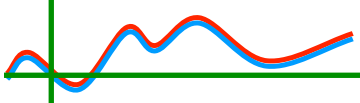
# APPENDICES



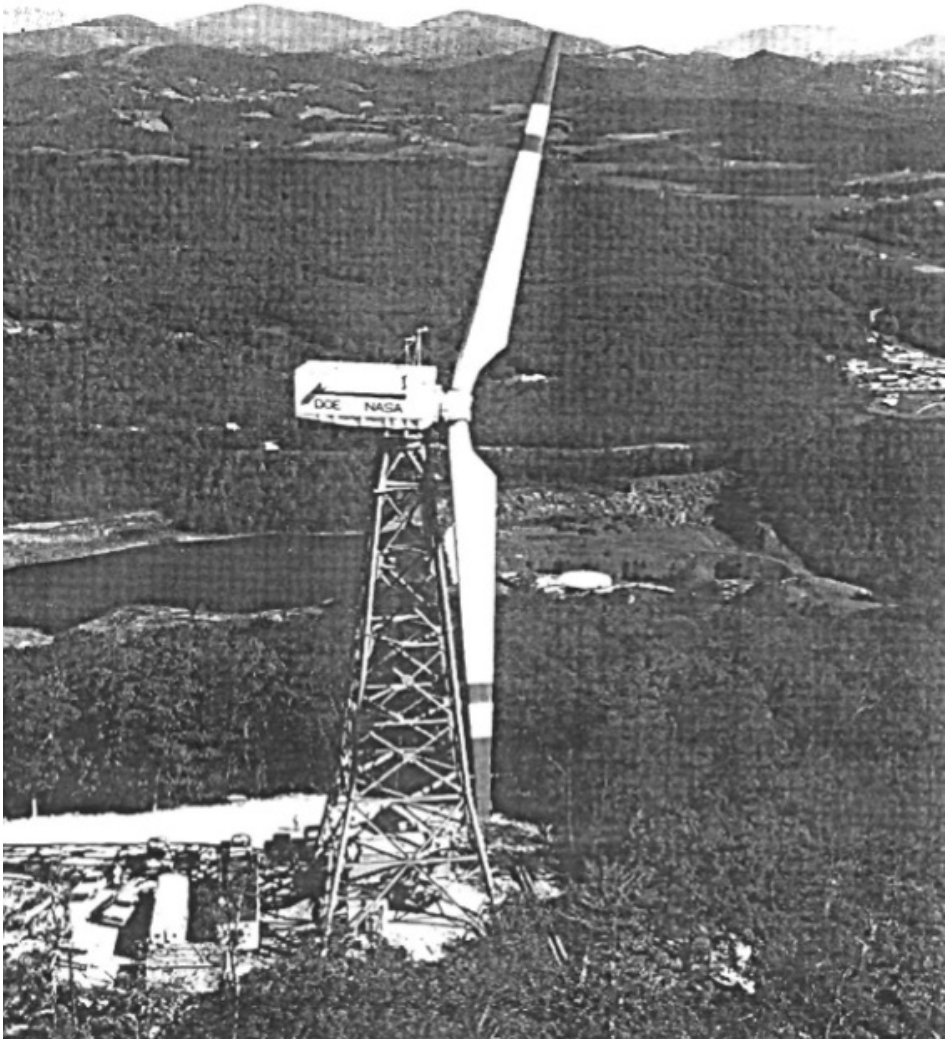
# CONTENTS

# APPENDIX 1: INDUSTRIAL WIND TURBINES - A TIMELINE

## July 1, 1979

2MW MOD-1 Turbine installed

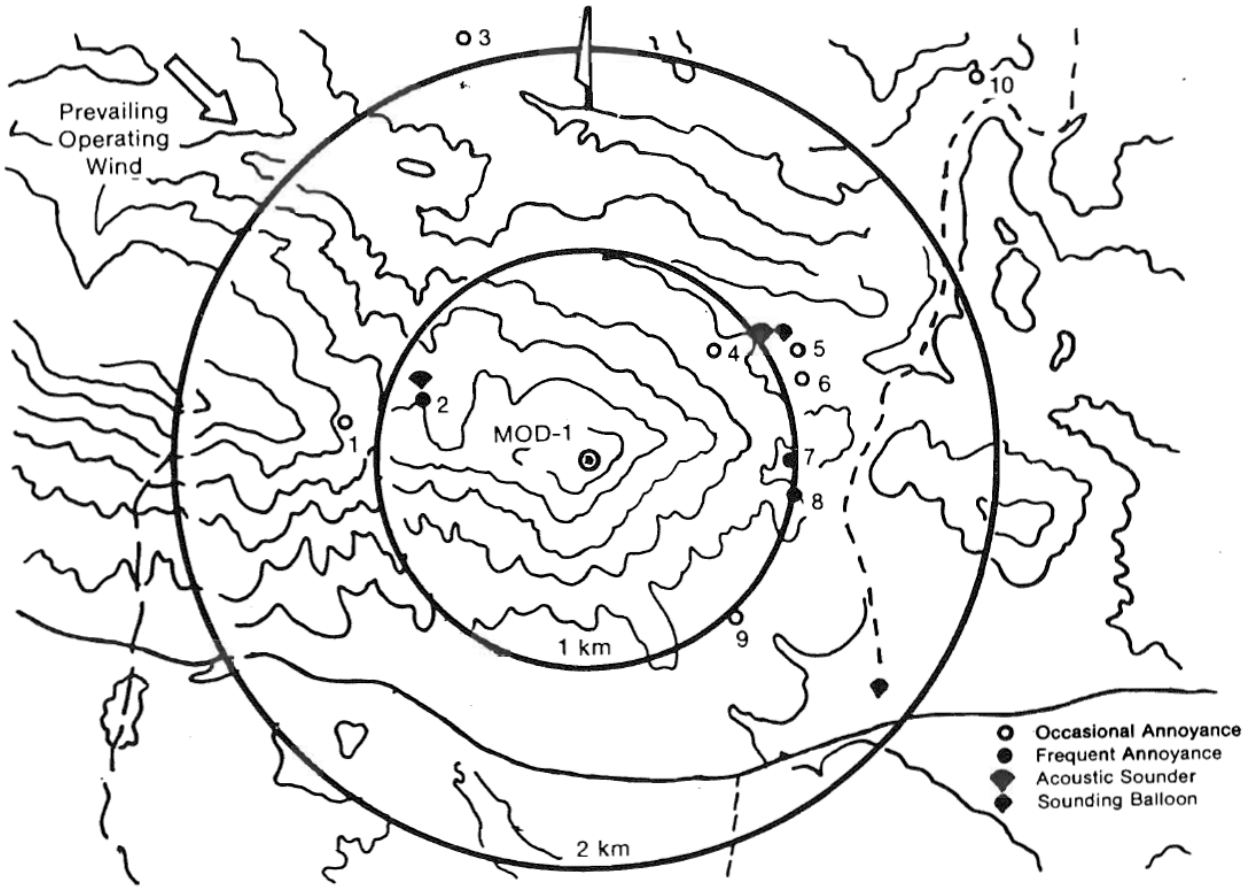
To trial industrial-level wind energy generation in the US, the 5th operational wind turbine is installed near Boone, North Carolina.



## September 1, 1979

**First complaints received from a dozen families within a 3km radius of turbine.**

Much to everyone's surprise, complaints were made by some residents (see dots on image for location). The annoyance was described as an intermittent "thumping" sound accompanied by vibrations. .. A "feeling" or "presence" was described, felt rather than heard, accompanied by sensations of uneasiness and personal disturbance. .. The "sounds" were louder and more annoying inside the affected homes. .. Some rattling of loose objects occurred. In one or two severe situations, structural vibrations were sufficient to cause loose dust to fall from high ceilings, which created an additional nuisance.



## October 1, 1979 — January 1, 1981

**Wind turbine operation creates enormous sound pressure waves**

Many collaborators, including NASA and SERI fully investigated acoustic, seismic and atmospheric aspects using turbine operational information and data recordings in a series of field experiments (the NASA research). This image from the field studies shows the sound pressure caused by rotating blades passing the tower.

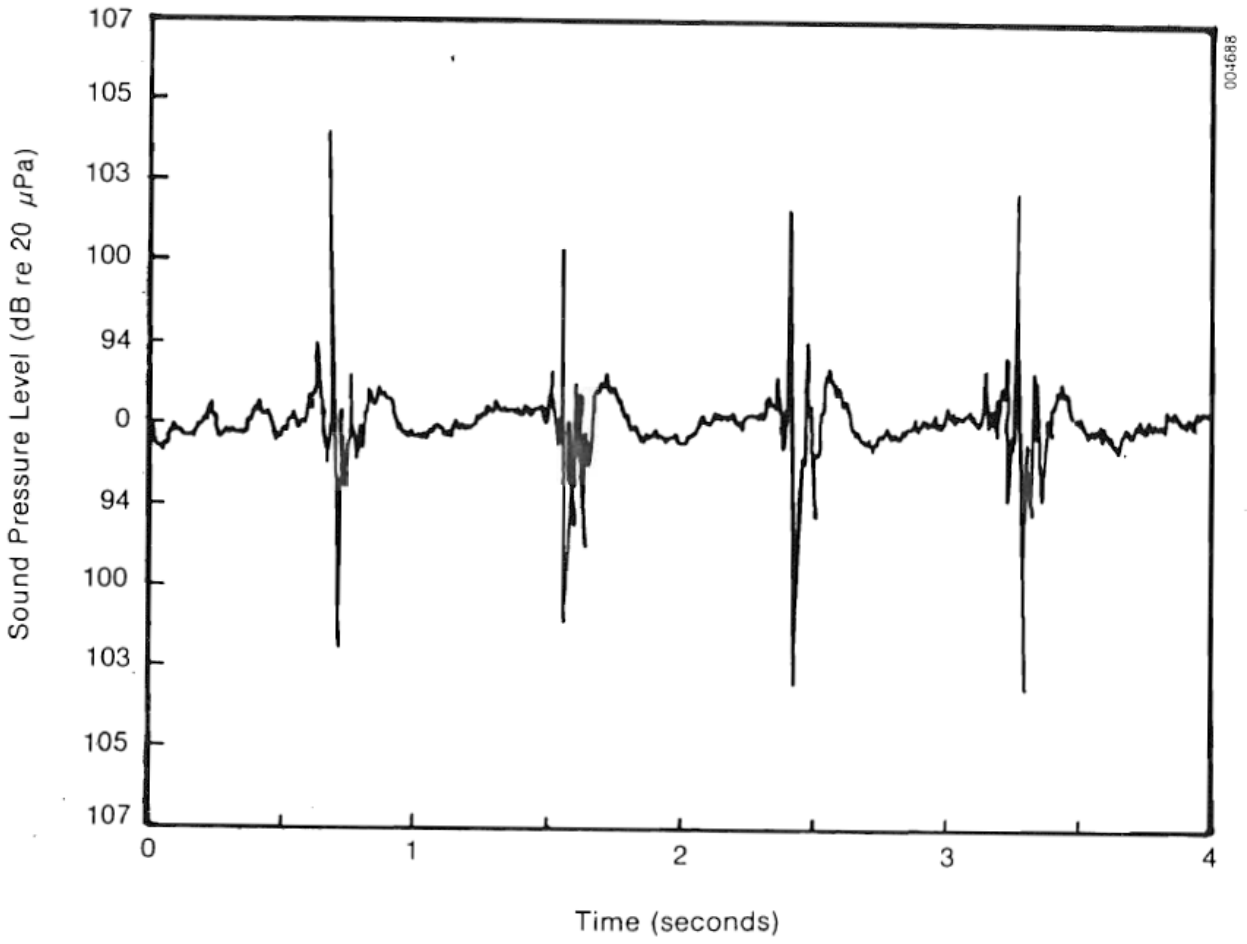
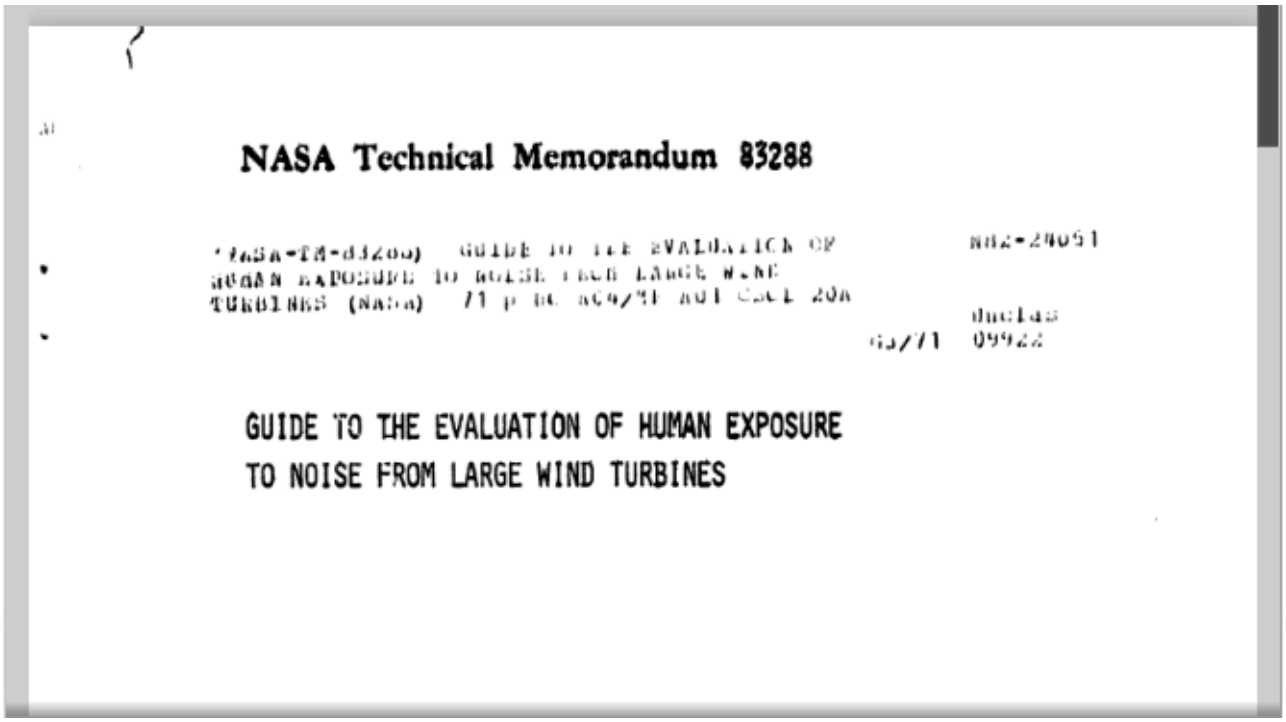



Figure 3-3. Typical Pressure-Time Plot of MOD-1 Acoustic Emissions Containing Strong Period Impulses. (Two complete rotor revolutions and four blade passages)

## March 1, 1982

**Householders are exposed to Low Frequency Noise (LFN) from wind turbines while indoors.**

NASA's Guide to the evaluation of human exposure to noise from large turbines - 'Receiver exposure' includes noise evaluation inside homes.



NASA Technical Memorandum 83288

GUIDE TO THE EVALUATION OF HUMAN EXPOSURE
TO NOISE FROM LARGE WIND TURBINES

[Note: NASA memorandum was produced before the age of computers, and the quality is as it appears when scanned and placed in the internet. The quality leaves much to be desired. However, it may be possible if you are interested to get a original document from NASA.]

## March 2, 1982

**Closed windows and doors do not protect occupants from LFN**

Further NASA research showed that even with windows shut, houses do not stop LFN sound energy. Measured levels inside the home are significantly higher than predicted within the LFN range. The house acts like a drum for LFN.

There are very few data available at the low frequencies (below 50 Hz). In this range the wavelengths are comparable to the dimensions of the rooms and there is no longer a diffuse sound field on the inside (ref. 29). Other complicating factors are the role of stiffness at these lower frequencies and 45

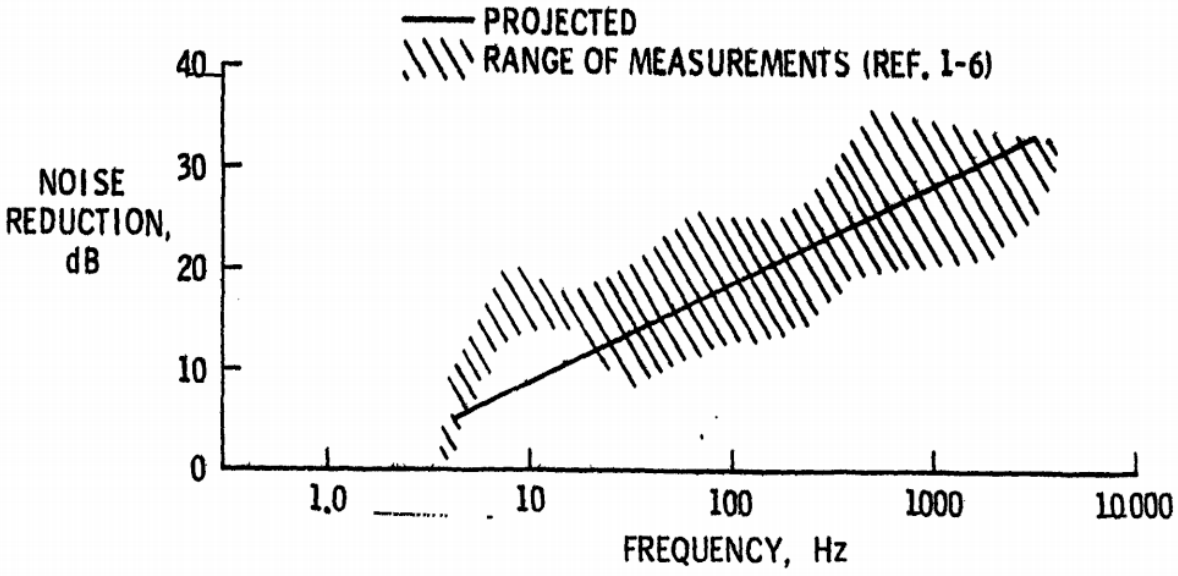



Figure C-10.- House noise reduction as a function of frequency for the windows closed condition.

the existence of pressure leaks. The inside distribution of pressure can be non-uniform because of standing wave patterns, organ pipe modes and cavity resonances due to room, closet and hall way configurations. The anticipated large variation of sound pressure levels from one location to another at very low excitation frequencies has not been documented for houses. Thus, it is difficult to characterize the low frequency noise environment inside a house structure based on a knowledge of the outside noise environment.

## March 3, 1982

**Turbine redesign from downwind to upwind does not fix LFN problem**

The position of the turbine was thought to contribute to the problem. The MOD-1 wind turbine was a downwind turbine. The acoustics of upwind turbines were investigated. A change in configuration of the turbine did change the noise profile, however, as the blades still must pass a tower, LFN sound pressure emissions remain high.

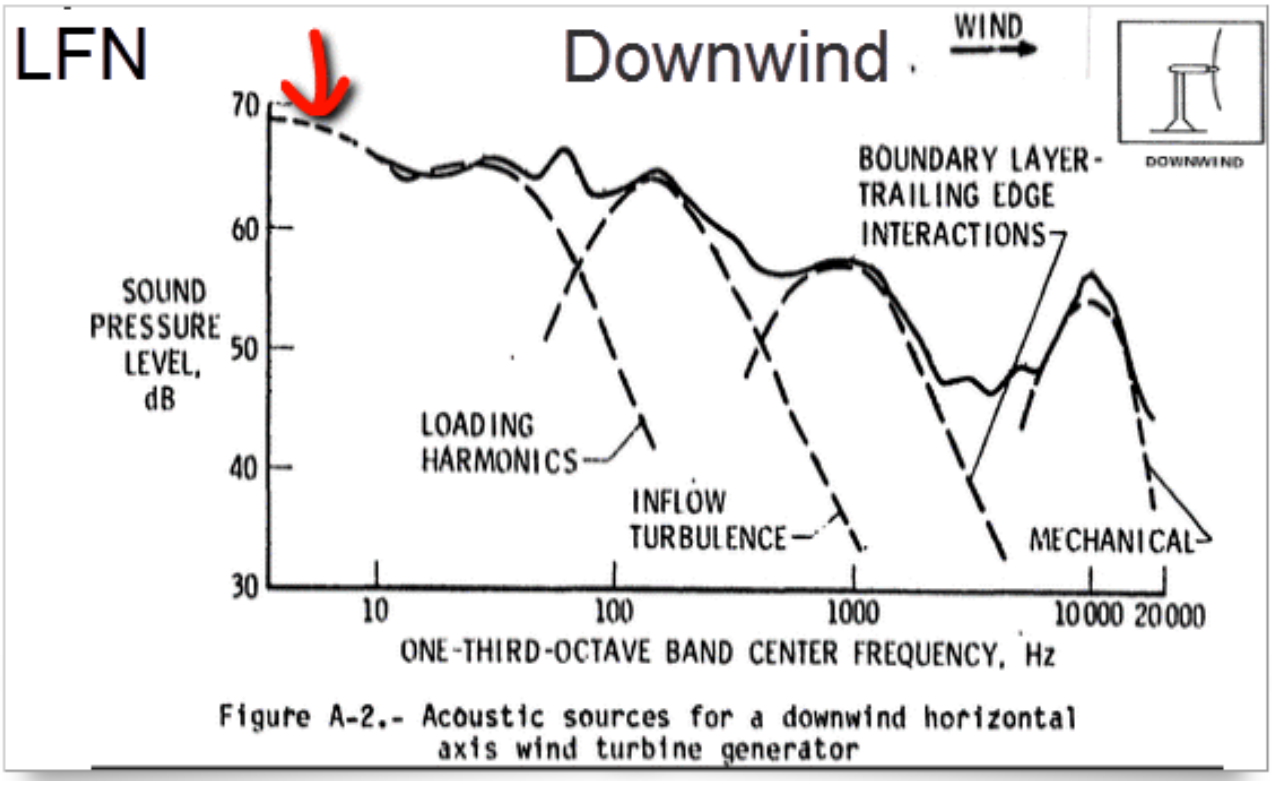



Figure A-2.- Acoustic sources for a downwind horizontal axis wind turbine generator

## September 1, 1982

**NASA research on human impacts provided to wind industry**

Wind industry is provided with research through this summary article in the Noise Control Engineering Journal. It describes noise-induced house responses, including frequencies, mode shapes, acceleration levels and outside-to-inside noise reductions. The role of house vibrations in reactions to environmental noise is defined and some human perception criteria are reviewed.

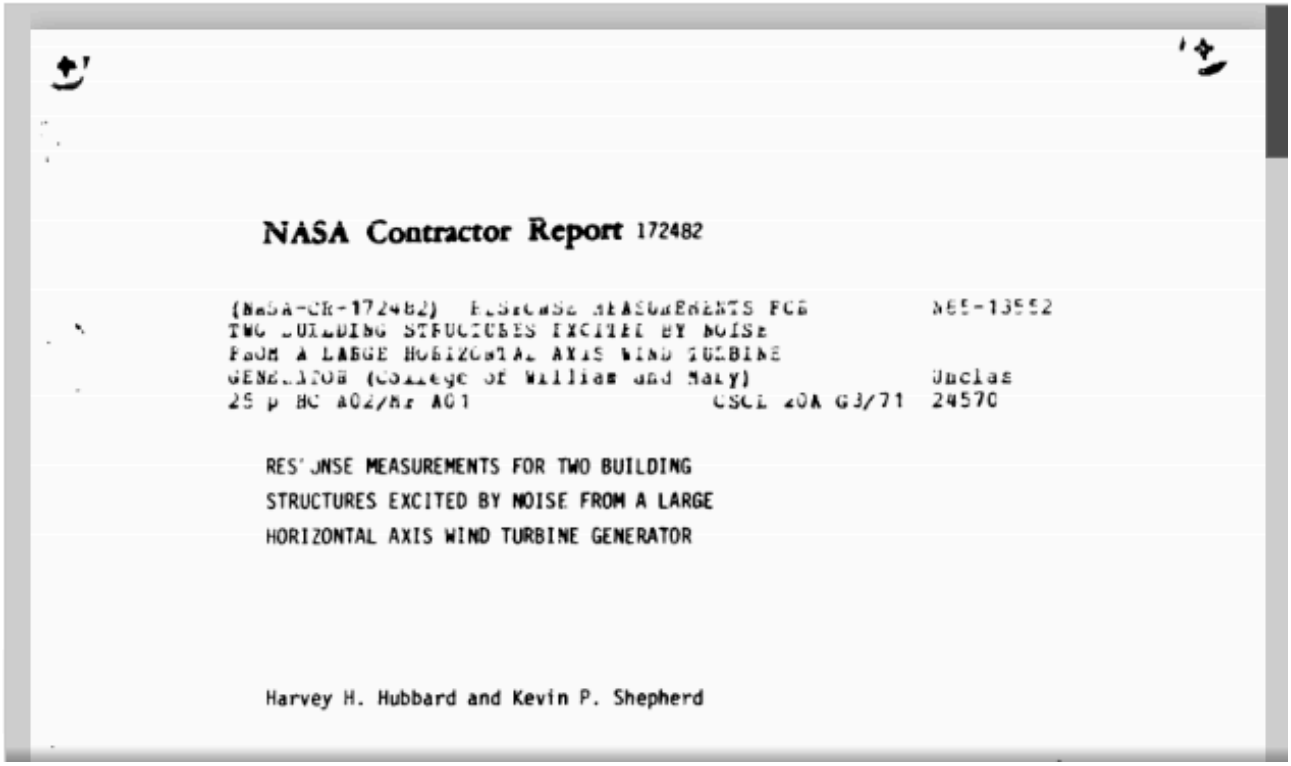
# Noise Induced House Vibrations and Human Perception*

**Harvey H. Hubbard,** member INCE,† summarizes noise induced house responses including frequencies, mode shapes, acceleration levels and outside-to-inside noise reductions. The role of house vibrations in reactions to environmental noise is defined and some human perception criteria are reviewed.

## November 1, 1984

**Noise inside homes worse than outside**

More NASA research shows that house structure excitation from wind turbine operation is similar to the sonic boom created by jet aircraft passing overhead. Interior noise can be greater than outside noise. Many people complain that wind turbines sound like a jet that never lands - this is why. There is an overlap between the peak acceleration level (vibration measure) and peak sound pressure levels within two structures that had been excited by commercial jets, helicopters and wind turbines.



NASA Contractor Report 172482

(NASA-CR-172482) RESPONSE MEASUREMENTS FOR TWO BUILDING STRUCTURES EXCITED BY NOISE FROM A LARGE HORIZONTAL AXIS WIND TURBINE GENERATION (College of William and Mary) 25 p HC A02/MF A01 CSCL 20A G3/71

N85-13552

Unclas 24570

RESPONSE MEASUREMENTS FOR TWO BUILDING STRUCTURES EXCITED BY NOISE FROM A LARGE HORIZONTAL AXIS WIND TURBINE GENERATOR

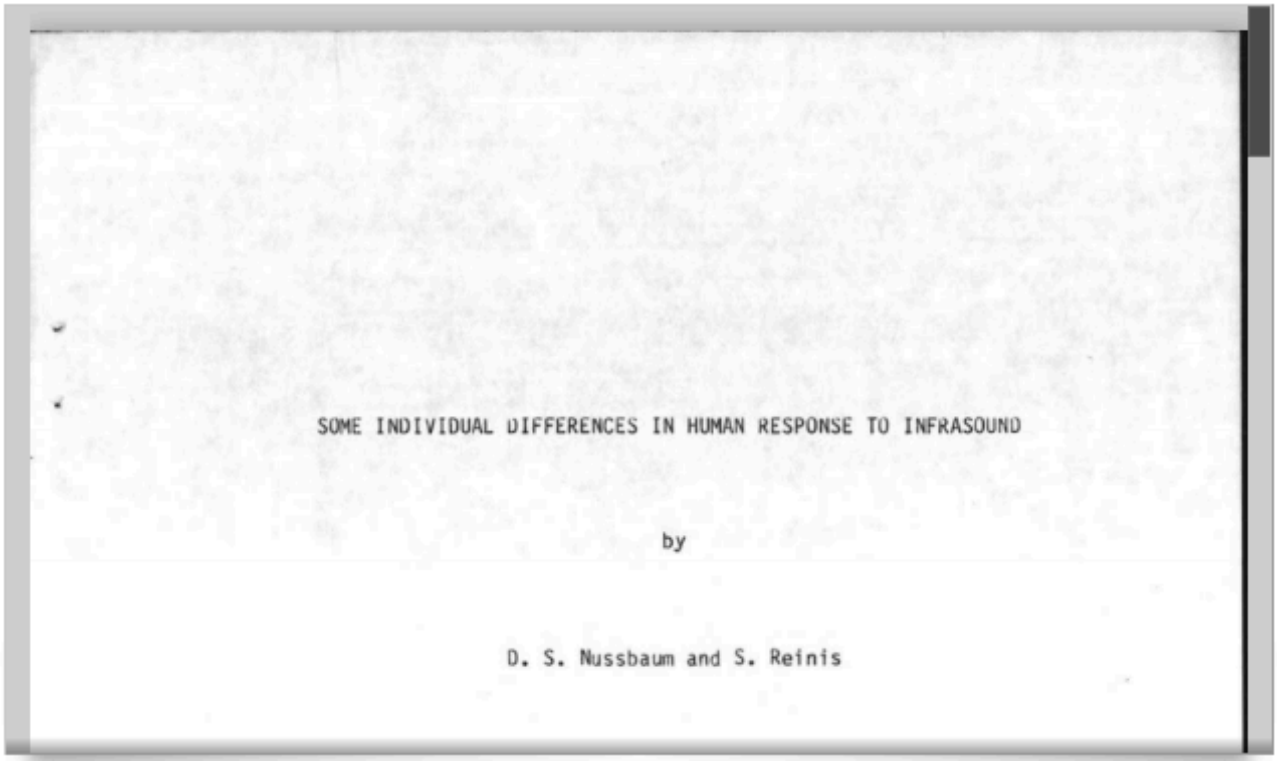
Harvey H. Hubbard and Kevin P. Shepherd

[Note - as before: NASA memorandum was produced before the age of computers, and the quality is as it appears when scanned and placed in the internet. The quality leaves much to be desired. However, it may be possible if you are interested to get a original document from NASA.]

## January 3, 1985

**Hypothesis for infrasound-induced motion sickness**

It was known that not every one responded to infrasound in the same way and studies were commenced to determine the possible 'transducers' for infrasound in the human body and explore how they might differ between individuals. People who suffer from infrasound were found to be measurably different to people who did not. The resulting hypothesis proposes the differences are related to anatomical differences (diameter of inner ear), neural responsiveness as well as processing of information in the brain (central nervous system). Clear parallels to motion sickness was made.



SOME INDIVIDUAL DIFFERENCES IN HUMAN RESPONSE TO INFRASOUND

by

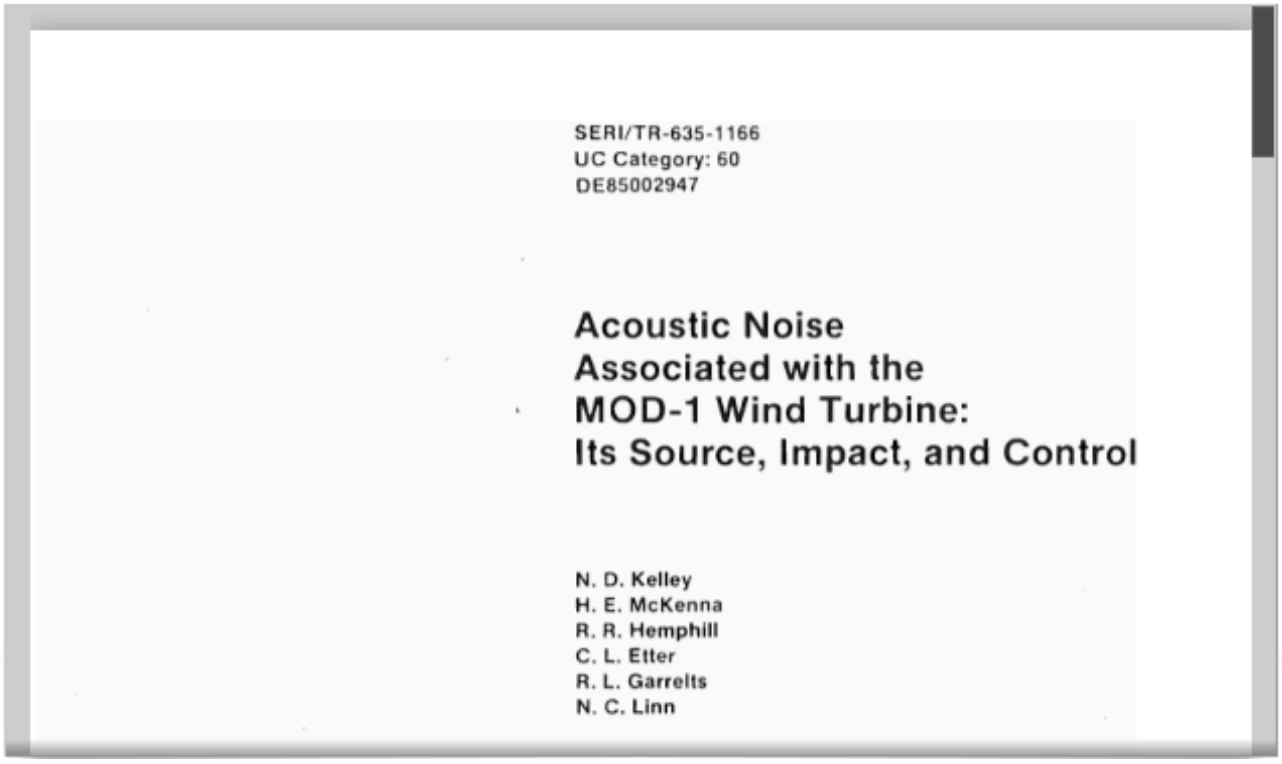
D. S. Nussbaum and S. Reinis

[Note - as before: Memorandum was produced before the age of computers, and the quality is as it appears when scanned and placed in the internet. The quality leaves much to be desired.]

## February 1, 1985

**Major research on community annoyance from wind turbine released**

Extensive NASA research established the origin and possible amelioration of acoustic disturbances associated with the operation of the MOD-1 wind turbine. Results show that the source of this acoustic annoyance was the transient, unsteady aerodynamic lift imparted to the turbine blades as they passed through the lee wakes of the large, cylindrical tower supports. Nearby residents were annoyed by the LFN impulses propagated into the structures of the homes in which the complainants lived. The situation was aggravated further by a complex sound propagation process controlled by terrain and atmospheric focusing.



SERI/TR-635-1166
UC Category: 60
DE85002947

Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control

N. D. Kelley
H. E. McKenna
R. R. Hemphill
C. L. Etter
R. L. Garrelts
N. C. Linn

## November 1, 1987

**Laboratory simulation of wind turbine annoyance conducted**

Kelley continued researching the annoyance from wind turbines in a 'laboratory situation'. A testing facility was constructed and furnished with a control room, listening room and speaker room. Subjects were exposed to LFN emission profiles similar to that detected in the MOD-1 turbine and asked to rate their annoyance.

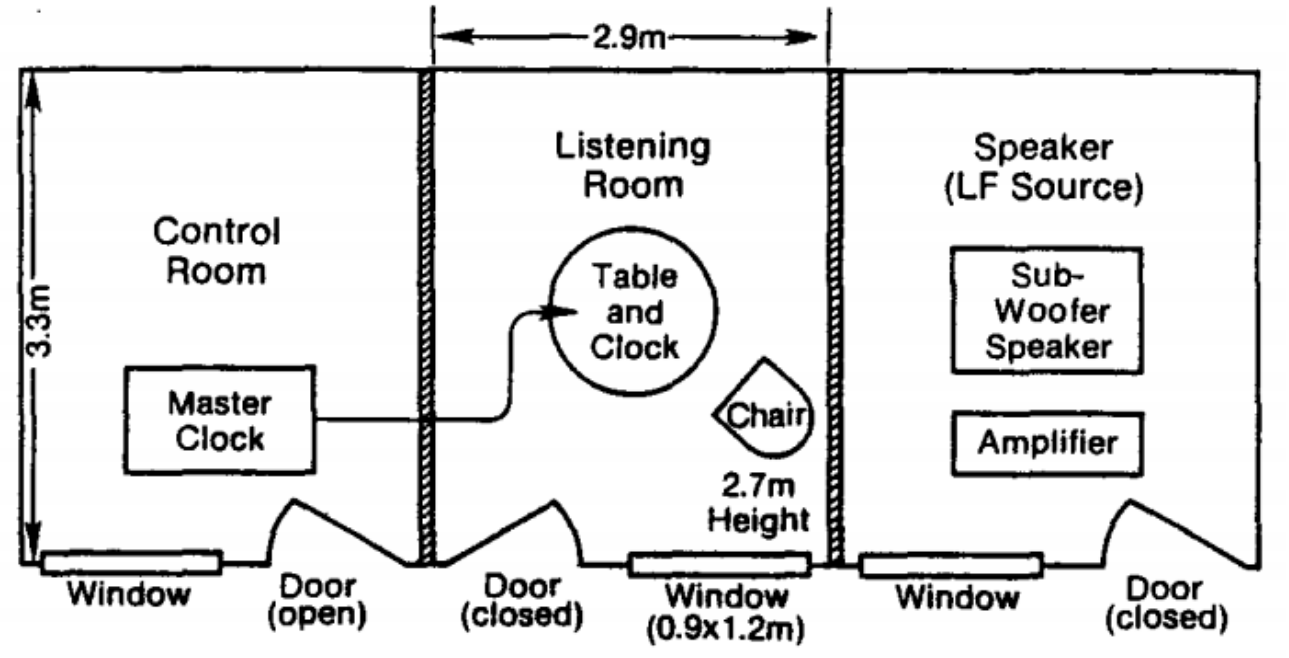



Figure 5. PLAN VIEW SCHEMATIC OF PHYSICAL ARRANGEMENT OF TESTING FACILITIES

# November 2, 1987

**Wind turbine annoyance measured**

Participants rated their perceptions in various LFN environments using this scale, recording noise, annoyance, vibration and pulsations.

Table 2. SUBJECTIVE RANKING CRITERIA FOR LOW-FREQUENCY (LF) NOISE ENVIRONMENTS

| Rank | Stimuli Response Rating 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | Perception | | | | | |
| Noise level (loudness) | Can't hear | Barely can here | Weak, but definitely audible | Moderate loudness | High noise level, loud | Very high noise level, very loud |
| Annoyance/ displeasure | None | Barely aware of presence | Definitely aware of presence | Moderate distraction/ some irritation | Very annoying, irritating | Extremely annoying, uncomfortable |
| Vibration/ pressure | None | Feel presence | Definitely feel vibration/ pressure | Moderate vibration/ pressure feeling | Very noticeable | Severe vibration |
| Pulsations | None | Barely feel pulses | Definite pulses or bumping | Moderate booming or thumping | Heavy booming or thumps | Very heavy pulses, booms, thumps |
| | Acceptable | | ??????? | | Clearly unacceptable | |

## November 3, 1987

**Lab studies confirm dB(A) worst noise measure for predicting annoyance**

Of all the noise filters tested, dB(A) was shown to be the worst of all at predicting annoyance from LFN.

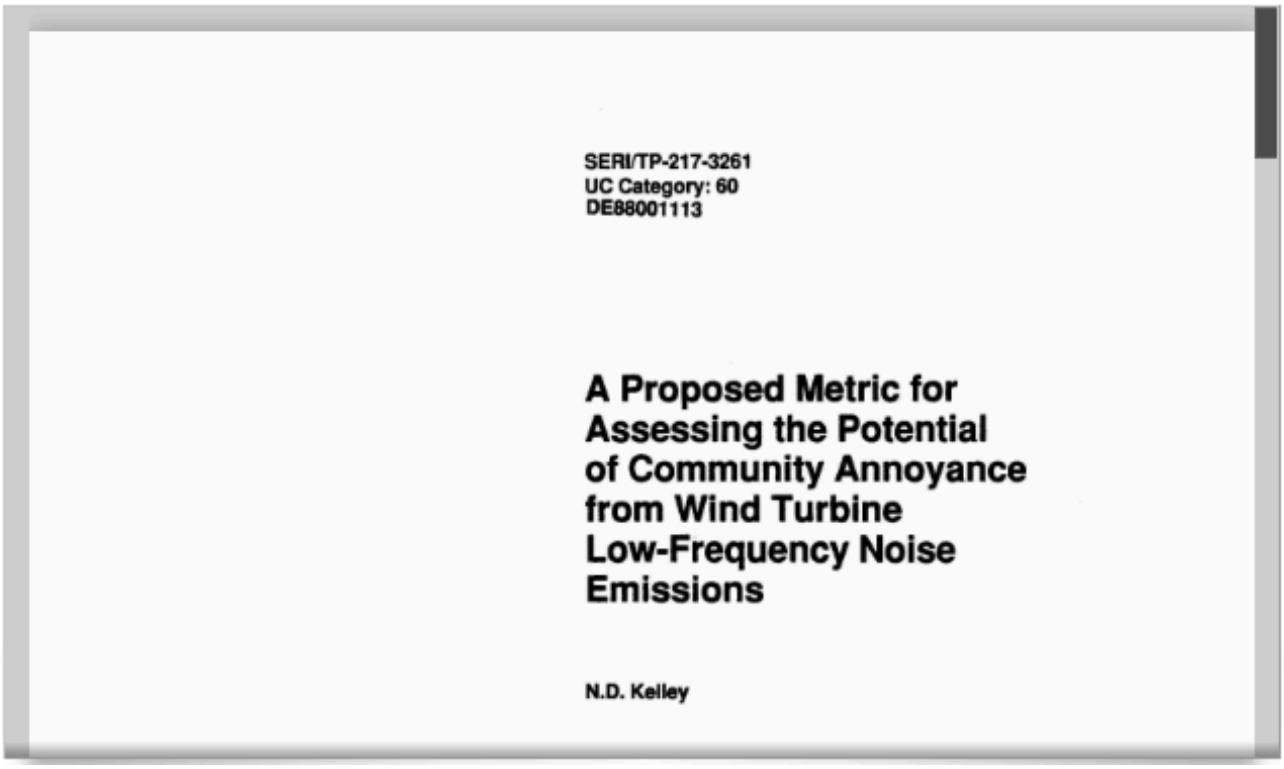
Table 3. CORRELATION COEFFICIENTS OF EVALUATOR ANNOYANCE RATINGS OF LF NOISE STIMULI VERSUS SIX NOISE METRICS

| Metric | Noise Level | Annoyance/ Displeasure | Vibration/ Pressure | Pulsations | Mean |
|---|---|---|---|---|---|
| $G_1$ | 0.898 (0.033) | 0.933 (0.018) | 0.709 (0.170) | 0.819 (0.115) | 0.840 (0.084) |
| $G_2$ | 0.873 (0.071) | 0.879 (0.053) | 0.701 (0.157) | 0.769 (0.148) | 0.806 (0.107) |
| LSPL | 0.898 (0.035) | 0.924 (0.034) | 0.711 (0.155) | 0.831 (0.107) | 0.841 (0.083) |
| LSL | 0.935 (0.021) | 0.958 (0.014) | 0.732 (0.174) | 0.860 (0.097) | 0.871 (0.077) |
| C | 0.940 (0.030) | 0.947 (0.008) | 0.725 (0.167) | 0.841 (0.098) | 0.863 (0.076) |
| A | 0.384 (0.464) | 0.269 (0.413) | 0.413 (0.137) | -0.077 (0.719) | 0.247 (0.433) |

## November 4, 1987

**Wind industry told that dB(A) unsuitable to measure LFN emissions from wind turbines**

Wind industry informed of how to predict annoyance from LFN emissions from wind turbines at Windpower '87 Conference. Kelley explains how to measure LFN emissions that annoy neighbours of wind farms. LFN can be intensified inside homes. The dB(A) filter cuts out all the LFN and is therefore unsuitable. G-weighted scales were better correlated with noise, annoyance, vibration and pulsations.



SERI/TP-217-3261
UC Category: 60
DE88001113

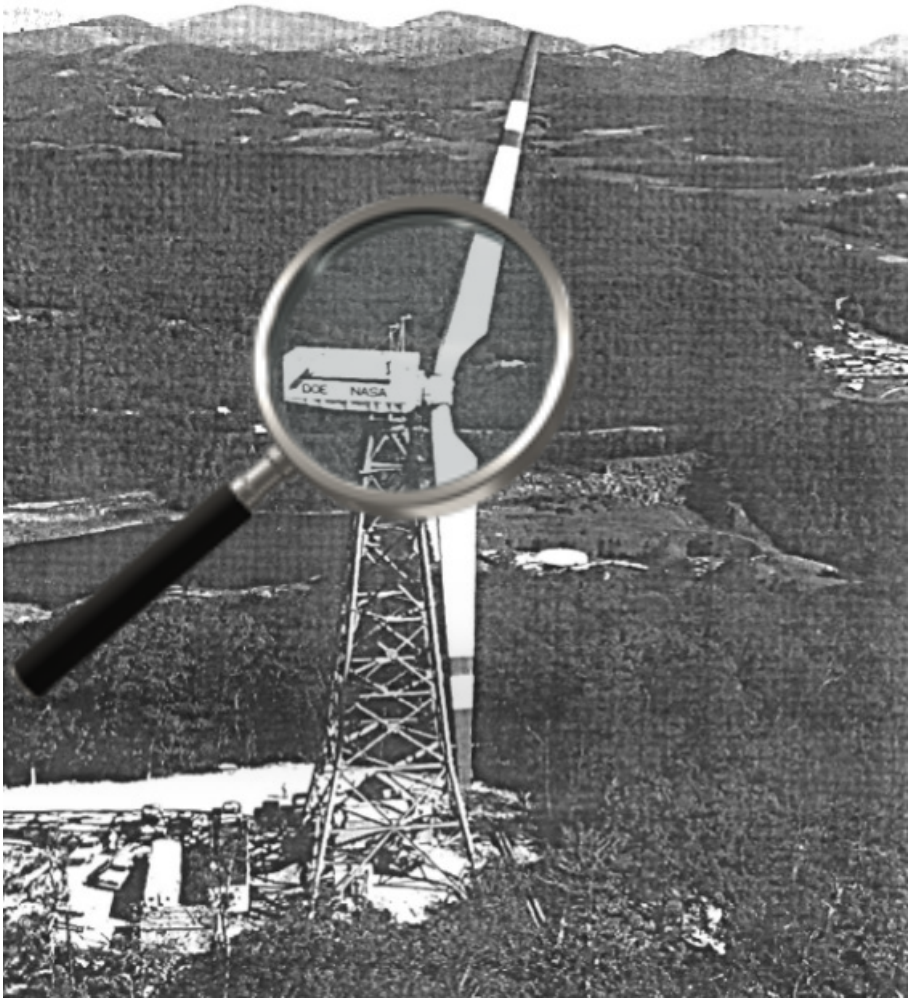
A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions

N.D. Kelley

## January 2, 1988

**End of NASA research**

This was essentially the end of almost a decade of NASA research into the unexpected annoyance of wind turbine operation on neighbours. It revealed the fundamental flaw - the turbines blades passing the tower, which generates huge pressure waves - LFN emissions. Depending on topography, weather and the location of houses and turbines, some LFN emissions were focussed and reacted with homes. The sensation from LFN emission generated many complaints. The levels were higher inside the homes than outside. LFN can not be detected when dB(A) filters are applied. Susceptible people experience a range of symptoms including motion-sickness-like symptoms.



## January 1, 1995

**Wind developers regroup and respond to NASA research, creating the Noise Working Group**

Seven years have passed. In an attempt kick start the wind industry again, a group of mostly wind farm developers, calling themselves the Noise Working Group was established in the UK by the Department of Trade and Industry and through the Energy Technology Support Unit (ETSU - now called Future Energy Solutions). They met and created a set of procedures for measuring wind farm noise. Their aim was to promote the development of the wind industry, without the burden of dealing with community annoyance.

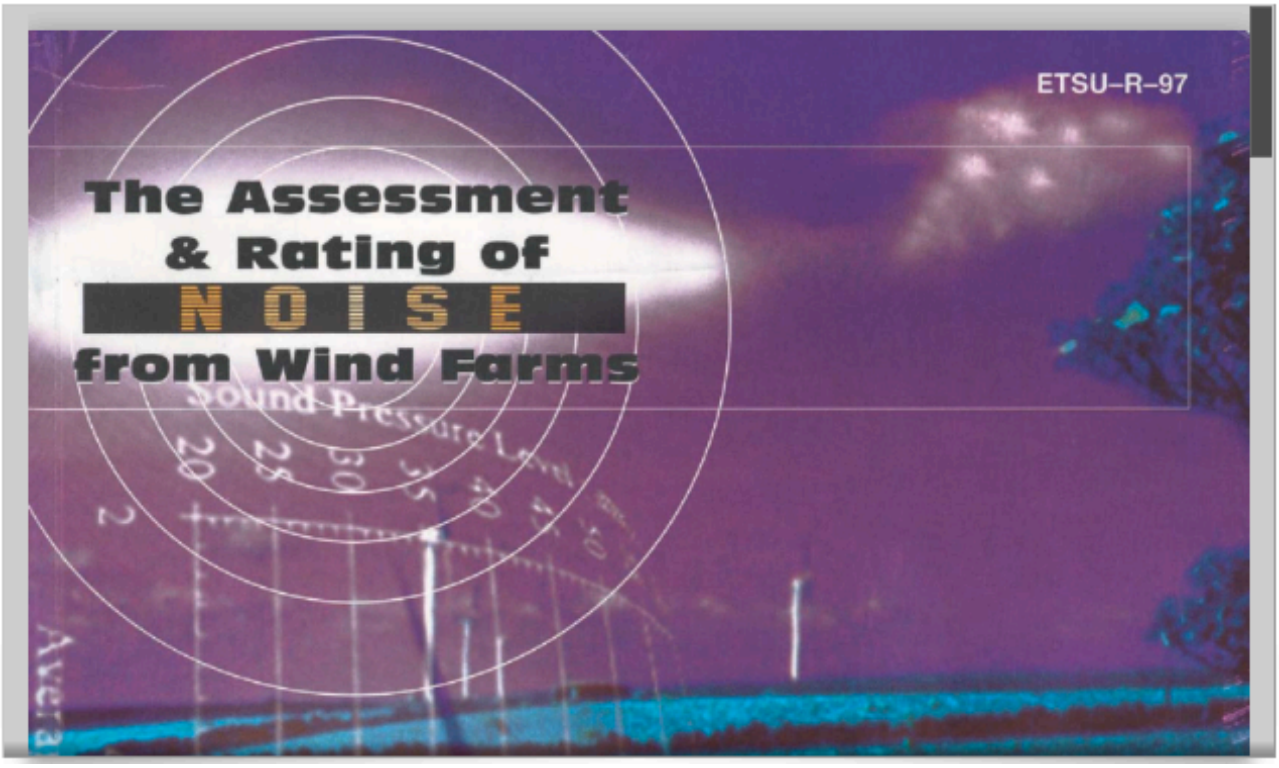
**Members of the Noise Working Group:**

| | |
|---|---|
| Mr R Meir, Chairman | DTI |
| Dr M L Legerton, Secretary | ETSU |
| Dr M B Anderson | Renewable Energy Systems |
| Mr B Berry | National Physical Laboratory |
| Dr A Bullmore | Hoare Lea and Partners |
| Mr M Hayes | The Hayes McKenzie Partnership |
| Mr M Jiggins | Carrick District Council |
| Mr E Leeming | The Natural Power Company Ltd |
| Dr P Musgrove | National Wind Power Ltd |
| Mr D J Spode | North Cornwall District Council |
| Mr H A Thomas | Isle of Anglesey County Council |
| Ms E Tomalin | EcoGen Ltd |
| Mr M Trinick | Bond Pearce Solicitors |
| Dr J Warren | National Wind Power Ltd |

## September 1, 1996

**Noise Working Group produce ETSU-R-97 guidelines for assessing wind turbine noise**

Noise standard document produced by the Noise Working Group makes it plain that its purpose is to create guidelines that will promote the development of the wind industry by not placing "unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities."



## September 2, 1996

**ETSU deliberately excludes testing inside homes**

Without any supportive evidence, a 10 dB(A) buffer is assumed to occur inside homes compared to outside. No need to take measurements inside just deduct this 10 dB(A) from outside noise level readings and say that this is equivalent to the inside noise level.

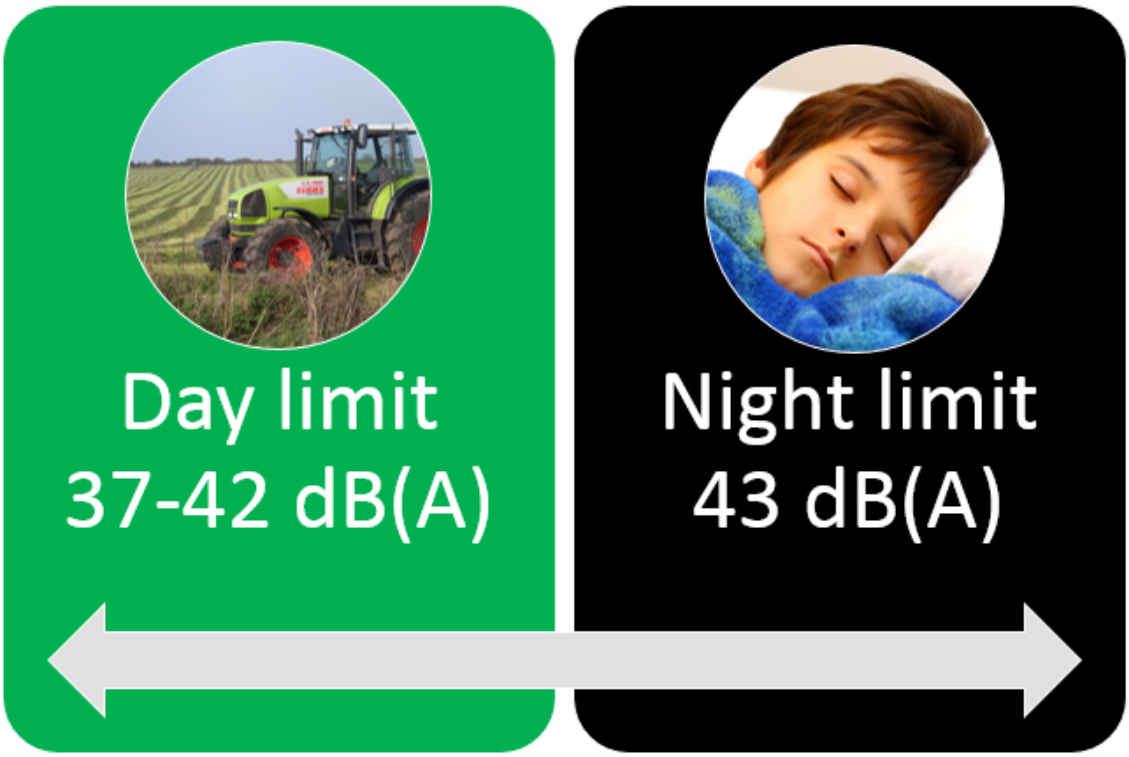
3.11 Further down page 60 it says that *On balance it is considered that a margin of 5dB(A)* (by which it means 7dB in BS4142 terms) *will offer a reasonable degree of protection to both the internal and external environment without unduly restricting the development of wind energy which itself has other environmental benefits.* There is no foundation whatsoever for this assertion. No evidence is brought forward or referred to.

3.12 So the position in the argument so far is this. The NWG has decided, without any foundation, that the 5dB "marginal significance" in BS4142 could be 7dB. It has decided, against all normal practice, that the background noise level for assessment purposes ought to be the average of background levels in any particular condition rather than the lowest level. In wind controlled background noise the average is likely to be at least 4dB more than a realistic background level. So the NWG consider that 11dB over background is appropriate for wind farms as against normal practice for industrial noise of 5dB over background noise. Of course I have to bear in mind that ETSU-R-97 does not purport to offer a method of assessment of impact. So the NWG is proposing that, for wind farms, a level of noise that is likely to give rise to complaints is appropriate because of the particular public benefits of wind farms. I cannot agree with this. As I exemplify elsewhere other projects of public benefit have to meet the stricter standard of 5dB above background.

## September 3, 1996

**ETSU sets night time noise limit higher than day time limit**

ETSU sets night time noise limit high of 43dB(A), while day time limit is 37-42 dB(A). Critics write "The conclusions of ETSU-R-97 are so badly argued as to be laughable in parts (the daytime standard is based on the principle that it does not matter if people cannot get to sleep on their patio so long as they can get to sleep in their bedrooms). It is the only standard where the permissible night time level is higher than the permissible day time level."



# September 6, 1996

## ETSU avoids measuring LFN from wind turbines

The sampling and filtering protocols in ETSU remove the dominant LFN component of the noise emissions from wind turbines

### Noise measurement

ETSU requires noise levels to be measured using the '$L_{A90\ 10min}$' measurement. In this case the 'A' indicates the A weighting measurement that most closely accords with the sensitivity of the human ear. However, given the significant low frequency content of wind turbine noise, the use of the C weighting measurement has been suggested by some acousticians and audiologists [Ref 38] to better indicate the true noise impact.

The '90' indicates the measurement of the noise level exceeded for 90% of the time. This measurement is effective for broadband noise such as traffic noise but not when measuring intermittent noise as produced by wind turbines. Some acousticians have proposed using the $L_{A50}$ measurement [ETSU Ref 1 page 16] that indicates the noise level exceeded for 50% of the time or the $L_{AEQ}$ the measurement indicating the equivalent continuous sound pressure level.

The '10 min' indicates the measurement is averaged over a 10 min period. This may work effectively when measuring broadband noises such as traffic noise but not when measuring intermittent noise as produced by wind turbines. It has already been proposed that the $L_{Aeq\ 125\ milliseconds}$ measurement be used to monitor for excess amplitude modulation.

## September 7, 1996

**ETSU does not measure aerodynamic modulation**

Wind turbines emit highly intrusive LFN thumping noises (excess amplitude modulation) that are essentially filtered out and ignored by the measurement protocols recommended in the ETSU, thereby failing to protect residents from this annoyance. The noise is comparable to that of helicopters. Because of its LFN nature, the annoyance can be experienced at significant distances from turbines.

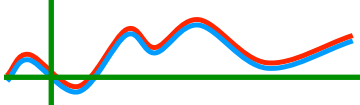
1. There is a phenomenon called aerodynamic modulation (AM) that causes wind turbine noise to take on a loud, "thumping" character and to become audible at a considerable distance from the wind turbines.

2. The fluctuating (amplitude modulated) noise caused by aerodynamic modulation is more noticeable and annoying than broadband noise of the same sound level.

3. The Government is aware of the existence of aerodynamic modulation and has acknowledged that it can be an issue in the case of planning applications for wind farms close to residences in low background noise areas. The Government has, however, refused to take action to update the noise guidelines embodied in ETSU-R-97.

4. The noise monitoring recommended in ETSU-R-97 is totally ineffective in protecting residents from aerodynamic modulation noise, because the specified noise descriptor (LA90, 10min) ignores the noisiest 90% of each ten-minute measurement period and gives a result based on the loudest noise during the quietest 10% of the period.

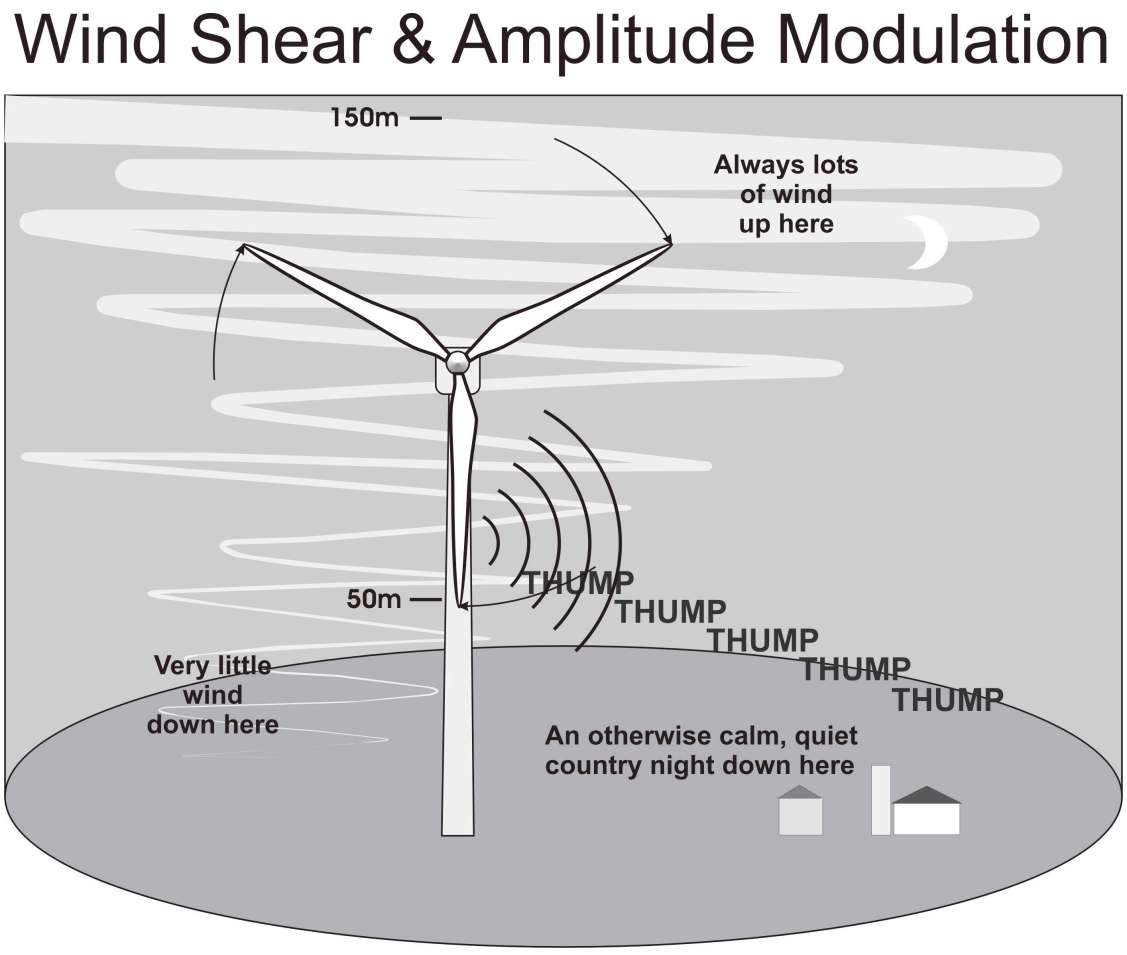
5. ETSU-R-97's recommendation that noise monitoring is carried out at the nearest noise sensitive properties fails to take account of the fact that aerodynamic modulation noise can be heard at considerable distances from a wind farm and can be difficult to detect closer to the wind farm.



## September 8, 1996

**ETSU silent on wind shear and LFN propagation**

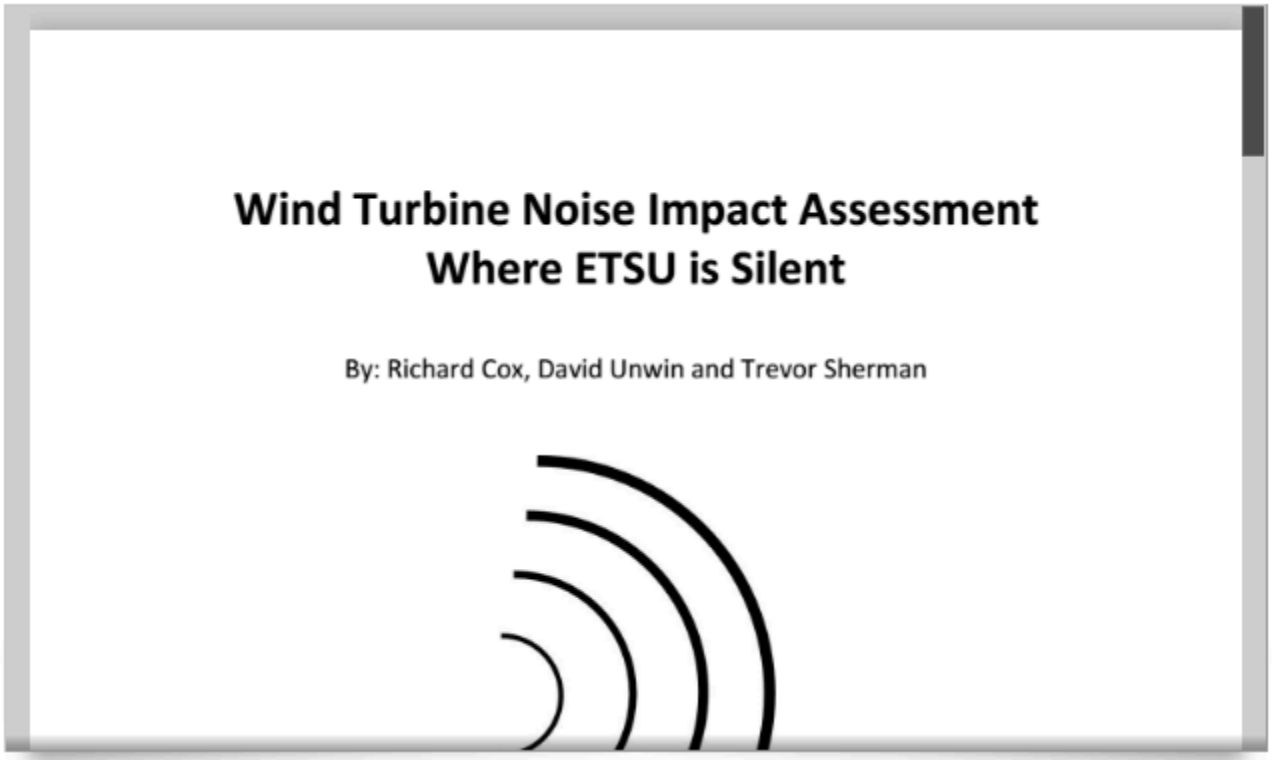
Wind shear occurs when wind speed at upper levels is higher than at lower elevations, which is common at night. This means there is more noise emitted and less masking of the noise at homes. Instead, the ETSU assumes as wind turbine noise increases, there will be a proportional increase in background noise due to increased wind speed.



## October 1, 1996

**ETSU falsely elevates background noise readings to hide noise produced by wind turbines**

Under ETSU, background noise levels set the benchmark for turbine noise criteria. ETSU artificially elevated background levels by using techniques such as poor microphone shielding, limiting monitoring locations, sample size, sample time of day, sample duration, survey period, sample processing.



## February 1, 2003 — March 1, 2003

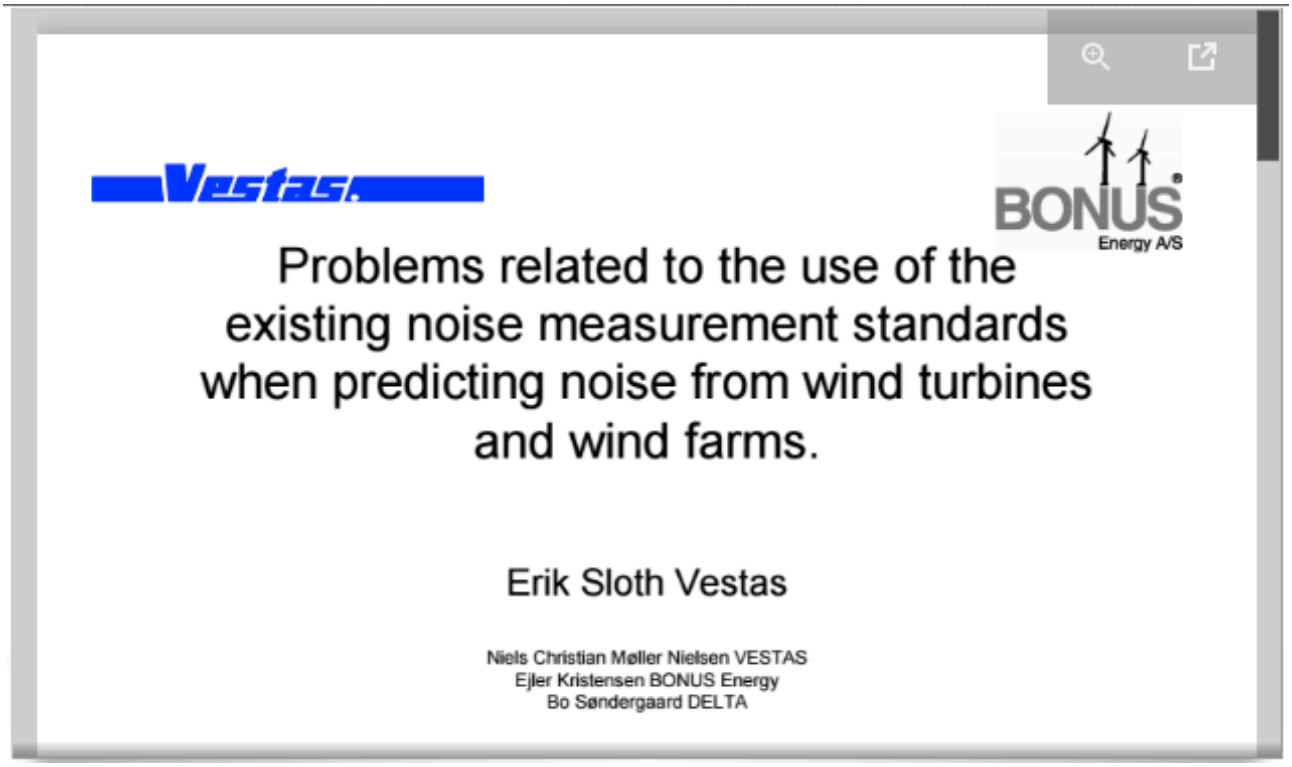
**Australian 1st wind farm noise guidelines follow ETSU**

South Australian EPA release Environmental Noise Guidelines: Wind Farms. The allowable noise limit is set at 35 dB(A). Section 2.2 specifies that the noise criteria for a new wind farm development should not exceed 35 dB(A). The guidelines follow ETSU: use of dB(A) as the exclusive noise measure; deliberating excluding LFN and testing inside homes. In relation to LFN and infrasound it writes: "The EPA has consulted the working group and completed an extensive literature search but is not aware of infrasound being present at any modern wind farm site". The EPA had never carried out any field research to support that assertion.

## July 28, 2004

**Wind industry knows noise models inadequate**

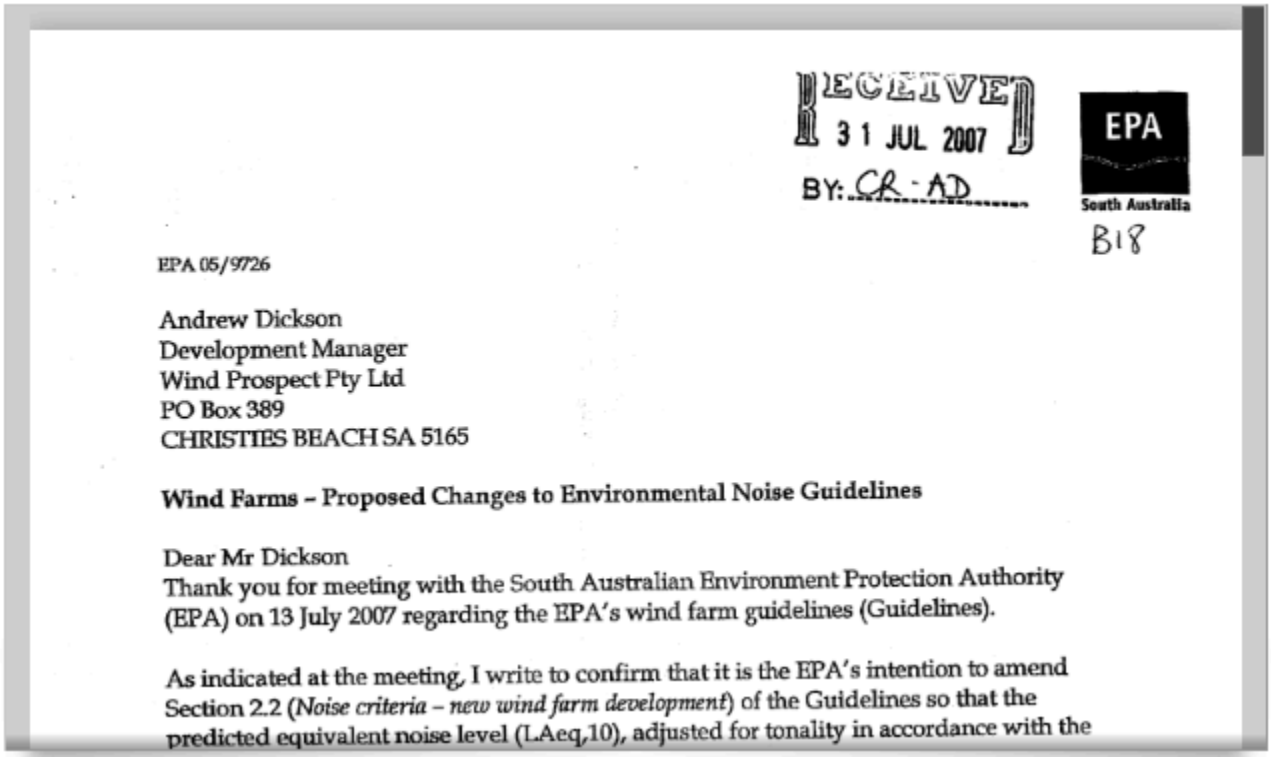
At a Australian Wind industry conference, AUSWEA, Eric Sloth from Vestas presented collaborative research findings (Vestas, Bonus, Delta - later named as Siemens) that confessed that their noise prediction models were inadequate and further research was required.



## July 27, 2007

**Australian wind industry increases turbine noise limit from 35 dB(A) to 40 dB(A)**

This letter from the EPA confirms that the development manager from Wind Prospect was able to convince the SA EPA to up the allowable turbine noise limit from 35 dB(A) to 40 dB(A).



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31 JUL 2007
BY: CR - AD

EPA
South Australia

B18

EPA 05/9726

Andrew Dickson
Development Manager
Wind Prospect Pty Ltd
PO Box 389
CHRISTIES BEACH SA 5165

**Wind Farms – Proposed Changes to Environmental Noise Guidelines**

Dear Mr Dickson
Thank you for meeting with the South Australian Environment Protection Authority (EPA) on 13 July 2007 regarding the EPA's wind farm guidelines (Guidelines).

As indicated at the meeting, I write to confirm that it is the EPA's intention to amend Section 2.2 (*Noise criteria – new wind farm development*) of the Guidelines so that the predicted equivalent noise level (LAeq,10), adjusted for tonality in accordance with the

## July 1, 2009

**Sixty years of WHO research shows sleep deprivation, caused by noise, is a serious adverse health effect**

The WHO reviews the available evidence and concludes sleep deprivation can lead to consequences for health and well-being. They write: "Sleep is a biological necessity and disturbed sleep is associated with a number of adverse impacts on health.... (and) is viewed as a health problem in itself (environmental insomnia), (as) it also leads to further consequences for health and well-being"

## July 1, 2009

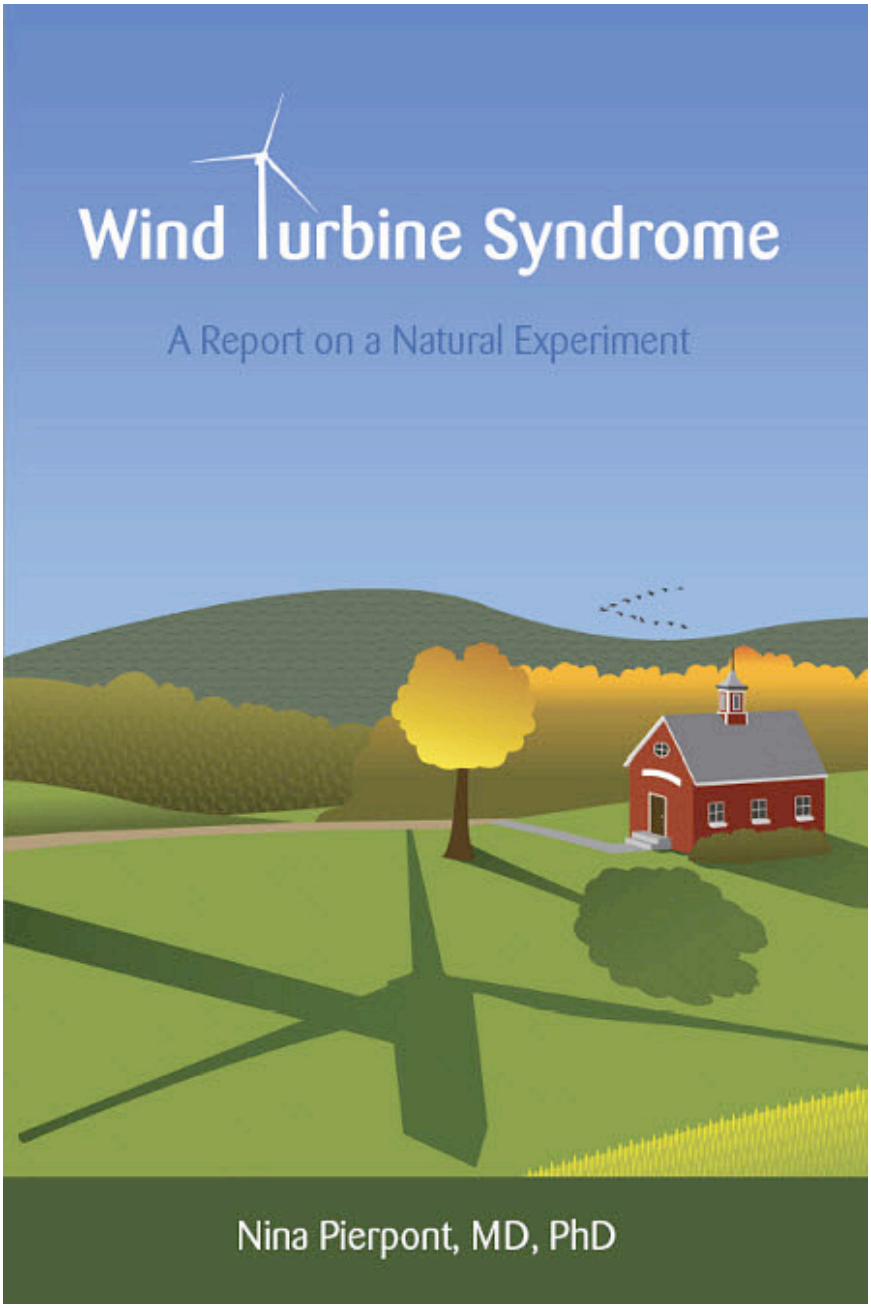
**New version of EPA guidelines - limit up to 40 dB(A)**

New version of SA EPA Environmental Noise Guidelines: Wind Farms. For no other reason than wind industry lobbying, the allowable noise limit is increased from 35 dB(A) to 40 dB(A). The guidelines continue to follow ETSU: use of dB(A) as the exclusive noise measure; deliberating excluding LFN and testing inside homes. In relation to LFN and infrasound it continues to assert: "The EPA has consulted the working group and completed an extensive literature search but is not aware of infrasound being present at any modern wind farm site". The EPA had never carried out any field research to support that assertion.

## July 3, 2009

**Wind turbine syndrome described**

Dr. Nina Pierpont explains how turbine infrasound and LFN create the range of symptoms associated with Wind Turbine Syndrome. Case histories provided as supporting data.



## January 1, 2011

**Infrasound also generated by movement of the turbine tower**

In a study to investigate and mitigate LFN and infrasound from wind turbines that interfere with seismic monitoring to detect nuclear detonations, it was shown that the wind turbine tower itself moves and this is another source of infrasound

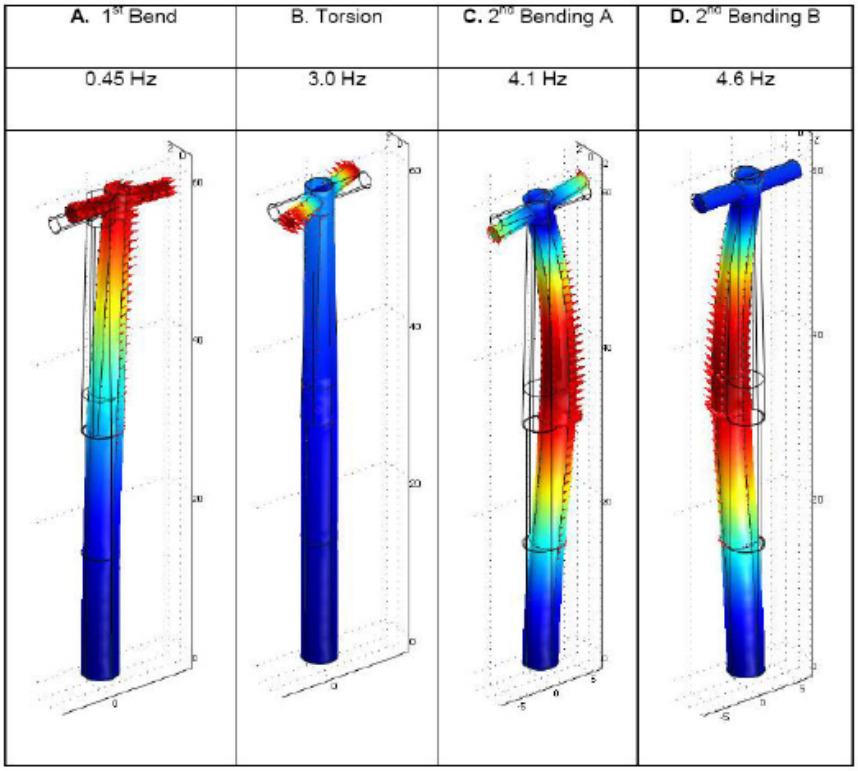



**Figure 4. Frequency response based on FFT and eigenfrequency analysis of vibrations measured at the base of Tower 5 at Crystal Rig on a Nordex N80 wind turbine.**

## June 29, 2011

**Vestas knew that low frequency noise from larger turbines needed greater setbacks**

This is a letter from the CEO of Vestas, lobbying the Danish government not to bring in significant noise regulations, admitting that low frequency noise from larger turbines will increase setback distances needed for neighbours.

TRANSLATIONZ

Suite 413, 1 Queens Road
Melbourne, VIC 3004
Melbourne Phone (03) 9005 6661
Sydney Phone (02) 8003 5446
Brisbane Phone (07) 3040 0226
Perth Phone (08) 6102 1211

www.translationz.com.au

Vestas

Karen Ellemann, Minister of Environment
Department of Environment
Højbro Plads 4
1200 Copenhagen K

[Stamp:RECEIVED
BY THE DEPARTMENT
30 JUNE 2011]

Date
Randers, 29 June 2011/erkjs

Dear Karen Ellemann,

Following previous correspondence, I am writing this letter to express my concern regarding the limits for low frequency noise from wind turbines now being proposed.

Back in January 2011 we applauded your announcement of the new regulations regarding low frequency noise and the fact that you also then emphasised that those regulations would not be tightened and that it was a question of improving the security in connection with the installation of wind turbines. Accordingly, the reaction

## December 1, 2011

**Draft NSW guidelines for wind farms released for discussion**

New guidelines for wind farm operation are drafted. Some LFN testing proposed and C-weighting used. Lower noise limits (drop from 40 to 35 dB(A) are proposed. 2km setback. No in home testing performed.

## March 1, 2012

**Vestas attempt to avoid LFN measurement**

Wind turbine manufacturer Vestas implores NSW government to remove any reference to LFN and exclude any testing, Also ask for noise limits to stay at 40 dB(A).

Vestas

Vestas Australian Wind Technology Pty Ltd

14 March 2012

Policy, Planning Systems and Reform
NSW Department of Planning and Infrastructure
GPO Box 39
SYDNEY NSW 2001

By email: innovation@planning.nsw.gov.au

Dear Sir/Madam

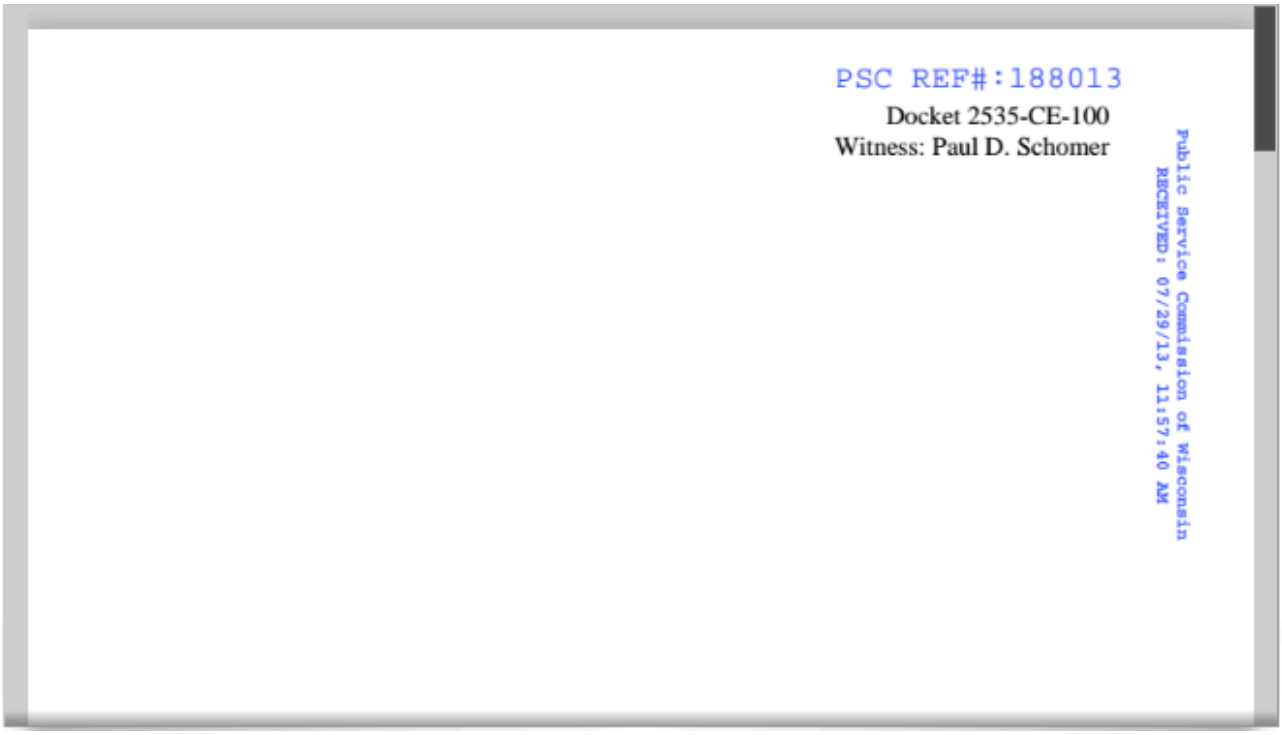
**DRAFT NSW PLANNING GUIDELINES: WIND FARMS**

Thanks you for the opportunity to make a submission on the *Draft NSW Planning Guidelines: Wind Farms* (**the Draft Guidelines**).

## August 1, 2013

**Wind developers refuse to cooperate with noise impact studies**

Dr. Paul Schomer, George Hessler and Rob Rand investigates the Shirley Wisconsin wind farm acoustic annoyance and concludes "Most residents do not hear the wind-turbine sound; noise annoyance is not an issue. The issue is physiological responses that result from the very low-frequency infrasound and which appears to be triggering motion sickness in those who are susceptible to it." Schomer laments the difficulty of studying wind turbine annoyance when developers refuse to cooperate by allowing on-off testing.



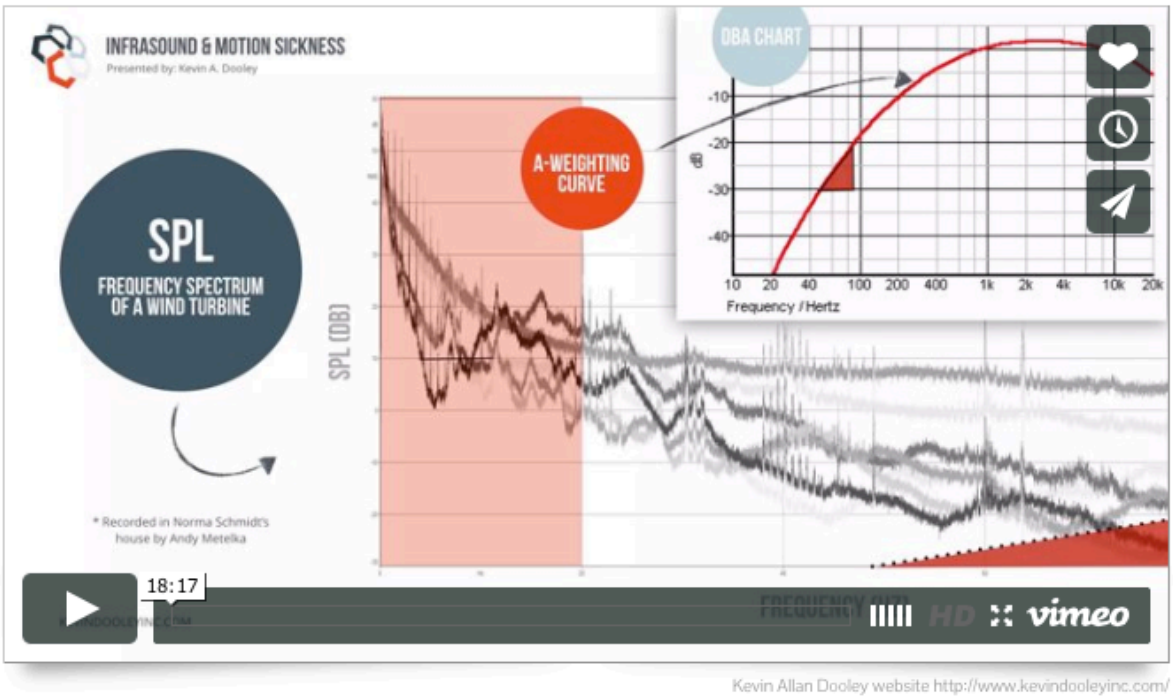
PSC REF#:188013
Docket 2535-CE-100
Witness: Paul D. Schomer

Public Service Commission of Wisconsin
RECEIVED: 07/29/13, 11:57:40 AM

## September 1, 2014

**Cones of wind turbine infrasound hypothesis and motion sickness**

Kevin Dooley proposes that 'cones' of infrasound exposure from wind turbines is related to motion sickness symptoms.

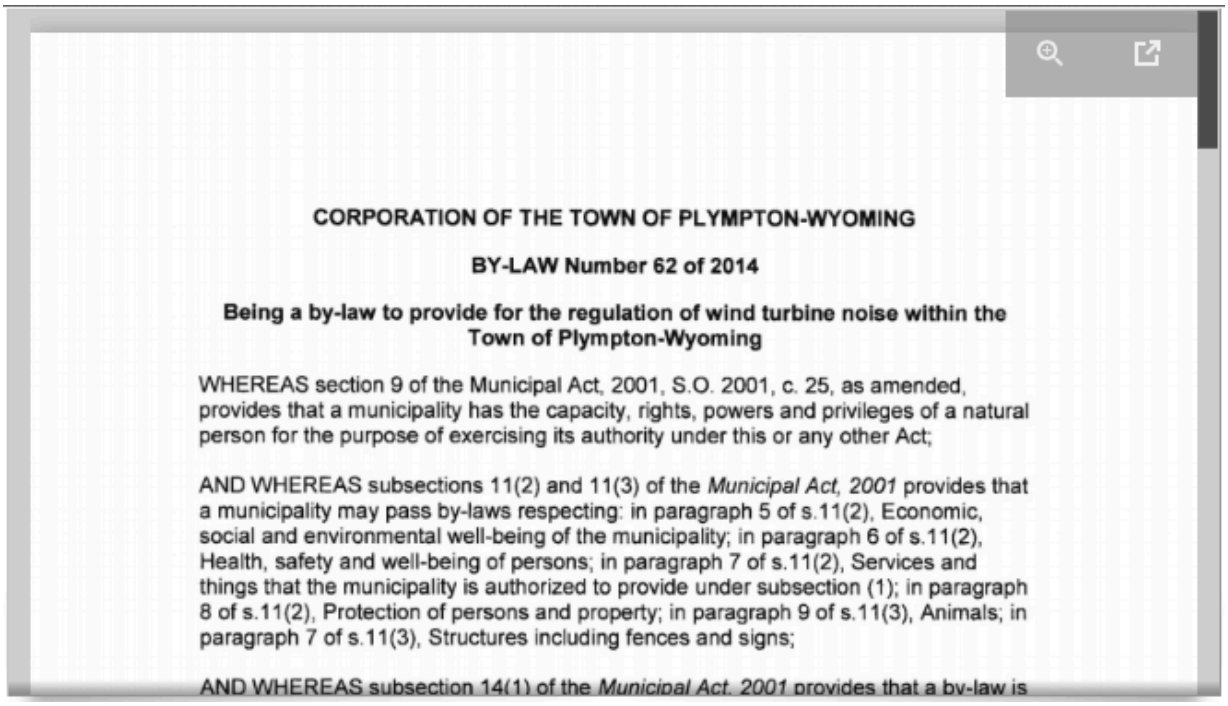



Kevin Allan Dooley website http://www.kevindooleyinc.com/

## October 1, 2014

**Ontario Council enacts new by-law including infrasound from wind farms**

Under the bylaw, if a resident complains about infrasound, the municipality would hire an engineer qualified to take the measurements before laying a charge. If a company is found guilty – can range from $500 to $10,000 per offense and could exceed $100,000 if the offense continues. The municipality recoups the cost of the specialized testing under the bylaw.



**CORPORATION OF THE TOWN OF PLYMPTON-WYOMING**

**BY-LAW Number 62 of 2014**

**Being a by-law to provide for the regulation of wind turbine noise within the Town of Plympton-Wyoming**

WHEREAS section 9 of the Municipal Act, 2001, S.O. 2001, c. 25, as amended, provides that a municipality has the capacity, rights, powers and privileges of a natural person for the purpose of exercising its authority under this or any other Act;

AND WHEREAS subsections 11(2) and 11(3) of the *Municipal Act, 2001* provides that a municipality may pass by-laws respecting: in paragraph 5 of s.11(2), Economic, social and environmental well-being of the municipality; in paragraph 6 of s.11(2), Health, safety and well-being of persons; in paragraph 7 of s.11(2), Services and things that the municipality is authorized to provide under subsection (1); in paragraph 8 of s.11(2), Protection of persons and property; in paragraph 9 of s.11(3), Animals; in paragraph 7 of s.11(3), Structures including fences and signs;

AND WHEREAS subsection 14(1) of the *Municipal Act, 2001* provides that a by-law is

## October 1, 2014

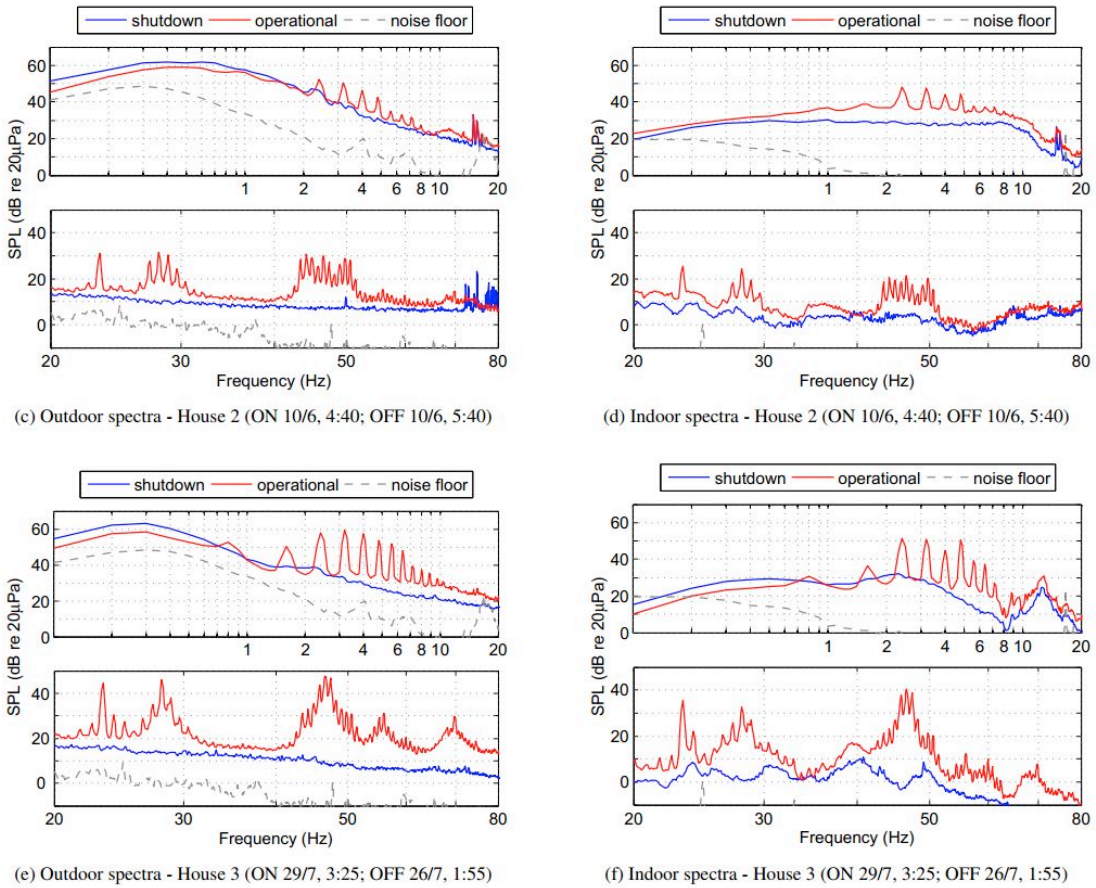
**US Wind farm declared 'Hazard to Human Health'**

The Brown County Board of Health declared the Shirley-Wisconsin wind farm 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."

## November 1, 2014

### Infrasonic wind turbine signature in homes

Private noise testing still was happening inside peoples homes because they were suffering. However this was happening without the co-operation of the wind turbine operators. They refuse to provide on-off testing to demonstrate that the turbines are causing the infrasonic pulses inside their homes or provide hub-height wind speed data to determine wind shear. One such study was underway at Waterloo South Australia when a cable fault allowed de facto on-off testing to be conducted. They demonstrate that the 'wind turbine signature' of the pulses created by the blades passing the tower is only evident when turbines are operational.




(c) Outdoor spectra - House 2 (ON 10/6, 4:40; OFF 10/6, 5:40)

(d) Indoor spectra - House 2 (ON 10/6, 4:40; OFF 10/6, 5:40)

(e) Outdoor spectra - House 3 (ON 29/7, 3:25; OFF 26/7, 1:55)

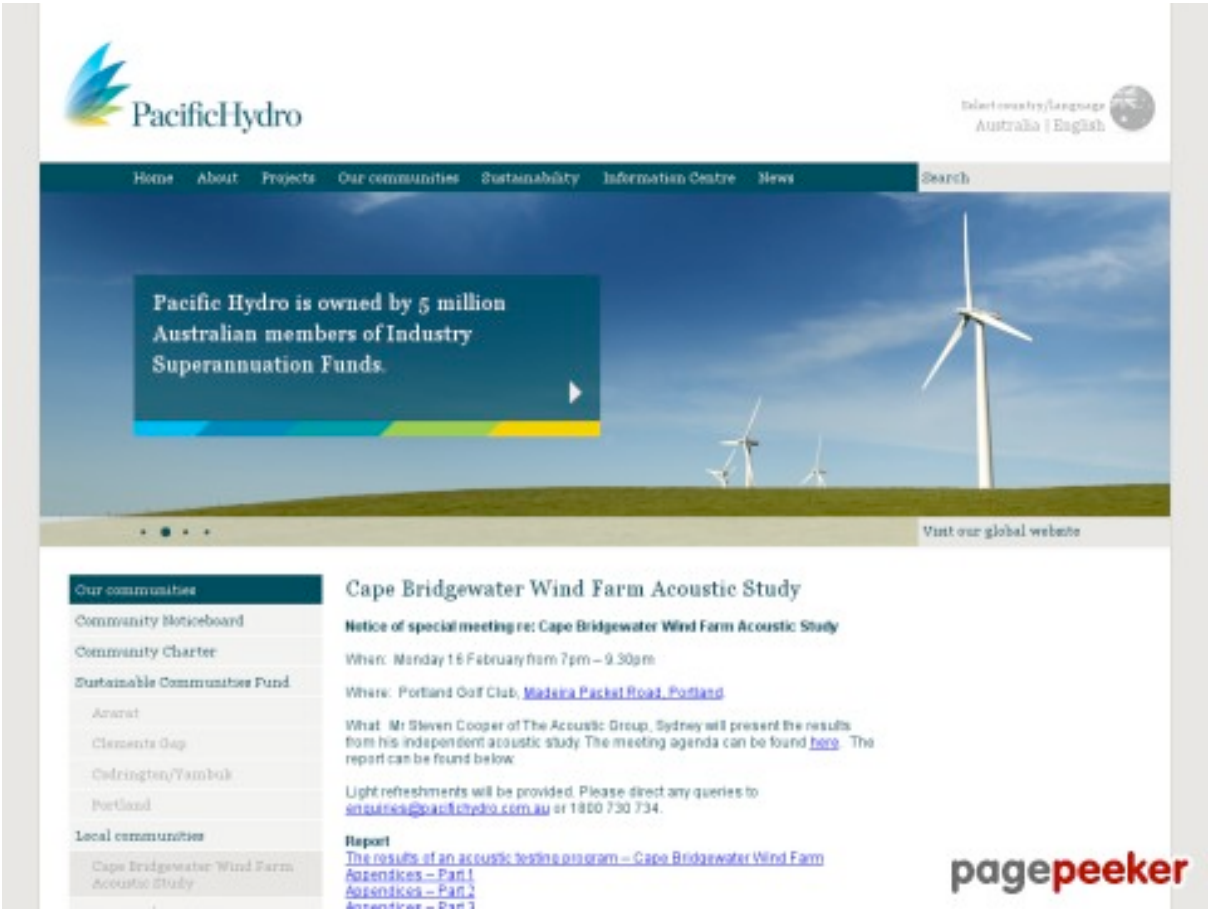
(f) Indoor spectra - House 3 (ON 29/7, 3:25; OFF 26/7, 1:55)

Figure 6 – Comparison of outdoor and indoor narrow-band spectra with local wind conditions similar to wind farm shutdown conditions

## November 14, 2014

**Cause and effect relationship established - Turbine LFN and human sensation of annoyance in homes**

Commissioned by Pacific Hydro, and performed by Steven Cooper at Cape Bridgewater with 6 individuals who kept diaries of the sensations they were experiencing. Parallel in-home testing of turbine noise revealed wind turbine signature and its presence correlated with annoyance as recorded in participant diaries. A cause and effect relationship is undeniable.

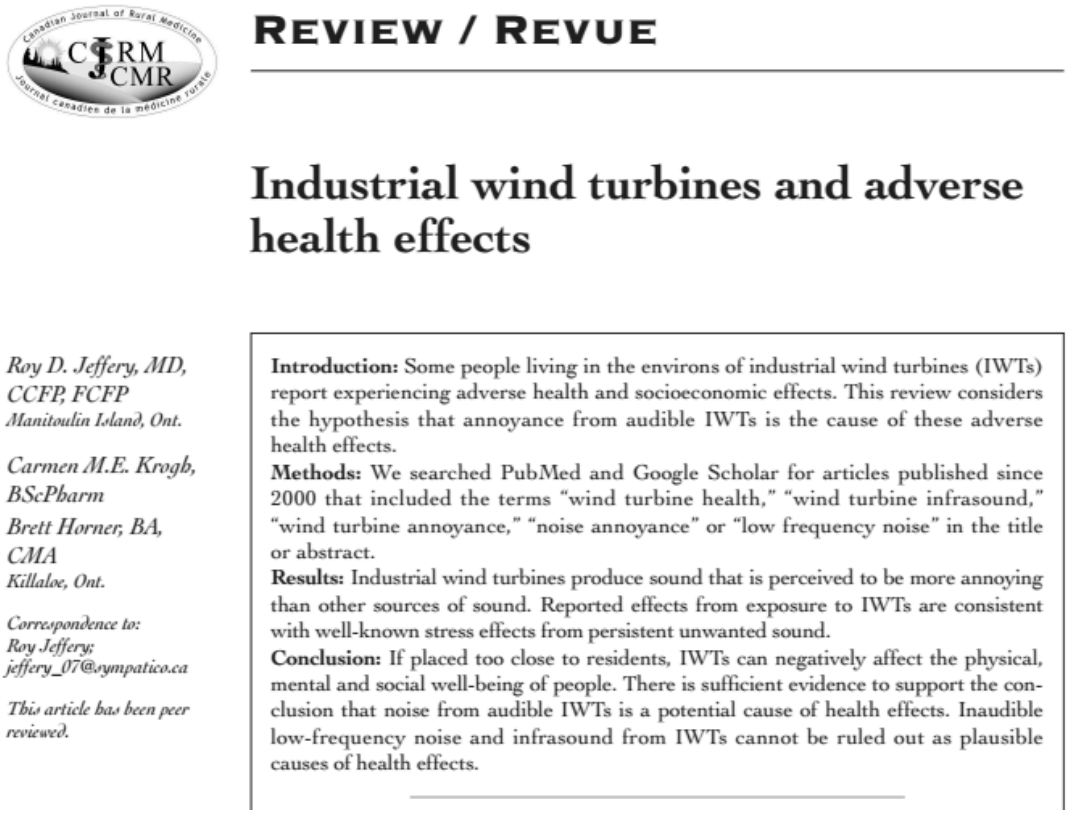



[Note - as before: The quality leaves much to be desired.]

## December 1, 2014

**Evidence mounts that wind turbines impact on health**

21 peer reviewed papers on the adverse health effects of wind turbines



REVIEW / REVUE

# Industrial wind turbines and adverse health effects

*Roy D. Jeffery, MD, CCFP, FCFP*
*Manitoulin Island, Ont.*

*Carmen M.E. Krogh, BScPharm*

*Brett Horner, BA, CMA*
*Killaloe, Ont.*

*Correspondence to:*
*Roy Jeffery;*
*jeffery_07@sympatico.ca*

*This article has been peer reviewed.*

**Introduction:** Some people living in the environs of industrial wind turbines (IWTs) report experiencing adverse health and socioeconomic effects. This review considers the hypothesis that annoyance from audible IWTs is the cause of these adverse health effects.

**Methods:** We searched PubMed and Google Scholar for articles published since 2000 that included the terms "wind turbine health," "wind turbine infrasound," "wind turbine annoyance," "noise annoyance" or "low frequency noise" in the title or abstract.

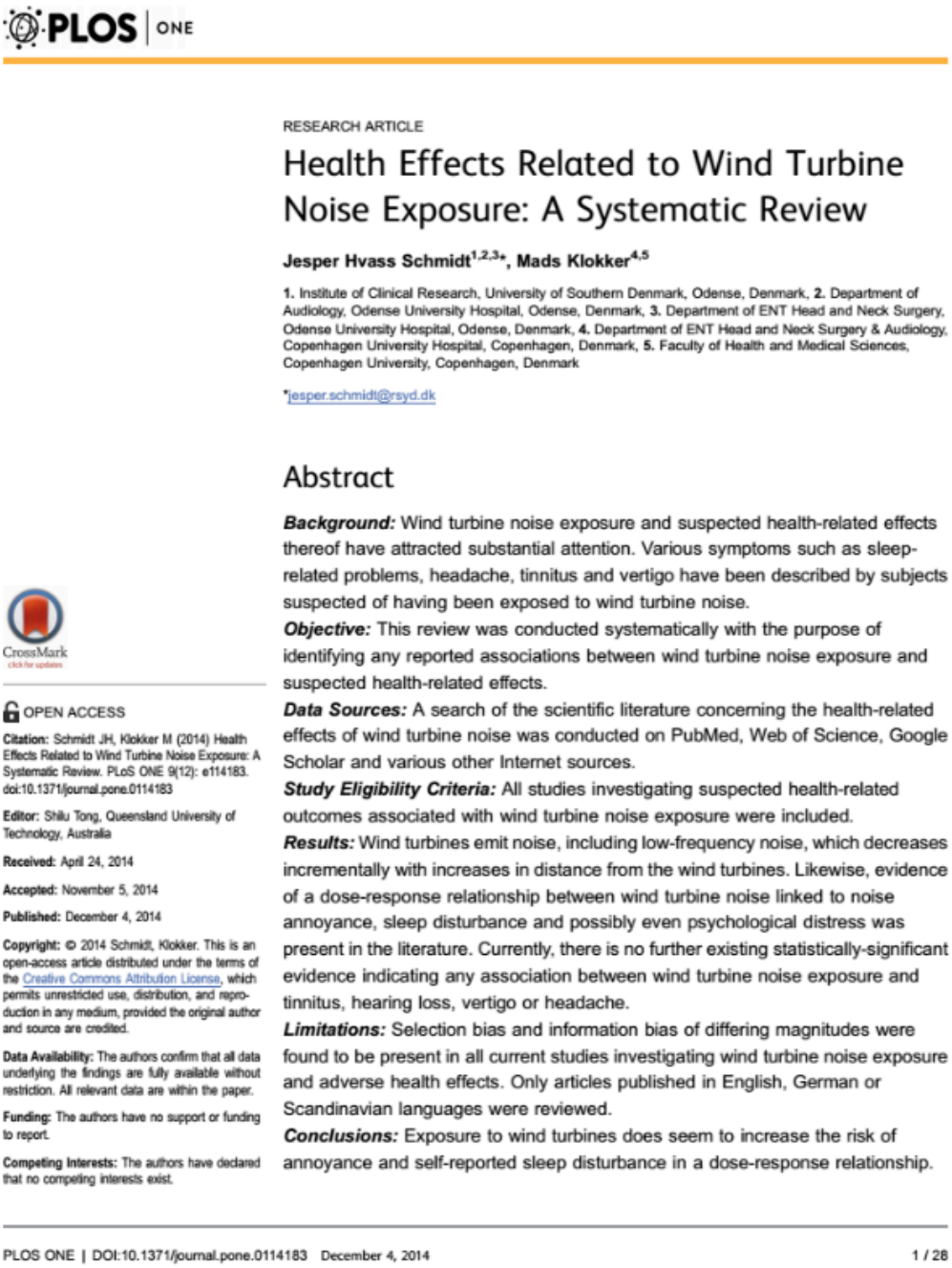
**Results:** Industrial wind turbines produce sound that is perceived to be more annoying than other sources of sound. Reported effects from exposure to IWTs are consistent with well-known stress effects from persistent unwanted sound.

**Conclusion:** If placed too close to residents, IWTs can negatively affect the physical, mental and social well-being of people. There is sufficient evidence to support the conclusion that noise from audible IWTs is a potential cause of health effects. Inaudible low-frequency noise and infrasound from IWTs cannot be ruled out as plausible causes of health effects.

## December 1, 2014

### Sleep deprivation by wind turbine noise: a dose-response relationship identified

Danish study concludes that noise from wind turbines increases the risk of annoyance and disturbed sleep in exposed subjects in a dose-dependent relationship. The higher the dose or exposure to LFN and infrasound, the worse the disruption to sleep.



PLOS | ONE

RESEARCH ARTICLE

# Health Effects Related to Wind Turbine Noise Exposure: A Systematic Review

**Jesper Hvass Schmidt**[1,2,3]*, **Mads Klokker**[4,5]

**1.** Institute of Clinical Research, University of Southern Denmark, Odense, Denmark, **2.** Department of Audiology, Odense University Hospital, Odense, Denmark, **3.** Department of ENT Head and Neck Surgery, Odense University Hospital, Odense, Denmark, **4.** Department of ENT Head and Neck Surgery & Audiology, Copenhagen University Hospital, Copenhagen, Denmark, **5.** Faculty of Health and Medical Sciences, Copenhagen University, Copenhagen, Denmark

*jesper.schmidt@rsyd.dk

## Abstract

***Background:*** Wind turbine noise exposure and suspected health-related effects thereof have attracted substantial attention. Various symptoms such as sleep-related problems, headache, tinnitus and vertigo have been described by subjects suspected of having been exposed to wind turbine noise.

***Objective:*** This review was conducted systematically with the purpose of identifying any reported associations between wind turbine noise exposure and suspected health-related effects.

***Data Sources:*** A search of the scientific literature concerning the health-related effects of wind turbine noise was conducted on PubMed, Web of Science, Google Scholar and various other Internet sources.

***Study Eligibility Criteria:*** All studies investigating suspected health-related outcomes associated with wind turbine noise exposure were included.

***Results:*** Wind turbines emit noise, including low-frequency noise, which decreases incrementally with increases in distance from the wind turbines. Likewise, evidence of a dose-response relationship between wind turbine noise linked to noise annoyance, sleep disturbance and possibly even psychological distress was present in the literature. Currently, there is no further existing statistically-significant evidence indicating any association between wind turbine noise exposure and tinnitus, hearing loss, vertigo or headache.

***Limitations:*** Selection bias and information bias of differing magnitudes were found to be present in all current studies investigating wind turbine noise exposure and adverse health effects. Only articles published in English, German or Scandinavian languages were reviewed.

***Conclusions:*** Exposure to wind turbines does seem to increase the risk of annoyance and self-reported sleep disturbance in a dose-response relationship.

OPEN ACCESS

**Citation:** Schmidt JH, Klokker M (2014) Health Effects Related to Wind Turbine Noise Exposure: A Systematic Review. PLoS ONE 9(12): e114183. doi:10.1371/journal.pone.0114183

**Editor:** Shilu Tong, Queensland University of Technology, Australia

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**Published:** December 4, 2014



**Data Availability:** The authors confirm that all data underlying the findings are fully available without restriction. All relevant data are within the paper.

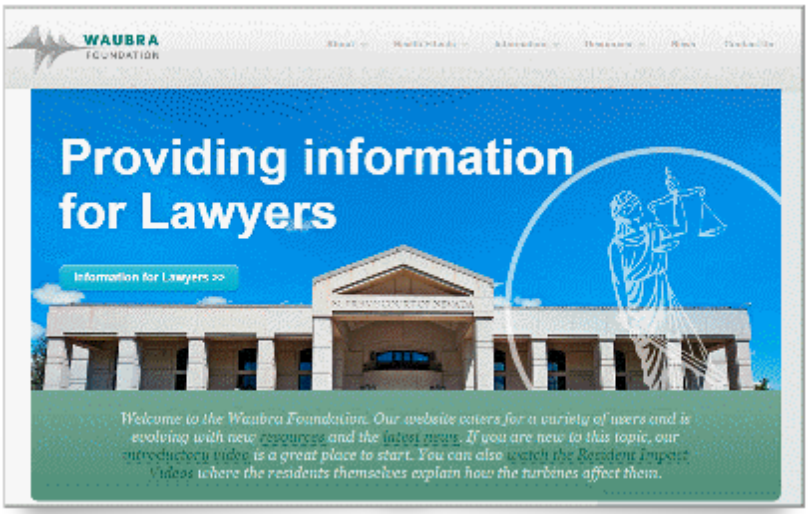
**Funding:** The authors have no support or funding to report.

**Competing Interests:** The authors have declared that no competing interests exist.

## February 14, 2015

**The story so far ...**

We have now come full circle - just as was found 30 years ago - the dB(A) noise filter is totally irrelevant, infrasound LFN is the cause of adverse heath effects and as this is not attenuated, but is often amplified by structures, in-home testing must be used to protect neighbours. Find out more, as the story continues to develop through the Waubra Foundation, a not-for-profit organisation that represents the communities that have been adversely impacted by wind turbines.


WAUBRA
FOUNDATION
Advocating full spectrum noise measurements
Information for Acousticians & Noise Regulators >>
Welcome to the Waubra Foundation. Our website caters for a variety of users and is evolving with new resources and the latest news. If you are new to this topic, our introductory video is a great place to start. You can also watch the Resident Impact Videos where the residents themselves explain how the turbines affect them.


WAUBRA
FOUNDATION
Giving hope to Residents
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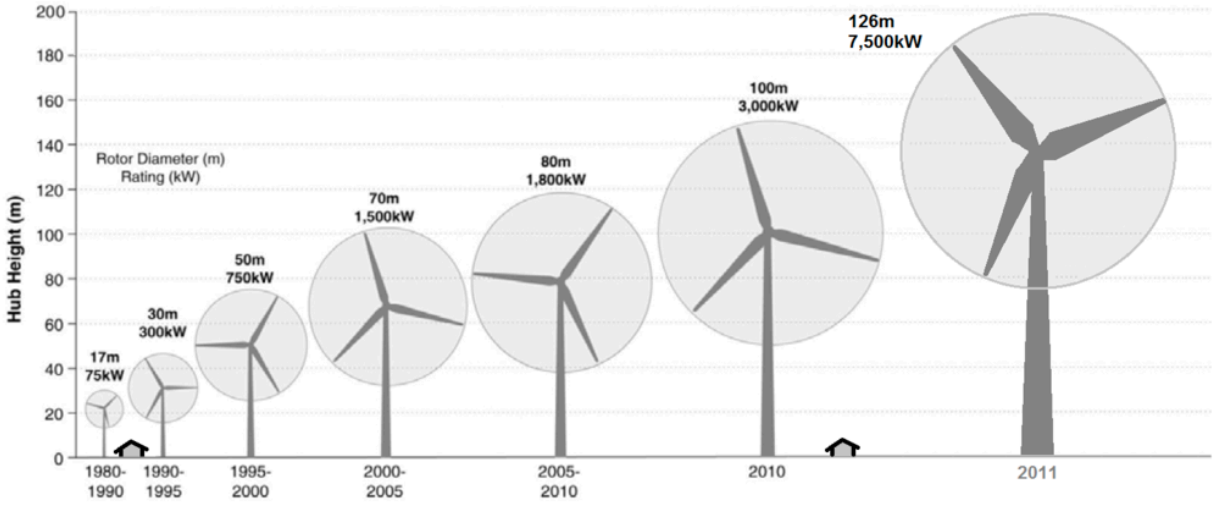
# APPENDIX 2: MODERN HISTORY OF WIND TURBINES[1]




1 http://en.wikipedia.org/wiki/History_of_wind_power

# APPENDIX 3: SPECIFICATIONS OF LARGEST TURBINES2

| Manufacturer | Blade Length | Capacity |
|---|---|---|
| Vestas V164 | 80 m | 8 MW |
| Enercon E126 | 63 m | 7.5 MS |
| Samsung S7.0 171 | 85 m | 7 MW |
| Repower 6M Series | 63 m | 6.15 MW |
| Siemens SWT-6.0 | 75 m | 6 MW |
| Alstom Haliade | 75 m | 6 MW |
| Sinovel LS6000 | 64 m | 6 MW |
| Arvena M5000 | 68 m | 5 MW |
| Gamesa G5MW | 64 m | 5 MW |
| Bard 5MW | 61 m | 5 MW |
| XEMC 5MW | 57 m | 5 MW |

2 http://www.windpowermonthly.com/10-biggest-turbines

# APPENDIX 4: WORLD RECORDS FOR WIND TURBINES[3]

**Largest capacity**

The Vestas V164 has a rated capacity of 8.0 MW,[50] has an overall height of 220 m (722 ft), a diameter of 164 m (538 ft), and is the world's largest-capacity wind turbine since its introduction in 2014. At least five companies are working on the development of a 10 MW turbine.

**Largest swept area**

The turbine with the largest swept area is the Samsung S7.0-171, with a diameter of 171 m, giving a total sweep of 22966 m2.

**Tallest**

Vestas V164 is the tallest wind turbine, standing in Østerild, Denmark, 220 meters tall, constructed in 2014.

**Tallest Hybrid Wind turbine**

Suzlon Energy S97 120m is the tallest hybrid wind turbine,[51] in Kutch, Gujarat, India. The turbine is 120 metre tall and was installed in November 2014.

**Highest tower**

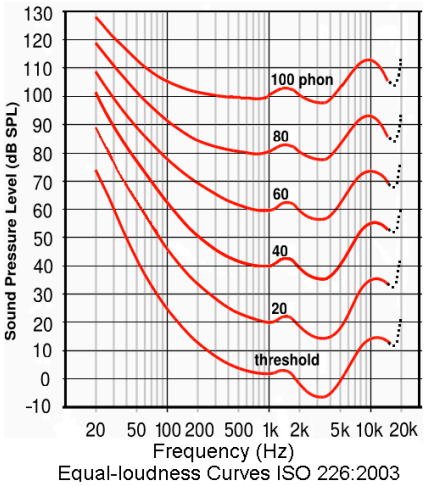
Fuhrländer installed a 2.5MW turbine on a 160m lattice tower in 2003 (see Fuhrländer Wind Turbine Laasow)

**Largest vertical-axis**

Le Nordais wind farm in Cap-Chat, Quebec has a vertical axis wind turbine (VAWT) named Éole, which is the world's largest at 110 m.[52] It has a capacity of 3.8 MW.[53]

**Largest 2 bladed turbine**

Today's biggest 2 bladed turbine is build by Mingyang Wind Power in 2013. It is a SCD6.5MW offshore downwind turbine, designed by aerodyn Energiesysteme[54][55]



Equal-loudness Curves ISO 226:2003

**Most southerly**

The turbines currently operating closest to the South Pole are three Enercon E-33 in Antarctica, powering New Zealand's Scott Base and the United States' Station since December 2009[56][57] although a modified HR3 turbine from Northern Power Systems operated at the Amundsen-Scott South Pole Station in 1997 and 1998.[58] In March 2010 CITEDEF designed, built and installed a wind turbine in Argentine Marambio Base.[59]

**Most productive**

Four turbines at Rønland wind farm in Denmark share the record for the most productive wind turbines, with each having generated 63.2 GWh by June 2010.[60]

**Highest-situated**

Since 2013 the world's highest-situated wind turbine is made by United Wind power China Guodian Corporation installed by the Longyuan Power and located in the Naqu country, Tibet (China) around 4,800 meters (15,700 ft) above sea level.[61][62] The site uses a 1500 kW wind turbine designed by aerodyn Energiesysteme.[63]

**Largest floating wind turbine**

The world's largest—and also the first operational deep-water large-capacity—floating wind turbine is the 2.3 MW Hywind currently operating 10 kilometres (6.2 mi) offshore in 220-meter-deep water, southwest of Karmøy, Norway. The turbine began operating in September 2009 and utilizes a Siemens 2.3 MW turbine.[64][65]

[3] http://en.wikipedia.org/wiki/Wind_turbine

# APPENDIX 5: A TIMELINE OF THE HISTORY OF WIND POWER[4]

[From 1887] people have harnessed the wind's energy for electricity. But how did it develop into a clean, abundant and free solution to tackling global warming?

**By Niki Nixon.**

**July 1887, Glasgow, Scotland**
The first windmill for electricity production is built by Professor James Blyth of Anderson's College, Glasgow (now Strathclyde University). The professor experiments with three different turbine designs, the last of which is said to have powered his Scottish home for 25 years.

**Winter 1887 – Ohio, US**
Professor Charles F. Brush builds a 12kW wind turbine to charge 408 batteries stored in the cellar of his mansion. The turbine, which ran for 20 years, had a rotor diameter of 50m and 144 rotor blades.

**1890s – Askov, Denmark**
Scientist Poul la Cour begins his wind turbine tests in a bid to bring electricity to the rural population of Denmark. In 1903, Poul la Cour founded the Society of Wind Electricians and in 1904 the society held the first course in wind electricity. La Cour was the first to discover that fast rotating wind turbines with fewer rotor blades were most efficient in generating electricity production.

**1927 – Minneapolis, US**
Joe and Marcellus Jacobs open the Jacobs Wind factory, producing wind turbine generators. The generators are used on farms to charge batteries and power lighting.

**1920s**
The first vertical axis wind turbine, the Darrieus turbine, is invented by Frenchman George Darrieus who in 1931 has it patented in the US. The design, often referred to as the "eggbeater windmill", due to the appearance of its two or three blades, is still used today.

**1931 – Yalta, former USSR**
A precursor to the modern horizontal wind generator is used in Yalta, generating 100kW. The turbine has a 30m tower and a 32% load factor, meaning it provides 32% of its potential energy output, pretty good even by today's standards.

**1941 – Vermont, US**
The world's first megawatt wind turbine is built and connected to the power grid in Castleton, Vermont. The turbine has 75-foot blades and weighs 240 tons.

**1956 – Gedser, Denmark**
The Gedser wind turbine is built by Johannes Juul, a former student of Poul la Cour. The 200kW, three-bladed turbine inspired many later turbine designs, and Juul's invention - emergency aerodynamic tip

[4] http://www.theguardian.com/environment/2008/oct/17/wind-power-renewable-energy

breaks – is still used in turbines today. The turbine operated until 1967 and was refurbished in the mid 1970s at the request of Nasa.

**1970s – Ohio, US**
The United States government, led by Nasa, begins research into large commercial wind turbines. Thirteen experimental turbines are put into operation and the research paves the way for many of the multi-megawatt technologies used today.

**1980 – New Hampshire, US**
The world's first wind farm consisting of 20 turbines is built in New Hampshire. The wind farm however, is a failure as the turbines break down and the developers overestimate the wind resource.

**1981 – Washington and Hawaii, US**
In 1981 the 7.5mW Mod-2 is build by Nasa, followed in 1987 by the 3.2mW, two-blade wind turbine Mod-5B. Both turbines break records for diameter and energy output.

**1991 – Vindeby, Denmark**
The first offshore wind farm is created in Vindeby, in the southern part of Denmark. The wind farm consists of 11 450kW turbines.

**1991 – Cornwall, UK**
The UK's first onshore wind farm is opened in Delabole, Cornwall. The farm consists of 10 turbines and produces enough energy for 2,700 homes.

**2003 – north Wales, UK**
The UK's first offshore wind farm is opened. North Hoyle offshore wind farm is located 7-8km off the north Wales coast between Prestatyn and Rhyl and consists of 30 2mW turbines.

**2007 - Stirling, UK**
Installed capacity of wind power in the UK reaches 2gW, with the opening of the Braes O'Doune wind farm, in Scotland, which produces 72mW of power.

The UK announced plans for thousands of new offshore wind turbines which could power every home in Britain by 2020.

**2008 - UK**
The EU sets the UK government a target to increase the contribution of renewables to UK electricity to 20% by 2020 as part of efforts to dramatically reduce greenhouse gas emissions and enhance energy security.

Plans to build one of Europe's largest onshore wind farms in the Outer Hebrides were rejected after Scottish ministers ruled the £500m scheme would devastate a globally significant peatland.

There are currently 186 operational wind farms in the UK (both onshore and offshore) with 2,120 turbines creating enough energy to power the equivalent of 1,523,052 homes and saving 6,156,175 tonnes of carbon. There are 42 in construction, with a further 134 consented and 268 in planning.

# APPENDIX 6: REFERENCES ON SLEEP DEPRIVATION.

The metabolic consequences of sleep deprivation, Kristen L. Knutsona, Karine Spiegelb, Plamen Peneva, Eve Van Cautera. Sleep Medicine Reviews, Vol. 11, Issue 3, June 2007, pp163-178.

Effects of Sleep Deprivation on Behaviour, Subsequent Sleep, and Dreaming.Ralph J. Berger , Ian Oswald. BJ Psych, 108, pp 455-457, 1 July, 1962.

Sleep, sleep deprivation and depression: A hypothesis derived from a model of sleep regulation. Borbély, A. A.; Wirz-Justice, A. Human Neurobiology, Vol 1(3), Oct 1982, 205-210.

Neurocognitive Consequences of Sleep Deprivation Jeffrey S. Durmer, M.D., Ph.D.,1 and David F. Dinges, Ph.D. Seminars in Neurology, Vol 25, No 1, 2005.

Sleep deprivation: Effect on sleep stages and EEG power density in man. Alexander, A Borbely, Fritz Baumann, Daniel Brandies, Inge Strauch, Dietrich Lehmann. Electrocephalography and Clinical Neurophysiology, Vol. 51, issue 5, May 1981, pp483-493.

The Cumulative Cost of Additional Wakefulness: Dose-Response Effects on Neurobehavioral Functions and Sleep Physiology From Chronic Sleep Restriction and Total Sleep Deprivation. Hans P.A. Van Dongen, Greg Maislin, Janet M. Mullington, David F. Dinges. SLEEP, Vol. 26, No. 2, 2003

Effects of sleep deprivation on performance: A meta-analysis. Pilcher, June J.; Huffcutt, Allen J. Sleep: Journal of Sleep Research & Sleep Medicine, Vol 19(4), May 1996, 318-326.

A review of studies concerning effects of sleep deprivation and fatigue on residents' performance. Samkoff, J S; Jacques, C H. Academic Medicine: November 1991.

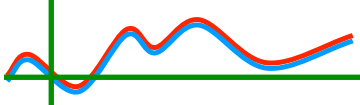
The impact of sleep deprivation on decision making: A review. Harrison, Yvonne; Horne, James A. Journal of Experimental Psychology: Applied, Vol 6(3), Sep 2000, 236-249.

The impact of sleep deprivation on decision making: A review. Harrison, Yvonne; Horne, James. Biological Psychology. Vol. 7, Issue 1-2, September 1978, pp55-102.

Resident performance and sleep deprivation: a review. Asken, M J; Raham, D C. Journal of Medical Education: May 1983.

The impact of inadequate sleep on children's daytime cognitive function. Ronald E. Dah. Seminars in Pediatric Neurology. Volume 3, Issue, March 1996. pp44-50. Sleep Disorders in Childhood.

Sleep deprivation in depression: what do we know, where do we go? Anna Wirz-Justicea, Rutger, H Van den Hoofdakkerb, Biological Psychiatry, Vol. 46, Issue 4, 15 August 1999, pp445–453.



Sleep deprivation and pain perception. Stefan Lautenbachera, Bernd Kunermanna, B Jurgen-Christian Kried, Sleep Medicine Reviews, Volume 10, Issue 5, October 2006, pp357-369.

Invited Review: How sleep deprivation affects gene expression in the brain: a review of recent findings. Chiara Cirelli. Journal of Applied Physiology Published 1 January 2002 Vol. 92 no. 1, 394-400 DOI:

Sleep deprivation therapy. H. Kuhs, R. Tollea, Biological Psychiatry, Vol 29, Issue 11, 1 June 1991, pp1129-1148.

Effects of sleep deprivation on neural function: an integrative review. T.W. Boonstra, J.F. Daffertshofer, P.J. Beck. Cell. Mol. Life. Sci, 64 (2007) pp 934-946.

Short Sleep Duration and Weight Gain: A Systematic Review. Sanjay R. Patel, andFrank B. Hu2,3,4. Obesity. Volume 16, Issue 3, pp 643–653, March 2008.

Partial night sleep deprivation reduces natural killer and cellular immune responses in humans. M. Irwin, J. McKlintick, C. Costlow, M. Fortner, J. White, J.C. Gillin. The FASEB Journal vol. 10 no. 5 643-653 April 1996.
Sleep and Depression. Tsuno, Norifumi; Besset, Alain; Ritchie, Karen. Journal of Clinical Psychiatry, Vol 66(10), Oct 2005, 1254-1269.

Sleep deprivation and the control of ventilation. (PMID:6418047) White, DP, Douglas NJ, Pickett, CK, Zwillich CW, Weil, JV. The American Review of Respiratory Disease. [1983, 128(6): 984-986]

Effect of Sleep Deprivation on Response to Immunizaton Karine Spiegel; John F. Sheridan; Eve Van Cauter. JAMA. 2002;288(12):1471-1472. doi:10.1001/jama.288.12.1469.

The consolidation hypothesis for REM sleep function: Stress and other confounding factors — A review J.A. Horne, M.J. McGrath. Biological Psychology. Volume 18, Issue 3, May 1984, Pages 165–184

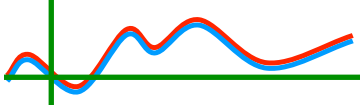
Neurocognitive Consequences of Sleep Deprivation. Namni Goel, Hengyi Rao, Jeffery S. Durmer, David F. Dinges. Seminars in Neurology. 2009 Sept. 29(4) pp320-339.

The metabolic consequences of sleep deprivation. Kristen, L. Knutsona, Karine Spiegelb, Plamen Peneva, Eve Van Cauter. Sleep Medicine Reviews. Volume 11. Issue 3, June 2007. pp163-178.

Sleep. 2010 Mar 1; 33(3): 335–342. Sleep Deprivation Impairs the Accurate Recognition of Human Emotions. Els van der Helm, Ninad Gujar, Matthew, P. Walker.

# APPENDIX 7: COMMON REPORTED SYMPTOMS EXPERIENCE BY PEOPLE EXPOSURE TO INDUSTRIAL WIND TURBINE IMMISSIONS

- Sleep disturbance, loos of sleep
- Headache, including migraines
- Tinnitus
- Ear pressure (often described as painful)
- Balance problems / dizziness
- Vertigo
- Nausea
- Visual blurring
- Irritability
- Problems with concentration and memory
- Panic episodes
- Tachycardia (fast heart rate)
- Unusual feeling of ‘fullness’
- Loss of cognitive function
- loss of short-term memory
- inability to focus on a task
- A feeling of unease
- Nervousness



# APPENDIX 8: IMPLICATIONS OF THE A-WEIGHTING: LOOKING OUTSIDE THE BOX

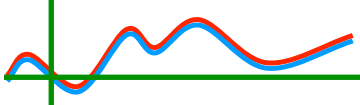
The universal acceptance of the A-Weighting as the standard for environmental noise assessment is flawed on basic principles. It represents an archaic attempt to condense complex data into a single number that is of littel relevance to the reception of sound by the human body. It has no place in public health. While the initial use of the A-weighting, first developed when the science of acoustics was in its infancy, is somewhat understandable, to continue to use a system that fails in its basic objective is at the least naive and at the most nothing short of criminal.

The A-weighting, as discussed earlier, was determined by Harvey Fletcher and Wilden Munsen in the 1920s as a result of their research into human hearing thresholds. It was based on the equal loudness curves, and in particular, the 40 phon curve. The immediate problem is that human hearing response for each frequency is different depending on the actual loudness of the sound (see Equal Loudness Curves ISO 226:2003). Combine this with Fletcher and Munsen's method of testing that used a small number of participants who were subjected to single tones, using occluded-ear headsets, and you have a very artificial hearing experiment of questionable value to normal, unoccluded, hearing in the everyday environment.

The use of a single statistic to represent a complex phenomena is flawed on first principles. The very process of AVERAGING has the effect of hiding or distorting data. The reader's attention is drawn to the simple analogy of using a single representative figure to describe sound pressure levels during the night with respect to sleep disturbance. Noise levels in the natural (and man-made) environments are ever-changing. There is no one sound level, even in the quietest of environments. The environment's only constant is that sound pressure levels are continually changing.

The example of a human response to sound with respect to sleep disturbance is worth reviewing:

Consider sound pressure levels measured in a bedroom during nighttime normally associated with sleeping. There would inevitably be a continuously varying sound pressure level. This is the result of numerous factors: creatures of the night; neighbours; traffic; weather, the list goes on. But what environmental guidelines suggest is that this continuously varying level of sound be given a single, easy to understand, statistic: the LAeq16h. That is, the A-Weighted sound pressure level that represents the same quanta of sound energy if that level was experienced at a single, unchanging loudness during a 16 hour period. This is simply a form of AVERAGE. Thus all the peaks and

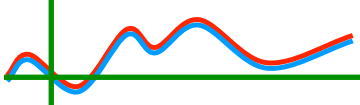


troughs are levelled out to give a single, flat-response value. This equates to an oversimplification of a very complex soundscape. It has no meaning in real life. Imagine if the instruments in an orchestra all played at the same loudness. The beauty of the composition would be all but lost. Another example of the limited value of the average size of tee shirts. We could determine an average by investigating a large number of tee shirts in shops. While that may be useful in determining the percentage of each size to manufacture, it is of no value for an individual person who goes to buy a tee shirt for themselves. You would not buy an average shirt unless it fitted you. Again we see that *averages have little relevance to an individual situation*. Population statistics, for example, often use averages to describe the number of children per family in a particular population. The average number of children per family in the United States for 2014 is 3.13: in many respects a meaningless number. There is no such thing as 0.13 of a child. Let's take another analogy to simplify the point relating more to wave energy.

Imaging that you wanted to measure the level of the water in a swimming pool. You could do this by taking a simple measurement at one end. However, you would fint it continually varying. The reason is that people are jumping into the pool and swimming, splashing about and simply having fun. Obviously the water level we are measuring will be going up and down continuously, but if we take enough measurements we might be able to describe what we think the level might be if there was nobody swimming and the pool and it was allowed to become still. But we might still be able to make a reasonable estimate of the depth of water in the pool and from this and knowing the dimensions of the pool calculate the volume of water. But the burning question is: Does the level of the water in the pool best describe the volume of the water in the pool, and for what purpose?

The obvious answer is: Yes and No. If we want to calculate the volume of water in the pool for the purpose of adding chlorine to keep the water fresh and free from bacteria, then our estimate might not be too bad. But if we wanted to determine how high the walls of the pool should be to stop waves washing over the edge, just knowing the average level of the water is insufficient. The point is, the form of measurement (statistic) must be **fit-for-purpose**. The simple point is that the A-Weighting is not fit for purpose as a measurement of noise with respect to sleep disturbance. To explain this point, let us return to the hypothetical example relating to sleep disturbance:

It is not difficult to comprehend that any small variance of sound pressure levels will be 'ironed-out' using any sort of averaging statistic. So the overall level we get from a night's monitoring will be a single number. But how is that useful? Just like measuring the height of water in our swimming pool in the previous example, one single, average measurement is only suitable for some purposes. Not all. If somebody fired a gun outside the window of the bedroom where our subject was sleeping, while that will have little effect on the overall average level (LAeq), but it wile likely have a profound effect



on our subject. So while our subject would undoubtedly be woken up, and no doubt frightened into the bargain, the single-figure statistical representation of the average sound level will be little changed and probably still within the normal range for uninterrupted sleep (refer to the WHO guidelines as mentioned earlier). The salient point is that averages hide data.

The important fact is that the **human organism responds to peaks, not to averages**. Man's very survival depended upon being able to sense and respond to peaks. Averages mean very little - in terms of survival. When we consider peaks, that does not mean just loud peaks (or maxima). It also refers to lows (or minima) and discontinuities of level and timbre. A perfect example where minima are important was introduced to me by ????? who was the Chief Of Staff of the New Zealand Defence Force.

What he ??? told me was that when you are fighting in the jungle (literally) the average background sound level of a jungle is of extreme importance. That is, the sound of the animals and insects, the wind and weather are all important indicators that your survival can depend on. When everything is 'normal', there normal soundscape. The problem arises when the normal sounds of the jungle 'go quiet', when animals and insects stop making their usual noise. This can mean only one of two things: either a leopard (or other predator) is in the vicinity, or there is a sniper close by. In either case, the absence of 'normal' jungle sounds is vital to your very survival. It is a case of minima being of equal importance to maxima.

## Alternative acoustic pathways & adverse health effects

The predominant focus of environmental protection with respect to acoustics has historically been based on noise-induced hearing loss. This has been the prime thrust of public health regulation for the best part of a century, but it is far from the only danger. The effect of acoustic energy on the human organism is not restricted to the auditory pathways - or the vestibular system (balance). There is now compelling neurophysiological evidence to support the pathway that low-frequency and infrasound uses to impact on the human body by way of the landmark work of Professor Alec Salt. Low-frequency and infrasound research has a far longer history, however, as stated by C. Maschke[5]:

> **"Historically, early work on low frequency noise and its effects on health and performance were stimulated by the American and Russian space programs, sources of very high levels of low**

[5] Editorial - Introduction to the Special Issue on Low Frequency Noise. Noise and Health 2004, 6;23,1-2.

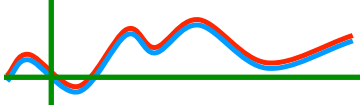
> frequency noise and vibration. Animal experiments in the last 50 years have shown that high levels of low frequency noise and vibration can influence the respiratory rate, the heart functions, the stomach and intestine functions and the function of the central nervous system, as well as increase the rate of abnormal mitosis. The increase of low frequency noise and vibrations in the everyday environment is a new challenge for industrialized nations."

Maschke goes on to state:

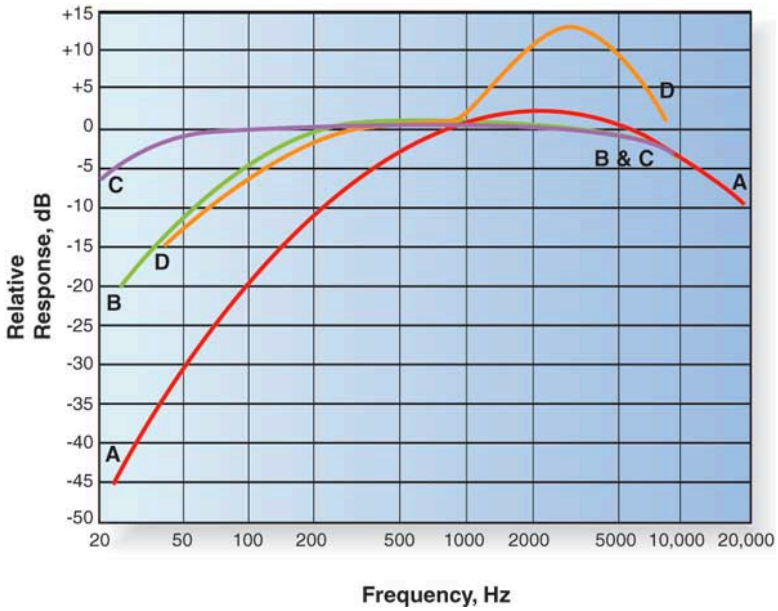
> "The frequency range below 200 Hz is often called low frequency noise. The boundary is not fixed, but the range from 10 Hz to 200 Hz is of great interest regarding health. Low frequency noise contains both infrasound and some so-called audible noise. Despite the general understanding that infrasound is not audible, it is possible for humans to perceive infrasound if the sound level is high enough, although there is a change in the aural detection process at which the tonality of the auditory sensation is lost. The phenomena of human perception of low frequency noise is reviewed in the first contribution by Moller and Pedersen (Department of Acoustics, Aalborg University, Denmark)."

It is important to understand that low-frequency noise and infrasound are part of the everyday acoustic environment. Regardless of whether or not people can consciously 'hear' or perceive infrasound, nevertheless it is present. Much infrasound is the result of naturally-occurring weather such as wind, rain, water, waves, storms etc. Mankind is also responsible for adding to this natural infrasound background as a result of transportation (cars, trucks, ships, planes, helicopters), heating and ventilation systems (HVAC), industrial plant and machinery.

An important aspect of infrasound is that it is hard to contain at the source. Infrasound is hard to control, travelling greater distances with little attenuation (approximately 3dB per doubling of distance) than higher frequencies. Much infrasound passes directly through walls and windows, even double-glazed windows, much to the chagrin of environmental protection officers. The universal use of the A-Weighting is virtually blind to frequencies below 200Hz. (See figure overleaf.) In fact the A-Weighting progressively under-reports the sound pressure level of frequencies below 1000 Hz.



The point is, **for a low frequency of 20 Hz, the A-Weighting underreports this by 50.5 dB**! What is the point of having a compliance for wind turbines that uses a criteria such as no louder than 30 dBA or background plus 5 dB? **The A-Weighting has already subtracted 50.5 dB from that frequency!** Any use of the A-Weighting to measure sound pressure levels with respect to sleep disturbance is totally meaningless, regardless of the equal loudness curves for average human hearing.




Low-frequencies and infrasound, as a result of their longer wavelengths, are far more easily diffracted as it interacts with the landscape. In this way, **infrasound can follow ground contours for great distances**. Furthermore, in terms of human annoyance, it has long been established that low frequency sound is far more annoying that higher frequencies that are normally associated with transportation sound sources, for example.

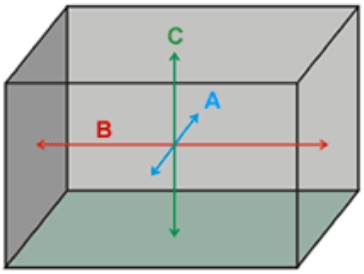
Low-frequencies and infrasound also appear as vibrations, in combination with the actual acoustic transmission through air and water. Of more concern is the fact that man-made dwellings and buildings (for industrial purposes) can effectively 'amplify' low-frequencies due to resonance. In this way, **houses can act as amplifiers of low-frequency and infrasound, turning houses into three-dimensional loud speakers that we choose to live in**. See diagram below for three resonance modes for a room. Numbers are abitrary.

$$\frac{\text{SPEED OF SOUND / 2}}{\text{ROOM DIMMENSION}} = \text{RESONANT FREQUENCY}$$

A. $\frac{1130 / 2}{12 \text{ ft.}} = 47\text{Hz}$

B. $\frac{1130 / 2}{14 \text{ ft.}} = 40\text{Hz}$

C. $\frac{1130 / 2}{8 \text{ ft.}} = 70\text{Hz}$




The basic physics of resonance of dwellings cannot be altered at the whim of a wind turbine consent plan. Shielding or insulating against low-frequencies and infrasound is one of the hardest goals to achieve.

It is important to understand that not only do industrial wind farms produce significant amounts of low-frequency and infrasound, but those emissions are in addition to, and significantly different from, all other naturally occurring sources. Because they are different to naturally-occurring infrasound, it is considered impossible for people to habituate to them. Regardless of conscious perception, infrasound and low-frequency sound can and does impact on the human organism, despite the best intentions of wind turbine proponents to down-play the effects. The long term effects of windfarm-generated infrasound and low-frequencies on nearby residents is yet to be established through longitudinal, case-control studies. However, the absence of such research does not make such frequencies safe, simply because science has not had long enough to dot the ‘i’s and cross the ‘t’s. One such potential health hazard is VibroAcoustic Disease (VAD).

## Vibroacoustic Disease

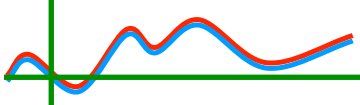
The effects of low-frequency and infrasound was intensively studied by Colonel Nuno A.A. Costello-Branco, MD, (and colleagues) at the Centre for Human Performance, Alverca, Portugal. What came to be known as VAD was first documented during the 1980s by Costello-Branco and his team studying people employed in the aircraft manufacturing industry. The studies included airplane technicians, then later commercial and military pilots, mechanical engineers, restaurant workers and finally disc jockeys. To quote Maschke again:

> “Experiments with both animals and humans have shown that the vibroacoustic stressor causes thickening of the cardiovascular structure (cardiac muscle and blood vessels). The pericardium

> thickening without inflammatory process and in the absence of diastolic dysfunction (pathological changes of the diastolic blood pressure function; second value of the blood pressure measurement) is therefore the clinical characteristic of VAD. Depression, increased irritability and aggression, a tendency for isolation and decreased cognitive skills (flexibility of thinking) are additional parts of the clinical picture of VAD."

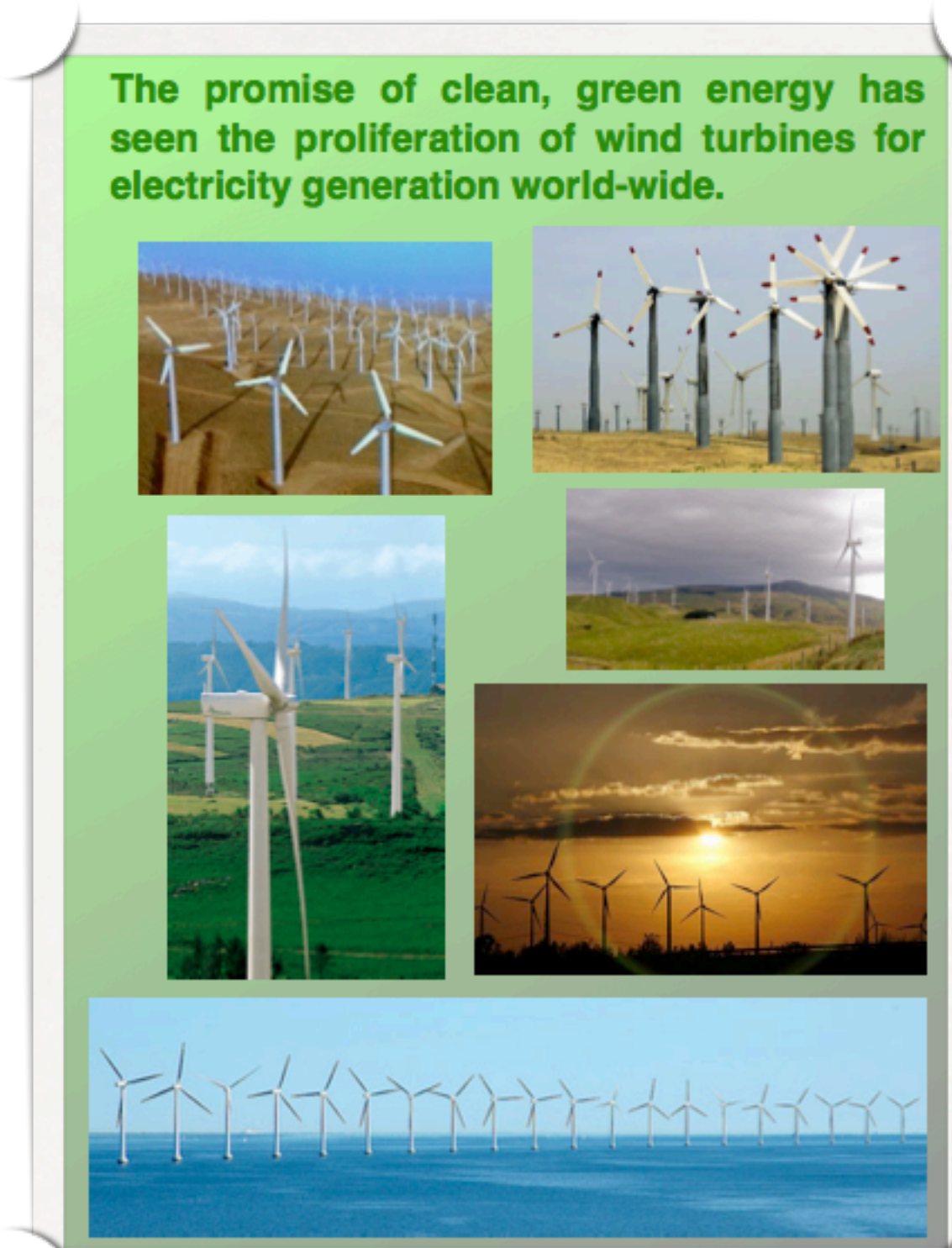
Although still relatively unknown as a pathological entity, the sheer volume of scientific output from Castelo-Branco and others produced over the last 25 years have established beyond reasonable doubt that a cause and effect relationship between low-frequency and infrasound exposure to adverse human health effects. To quote Castelo-Branco directly on VAD:

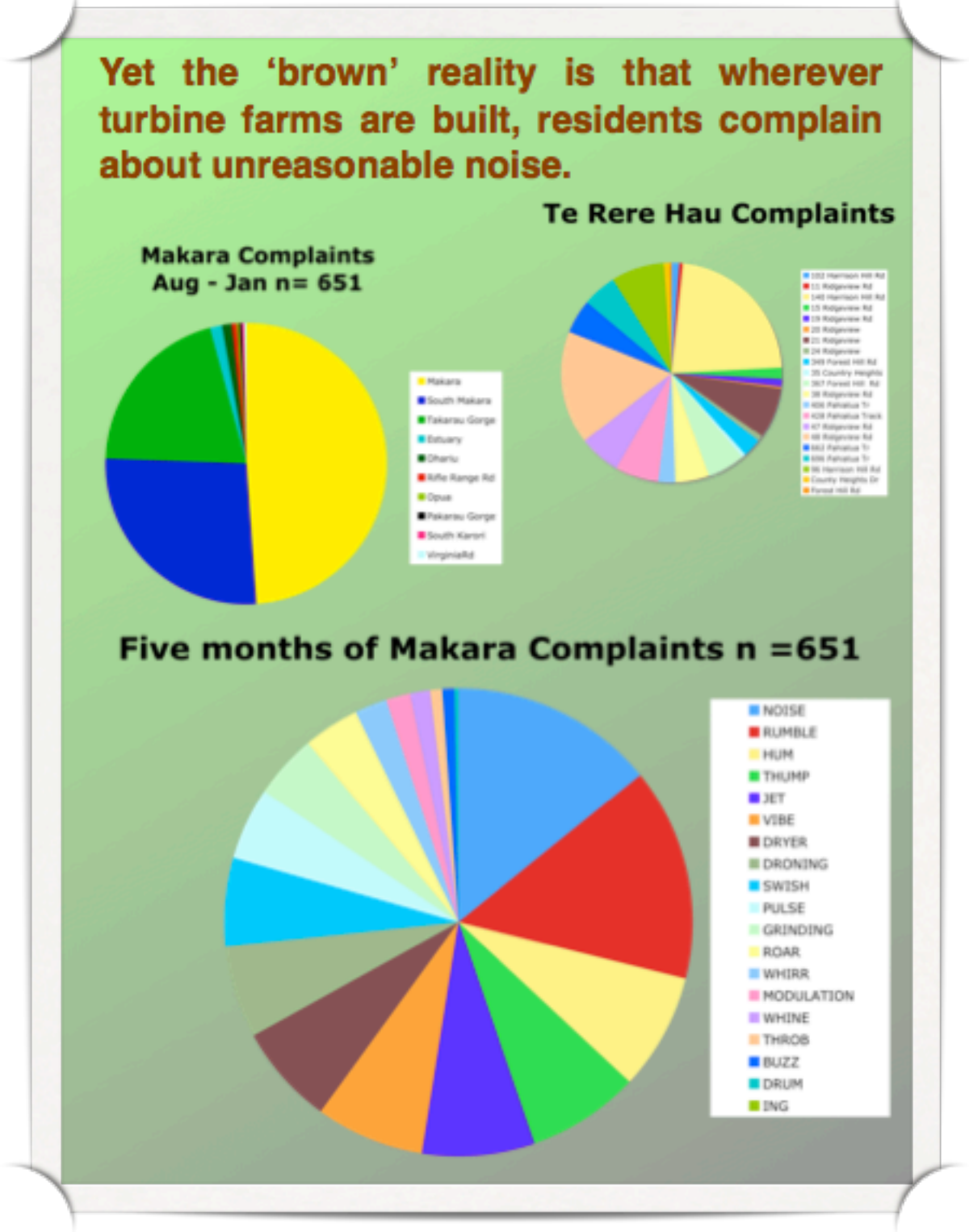
> "The agent of disease has already been identified - Low Frequency Noise.
>
> Specific LFN effects have already been well defined: abnormal growth of extra-cellular matrices, in the absence of an inflammatory process, seen in both cardiovascular and respiratory system structures, in both LFN-exposed human and animal models.
>
> The genotoxicity of LFN exposure has been demonstrated in both human and animal models.
>
> Non-invasive diagnostic methods have already been defined: echocardiography to visualize thickened cardiac structures, P 0.1 ($CO_2$) index to measure the dramatically reduced respiratory drive, and evoked potentials that disclose important topographical changes and increased latencies in the P3 and N2 components, both indicative of cognitive impairment."



# APPENDIX 9: A PLANNING FAILURE - HOW GIS CAN HELP

Summers, R.S., Rapley, B.I. ESRI User 15th Annual User Conference, Wellington, November 8-11, 2010.



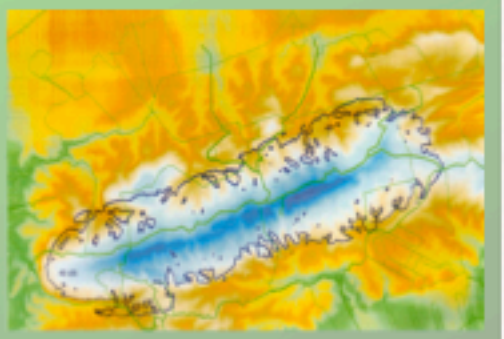

Yet the 'brown' reality is that wherever turbine farms are built, residents complain about unreasonable noise.
Te Rere Hau Complaints
Makara Complaints
Aug - Jan n= 651
Makara
South Makara
Takarau Gorge
Estuary
Ohariu
Rifle Range Rd
Opua
Pakarau Gorge
South Karori
VirginiaRd
Five months of Makara Complaints n =651
NOISE
RUMBLE
HUM
THUMP
JET
VIBE
DRYER
DRONING
SWISH
PULSE
GRINDING
ROAR
WHIRR
MODULATION
WHINE
THROB
BUZZ
DRUM
ING

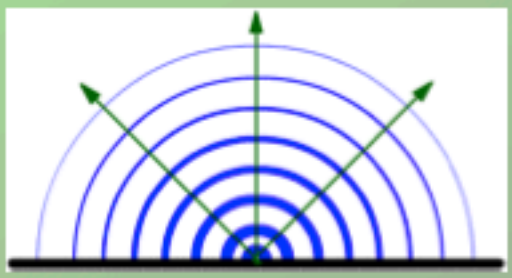
# Traditional computer noise modeling is complex and frequently observed to fail in the real environment.

Complex maps that present a jumble of colours are difficult for lay people to interpret.

Professionals may find it difficult to present complex data in a way that makes it accessible to lay people.

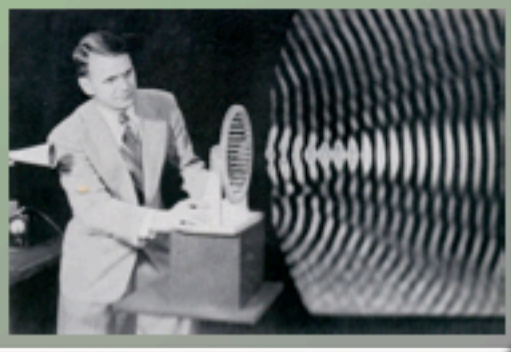
It is important that information be presented clearly and unambiguously so that residents can fully comprehend the potential impact of proposed industrial developments, particularly in rural environments.





Traditional approaches are based on the theory of hemispherical spreading from multiple point noise sources.

Turbine farms, however, may be better described in terms of a line source in many instances.



# Conventional computer-based noise modeling

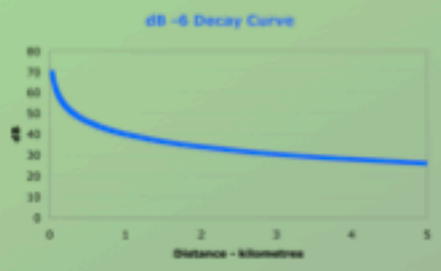
Conventional noise modeling is based on the premise of hemispherical spreading from a point source(s). The frequencies are modeled as octave bands between 31.5 to 8000 Hz. The environmental factors that may influence the sound pressure level at a distance include reduction due to distance, absorption by air and basic effects of wind (wind shadow).

Many models *fail* to take into account air turbulence, ground absorption and the screening effects of vegetation.

With specific reference to wind turbine noise, the models do not take wake and turbulence into account, nor the effects of atmospheric stability (temperature).

Significant errors can occur if the noise spectrum is restricted to 31.5 - 8,000Hz. The general assumption for a point source is that sound reduces at the rate of -6dB per doubling of distance.

For low frequencies, that is below 200 Hz extending down into infrasound [below 20 Hz], reduction is closer to -3 dB per doubling of distance.





The significance of this is that while sounds emitted by wind turbines in the general audio region of 31.5 - 8,000 Hz attenuate to near background levels within 1-2 kilometers, for the low frequency and infrasound regions, background levels may not be theoretically achieved for tens of kilometres (40 in this model). This explains why, on clear nights, you can hear the rumble of a train many kilometres away. The most frequent complaint regarding wind turbine noise is *LOW FREQUENCY.*

# Proof of serious noise nuisance

**BY GRANT MILLER - Manawatu Standard.**

**A Manawatu wind farm is facing court action amid lingering doubt it is complying with noise limits.**

After receiving hundreds of complaints about noise from Te Rere Hau wind farm on the Tararua Range for more than a year, Palmerston North City Council has applied to the Environment Court for stricter rules and better sound monitoring.

On average, the council receives one complaint a day.

Neighbours of the wind farm near Palmerston North have consistently complained about "whining mechanical noise", "droning", "loud humming", "grinding and swishing" and likened the sound to a "roaring train that never arrives".

The owner of the farm, New Zealand Windfarms, continues to argue it is complying with its resource consents.

Chief executive Chris Sadler declined to comment because legal proceedings were underway, but said his company would respect the process and participate fully in it.

For months the council has maintained there is reasonable doubt about the farm's consent compliance and the application to the court calls for greater notice to be taken of the actual experience of nearby residents.

**According to NZ Windfarms' consent application, many residents were supposed to experience "nil noise effects" from the two-bladed turbines.** The council argues that **not only do residents hear wind farm noise, they hear tonal noise – considered the most irritating for humans because of its pure pitch.**

The council wants the court to impose a five-decibel penalty for tonal noise.

If the penalty is imposed, NZ Windfarms will have to do something to run a quieter wind farm. That could include making technical improvements or switching some turbines off in particular wind conditions.

Noise consultants for NZ Windfarms have argued a tonal penalty should not apply.

Twenty residents have filed affidavits with the Environment Court and a hearing is likely to be held next year.

Ridgeview Rd. resident Ciel Wallace was pleased to see NZ Windfarms being brought to account. "It's about time this action was taken."

Mr Wallace said he would sometimes hear a low rumble, "swish, swish, swish" or high-pitched whine.

The noise was worse for many of his neighbours, he said.

NZ Windfarms has previously been dismissive of public concern about wind farm noise.

Former chief executive Steve Cross told the Manawatu Standard in May that the company did not need to be accountable to the public or the media.

However, the total number of complaints from about 20 households near the farmhas climbed to more than 500.

The council is arguing NZ Windfarms underestimated the effects of wind farm noise on the amenity of the area.

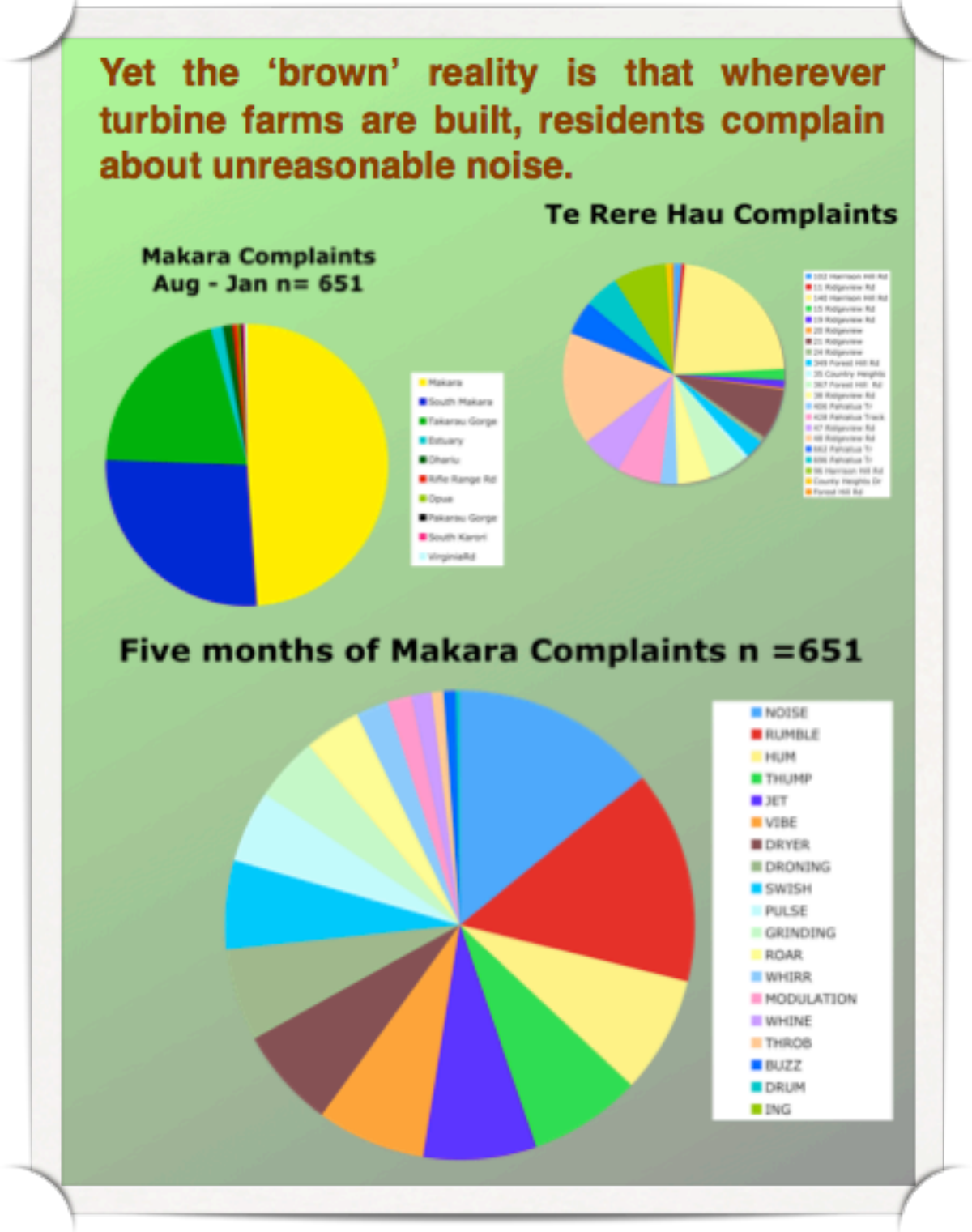
Earlier this year, NZ Windfarms obtained a resource consent to extend the windfarm by 56 turbines, although the total number is unlikely to exceed 97 in the medium term.

**22 October, 2010**

# GIS - Client-Centered Perspectives

GIS can provide multiple perspectives from the client's point of view:

**The promise of clean, green energy has seen the proliferation of wind turbines for electricity generation world-wide.**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Five months of Makara Complaints n =651
NOISE
RUMBLE
HUM
THUMP
JET
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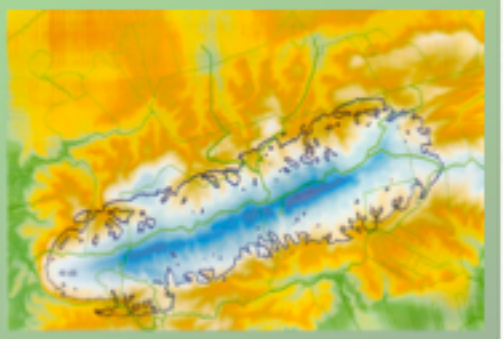

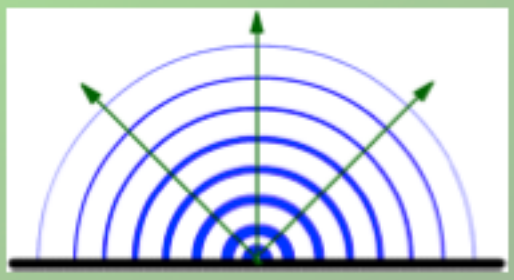

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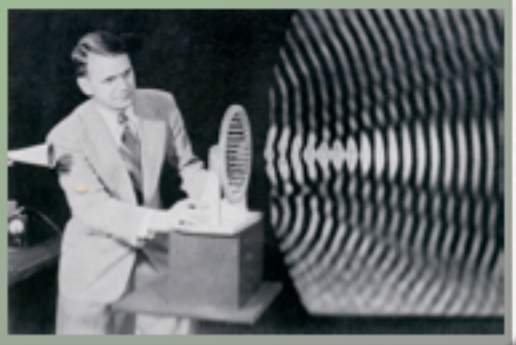


# APPENDIX 10: LETTER TO THE AMA

28 March 2014

Dr Steve Hambleton, President,
Prof. Geoffrey Dobb, Vice-President,
Australian Medical Association,
P.O. Box 6090,
KINGSTON, A.C.T. 2604

Dear Dr Hambleton, Professor Dobb and AMA members,

I recently became aware of your position statement on wind farms and health dated 14 March, 2014.

I have to say that this public statement has given me great concern with respect to a number of points which I will outline for you.

Your opening statement:

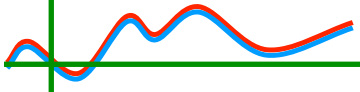
> **"Wind turbine technology is considered a comparatively inexpensive and effective means of energy production. "**

This raises a number of issues that I feel are inappropriate for a medical organisation to comment on. Firstly, line one is a statement regarding the economics of wind turbines which has no place in a statement regarding potential health effects. It is not within your organisation's professional competence to comment on economic matters and to do so raises questions regarding your credibility and apparent bias. How would your organisation feel about the OECD (Organisation for Economic Co-operation and Development) making statements about medical practice?

Secondly, your position statement then passes comment on acoustic immissions:

> **"Wind turbines generate sound, including infrasound, which is very low frequency noise that is generally inaudible to the human ear."**

To the best of my knowledge, medical practitioners are not generally known for their skill or expertise in acoustics, other than that directly associated with audiometry. To pass comment on areas beyond your knowledge is dangerous and leaves you wide open to serious challenge. Purporting to be experts in areas outside of medicine does not serve your credibility well.



The statement goes on to comment on infrasound, comparing immissions from different sources, yet lacking any sort of scientific credibility because of the significant lack of detailed evidence. Rather, the statements are reckless generalisations that provide no basis for comparison, let alone comprehension, other than in the broadest sense.

> **"Infrasound is ubiquitous in the environment, emanating from natural sources (e.g. wind, rivers) and from artificial sources including road traffic, ventilation systems, aircraft and other machinery."**

Such broad comparisons do not enhance scientific debate and offer little enlightenment to the uninformed, rather, they are more likely to mislead due to their lack of specificity. It is a well-established fact that low frequency and infrasound immissions from industrial wind turbines differ significantly in a number of critical ways, compared to natural sources like wind and water. Further, man-made sources such as road traffic all differ significantly from natural sources of infrasound. The most significant difference relates to the amplitude modulation of the signal due to blade pass frequency. This phenomenon is not apparent in natural or many other man-made sources: your comparison is without scientific foundation.

Next you appear to have become experts in engineering:

> **"All modern wind turbines in Australia are designed to be upwind, with the blade in front of the tower. These upwind turbines generate much lower levels of infrasound and low frequency sound."**

The first statement is factual. The second statement leaves out an important fact; when turbulent air is fed into the 'modern' upwind-bladed industrial turbines, they can generate significant quantities of infrasound and low-frequency noise. This was established in 1989 in Hawaii by NASA researchers Hubbard and Shepherd. Turbulence resulting from wind turbines being installed too close together, without complying with the international standard for turbine separation distances, is thought to be contributing to the infrasound and low-frequency noise problems at number of Australian wind development sites. Based on the evidence, it would not be unreasonable for the general public to assume that wind developers and turbine manufacturers are more concerned with maximising profit and income from renewable energy certificates (RECS) than from achieving engineering efficiency and safeguarding public health. While the profit motive is an integral part of normal, accepted business practice, profiteering at the expense of public health is unacceptable. When profit overrides public health and well being of the general public, in the face of clear scientific/medical evidence, the practice is doubly damnable and ethically indefensible. To quote the obvious: "The devil is in the detail". The fact that upwind industrial turbines create sounds that affect animals and humans is abundantly obvious and to

compare this version of industrial wind turbine to older technology is of no benefit to those who suffer from the acoustic immissions from the current machines.

Your second paragraph alludes to such 'devils'. While you state that:

> **"Infrasound levels in the vicinity of wind farms have been measured and compared to a number of urban and rural environments away from wind farms. The results of these measurements have shown that in rural residences both near to and far away from wind turbines, both indoor and outdoor infrasound levels are well below the perception threshold, and no greater than that experienced in other rural and urban environments."**

the reality is that these statements misrepresent the facts. In essence, what you have done is to 'cherry-pick' the data. Further, your statement leads the reader to believe that as long as sound levels are below conscious, and perhaps audible perception, there is no problem. This could not be further from the truth.

A significant problem with the determination of environmental noise relates to the inappropriate use of the A-weighting, still so commonly applied. As it significantly underestimates frequencies below 1,000 Hz and above 3,500 Hz this negates its usefulness in measuring low frequency and infrasound. The point should be obvious. Unfortunately regulation so often lags behind scientific knowledge.

Medicine, while based on a good deal of science, remains, as practiced, an ART. The reason for this is that the practice of medicine involves human beings. Human beings are not simply a collection of chemicals, cells and tissues, randomly existing in the biosphere. Rather they are sentient beings that are subject to multiple stimulatory mechanisms. This is one instance where a holistic viewpoint is nearer the truth than the traditional reductionist viewpoint. The consequence of this view needs further elaboration which you have chosen to omit . . .

The scientific method is something which is much talked about, but little understood, even by some scientists! The fact of the matter is that science begins with observation. This observation then gives rise to a question: how is that so? What caused that? How does that work? How did that happen?

The question, which usually has some practical relevance, leads to the creation of a 'model' of the 'how'. That model is referred to as the hypothesis. And of course a hypothesis leads to the development of a testing methodology to see if it can be used to explain the facts. The testing usually takes place in a controlled environment where the idea (hypothesis) is put to test by way of practical experiments. With good design, these should attempt to limit the number of variables (things that can be manipulated/

changed) and keep all other factors the same. In an ideal world, a control situation could be used to compare the test circumstances to the 'normal' condition. A perfect example is a drug trial. Subjects would be randomly assigned (so as not to bias the results) to one of two groups. One group would receive the 'test substance' while the other, the control group, would receive a placebo. That is, they would receive a substance (for example a pill) but it would be inactive, that is, lacking the chemical species under test. The strength of the findings is further enhanced if the experimenter and the subjects are both blinded as to who got the real drug. That is the basis of the modern scientific method.

Another perfectly legitimate and accepted method of study for obtaining comparative data is that of the case crossover design, where people act as their own controls. This design is used to demonstrate a causal relationship in situations like allergic reactions to some foods and particular drugs, for example. People living with industrial wind turbines are conducting this experiment all the time. They go away, and notice their symptoms ameliorate. They come back home, and under certain predictable wind and weather conditions, their symptoms recur. This is a clear demonstration, using the scientific method, of a direct and causal relationship between exposure and response. This is why some doctors are advising their patients to move away. It is clear that the exposure to wind turbine noise is damaging their patient's health, and there is nothing else they can suggest.

A common mistake, when selecting scientific data, relates to a process of choosing what to include. When selection bias exists in data selection, this is colloquially known as 'cherry-picking'. When this occurs, it necessarily introduces a bias that affects the results. This is apparent from your statement above relating to human perception of sound. If you scan the literature more widely, then a plethora of papers appear which contradict the basis of your argument. To only present one side of the argument is to short-change the readers and the general public. It also facilitates the generation of false impressions.

To return to the scientific method for a moment: when an observation has been made; a question arisen; a hypothesis created; a series of experiments formulated to test the hypothesis and ultimately the results analysed, there are two relevant tests that need to be applied. First, the results have to either support or reject the hypothesis. That means that the hypothesis needs to be able to be falsified and results obtained which are relevant to support or rejection the hypothesis's claim. Variables need to be measurable. The second test, and equally important, is that the consequences of the results, i.e. acceptance or rejection of the hypothesis, have to be consistent with what is already known. To take an example: If the results of an experiment lead to the conclusion that the 'conservation of momentum' did not always occur, then there would be a great deal of concern. Physicists are most unlikely to let go of such a well-

supported observation as the conservation of momentum. So, the new findings of an experiment have to fit with our existing reality.

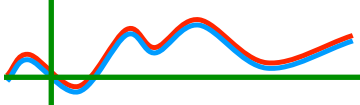
In order to fit with our current reality, or paradigm, there needs to be both internal (within the experiment) and external (in relation to what is already generally known and accepted) consistency to be valid. This is not to say that one day we might not reject the generally accepted view of the conservation of momentum, only that there would need to be extraordinary evidence to cause us to reach that conclusion.

What assists us with comprehending new knowledge and integrating it into our existing understanding of how the universe works is the existence of a mechanism. That is, a way in which we can explain the circumstances we discover through our experiment within the current bounds of knowledge. For your stance to be accepted, there would need to be not only no evidence to the contrary, but also the lack of any understandable mechanism of action. Neither are in fact the case.

Many scientific papers expound the observation that stimuli below conscious perception do, in a number of instances, result in physiological response. This is the case for the effects of low frequency and infrasound, and was noted by Kelley 1987, Chen, Qibai & Shi 2004, Swinbanks 2012, and Schomer 2013 in addition to the work of Professor Salt, a leading neurophysiologist working in this area. Further, there are many plausible mechanisms to explain how sub-conscious perception threshold stimuli may interact with living organisms. The old notion that perception is the threshold above which biological effects occur is not only out-dated, it is a non-sequitur. Take x-rays for example, they are not readily consciously perceivable yet can be quite harmful. Light is in a similar category. Sound is another physical phenomenon that does not need conscious perception to be received by an organism or for that organism to react.

The work of Professor Alec Salt has done much in recent years to elucidate theory on the biological reception of low-frequency sound, complimenting this with extensive laboratory experimentation. To ignore this work is a travesty and is tantamount to lying by omission to the general public. It is another example of cherry-picking the data that effectively distorts the final impression. To add to this work, the research of Dr. Carey Balaban has done much to throw light on the neuronal mechanism of sound reception by the human body. We now have theory, experimental evidence and empirical observation, all pointing in the same direction. To blithely ignore such a body of science and come up with a generalisation of ‘no harm’ is not only lying to the general public but supports a point of view that is largely sympathetic to the commercial, industrial profit motive. This commercial bias has no place in medicine or public health.

The most recent article to come out of Washington University, St. Louis, Missouri, from Professors Salt and Lichtenbaum is worthy of mention here. Their landmark paper appears in Acoustics Today, Volume 10, Issue 1, pp 20-28, Winter 2014. In their

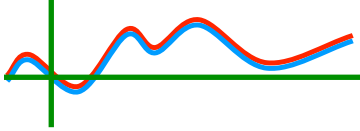


paper: How does wind turbine noise affect people?, they succinctly describe the results of their recent work on the effects of low frequency and infrasound on the cochlea mechanism. It appears that the roles of the inner and outer hair cells differ in many significant ways. In particular, the outer hair cells account for only 5 % of the afferent nerve fibres in the acoustic nerve and are of Type II in comparison to the inner hair cells which equate to 95% of the acoustic nerves and are of Type I. Further, the inner hair cells, which are largely responsible for the faculty of hearing in the accepted frequency spectrum of 20 to 20,000 Hz, do not touch the tectorial membrane. They operate by way of transducing movements in the fluid below the membrane into nerve impulses. The outer hair cells, by contrast, are directly connected to the tectorial membrane and are far more responsive to low frequency and infrasound.

The point that Salt and Lichtenbaum are making is that the energy that enters the ear canal as low frequency and infrasound is readily translated into neural impulses which reach the brain, albeit they may not be consciously interpreted as sound, but they still reach the cognitive engine. Another critical point concerns their findings that biologically generated amplitude modulated signals occur in the pulse trains of nerve impulses from the inner hair cells as a result of stimulation from a 500 Hz tone summed with 4.8 Hz. (Their Figure 2.)

Their work is a clear demonstration of a biologically-generated modulation to a non-modulated stimulus. The cochlear microphonic response is generated by the outer hair cells,responding to both the high and low frequency components. This occurs either by saturation of the mechano-electric transducer or by cyclically changing the mechanical amplification of the high frequencies. Being insensitive to the lower frequencies, the inner hair cells detect only the high frequency component, which is amplitude modulated at twice the infrasound frequency, in their example. Thus, the inner hair cells essentially ‘see’ the effect of a high-pass filtered version of what the outer hair cells perceive. This is the most clear demonstration of the effect of infrasound on the cochlea. The biophysics of the ear creates an amplitude-modulated signal from a non-amplitude modulated source of two pure tones. This is a neurophysiological explanation of the effect reported by subjects who complain of adverse effects from living too close to industrial wind turbine installations. To ignore such clear evidence is to deny the very substance of the scientific method in favour of a biased commercial approach to public health.

The deliberate exclusion of empirical data, failure to acknowledge existing scientific knowledge and theory is to effectively lie by omission. Such distortion of reality is to degrade science, medicine and discredit the practitioners of those disciplines. I take exception to such biased reporting and the distribution of such misinformation. It is to degrade my profession as a scientist, researcher and consultant.



Your clear statement:

> **"The available Australian and international evidence does not support the view that the infrasound or low frequency sound generated by wind farms, as they are currently regulated in Australia, causes adverse health effects on populations residing in their vicinity."**

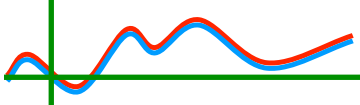
is but another example of cherry-picking the data to suit your own position. To arrive at this position it is necessary to actively ignore any scientific data to the contrary. This is clear evidence of bias. What makes this all the more serious is that it appears to be based on the commercial profit motive.

As if adding insult to injury, the following sentence only serves to reinforce this bias viewpoint and flies in the face of the first principle of scientific methodology: OBSERVATION.

> **"The infrasound and low frequency sound generated by modern wind farms in Australia is well below the level where known health effects occur,"**

There is a veritable mountain of evidence to the contrary, yet your organisation chooses to dismiss it. This can be interpreted in no other way than a deliberate attempt to distort reality. The number of observations of demonstrable harm are enormous. The fact that working medical practitioners are observing these and reporting them, and indeed dealing with the consequences, seems to be a point that has completely passed by your organisation. I have personally investigated numerous cases where there is clear evidence of harm including: sleep deprivation; nausea; vertigo; feeling of general malaise; tiredness, irritability; changes in normal mood; inability to concentrate; reduction of appetite; headaches etc. etc. There is clear evidence of stress-related pathology and behavioural changes. Many of these, I might add, occur in people who did not initially have any negative feelings towards the construction of wind turbines, only noticing the symptoms after mechanical commissioning. This is clear evidence of the lack of a nocebo effect. Animal studies only add to this milieu, yet your organisation seems to have also totally ignored animal studies, again misrepresenting the situation.

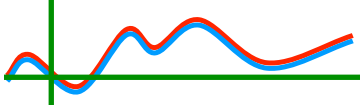
As the result of health effects reported across the world by people living in close proximity to wind turbine developments, a term has arisen: Wind Turbine Syndrome. This is something of a misnomer. Rather it should be termed: Infrasound and Low-Frequency Syndrome. The point is that the same condition has been extant for decades, associated with sources other than indsutrial wind turbines. The introduction of large-scale industrial wind turbine installations is a relatively recent development,



hence the origin of the term. However, the health effects of low frequency and infrasound have been known for much longer.

In 1984 David Lange was elected Prime Minister of New Zealand. When he moved into the top office in the Beehive (parliamentary building in Wellington, New Zealand) he suffered inexplicable bouts of vertigo and nausea. Such were the severity of the symptoms that he began spending less and less time in the office in order to reduce his feelings of malaise. It was subsequently determined that the air conditioning system was responsible for high levels of low-frequency noise and infrasound. Normally consciously undetectable by the human ear, these rapidly fluctuating levels of air pressure caused by the ventilation fans and resonance in the pipes lead to a redesign of the ventilation system in parliament's building. Once the modifications to the ventilation system had been carried out, the Prime Minister no longer became ill when working in his office. This is simply another example of a well-known phenomenon associated with ventilation systems in buildings which result in negative health effects for the occupants. This general phenomenon, isolated in the late 1960s termed 'Sick Building Syndrome'. It is, in essence, little different from the situation that currently exists for thousands of people around the world who live close to industrial wind turbines. The physics is virtually the same. The neurobiology is virtually the same. The health effects are virtually the same. It is well-known by ventilation installers and acousticians that this phenomenon is both well-reported and well-understood. There even exist mitigating technologies to deal with the problem! Phase cancelling technology is frequently employed in situations where low frequency and infrasound resonance occurs in modern buildings. Engineers know that these problems cause health effects, that is why they developed the mitigation technology!

The existence of the phenomenon, its known health effects and potential remediation is powerful evidence as to the reality of the phenomenon. The poignant fact is that no such simple fix is technologically possible in the open environment due to physical factors. Therefore, that the same situation occurs with the physics of sound in open environments should come as no surprise. However, to omit such knowledge from the debate is to negate a significant proportion of existing scientific knowledge and technological understanding. Engineers could feel aggrieved. Commercial bias and the promotion of the profit motive ahead of public health is the only reasonable explanation for the stance taken by your organisation with the release of the statement regarding health effects of industrial wind turbines. This action is shameful and does much to discredit your organisation as a defender of public health and well-being and undermines the very process of science, upon which your discipline of medicine is so reliant.



Perhaps the most egregious statement from your organisation concerns blaming the individuals for their health conditions:

> **"Individuals residing in the vicinity of wind farms who do experience adverse health or well-being, may do so as a consequence of their heightened anxiety or negative perceptions regarding wind farm developments in their area."**

To pass the buck in this fashion is to abdicate the most basic responsibility of a medical practitioner. To blame the patient for being sick is not only cowardly, but it is against the Hippocratic oath. "It's all in the mind" is a coward's way of explaining the phenomenon. It blatantly ignores the evidence and is yet another indication of commercial bias. To vindicate a phenomenon for the purpose of commercial gain or social bias is reprehensible. I can find no other explanation, for to ignore such a large body of evidence to the contrary is to jeopardise the health and safety of your patients, betraying the very patients you are duty-bound and legally obliged to serve.

Apparently not content with this stance, your organisation goes further blaming the observed effects on misinformation.

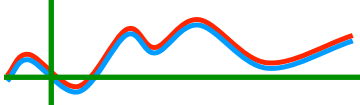
> **"The reporting of 'health scares' and misinformation regarding wind farm developments may contribute to heightened anxiety and community division, and over-rigorous regulation of these developments by state governments."**

Nothing could be further from the truth. In my own experience I have observed, first hand, the commercial spin from wind turbine companies, predicated on their own commercial gain.

Surprisingly perhaps, we are in agreement on one point:

> **"The regulation of wind farm developments should be guided entirely by the evidence regarding their impacts and benefits."**

The above statement is reasonable, only providing that the process allows for all evidence to be considered, not a subset which necessarily supports only one point of view. The abundance of health effects needs to be appropriately acknowledged, catalogued and studied. There is seldom smoke without fire. To simply blame any physiological or health effects on mental state is to consign all patients who present with adverse symptoms to the mental asylum. It also ignores the seriousness of the mental health problems being reported which include severe depression, sometimes with suicidal ideation, which I am sure you would recognise is a psychiatric emergency.



Today, a significant amount of scientific evidence exists within the literature to attribute health effects to low frequency and infrasound. Scientific evidence of reasons for individual susceptibility for acute symptoms of Wind Turbine Syndrome exist. Susceptibility factors that even Professor Geoffrey Leventhall now accepts. Three such examples of an individual's differential response to infrasound and low frequency noise would include:

The work of Paul Schomer regarding motion sickness.

The recent publication of environmental triggers for migraine headaches by Dr. Haken Enbom.

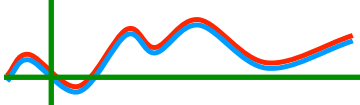
The size of the helicotrema - reference Salt and Lichtenbaum.

This work is further supported by the paediatrician, Nina Pierpont, who is eminently more qualified to speak on the subject than many others, possessing as she does degrees in biological science and medicine.

Pierpont identified in a case series cross over study that there were three susceptibility factors which increased the risk of people developing these symptoms when others in the same household did not develop the symptoms. The factors included a history of migraines, motion sickness and inner ear pathology. Why have the AMA ignored the work of a paediatric colleague when it is clearly supported by the work of others who are completely independent and in some instances their work preceded hers? Indeed the work over decades by the pathologist, Dr. Nuno Castelo Branco in Portugal has done much to elicit the underlying physiology and manifestation of what has become known as Vibroacoustic Disease.

Why has the AMA ignored this extensive body of work that centres on a potentially serious public health problem? Vibroacoustic Disease is an acknowledged problem in the aircraft industry and mitigations have been developed to deal with the health effects of workers as they become affected. These include echo cardiograms to detect endocardial thickening, as well as the recording of a number of documented behavioural and health changes. Mood alteration, changes in lung function accompany the physiology seen in the histology. Such an extensive body of knowledge has been accumulated in the previous two decades that it is surely criminal to ignore the work of so many scientists and physicians. It must be noted that Vibroacoustic Disease is not just an issue for the aviation industry.

At the Internoise conference in 2012 in New York, Alec Salt stated that infections can block the helicotrema and that such people are extremely sensitive to low-frequency noise. Salt also makes mention of the difference between the inner hair cells' response to velocity (fluid-coupled) versus the outer hair cells' response to displacement. This thesis reinforces Swinbank's assertion at the fourth international conference on wind



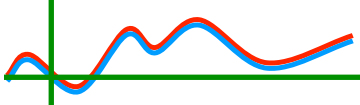
turbine noise in Rome, 2011, (“The audibility of low frequency wind turbine noise.”) that is is incorrect to assess low-frequency noise by absolute sound pressure level, but rather the acceleration or rate-of-change of pressure. This is the effect that causes low-frequency sensitivity to fall dramatically as the frequency is reduced (for the inner hair cells). For comparison with a sound level of 100dB at 1Hz, the equivalent hair cell response requires only 69dB at 6Hz, since the acceleration of pressure becomes much greater the faster the rate-of-change. Swinbanks has measured infrasound of 6 Hz at 64 dB.

The importance of the helicotrema in this respect is also recognized in the benchmark paper by Moller & Pedersen paper in 2004:

> **"Extraordinary sensitivity to low-frequency sound might be explained by abnormalities in the person's hearing organs. A theoretical example could be an abnormally small aperture in the helicotrema at the apex of the cochlea. For low--frequency sound the helicotrema acts like a kind of pressure equalization vent for the perilymph in the cochlea, equalizing the pressure between the scala tympani and the scala vestibuli. If the helicotrema is unusually narrow or blocked, it cannot equalize the pressure fast enough, and an unusually high pressure will build up between the scala tympani and the scala vestibuli. The result is a greater mechanical excitation of the basilar membrane, and thus a higher sensitivity to these sounds is expected. For examples of simulations of the effect of the size of helicotrema see e.g. Schick (1994)."**

This work is important as it highlights one of the most important aspects of controlling sound perception at low frequencies. Low frequency hearing is well-documented and represents a simple fluid-mechanical system. Low frequency hearing has little to do with emotional state, as you imply. It is simply the response of a hydromechanical system where the stiffness or softness of the absorber (tectorial membrane) is related to the size of the orifice between the two (helicotrema) and the tensioning of the membrane through neural biomechanical feedback (outer hair cells). Your statement of position ignores an enormous body of evidence, instead apparently relying on commercially-based industry rhetoric in the absence of good science.

I do agree with wide and open consultation, though I am yet to see this practiced in an unbiased way.



> **"Such regulation should ensure that structured and extensive local community consultation and engagement is undertaken at the outset of planning, in order to minimise misinformation, anxiety and community division."**

Your final position statement is yet another example of what I believe is the intention to mislead by understating the case, that is, lying by omission.

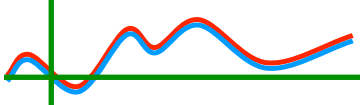
> **"Electricity generation by wind turbines does not involve production of greenhouse gases, other pollutant emissions or waste, all of which can have significant direct and indirect health effects."**

Yes, the actual operation of wind turbines does not directly generate CO2 immissions in the same way as a coal-fired plant. However, the manufacture of industrial wind turbines involves a large production of CO2 and other waste products, all of which, it could be argued, pose a risk to human health. Industrial wind turbines generators also rely an a large quantity of 'rare-earths' which are costly to extract and harmful to the environment. To tell only half the story is to mislead the public in line with a particular commercial viewpoint, rather than to present information that is relevant to public health in an unbiased, professional and scientific way.

Other pertinent facts such as life time of plant, maintenance and other issues are conveniently ignored by this blanketed approach. Medical practitioners would be well-advised to not pretend that they are any other sort of expert than those associated directly with human physiology and health. To make statements with authority on technological matters and matters of economics is beyond the mandate of a medical practitioner and your association. Medical practitioners would soon object if engineers started offering advice on brain surgery techniques and critiquing surgeons without providing all the data. There is a significant danger when members of a professional society, who are endowed with some respect due to occupation or position, extend their opinions beyond the boundaries of their knowledge.

Being a medical practitioner does not grant licence to pontification on other disciplines. Medical Practitioners have a unique place in society and that very position is put in serious jeopardy when organisations purporting to represent the body of members come out with public statements so biased and lacking in fundamental rigour that it brings the whole profession into question. Simply put: "A cobbler should stick to his last, a tailor should stick to his thread".

I speak with some authority on these matters as I have been a scientist for some years, having a bachelors degree in biological science, a masterate in technology and a PhD in acoustics and human health. Indeed my PhD thesis focussed on the physical measurement and consequences of low frequency sound within the working



environment. Further, I have spearheaded a 15 year development project resulting in a new pc-based technology for environmental sound monitoring and analysis. This technology was recently extended to include vibration and exogenous radiation.

Through the use of this technology I have been able to observe and analyse first-hand, the occurrence of, and human effects of, noise and vibration in the work environment of soldiers. Evaluation included audiometric analysis, whereby I also spearheaded a new automated screening audiometer for use in high noise environments in the field, and psychological assessment of cognition and mood. The results of my work are embargoed for military reasons. However, I can say that sound, particularly low frequency sound, is responsible for many physiological and psychological manifestations that can seriously affect human performance and cognition.

The obviously biased statements made by your organisation regarding the impact of wind turbines on human health are an insult to my work and insulting to science as a whole. To misrepresent the physical situation and to shift blame to the mind-state of affected individuals is to abdicate your responsibility as physicians. Further, it degrades the concept and professional esteem of medical practitioners, mocking the patient who makes genuine complaint. This can only be seen to erode the patient-doctor relationship and as such is surely a serious threat in its own right to the practice of medicine and the promotion of public health.

I urge you and your colleagues to rethink your position with all due speed. Simply put: do not comment on areas beyond your own boundaries of knowledge. Do not tell half-truths, present commercially biased information in the name of health care and stop lying directly and by omission to your patients and the public at large. This matter needs to be urgently addressed to minimise the fallout and retain the respectability that the practice of medicine deserves and the good name of your organisation.

Sincerely yours,

Bruce Rapley - BSc, MPhil, PhD.

Principal Consultant, Acoustics and Human Health,

Atkinson & Rapley Consulting Ltd.

# APPENDIX 11: LETTER TO BROWN COUNTY

Atkinson & Rapley Consulting Ltd.

37 Ferguson Street, Palmerston North, New Zealand, 4412.

Ph +64 6 357 1079 www.smart-technologies.co.nz

Wednesday, 10 December 2014

Brown County Citizens for Responsible Wind Energy

BOHsupport@bccrwe.com

To whom it may concern:

I was recently made aware of your situation regarding the Shirley wind farm and the decision by the Brown County Board of Health to declare it a health hazard. In my view this is entirely appropriate, as all industrial-scale wind turbines are a potential health hazard to humans if located too close to homes, workplaces, and recreation areas as your recent declaration clearly acknowledges with the inclusion of “residents, workers, visitors and sensitive passersby”. If it is of use to you, I would like to share some comments from my own knowledge and experience.

My qualifications are a BSc in Biological Systems, an MPhil in System Design and Testing of Medical Biostimulators and a PhD in Acoustics and Human Health. Much of my academic work has been involved in studying environmental factors that affect people. My PhD specifically addresses the effects of environmental sound energy (including infrasound) on hearing and cognition in the military environment. I now operate a consultancy in acoustics and human health here in New Zealand. The last fifteen years has largely been devoted to the design and development of a new instrument for the detection and analysis of environmental sound with respect to human impact assessment.

Industrial wind turbine installations provide a unique acoustic addition to the natural, rural soundscape. These sound emissions are unlike anything mankind has been exposed to during its long evolution over millennia, although there are other relatively recent sources of environmental sound and vibration that are similar in nature and cause adverse effects on sleep and health, such as gas turbines power generators. Both gas and wind turbines emit infrasound and low frequency noise (ILFN). Both gas

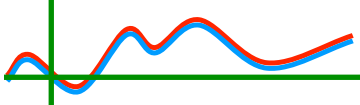
turbine and wind turbine ILFN emissions were specifically identified as directly causing “noise annoyance” symptoms including sleep disturbance and body vibrations by NASA researchers including Dr Neil Kelley as early as 1982.

Accordingly, even at very low levels, the sound of industrial wind turbines is easily distinguishable and significantly different from, naturally occurring sounds. Claims by wind energy companies that the sound of turbines can be compared to the rustling of the trees or a babbling brook are, quite simply, laughable. The wind turbine industry continues to make these absurd claims, with panache, despite the nonsensical nature of their argument and to the detriment of people’s sleep, their physical and psychological health. The wind industry is not yet significantly directly affected by the consequences of their stance, although there are signs of a decreasing social licence to operate in rural areas in many parts of the world, in part because of their dishonest denials of any knowledge of harm to human health.

As a practicing scientist, much of my academic focus is on the philosophy and process of science, in particular, the scientific method. This much-misunderstood concept proves to be a real stumbling block for both the scientific and lay communities. While science is the very process of moving us from a system based on belief to one based on empirical observation, what some would refer to as ‘facts’, that process is often bastardised by the over-riding humanistic characteristic of desire. Simply put, we want things to be the way we want them, not the way they are. The wind industry wants wind turbines to be accepted as a harmless, carbon-neutral, green technology. Nothing could be further from the truth.

The pursuit of the Green Dream and the common human frailties of procrastination and obfuscation have led us into the unchartered waters of the current dilemma of dogma vs. people. It is all too easy to sit back and say, “I’m doing my bit for the planet by voting for ‘Green’ energy”. However, well-meaning couch potatoes usually achieve very little, nor do the majority see the consequences of ignoring the existing known science or refusing to objectively investigate clusters of reported health problems. Fortune goes not just to the brave, rather it goes to those who pursue their goal with tenacity. If that goal can tick the boxes of ‘best for humans’ and ‘best for the environment’ (the two are not always synonymous) all the better. Unfortunately voting for more large, horizontal-axis, upwind-bladed industrial wind turbines fulfils neither goal. However, the various subscribers to wind developers do result in financial windfalls for those who promote and build this technology, and steady reliable income for those who invest in these wind “farms” such as superannuation funds.

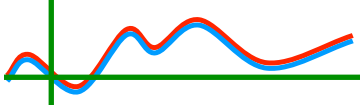
The scientific method is a useful methodology for investigating and solving problems, allowing us to better understand the world we live in. Where it breaks down is when the



pure, altruistic aims of the pursuit of knowledge are derailed by simple human greed. The difficulty is that for the method to succeed in its pure form, one must approach the problem with an unbiased mind and a skeptical view point. The Principal Supervisor for my PhD instilled in me the quest for knowledge and understanding, but in order to achieve that, I was told to question every assumption. “Take nothing for granted, trust no-one,” he always told me. “Check it out for yourself”. His reasoning was faultless. The history of the process of science is littered with good theories and ideas that died by the roadside because the objective evidence proved them wrong. While once accepted as “fact”, one simple accurate negation can exile a “good” theory to the dustbin of history - regardless of the passion with which it was once supported and the extent of that support. Science is not a process of consensus - rather it is a process of careful, accurate measurement, creating theories and testing them, constantly refining those theories based on meticulously collecting data and analysing the evidence without preconceived bias. It does not matter if 50 million people believe the world is flat, one single observation, a satellite image, for example, is able to disprove the concept. As the Austrian/British philosopher of science, Sir Karl Popper pointed out, negation is a vital part of the scientific method. All knowledge exists as conceptual models and is accepted only until it is negated.

My professor’s sage advice has served me well. It helped me to develop and hone my skills as an objective researcher who would fastidiously search for the ‘truth’. At the start of any project, one always has preconceived ideas and thoughts about how things work. This is a good thing, as it allows us to generate hypotheses to test and evaluate. But where the ‘wheels fall off’ is when we ignore the basic process of the scientific method. That is, the very first step is to observe the environment. Only from accurate and careful observation can theory develop. And so it is with the adverse health effects of industrial wind turbines. Objective observations should not be coloured by our own, or a corporation’s, desire for one particular intended outcome.

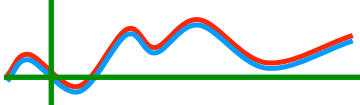
Observations of symptoms and sensations commonly reported by residents living near industrial wind turbines, and other emitters of infrasound and low frequency noise and vibration, especially in quiet rural environments, include: severe and unusual headaches; feelings of painful ear pressure; vertigo; problems with balance; nausea; poor sleep with sleep disturbance particularly with an unusual pattern of waking up suddenly in an anxious, frightened, panicked state; nervousness with symptoms of acute anxiety; sudden fear; a compulsion to flee; a sensation of a tight chest or pressure pulsations or resonance within their chest or abdominal cavity; body vibrations within their chest, abdomen or sometimes extremities such as lips; tachycardia and cardiac arrythmias; as well as problems with memory; cognition; and depression which can be so severe as to induce acute suicidal ideation – just to name a few.



As skeptical scientists, it is our duty to observe and take note of these reported symptoms and sensations, and try to formulate a hypothesis of how and why ("how come" rather than "what for") they occur. In fact, leading acousticians who have long worked in the specific field of low frequency noise impacts on humans, describe these symptoms as "noise annoyance" and have long noted their occurrences in response to a stimulus of environmental sound. Evidence from leading acousticians such as Harvey Hubbard and Neil Kelley from thirty years ago suggests that these long-reported symptoms labeled with the general descriptor of "annoyance" or "noise annoyance" are directly caused by exposure to impulsive infrasound and low frequency noise.

However, health practitioners seeing these residents do not recognise the term "annoyance", or "noise annoyance" as it is not a clinical diagnostic term. Usage of the term "annoyance" is therefore fraught with misunderstandings about the severity of the impacts and the range of symptoms associated with sound energy exposure. When "annoyance" is used by one group of professionals, such as acoustic experts working specifically in the field of low frequency noise, to mean severe symptoms with acknowledged adverse health impacts, but is then interpreted by other professionals such as public health experts and even practicing doctors to indicate something which is trivial and of no consequence, it is not surprising the current situation has arisen. Science, and the health of rural residents, is the poorer, to the commercial advantage of the noise polluters.

Thus the overly simplistic concept proposed by some critics (including Wikipedia) that these symptoms are more closely associated with hypochondria or nocebo effects than anything else, is a very biased and unscientific statement, not based on actual empirical field research with actual exposure doses in real rather than experimental populations. Such statements and hypotheses ignore a wealth of excellent objective acoustics research over the last fifty years, including important aero-acoustics research conducted thirty years ago by NASA affiliated researchers such as Hubbard, Shepherd and Kelley. The use of the term "nocebo effect" when referring to adverse health impacts from one source of noise such as wind turbines, but not with other sources of sound and vibration, such as open-cycle, gas-fired power station turbines, extractor fans used in underground mines or large compressors used in heating, cooling and ventilation (HVAC) systems is scientifically inconsistent and can only be explained as politically, commercially or ideologically driven. Usage of "nocebo" in such limited contexts and for only one sound source hints at an underlying bias to dismiss the phenomenon due to a lack of both scientific rigour and the willingness to consider alternatives. While psychogenic mechanisms may conceivably play a role for some individuals, in some circumstances, it is unlikely that this can be used as a blanket explanation for all symptoms, at all times, in all cases.



The history of science is replete with countless examples of the need to reassess our existing ideas in the light of new evidence. The discovery of a wood that does not float, a rock that burns and another rock that fogs photographic plates are but the tip of the iceberg of examples where we had to develop new understandings of how the universe works. The symptoms of sufferers living near wind turbines could be explained by numerous different causative factors, but to simply lump them all together under hypochondria or nocebo effects, and to do so without comprehensive empirical research first, is at the very least, sloppy science. Multiple causative factors are far more likely to be the reality.

There is an irrational belief, prevalent amongst many of the acoustical consultants employed by industry, that “what you can’t hear can’t hurt you”. This is far from the truth and a little history is needed to show how wrong the statement is with regard to how people hear. The history of public health offers us some insight as to how this situation arose. After the advent of the industrial revolution, when noisy machines were invented and put into the workforce, rather than continuing to rely on simple human (or animal) horsepower, loud noise came to be recognised as a health hazard. However the danger of loud sound was, of course, recognised well before the industrial revolution (1760-1840). Metal had been worked since the Bronze Age, somewhere around 3,300 BC. Iron was mined and smelted from approximately 1,300 BC and the working of hot iron gave rise to the blacksmith. Indeed, Aristotle is said to have begun his studies of sound after hearing the sound of a hammer on an anvil in a blacksmith’s shop. The deafness of the blacksmith is well-recorded throughout history.

Salient to this brief foray into the history of science is the fact that much of our understanding of the danger of loud sound was initially inhibited by our lack of knowledge of the physiology of the ear. Coming into the ‘modern’ era, the Italian physician Bernardino Ramazzini (1633-1714) was arguably the first physician to take a serious interest in what we now call public health. Ramazzini was an advocate of the use of Cinchona bark for the treatment of malaria. We now know that this bark actually contains high concentrations of quinine, so the treatment was legitimate - based on today’s knowledge. Of importance to the narrative is that Ramazzini came to be thought of as the Father of Occupational Medicine with the publication of his work: De Morbis Artificium Diatriba (The Diseases of Workers). In this landmark work he detailed the various hazards workers faced including: exposure to chemicals, dust, metals, repetitive or violent motions, odd postures and other causative agents. From these humble, early beginnings grew the discipline of occupational health. The invention of dynamite and its explosive properties proved that single events of very loud noise could cause deafness, and so we have inherited the concept that physiological damage only results from excessive audible noise levels. But it was not until the 20th century with the development of electrical technology that facilitated the invention of devices making it

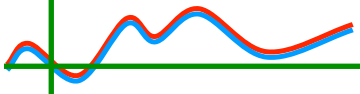
possible to actually measure the loudness of sound that significant progress could be made. Thereafter, it became feasible to measure sound levels in industry and correlate these to hearing loss.

The thesis that the absorption of large quanta of energy in a short period of time is the recipe for physiological damage, while true, does not tell us the full story. That is why the work of Ramazzini is of such importance, although it is also very true that we frequently fail to learn from history! Ramazzini also discovered RSI - Repetitive Strain Injury, now referred to as OOS - Occupational Overuse Syndrome. Each movement, in and of itself is of little consequence, but continual repetition can and does cause severe damage. From this we should learn that a small amount of energy, whether perceived as noise, pressure pulses or vibration, repeated over a long time frame, can also cause damage.

A critical failing of the various standards for wind turbine noise emissions is that they are predicated on the A-weighting which is designed to reduce the emphasis of both high and low frequencies, providing a completely erroneous description of the acoustic energy in the emission. The A-weighting was first determined in the late 1920s by Fletcher and Munsen, when technology was rather primitive by todays standards. While it has been revised several times, it still only provides a very generalised ‘snap-shot’ of the average human hearing of a healthy young adult. The fact that the original work was carried out on the occluded ear further degrades its useful application to real world conditions. Neither does the A-weighting take into account the broad variation of human hearing responses, or such conditions as hyperacusis, that affects a significant percentage of the population.

The legacy of this early work should not inhibit further advances in modern science. That the scientific method relies upon observation as its first step, and that those specific clinical observations of symptoms are commonly experienced and reported by wind turbine-affected people and others affected by other sources of high levels of infrasound and low frequency noise and vibration, should be a strong clue that there is a direct causal relationship. In fact, Kelley and his co-researchers demonstrated such a direct causal relationship between ILFN and symptoms (“annoyance”), including sleep disturbance, thirty years ago.

In the case of diseases, there is not one doctor on this planet who would advocate ignoring symptoms that are new and unusual. In the case of dangerous diseases like cancer, to do so could be virtually suicidal for the patient and downright unethical for the physician who may well be sued for medical malpractice. Similarly, just because we do not fully understand every step in the mechanism of action (causation) of adverse effects from acoustic input, that is not a valid reason for sitting on our hands and either ignoring symptoms or taking the easy way out and declaring such affected folk are



suffering from a psychosomatic disorder. If this were so, much of medicine would be disenfranchised for the want of a detailed understanding of the mechanisms of action of many modern drugs. You can't have your cake and eat it too!

A salient observation is that many of the proponents of wind energy (often paid by the wind industry) and who make such prognostications about suggestibility and hypochondriasis are not medical doctors, psychologists or psychiatrists, who would have the necessary qualifications, experience and medical expertise to make such diagnoses, provided they were actually seeing these people professionally and therefore bound by the ethical and legal construct of a "doctor – patient" relationship. In addition, the need to "take a history" themselves rather than offering 'armchair diagnoses' on the basis of insufficient information and no direct knowledge of the individual's circumstances is another important proviso. While the wind industry continues to obfuscate and use these non-specialists, or specialists with no direct clinical knowledge of the problems, to 'diagnose' the afflicted who suffer from adverse health effects associated with living in close proximity to wind turbine installations as suffering from the "nocebo effect", we are getting into very deep water.

In my opinion, such unqualified people should be taken to task over their pseudo-medical diagnoses based on second hand evaluation and consideration should be given to them being taken to court or other regulatory authorities, as appropriate, for falsely practicing as physicians. The simple message is, if it is not within your area of expertise and qualification - **DO NOT OFFER A DIAGNOSIS**. Diagnoses of nocebo or hypochondriasis need to be made after a careful clinical evaluation by suitably qualified health practitioners. These are diagnoses of exclusion when all other explanations have been examined and explicitly disproven.

My area of expertise and qualification is in acoustics and human health, so it is within my purview to make comment on the science associated with environmental triggers that may affect the human condition. There is now a considerable amount of research slowly trickling into the scientific journals, together with much old research, long-ignored by the wind industry, despite knowing full well that it exists, that is giving us a far better understanding of the potential mechanisms of causation as it relates to industrial wind turbine noise and adverse health effects.

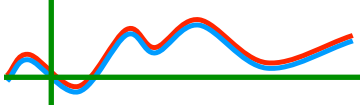
Perhaps the most important concept to deal with is the archaic notion that only loud sounds can cause adverse effects. This out-dated and naive philosophy necessarily ignores much of the modern research across a number of fields of endeavour in order to arrive at the conclusion that "if you can't hear it, it can't hurt you". Nothing could be further from the truth, but in order to understand that statement to its fullest extent, it is necessary to stop thinking in a simplistic way about how interactions occur between organism and environment. Many environmental stimuli are weak - not every form of

energy has to be at the same level as an atomic bomb to cause havoc. One of the critical aspects of this alternative understanding is that critical to an organism's survival is the information quotient of a signal, not just its strength. Life on this planet continues to survive down through the millennia, in large part due to its ability to respond to subtle environmental stimuli.

From neurophysiology we now know that the nervous system is digital, not analogue, as was once thought. There is no such thing as a strong or weak nerve impulse. It is purely binary, it either is, or it isn't. So now we have a conundrum to consider: How do we differentiate quantity? How do we distinguish bright from dark, hot from cold or loud from soft, if all nerve impulses are the same? The answer is surprisingly simple: biological organisms are digital creatures that use frequency-modulated nerve impulses to describe environmental input and control physiological activity. The brain is nothing more than a frequency modulation device, a difference engine. Every piece of information is coded as a pulse train of nerve impulses, and it is the frequency and timing of these impulses that encode all biological data. This applies to efferent control as well. By way of simple example, the number of nerves that fire to activate a muscle determines the strength of contraction. A few nerves firing produces a weak response, many nerves firing produces a much greater response.

The critical point to understand from this knowledge of neurophysiology is that life is measured, and moderated by, information-carrying, digital nerve impulses, not analogue strong/weak impulses. This puts a completely different perspective on things, albeit with a degree of scientific complexity and required background knowledge that social scientists may simply not be capable of understanding. With respect to environmental input, such as the acoustic emissions of wind turbines, it is not necessarily the strength (or loudness) of the signal that is important, rather it is the information quotient of that signal. To understand this, a knowledge of both biological evolution and animal behaviour is required. For the purposes of this exposition, I will attempt to keep things simple. . . To quote and old adage: "The pen is mightier than the sword". This simple metaphor concisely encapsulates the principle that the written word can have greater impact than the force of a sword thrust.

From the perspective of evolution, paying attention to fine detail is critical. To misidentify an object either as predator or prey could have immediate and dire consequences. As is always the case, the devil is in the detail. With respect to low frequency sound, the rumble of an earthquake is a good signal to flee to safety. The same is true of avalanches and falling trees. Subtle changes in the sound of the wind can also be harbingers of evil. So in order to survive, animals learned to interpret the information quotient of their sound environment. The snap of a twig or the soft footfall of a predator was sufficient to stimulate the sympathetic nervous system into immediate action: fight or flee. The important concept here is that the actual amplitude, or power, of the signal



is irrelevant: it is the information quotient of the signal that is of survival value. And so it is with wind turbine emissions.

Although much of the stimuli in the form of acoustic emissions from wind turbines and other sources of sound and vibration may well be below the threshold of auditory perception, and even below conscious perception thresholds for sound which is inaudible but still felt, for example, as a pressure pulse, that does not mean that it cannot be registered by the organism and directly or indirectly induce a measurable objective physiological response. That is precisely what the people are telling us, with the observational reports of their experiences. This particular research, measuring the full acoustic spectrum and concurrent human physiological responses with respect to sleep, blood pressure, heart rate and sequential cortisol measurements, has never been done in the field with respect to wind turbines, and is precisely what is now required.

The human brain is arguably our most complex structure, mysterious in its workings. What we do know is that it is built in layers and these are a product of a very long evolutionary process. Accordingly, we contain much in common with our more primitive ancestors. The brain of a snail or a snake is far less complex than that of a rabbit or a wolf, but the basic building blocks are the same. Taking this evolutionary process further, humans share much in common with both reptiles and mammals, the significant difference being the increased complexity of the cerebrum. The frontal lobe was the last part to evolve. The critical point is that while humans have this amazing cognitive engine in the form of the cerebrum, it is nonetheless still built on top of the primitive reptilian hindbrain. It is even referred to as such to this day.

In the reptilian hindbrain, there are very basic survival circuits and it is these that respond, automatically, to environmental signals. A snake does not need to consider complex calculus equations, or perhaps the work of Marcel Proust, in order to determine whether or not to strike at a particular image. Rather, its neural processing is orders of magnitude more simple. For this reason, what is important to a snake is not the concept of mathematical integration or the deeper meaning of Proust's *Les Plaisirs et les Jours*, rather the utmost question for the snake is: Is this lunch? And perhaps: Is it safe to strike? By way of diversion, while Proust was a French novelist, critic and essayist of the late 19th and early 20th century, his father was a prominent pathologist and epidemiologist who studied cholera in Europa and Asia.

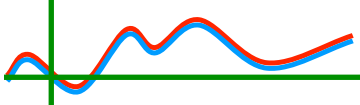
What we now know about the reptilian hindbrain is that it contains what may be thought of as digital 'filters', that is, neural circuits designed to respond only to specific input signals. In this case, acoustic input in a particular frequency range. These filters are continuously searching for the specific frequencies that spell out D-A-N-G-E-R. Once triggered, a series of hormonal and neuronal cascades ensue, all predicated on survival. If you do not 'hear' the soft foot fall of a predator, it may indeed be the last thing

that you do not hear! For this reason, these filters work at the limits of perception, that is, at very, very low levels. Survival of the species depends upon it!

The precise mechanisms regarding the 'digital filters' are now becoming better understood to the point that there is now good knowledge of how sub-threshold signals can, in fact, be perceived. One notable example is that of the brine shrimp, Artemia, a genus of aquatic crustacean. These organisms are of importance in that they are the only genus of the family Artemiidae that has changed little since the Triassic period (252.2 ± 0.5 to 201.3 ± 0.2 million years ago). These clever little critters understood that if you have a successful design, you don't mess with it. And indeed we have learned much from their 'primitive' neurophysiology and behaviour.

The brine shrimp have on their tails, micro projections or hairs. They function like ears in that they detect sound in water. These little stalk-like 'microphones' are always listening for danger signals. The danger to your average brine shrimp is usually in the form of a much later evolutionary predator: Fish. Now the important point is that fishes make sounds as they swim through the water, and that sound is different if they have their mouth closed or open. A fish swimming along and opening its mouth to eat a brine shrimp creates a totally different 'noise' in the water compared with a fish that has had lunch and is just cruising by. The difference in actual sound level is microscopic, yet the brine shrimp has a clever way of 'hearing' this really quiet, yet subtle, change in its otherwise noisy soundscape. Bear in mind that the water is actually quite a noisy place, there is a lot going on. So to survive, the brine shrimp needs to be able to distinguish microscopic changes in its soundscape in the presence of considerable noise in order to survive.

The clever part of the brine shrimp's defence mechanism and strategy is that it uses the background noise to 'amplify' the sub-threshold signal - the fish opening its mouth. The process is known as Stochastic Resonance, a concept well-known to electronic engineers for many decades. This 'random' noise has the effect of increasing the level of some of the sound impulses whereby they actually cross the threshold of perception barrier. When this happens, it is the 'frequency signature' or information quotient of the signal, that is important, not the absolute sound level. When this frequency signature is detected, the brine shrimp gives a quick flick of its tail that provides enough acceleration to allow it to, most of the time, avoid being on the fish's menu. This wonderful example from the Triassic period is still with us today, and the neuronal mechanism and subsequent processing still a part of the reptilian hindbrain that humans have inherited. This knowledge regarding the brine shrimp's clever use of stochastic resonance has been known for more than 20 years. (N.B. Stochastic Resonance requires a non-linear detector, not unlike our own hearing response!)

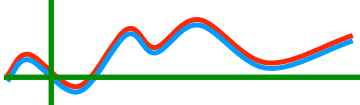


So while sociologists and acousticians, and many in public and environmental health as well as politics, continue to obfuscate, claiming that the nocebo effect is responsible for the negative impact of wind turbine emissions, they are simply showing their ignorance of a much more complex issue, not to mention their own bias for whatever reason and lack of objective analysis of the consistently reported observations of residents. Noise can be a harmful substance. Noise that is too loud can cause deafness. Aircraft and traffic noise annoys residents and disturbs sleep. Loud music disturbs neighbours, particularly with low frequencies that travel far greater distances with minimal attenuation (of the order of only 3dB per doubling of distance).

To state that the nocebo effect is responsible for the symptoms people report when living near industrial wind turbines is a logical fallacy, because the 'potential' causal agent, i.e. acoustic energy, is actually perceivable.

The nocebo, like the placebo effect, relies upon the potentially causal agent not being perceivable by the individual, thus they respond according to their perceptions rather than a real cause and effect relationship. With wind turbine immissions, the potentially causal agent, (acoustic energy) are largely perceivable, therefore, the nocebo response, by definition, cannot occur in this circumstance. The argument in favour of the nocebo effect is further refuted by the sheer number of people who were pro-turbine prior to commissioning. Only after commissioning did the symptoms appear and many were initially unwilling to accept that the turbines were responsible. However, when the turbines were not operating, or the complainants left the vicinity, their symptoms ameliorated, only to return when they returned to their homes, and the turbines. This is positive proof that the causal agent is the wind turbine immissions and that the psychological aspects such as nocebo are not responsible for the symptoms.

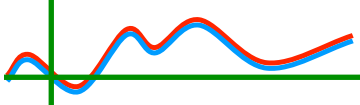
To explain this concept further, the nocebo effect is what could be referred to as a self-fulfilling prophecy. That is, if you have been convinced that a certain effect will manifest under certain circumstances, (in this case with some negative connotation) then it is likely to do so. The causal mechanism, is in fact, the state of mind, or the suggestibility, of the subject. Those who argue in favour of the nocebo effect are claiming that people who report suffering adverse health effects when industrial wind turbines are commissioned, are responding to negative publicity rather than a real, measurable phenomenon. While there can be a psychogenic effect in some cases, to label all reported adverse health effects as being purely of psychological origin is, at the very least, scientifically naive. The fact that there are numerous reported instances of animals responding physiologically and behaviourally to industrial wind turbines is sufficient to negate the argument for the 'nocebo effect'. As previously stated, Nocebo is the incorrect term to use. The correct term is psychogenic.



It is important to understand that humans respond to subtleties of the soundscape, not just the loudness of sound. For this reason the unique quality of wind turbine emissions can and does stimulate the 'primitive' filters in the reptilian hindbrain that then triggers the neuronal and hormonal cascade, initiating the "fight or flight" response of the sympathetic nervous system. As a result, adrenalin, noradrenalin, cortisol and a number of other chemicals flood the body as survival mode is rapidly turned on. As a direct result, even of sub-audible sound signatures, particularly in the low-frequency and infrasound range, a state of physiological and psychological anxiety and stress can be initiated. If this is occurs during the night, sleep can be disturbed, with repeated sudden awakenings in an anxious, frightened, panicked state, or reductions in the quality of sleep (REM sleep). This is what residents living near sources of pulsing infrasound and low frequency noise, including wind turbines, are reporting these effects from all around the world. The effects are accentuated if this happens in particularly quiet rural soundscapes because of the additional dominance of the very low frequency sound energy, which itself travels significant distances without much attenuation, as noted above.

A similar analogous situation arises for soldiers in a combat zone. Their sleep is repeatedly interrupted and their levels of physiological and psychological stress are also repeatedly elevated. Their survival depends on being able to detect danger and avoid it. Soldiers, however, get to go on leave for regular breaks, for recuperation, rest and recreation. Some affected residents living near industrial wind facilities are leaving their homes, temporarily and even permanently, where they can, for the same reasons. They know only too well that their long term survival and health depends on being able to escape in order to start to recover, so they can sleep and reduce the severity of their symptoms of physiological stress.

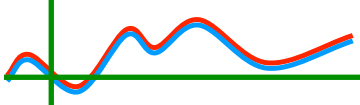
Now we need to look at the specifics of this response with respect to industrial wind turbine low-frequency emissions. For a brine shrimp, if the microscopic hairs on the tail are triggered by a marauding fish opening its mouth, it knows one thing - the fish is behind it. Otherwise it would have seen it and used a different avoidance strategy. The point is, the brine shrimp knew where the danger was and how to avoid it. Its survival since the Triassic period is proof of the effectiveness of the strategy. The problem with low-frequency noise, particularly from industrial wind turbines, is that it is not easy to determine the directionality of the source. Animals similarly have difficulty in determining the exact origin of a very low-frequency danger signal, which is why they are often observed to run in random directions in response to the rumble of an earthquake. Humans fare no better. The inability to determine the direction of the danger presents the cognitive engine (our brain) with a problem: Where is the source of the danger and what action should I take? Where should I run? In the absence of any other input, confusion is the end result.



While confusion is not necessarily a killer, the on-going stimulation that creates it can be. If the emissions from industrial wind turbines continue for long periods of time, as they can do for hours to days to weeks, then the human body simply cannot cope. An organism cannot survive for long with its autonomic nervous system constantly in a state of sympathetic dominance and the resulting physiological stress. For this reason, long term exposure to wind turbine emissions can and does cause a plethora of unpleasant, adverse health effects. The short term effects can be vertigo, feelings of pressure, tachycardia, fear and anxiety and reduced quality of sleep, while the long term effects are poorer absorption of nutritional requirements, reduction in immune system function and a gradual loss of cognitive ability and memory function. All this makes industrial wind turbine emissions unique in the human soundscape and why sociologists and acousticians will never solve the problem. The problem is also beyond many physicians. Rather, the answer lies somewhere between a number of disciplines that need to integrate their knowledge and investigate objectively so that an overall understanding can be achieved.

Such cross-disciplinary cooperation yields two additional pieces of information with respect to stimuli close to the limit of perception. When danger signals are detected by the digital filters in the primitive, reptilian hindbrain, the system goes on to 'yellow' alert. The hearing mechanism, in this case, turns up the sensitivity and the brain begins to focus more attention on the incoming auditory information. It is like hearing the snap of a twig in the jungle. This sharpens the senses so that you can determine if there really is a leopard about to pounce. This is the normal behavioural response of all animals. If there is a possibility of danger, animals increase the sensitivity of their sensory mechanisms in an attempt to determine the nature of the potential threat. And so it is with wind turbine sound, particularly in the low frequency region close to the level of perception. The body goes on high alert. This heightened level of vigilance has consequences if it continues for an extended period of time. In the natural environment, this state would not normally be sustained for more than a few minutes. The danger manifests and the animal fights or flees - survives or dies. If this heightened awareness continues unabated, the long term consequences can be disastrous in terms of health and well-being. And yes, people can die from the consequences of severe chronic stress. They can also die from a number of conditions caused by excessive adrenaline release acutely, such as Takotsubo heart attacks and acute hypertensive crises. Both these conditions have been reported by residents living near wind turbines as well as other sources of environmental ILFN, and are occurring without the usual known precipitants such as either an underlying adrenal tumour secreting excessive adrenaline or a severe, sudden emotional shock.

One final problem concerns the nature of low-frequency danger signals. The body cannot habituate to them. That is, you cannot not react to danger signals. It is a basic



survival instinct and why you are here today: your ancestors reacted to danger and took appropriate action. Sub-threshold signals are often detected as a result of stochastic resonance in the neural system and for this reason, to claim that if you cannot hear a noise it cannot affect you is blatantly laughable. All animals, including humans, frequently respond to subtle environmental stimuli, even though there is no conscious perception of it. Just because your conscious mind does not register a sound as audible does not mean that the body has not in fact perceived it and reacted in a different way.

The work of Professor Salt (Department of Otolaryngology Washington University School of Medicine St. Louis, Missouri) is critical to the understanding of this phenomenon. Of relevance is that some 5-10% of the afferent Type II fibres connect the outer hair cells of the cochlea to the brain, providing a source of information regarding low-frequency sound directly to the auditory cortex. What Salt found was that these Type II afferent nerves from the outer hair cells activate what he calls the alerting response. Further, the work of Professor Balaban, (Departments of Otolaryngology, Neurobiology, Communication Science & Disorders, and Bioengineering University of Pittsburgh) and others, has done much to support this by way of providing a better understanding of the neurophysiology. It is now known that the neural pathways from the cochlear pass through the parabrachial nucleus and the amygdala which explains the process of the alerting response and the triggering of fear.

What makes the unique sound immissions from wind turbines all the more sinister is that they occur at a comparatively low level, often around or even below the thresholds of hearing audible sound. This only makes them all the more dangerous for the reasons stated above. But this is not new scientific knowledge. Kelley and his co-researchers established that there was a direct causal link between pulsed sound energy and symptoms at levels well below the thresholds of audible sound in 1985, and followed this with laboratory research which definitively reproduced the symptoms when the study participants were exposed to the low levels of sound energy stimulus. In other words, the sensations and symptoms were known thirty years ago to be perceived or felt, but not heard.

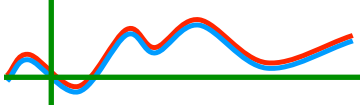
In conclusion to this discussion of the science of reaction to acoustic environmental stimuli, it is critical to understand that the issue involves multiple disciplines ranging from neurophysiology to behavioural science to evolution theory. Without sufficient understanding and the cooperation of multiple scientific disciplines, this complex riddle cannot be solved. To rely on the word of acousticians whose expertise is in measuring sound, or sociologists who study behaviour at a gross level, as the final arbiters of the discussion is simply ludicrous. Their lack of expertise and knowledge in relevant disciplines is compounded when these ‘experts’ are used by the wind industry, because of the wind industry’s commercial conflict of interest. Such mouthpieces of industry are not to be trusted and the potentiality of vested interests needs to be investigated in each

case where pseudo-experts are pontificating on the non-reality of human health effects from wind turbines. Remember: Science begins with observation. Observations in this instance refers to the careful reports of the residents experiencing the impacts, and those few acoustic and health professionals who have taken the time to listen very carefully to what these residents are reporting, and who have attempted to measure what they are exposed to.

Socrates believed there was only one good: Knowledge, and only one evil: Ignorance. While the population at large continues to allow the commercial interests of a minority of industries to rape the public health of human society while benefiting from the vast government subsidies predicated on green energy proliferation, the world is heading into a deep, dark place. I wonder what Socrates would have thought?

Those who are pro-wind turbines or indeed any other noise polluting industry, and have close ties to that industry, are working with a serious conflict of interest. For such pseudo-experts to continue to support an industry by way of simplistic science, cherry-picking data and relying on blaming the individual for the adverse effects they are experiencing is to display a degree of intellectual dishonesty that has serious consequences for public health. To turn a blind eye to the seriousness of the situation is indicative of moral bankruptcy. It is also ethically reprehensible. As Adolf Hitler is reported to have said, “If you tell a big enough lie and tell it frequently enough, it will be believed”. The time is long past when these dangerous advocates should be taken to task for their professional misconduct and abdication of their ‘duty of care’. The only effective way that such unprofessional behaviour can be countered is by holding these individuals and public officials responsible for the current situation accountable until governments, their advisors, acousticians and the noise polluting industries finally accept that they have to clean up their game.

In the case of wind turbines specifically, corporate greed and the abdication of responsibility by the rank and file voting for the Green Dream will ultimately lead to disastrous health consequences for an increasing number of individuals world-wide. That man can be so dismissive and callous in dealing with one’s fellow man is an indictment on the human race. That the Brown County Board of Health has made the motion to declare the Shirley wind farm a health hazard is courageous, as well as scientifically defensible, ethically and morally appropriate. I totally endorse your brave stance. You are right.



Yours faithfully,

Bruce Rapley. (BSc, MPhil, PhD.)

Principal Science Consultant,

Acoustics and Human Health,

Atkinson & Rapley Consulting Ltd.

Declaration of Conflict of Interest.

The writer declares no conflict of interest and has not been employed by the wind industry.

Rather the writer operates an independent scientific consultancy with no ties to, or received any financial support from any energy industry.

# APPENDIX 12: LETTER TO COMMISSIONER PASCOE - ACNC

Friday, 6 February, 2015

Commissioner Susan Pascoe

susan.pascoe@acnc.govt.au

Dear Commissioner Pascoe,

I have recently been made aware of the ACNC decision of December 11, 2014, regarding the ruling that the Waubra Foundation is not a Health Promotion Charity. I understand that Assistant Commissioner David Locke stated that:

> **"to date there has been no rigorous independent scientific evidence that finds that the ill health complained of is caused by the physiological effects from wind turbines nor that there are human diseases called "wind turbine syndrome" or 'vibroacoustic disease".**

As a consulting scientist in the area of acoustics and human health I write to advise you that I am appalled at the ignorance of your organisation's staff. I have worked closely with a number of people who have been affected by living in close proximity to industrial wind turbines and can personally attest to the considerable adverse health effects they suffer from.

I request to be advised of the qualifications of Assistant Commissioner David Locke together with an explanation of how he could possibly come to such a ludicrous conclusion. Having worked in this area for some years and possessing a PhD in acoustics and human health I take it as an absolute insult to me, my profession and my academic qualifications that such a nonsensical finding could be promoted. I can only conclude that there is some more sinister, political agenda that underpins the ruling.

Assistant Commissioner Locke displays his considerable ignorance of such illnesses as Vibroacoustic Disease and Wind Turbine Syndrome. Further, that he chooses to focus on "physiological effects" at the expense of the complex interactions between environmental variables and human reaction beggars belief.

The condition known as Vibroacoustic Disease has been well-established for more than a decade and is underpinned by a vast plethora of good, clinical and physiological evidence. There are numerous papers in the scientific literature if only Assistant Commissioner Locke would take the time to read them. To deny the existence of VibroAcoustic Disease is an egregious insult to the many scientists and clinicians who have worked for more than two decades on this research.

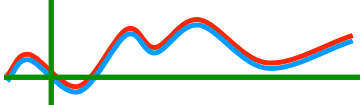
Assistant Commissioner Locke further displays his appalling ignorance of biology and medical science by selectively ignoring the wealth of information regarding stress-related conditions including sleep deprivation. In doing so he insults hundreds of international scientists and clinicians who have spent their lives studying such phenomena and providing appropriate treatment.

If Assistant Commissioner Locke had the appropriate academic qualifications and expertise to evaluate the scientific literature I am certain he would be amazed at the vast number of scientific and medical articles that abound on the physiological effects of sleep deprivation. That it can affect the human immune system, the digestive processes, the musculo-skeletal system and cognitive function of an individual makes a mockery of the pseudo-scientific mumbo-jumbo he is spouting. My own research has highlighted how the acoustic environment can affect not only hearing but also cognition and physical function. I take it as a gross insult that Assistant Commissioner Locke should choose to speak on topics of which he clearly has no knowledge.

Industrial wind turbines on the scale now in production are a relatively new phenomenon. With the increase in size, so the environmental acoustic hazard increases. It is basic physics. Perhaps Assistant Commissioner Locke would benefit from studying some basic science before he enters into making such ridiculous claims. Indeed his findings make a mockery of not only your organisation but its process that is clearly flawed.

The effects of environmental noise have been known for decades. There are even scientific journals dedicated to the topic, but as with all things bureaucratic, legislation lags behind the science. Environmental noise is a well-known pollutant and is even noted as such by the World Health Organization (WHO). The WHO produce guidelines for acoustic levels in residential areas with specific reference to sleep disturbance. Again Assistant Commissioner Locke is showing great ignorance that can surely only be underpinned by some ulterior motive or political agenda. Does he have connections with the wind industry?

Another salient point that Assistant Commissioner Locke appears to be blissfully unaware of is that the acoustic emissions from industrial wind turbines are unique, and cannot be compared to similar levels of other acoustic emissions, particularly in the low-frequency and infrasound regions. There are numerous scientific papers in the literature



that make this precise point, although wind industry executives still continue to live in the land of false hope, burying their heads in the sand, hoping that science will not catch them out. Well, unfortunately for them, it has.

There is significant new research, for example, the work of Steven Cooper at Cape Bridgewater, that clearly correlates human health effects and physiological responses to wind turbine immissions. While this work of Mr Cooper's appears new and exciting, in fact it is only providing conformation of what many of the scientists in the area have been saying for years. His work is, if you like, simply another piece of the puzzle vindicating the work of many of scientists that have gone before him. The work of Kelly springs to mind.

The unique acoustic signature of industrial wind turbines is providing scientists and clinicians alike with a number of unique challenges. The specific nature of that interaction is only now being studied to reveal the fascinating mechanism of interaction. There are numerous urgent calls for more scientific work to be carried out so that the 'i's can be dotted and the 't's crossed. As industrial wind turbines are a relatively new addition to the landscape, it takes time for the science to work out the answers, although much of the picture is becoming quite clear now.

The landmark work of Professor Alec Salt in the USA is one such example of how clinical research and the use of animal models can help to unlock the puzzle of why this sort of acoustic exposure can and does affect the organism. Neural pathways are now being discovered that makes yet another mockery of the ignorance of Assistant Commissioner Locke. Neuroanatomy and physiology are now showing us how this type of energy can cause such great havoc in the human body. While science at this level is very complex, requiring considerable academic training and experience, something Assistant Commissioner Locke appears to lack, I might be able to offer a more simple analogy as to how exogenous energy can have such significant effects on a living organism.

There are only 26 letter in the English alphabet, but the number of words that can be created from them seems almost limitless. Just pick up a Greater Oxford Dictionary and prepare to be amazed by its contents. These words, simply a jumble of 26 different, unique elements, when in the appropriate order can convey great meaning.

Even at the level of words, the effect is not complete. Rather it is the combination and order of the selected words that ultimately conveys meaning. The point is, it is the meaning to which humans respond, not simply the energy quotient. In terms of physics, the written or spoken word has little in the way of energy to offer. But, like a biochemical enzyme and its substrate, this 'lock and key' system provides an avenue for the generation of biochemical cascades that are the very process of life itself. Get the order right and the response is good. Get the order wrong and it can be a harbinger of death.

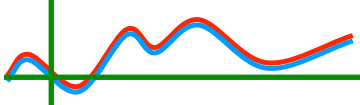
Take the example of a love sonnet; appropriately written and delivered, it can bring two people together in a state of emotional and physiological bliss. Get the order of the words wrong and it can be a declaration of war! As the British playwright, Stoppard said: “Words, words, it’s all we’ve got to go on!”.

The reason for using this simplistic analogy is for it to be the introduction to the biochemical language of science, notably biochemistry and human biology. The complex blueprint of human DNA is composed of only four ‘words’ (adenine, guanine, cytosine and tyramine) yet their complex interwoven structure is sufficient to grow and command every living cell in every person on this planet. (Obviously the same is true for plants, animals and bacteria.) The order of these biochemical sentences is a complex system, the language of which we have only just begun to understand in the past few decades. The point is, it is not the energy that is important, it is the information quotient of the sentences.

To explain the process of biochemical words even further, it may come as a shock to learn that the human body (and all animals as well) works on digital nerve impulses. Not analogue impulses but digital impulses. There is no hard or soft, quiet or loud nerve impulse. Every nerve impulse is the same as any other, and yet by their balletic dance they are able to convey every piece of meaning in every organism on the planet. (In order to function, the brain must be, and is, a difference engine.) It is these ‘digital words’ that make us what and who we are and how we function. It is these basic biochemical interactions (‘languages’) that are so important in understanding the interaction of environmental sound and the effects it has on living organisms.

What Assistant Commissioner Locke clearly does not understand is that this information pathway is the very reason that the acoustic (including infrasound) immissions of wind turbines can be so deadly to human organisms. They are ‘speaking’ in a ‘strange language’ directly to the human body, a language that we are only starting to comprehend. But in the absence of a more full understanding of the mechanism, what we do have is ‘cause and effect’. What clinicians refer to as ‘patient history’.

It may come as a further surprise to those not involved in the sciences or medicine, that in fact, much of medical diagnosis and treatment is based on ‘hearsay’. That is, what a patient reports. In the absence of a complete understanding of the biochemistry, physiology and neurobiology, clinicians are left with the dilemma of interpreting reported symptoms and making a diagnosis that will lead to treatment. By comparison, even with its vast arsenal, clinical medicine still has relatively few tools with which to ‘scientifically diagnose’ a problem. X-rays, MRIs and biochemical tests may confirm what a patient reports, but at the end of the day, it is what the patient reports that is of the greatest fundamental importance.



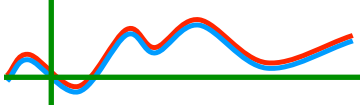
To ignore the symptoms reported by a patient is to commit a potentially fatal mistake and is in direct opposition to the Hippocratic oath that all doctors aspire to. Indeed, it could well constitute a case of medical misconduct, without even considering the potential disastrous results for the patient. It should be remembered that we learn from such patient testimony and this is how new disorders are discovered.

What we know is that, in the absence of a full understanding of the mechanism, patients are reporting the same type of symptoms related to living in close proximity to industrial wind turbines across the world. The work of Steven Cooper, while only one small step in the journey of discovery, is still one big and important step for scientific understanding of this issue. Using as he did, a case series crossover design, which is, in and of itself, a powerful experimental protocol, he was able to demonstrate the cause and effect relationship between environmental input and human physiological response.

To put this work in perspective, what Mr Cooper has done is join the dots. He has managed to link the phenomena to the reaction, using environmental monitoring and a case series crossover design, an experimental technique that is supported by Emeritus Professor Alun Evans. Other epidemiologists agree, but I see that Assistant Commissioner Locke intends to insult these eminent scientists as well with his ludicrous ruling and unscientific process.

The process of science is a journey of epic proportions. Only by combining millions of individual pieces of the jigsaw can the picture finally begin to emerge. Mr. Cooper's work is the most recent important step along that journey. The point is that, as we put together more pieces, the picture is beginning to emerge, and that picture shows us that the unique acoustic emissions of industrial wind turbines can and do affect humans (as well as other animals - of course). The process by which that effect is created is not through vast energy transfer, 'using a sledge-hammer to crack a nut'; rather it is by interfering with the complex and delicate structure on internal biochemical, neurophysiological pathways: The Nervous System.

The nervous system responds to the environmental input from industrial wind turbines by way of what can best be described as the function of a biological filter. That is, when a certain signature is detected, a particular chain of events is set in motion. That chain of events involves the outer hair cells of the cochlea, as well as the entire vestibular system (and possibly the gravisensors of the gut). Together, this 'acoustic' (that includes infrasound) energy that is detected by the human system that initiates a biochemical cascade. In the last handful of years, we have managed to get a handle on some of the neural pathways and how the brain interprets this unique input. The fact that the parabrachial nucleus is involved, as is the amygdala, is a significant finding. The end result is that one effect of the acoustic immissions so detected is to switch the



autonomic nervous system into what is known as sympathetic dominance. In this state, a range of very important physiological changes occur.

The circulation of the blood is redistributed, digestion all but stops, sweat glands produce copious amounts of sweat and the pupils of the eyes dilate - to name but a few. Adrenalin floods the body and a state of heightened cognitive awareness dominates brain function. If this situation is not reversed in a matter of minutes or hours, severe physiological consequences can result leading to reduced cognitive function, reduced immune function and ultimately myocardial and respiratory failure. Yes, it can kill you. In shorter time frames it can be likened to torture, and such methods are well known and have been used for prisoner interrogation for decades prior to the second world war.

Indeed, sleep deprivation has been used for hundreds of years. The Italian lawyer, Hippolytus de Marsiliis (1451 - ) introduced it as a new tool for use in the Catholic Inquisition. The idea soon gained widespread acceptance. It is still used today, see “How the CIA tortured its detainees”. The globalisation of this phenomenon was demonstrated by revelations in 2008 that a study of Chinese Communist torture techniques was being used as training material for interrogators based at Guantanamo Bay. Animal studies show that too much sleep deprivation causes death. How much more of a physiological connection does Assistant Commissioner Locke need exactly?

As Assistant Commissioner Locke is obviously unaware of the consequences of sleep deprivation, here is a brief list of some of the known effects:

- Irritability
- Cognitive impairment
- Memory lapses or losses
- Impaired moral judgement
- Severe yawning
- Hallucinations
- Symptoms similar to ADHA
- Impaired immune function
- Increased risk of Type II diabetes
- Increased heart rate variability
- Risk of heart disease
- Decreased reaction time

- Tremors
- Aches
- Suppression of growth
- Increased risk of obesity
- Decrease in body temperature and regulation

Is that enough of a physiological connection for Assistant Commissioner Locke?

May I suggest that your organisation familiarise itself with “Why Sleep Deprivation Is Torture”. There are many good, scholarly articles available on the internet using Google Scholar. There are in excess of 409,000 general articles on the topic and some 34,000 in the scientific literature.

It may seem outrageous to mention torture, however, I am not the first to do so. There are many other scientists and experts who have reached the same conclusion, and if you care to look in the scientific literature, you will actually find it. The reality is that living in close proximity to industrial wind turbines can be the same as torture, which explains why so many people are unwillingly leaving their homes in a desperate attempt to preserve their health and save their own lives. This is in no way hyperbole, making the position taken by Assistant Commissioner Locke all the more reprehensible.

I suggest that if Assistant Commissioner Locke is to draw such bizarre conclusions, he should be made personally liable for the physical and mental suffering that his ruling will cause. Perhaps then, and only then, might he realise that he has made an egregious error of judgement. Similarly, your own organisation should shoulder the responsibility of their actions and be financially liable for the human suffering caused by its ruling.

In conclusion, the ruling made by Assistant Commissioner Locke and your organisation is an egregious error of judgement and you should all be held, collectively and corporately, liable. The science is pointing the way to a clearer understanding of the dangers of environmental sound, much of which has been acknowledged for decades. In arriving at this interim ruling, Assistant Commissioner Locke insults me, my work, my qualifications and experience. Further, he insults the vast number of scientists who are working in this area, many of them for decades and are now trying to get the science in front of legislators before more human tragedy results.

It is my recommendation that Assistant Commissioner Locke and your organisation be held to account and the case tested in a court of law with regard to the ruling of December 11, 2014. I further suggest a class action suit be taken against the ACNC by those whose money will have been misappropriated by this ruling if it remains in place.

The current course chosen by the ACNC has aimed the ship towards the iceberg and if a real human tragedy is to be averted, that course needs to change now. If you fail to undertake this maneuver it is only a matter of time before that fateful collision occurs.

You have the chance of turning away from this ludicrous decision that is not only an insult to scientists around the world but also endangering the lives and well-being of countless residents who have committed no other crime than to allow industrial wind turbines built too close to their homes. For these unfortunate people, whose lives have been destroyed, there should be some recompense and your organisation needs to shoulder some of the responsibility for the consequences.

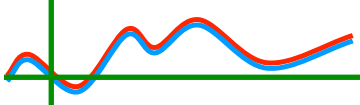
I wonder how brave Assistant Commissioner Locke would be if he were to be made personally liable for the potential adverse health effects of his misinformed ruling?

An important consideration that you must take heed of is that the Waubra Foundation is NOT just about the adverse health effects from industrial scale wind turbines. Rather it is concerned with the adverse effects of noise from ALL INDUSTRIAL SOURCES. In point of fact, I have referred people in New Zealand to the Waubra Foundation as I know from experience that they will get good-quality health information regarding the problems they are experiencing with infrasound and low-frequency noise from a variety of industrial sources.

The focus of my work, like the Waubra Foundation, includes ALL sources of environmental acoustics that have human impact. In point of fact, my PhD thesis on the effects of occupational noise in the New Zealand military is consequently embargoed because of issues affecting national security. Noise can have far-reaching effects, even affecting a country's security!

The point about adverse health effects experienced by those living in close proximity to industrial wind turbines is that in the vast majority of cases they were not aware of the potential hazards and openly welcomed the development. It is only after commissioning that the awful truth began to emerge. Many of these people have had to flee their homes as a consequence, often at great financial loss. The concept of the 'nocebo effect' is a red herring and fails on first principles. It is based on a misunderstanding of the concept of placebo/nocebo.

In my professional work I have found that I can rely on the Waubra Foundation as a valuable source of health information that is of great benefit to those who seek it. The work of the Waubra Foundation is to provide a source of information on how to deal with the effects of industrial noise and as such is a very valuable service. That they are also focussed on promoting research in the area that is vitally needed world-wide is an added benefit.



One final point: The consequences of your organisation's ruling is tantamount to misappropriation of funds. Hundreds of people have donated money to the Waubra Foundation, in good conscience, well-informed of the aims and objectives of that organisation. To rule that the Waubra Foundation is not a charity predicated on dissemination of health information and facilitating research related to industrial noise problems is to deny the reality of the situation and smacks of some sinister, political agenda. The consequence is that the money given in good faith will be misappropriated for some other purpose. This is what we call theft in New Zealand. And your organisation, as it stands, is solely responsible for that.

Please be advised that as I have been asked to provide expert testimony to the Senate Enquiry in Canberra later this month. I fully intend to provide them with all information regarding your organisation's actions in respect of the Waubra Foundation. The implications are considerable.

Yours faithfully.

Dr. Bruce Rapley, BSc, MPhil, PhD.

Principal Consultant: Acoustics and Human Health,

Atkinson & Rapley Consulting Ltd.

Palmerston North, 4412,

NEW ZEALAND

# APPENDIX 13: ABOUT THE AUTHOR

Dr. Bruce Rapley is a consulting scientist with Atkinson & Rapley Consulting Ltd. New Zealand, specialising in acoustics and human health.

He has three degrees from Massey University in New Zealand. A BSc in biological systems, an MPhil in technology (System Design and Testing of a Medical Biostimulator) and a PhD in acoustics and human health (Sound in the Military Environment: Detection, Measurement and Perception - undertaken in collaboration with the New Zealand Defence Force).

Dr. Rapley's area of expertise includes the interaction of exogenous energy and living systems. He has published a number of scientific papers in the field of bioelectromagnetics, applied acoustics and health.

For the past 15 years, Dr. Rapley has spearheaded a research and development project to produce a new environmental monitoring and analysis system for sound, vibration and low-frequency magnetic fields. This has culminated in the launch of the SAM technology in 2011. This dual-channel, comparative analysis system is purpose-built for on-site, remote monitoring of environmental noise, such as wind turbines or other industrial plants. It includes such features as automated one-touch English-language reporting, on-site or remote analysis, recording of sound events, full time SPL history with acoustic statistics, spectral analysis and amplitude modulation analysis.

The SAM technology has been used by local authorities, universities, research institutions and the New Zealand Military.

Now semi-retired, Dr. Rapley continues to consult, part-time, on problems related to acoustics and human health as well as continuing to development the environmental monitoring and analysis system: SAM - Evolution 5. In his spare time, he is engaged in writing books and scientific papers on topics relating to science and health.