooper study and its implications http://waubrafoundation.org.au/resources/acoustic-engineering-investigation-at-cape-bridgewater-wind-facility/

## Heightened Noise Zones / Constructive Interference of Sound pulses

Pierpont, N "*Wind Turbine Syndrome – Report of a Natural Experiment*" 2009 p109 "*Coming from several towers at once, these low frequency air pressure fluctuations may synchronize and reinforce, depending on the orientation of the towers and house and the timing of the individual turbines*" http://waubrafoundation.org.au/resources/dr-nina-pierpont-submission-australian-senate-inquiry/

Thorne R, "*The Dean Report*" 2010 http://waubrafoundation.org.au/resources/thorne-r-dean-wind-farm-report-waubra-wind-farm/

Bakker, H.H.C. and B.I. Rapley, *Sound, Noise, Flicker and the Human Perception of Wind Farm Activity.* Palmerston North: Atkinson & Rapley Consulting (2010)

Bell, A Technical Note "*Constructive Interference of Tonal Infrasound from Synchronised Wind Farm Turbines: Evidence and Implications"* Acoustics Australia Vol 42 No 2 Dec 2014 https://www.wind-watch.org/documents/constructive-interference-of-tonal-infrasound-from-synchronised-wind-farm-turbines-evidence-and-implications/

## Pressure bolts sensations – Related to pressure transient peaks??

Gardner, Andrew Statement of Evidence for Cherry Tree case, 2013 re pressure bolt sensations experienced at home at Macarthur Wind Development, Victoria http://waubrafoundation.org.au/resources/gardner-statement-vcat-cherry-tree-hearing/

Huson, L Expert Opinion for Cherry Tree case, 2013 http://waubrafoundation.org.au/resources/huson-l-expert-evidence-at-vcat-cherry-tree-hearing/

## Experimental Evidence relating to Acute Physiological Stress / Adrenal surge pathology

Inagaki T, Li Y & Nishi Y "*Analysis of aerodynamic sound noise generated by a large scaled wind turbine and its physiological evaluation"* International Journal of Science and Technology 2015 12: 1933 – 1944 http://waubrafoundation.org.au/resources/ingaki-et-al-analysis-aerodynamic-sound-noise-generated-by-large-scaled-wind-turbines/

Salt, A Lichtenhan J "*How Does Wind Turbine Noise Affect People"* Winter 2014 Acoustics Today (p 24 section 3 "*Excitation of Outer Hair Cell Afferent Nerve Pathways*") http://waubrafoundation.org.au/resources/salt-n-lichtenhan-j-t-how-does-wind-turbine-noise-affect-people/

Nishimura, K "*Effects of Infrasound on Pituitary Adrenocortical Response & Gastric Microcirculation in Rats*" Journal of Low Frequency Sound and Vibration Vol 7 no 1 1988 (20 – 33) http://waubrafoundation.org.au/resources/nishimura-k-effects-infrasound-pituitary-adrenocortical-response-gastric-microcirculation-rats/

Sharkey, S et al "*Takotsubo (Stress) Cardiomyopathy*" Circulation – Cardiology patient page http://circ.ahajournals.org/content/124/18/e460.full#sec-5

Pacak, K "*Phaeochromocytoma: a catecholamine and oxidative stress disorder"* 2011 Endocr Regul. 2011 Apr; 45(2): 65–90. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3414427/

## Vibration and ILFN Related Animal Pathology

Shannon et al 1994 "*Effect of Vibration Frequency and Amplitude on Developing Chicken Embryos"* Samuel Shannon, Al Moran, Linda Shackelford, Kevin Mason — Aircrew Protection Division, US Air Force http://waubrafoundation.org.au/resources/effects-vibration-embryonic-development-maturity-usa-army-aeromedical-research/

Report of Danish Mink Farmer Kaj Bank Olesen and Veterinary specialist Dr Karen Enevoldsen: http://wcfn.org/2014/06/07/windfarms-1600-miscarriages/ the Veterinary report is here: http://wcfn.org/documents/documents-re-mink-farm-tragedy/

## Population Noise Impact Surveys/Acoustic investigations

Multiple studies/surveys from various wind developments, particularly in Australia (Waterloo, Macarthur, Waubra, Cape Bridgewater, Cullerin) http://waubrafoundation.org.au/library/community-noise-impact-surveys/

Dr Bob Thorne's detailed investigation at Waubra and Cape Bridgewater Wind Developments in Victoria where he found that the health indicators of people chronically exposed to wind turbines were consistently worse than hospital inpatients, a population group usually with the worst health indicator data. http://waubrafoundation.org.au/resources/thorne-r-victorian-wind-farm-review-updated-june-2014/

## Field evidence of excessive noise / sleep disturbance out to 8 - 10km

http://waubrafoundation.org.au/resources/hansen-zajamsek-hansen-noise-monitoring-waterloo-wind-farm/
http://waubrafoundation.org.au/resources/schneider-p-cullerin-range-wind-farm-survey-follow-up-july-august-2013/
http://waubrafoundation.org.au/resources/macarthur-wind-energy-facility-preliminary-survey/
http://waubrafoundation.org.au/resources/waterloo-wind-farm-survey-2012/

## Diagnostic Criteria

McMurtry and Krogh "*Diagnostic Criteria for adverse health effects in the environs of wind turbines*"
JRSM Open *October 2014 vol. 5 no. 10 2054270414554048*

http://shr.sagepub.com/content/5/10/2054270414554048.full

## Effect of Noise on Children

Bronzaft, Professor Arline "*Wind Turbine Noise – Potential Adverse Impacts on Children's Wellbeing"*
http://waubrafoundation.org.au/resources/bronzaft-wind-turbine-noise-potential-adverse-impacts-childrens-well-being/

## UN Conventions to which Australia is a signatory:

Australia is a signatory to seven international Covenants and Conventions. Six of these have a clause which states that people have

***"The right to enjoy the highest standard of physical and mental health"***

https://www.humanrights.gov.au/chart-related-rights-and-articles-human-rights-instruments-human-rights-your-fingertips-human-rights

The final UN Convention is the Convention against Torture, Cruel, inhuman and degrading treatment. Sleep deprivation is explicitly mentioned as a method of torture by the UN Committee Against Torture who stated:

> ***"The Committee against Torture (CAT) has noted that sleep deprivation used for prolonged periods constitutes a breach of the CAT, and is primarily used to break down the will of the detainee. Sleep deprivation can cause impaired memory and cognitive functioning, decreased short term memory, speech impairment, hallucinations, psychosis, lowered immunity, headaches, high blood pressure, cardiovascular disease, stress, anxiety and depression."***

http://waubrafoundation.org.au/resources/un-convention-against-torture/