Submission to the Select Committee on Wind Turbines

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Systemic Failure of a Noise Standard: A Case Study of NZS6808:2010

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SYSTEMIC FAILURE OF A NOISE STANDARD:

A CASE STUDY OF NZS6808:2010

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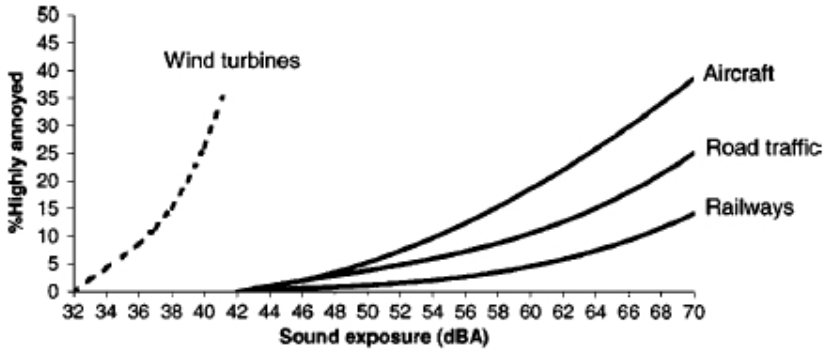
PART I

The Facts

Executive Summary

- Industrial-sized wind turbines used for the production of electricity are a relatively new phenomenon, arising out of the international oil crisis of the 1970s.
- The **acoustic emissions** from industrial wind turbines are **unique** and **cannot be compared to other sources of low-frequency or infrasound**, with the possible exception of HVAC[1] systems, (e.g. large ventilation fan).
- The **predominant acoustic emissions** from industrial wind turbines are in the **lower frequency region**, including **infrasound**.
- Most wind turbine noise standards utilise the ***A-Weighting that is designed to underreport frequencies below 1,000 Hz***.
- Thousands of residents living in close proximity to industrial wind farms report similar adverse health effects.
- The **adverse health effects include**: loss of sleep, sleep disruption; headaches; vertigo; tinnitus; dizziness; unusual feelings of 'fullness'; loss of balance; loss of cognitive function; loss of short-term memory; inability to focus on a task; a feeling of unease; nervousness; severe acute anxiety and depression; unexplained exhaustion or tiredness.
- The assumption in the New Zealand Standard that typical New Zealand homes will provide an attenuation of 15 dB outside to inside is ***demonstrably incorrect***.
- The assumption in the Nw Zealand Standard that wind speed measured at 80 or 100 m above ground level influences the level of noise at ground level is ***incorrect***.
- The assumption in the New Zealand Standard that increased wind speed at 100 m will mask the sound of turbines heard at ground level is ***incorrect***.
- In comparison to environmental noise at similar sound pressure levels, **wind turbine emissions are more annoying and disturbing than aircraft noise, road or rail traffic**. See overleaf.

[1] HVAC - Heating Ventilation Air Conditioning.



- **It is not physiologically possible for humans to habituate to the low-frequency or infrasound acoustic emissions from wind turbines.**

- The **neurophysiology** of the interaction of industrial wind turbine emissions are now known to be mediated by the **outer hair cells** in the cochlea, the **vestibular system** (utricle and saccule) and the **gravisensors** in the abdomen.

- Acoustic emissions from industrial wind turbines pose a major health risk for residents living in close proximity to wind farms. ***Effects have been observed in sensitive and sensitised individuals out as far as 10 km, sometimes further.***

- **Some people are more susceptible to the low-frequency and infrasound emissions** from industrial wind turbines including: people with a history of motion sickness, migraines and inner ear pathology or industrial deafness; the elderly; young children; invalids; people suffering from Autistic Spectrum Disorders; those possessing a congenitally-small or obstructed helicotrema as a result of infection and those with more sensitive hearing.

- The potential health effects from industrial wind turbines have been **known for** more than **30 years**.

- The wind industry has recruited a number of acousticians and agencies to promote their stance. Much of that support is simply propaganda with a spin that supports wind energy generation, regardless of the consequences for public health.

- The **Australian Medical Association** has taken a stand to support wind energy and in doing so has **stepped well outside their area of knowledge and expertise**.

- There is now evidence to support the contention that **Vibroacoustic Disease** may result from exposure to industrial wind turbine emissions.

- **Independent research is urgently needed** to confirm the dangers of the low-frequency emissions from industrial wind turbines that is not constrained by the wind industry's agenda. **The dose-response relationships must be determined with all possible speed**.

Key Facts

- Wind has been used from ancient times as a source of power.

- Wind has been used to generate electricity only since 1887.

- Modern, large industrial wind turbines originated during and following the oil crisis of the 1970s.

- Since the work of **Kelley, and Hubbard & Shepherd** at **NASA in the 1980's**, it has been known that industrial wind turbine emissions cause adverse health effects. (*Though continually denied or ignored by commercial interests despite major changes to wind turbine design specifically to reduce impulsive infrasound and low-frequency emissions because of known adverse health effects.*)

- The purpose of a standard is to provide a document outlining the requirements, specifications, guidelines and/or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose[2].

- In general, Australia uses the New Zealand standard for wind turbine noise emissions, NZS6808:2010, as a basis for many of their wind farm noise standards and compliance orders.

- NZS6808:2010 fails to fulfil its obligations in protecting the public health of residents living in close proximity (<10 km) to industrial wind turbine farms.

- This document outlines the reasons for failure of NZS6808:2010 that are summarised in the following points.

[2] ISO http://www.iso.org/iso/home/standards.htm

NZS6808:2010 - its failures

- **The Standards Committee was overly represented by people with close associations to the wind industry**, opening the door for **conflict of interest favouring the commercial aspirations of wind turbine developers**.

- **The Standards Committee was funded by Wind Energy Association and Energy Efficiency Conservation Authority (EECA).** Clearly they would want to protect their own interests.

- Although **NZS6808:2010 claims to protect the health and amenity of local residents**, it **fails to do so**. This is why two of the most qualified and experienced members of the NZ Standards committee did not support NZS6808:2010, one of these members registering his extreme disapproval (which is noted in the standard!).The other member withdrew from the final vote.

- While **NZS6808:2010** is theoretically **designed to provide protection against sleep disturbance** and to maintain reasonable amenity at noise sensitive locations, it **fails in this basic aim** as demonstrated by the plethora of complaints from residents living in close proximity to industrial wind farms in New Zealand.

- **NZS6808:2010 relies upon the $LA_{90(10\ min)}$ statistic**, citing 40 dB as the limit at noise sensitive locations. **This is clearly inadequate** and based upon false assumptions.

- **Another false assumption is that there will be an attenuation of 15 dB between outside to inside a dwelling. This is demonstrably untrue, see Dickinson 2009[3].**

[3] Dickinson, P.J. "Nonsense on Stilts. Proceedings of ACOUSTICS 2009.

Berglund on sleep disturbance

NZS6808:2010 quotes Berglund *et al*. in reference to sleep disturbance.

Berglund *et al*'s. relevant findings **based on studies of transportation noise** are:

- **[Both] continuous and intermittent noise affects sleep.**
- **Sleep disturbance correlates with increasing sound levels.**
- **Measurable sleep disturbance begins at 30 dB L_{Aeq}.**
- Effects on sleep include changes in sleep patterns and reduction in REM sleep.
- Subjective effects include: difficulty falling asleep; poor sleep quality; headaches; tiredness.
- Sensitive groups have been identified including shift workers, elderly, and people with physical or mental disability.
- **When the noise is composed of a large proportion of low-frequency sounds a still lower guideline value is recommended, because low-frequency noise (e.g. from ventilation systems) can disturb rest/sleep even at low sound pressure levels.**
- **"guidelines should be based on a combination of values of 30 dB $L_{Aeq,8h}$ and 45 dB L_{Amax}"**
- **"To protect sensitive persons, a still lower guideline value would be preferred".**
- ". . .sleep disturbance from intermittent noise events increases with maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep".

World Health Organization on sleep disturbance

- **"If negative effects on sleep are to be avoided the equivalent sound pressure level should not exceed 30 dBA indoors for continuous noise."**

- "If the noise is not continuous, sleep disturbance correlates best with LAmax and effects have been observed at 45 dB or less. This is particularly true if the background level is low. Noise events exceeding 45 dBA should therefore be limited if possible."

- "**For sensitive people an even lower limit would be preferred.** It should be noted that it should be possible to sleep with a bedroom window open (a reduction from outside to inside of 15 dB) based on European houses."

- "**To prevent sleep disturbances**, one should thus **consider** the equivalent sound pressure level and the **number and level of sound events**. Mitigation targeted to the first part of the night is believed to be effective for the ability to fall asleep."

Attenuation of wind turbine noise in a typical New Zealand or Australian rural home

- Based on the work of **Dickinson 2009**, a reduction in noise level of the order of 15 dB for a standard weatherboard New Zealand home is only possible if the percentage of the wall opening (window/door) is of the order of **3% or less**.

- Limiting open window area to 3% is an unrealistic expectation given the nature of New Zealand's temperate climate. Opening a window on hot summer nights is the only practical alternative for most home owners as air conditioning systems are not common in rural domestic dwellings.

- Transmission of sound through **4mm glass**, as is standardly used in New Zealand homes, **does little to attenuate low frequencies**, such as those emitted from industrial-scale wind turbines.

- **The reliance of NZS6808:2010 on an attenuation of 15 dB is not realisable with an allowable external sound level of 40 dB $L_{A90(10\ min)}$ for the average New Zealand home. The World Health Organization's recommendation of 30 dB or less for sleeping would not be achieved.**

Low-frequency sound and the failure of the A-Weighting.

- NZS6808:2010 relies on the use of the A-Weighting for sound measurements related to wind turbine emissions.

- **The A-weighting is an anachronistic standard from the 1930s** that was designed to simulate human hearing for sounds above 70 decibels. In laboratory studies it was found that the ear was much less sensitive to the lower frequencies and the A-Frequency Weighting allowed for this by filtering out the low-frequency and infrasound.

- The acoustic output from industrial wind turbines is predominantly in the lower frequencies, therefore ***measurements using the A-Weighting are meaningless***. NZS6808:2010 fails to take the latest science into account.

- **NZS6808:2010 does not take into account the latest scientific findings** regarding the human reception of sound, particularly low-frequency and infrasound.

- The most **recent neuroscience discoveries** regarding human hearing **establishes the mechanism** by which low-frequency and infrasound acoustic energy is received by the human body.

- The **mechanism** of reception of low-frequency and infrasound involves the **outer hair cells** of the cochlea that are in direct contact with the tectorial membrane.

- Nerve impulses have been measured in laboratory experiments to show the neural signature of low-frequency and infrasound reception via the outer hair cells.

- The **vestibular (balance) system** of the inner ear is also **capable of receiving low-frequency and infrasound**, although this may not result in the 'perception' of audible sound.

- NZS6808:2010 ignores the enormous number of observations from people around the world who suffer adverse health effects in the presence of functioning industrial wind farms.

- The most recent work of **Steven Cooper provides concrete evidence of a causal relationship between the power output of industrial wind turbines and reported adverse health effects** (recorded as sensations).

- **NZS6808:2010[4] admits that industrial wind turbines emit some low-frequency and infrasound, claiming they are "well below the threshold of human perception".**

- **NZS6808:2010 perpetuates the myth that "what you cannot audibly perceive cannot harm you".** This myth is demonstrably untrue and much science must be discounted before such an outrageous claim can be made. **NZS6808:2010 simply ignores the science that does not suit its purpose.**

- **NZS6808:2010 rejects the evidence that many people from around the world are reporting adverse health effects from low-frequency sound or vibration from industrial wind turbine installations.**

- **NZS6808:2010 claims** that, with regard to the reported adverse health effects from people around the world, the "**paucity of evidence does not justify at this stage**, any attempt to **set a precautionary limit** more stringent than those recommended in 5.2 and 5.3.".

- **To arrive at the above conclusion, the authors (and users) of NZS6808:2010 must deliberately ignore a veritable mountain of evidence to the contrary, including the recent scientific discoveries of the mechanism of action of low-frequency and infrasound on the human body.**

- **To maintain this position of 'no effect,' the authors** (and users) **of NZS6808:2010 must ignore all the medical evidence from physicians** who are reporting patients who present with adverse health effects from living in close proximity to industrial wind turbines.

- **To maintain the above stance, wind turbine noise standards must also ignore the latest ruling from Brown County, Wisconsin,** that:

  "To declare the Industrial Wind Turbines at Shirley Wind Project in the Town of Glenmore, Brown County, WI., 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."

[4] NZS6808:2010, 5.5.1, p 23.

NZS6808:2010 and special audible characteristics

- **NZS6808:2010 acknowledges the presence of special audible characteristics** including: tonality; impulsiveness and amplitude modulation.

- **Because NZS6808:2010 utilises the A-Weighting much of the important special audible characteristics will not be detected or deliberately ignored.**

- **NZS6808:2010[5] claims that "measurements show that wind turbine sound does not contain a large proportion of low frequency components". *This is totally incorrect*.**

- **The *majority of acoustic emissions from industrial wind turbines are in the low-frequency and infrasound region*.**

- **Only through the use of the A-Weighting that *specifically under-reports frequencies below 1000 Hz* can the above claim be made.**

[5] NZS6808:20140, C5.5.2, p 24.

Summary of Key Points

- **NZS6808:2010** is a standard that **ignores much of the empirical evidence** relating to adverse health effects experienced by people who live in close proximity to industrial wind turbine installations.
- The standard was created by a committee, the majority of whom had current or past associations with the wind industry: the **potential for commercial conflicts of interest is obvious**.
- **The standard favours industry at the expense of public health and denies any scientific evidence that would jeopardise this stance.**
- **The standard promotes the scientifically incorrect view that "what you cannot hear (perceive audibly) cannot harm you".**
- **The standard relies on an out-dated acoustic metric, the A-Weighting, that specifically under-reports frequencies below 1,000 Hz.**
- **The standard is in urgent need of revision.** It must take into account the wealth of empirical and medical evidence of adverse health effects. It must also take notice of the latest scientific evidence that reveals the mechanism of action of low-frequency and infrasound on the human receiver.
- **Such a new standard must be predicated on the preservation of public health and amenity**, with particular reference to ensuring people can get **adequate sleep**, rather than supporting the proliferation of an industrial technology that clearly can and does have an adverse effect on human health.
- **The standard[6] should take into account how it will protect vulnerable groups** within the population including:
  - people with a history of motion sickness, migraines and inner ear pathology or industrial deafness;
  - the elderly;
  - young children;
  - invalids;
  - people suffering from Autistic Spectrum Disorders;
  - those possessing a congenitally-small or obstructed helicotrema as a result of infection and those with more sensitive hearing.

[6] Although it is realised that standards criteria are based on 90% of the population.

Questions for the Senators

After reading this and other documentation, do you agree: that something you cannot perceive can hurt you?

There is a significant body of scientific evidence that has been presented to you through this and other documents and forums.

In weighing that evidence, do you now agree that there is a case for further independent research into the low-frequency and infrasound emissions of wind turbines with respect to public health?

If you have answered "Yes" to either or both of the above questions, the following questions may assist you in clarifying the way forward.

How will the senate:

Address the urgent need for a new wind turbine standard that will be protective of public health?

Facilitate unbiased, independent research into wind farm emissions, free from interference from commercial vested interests?

Facilitate independent monitoring of low-frequency and infrasound emissions of existing wind farms?

Monitor the health and well-being of those currently subjected to adverse wind farm emissions?

Manage the emissions of existing wind farms where there is clear evidence of adverse harm to residents?

Support those already adversely affected by wind turbines?

Compensate those affected residents who have suffered serious adverse health effects from existing wind farms?

Compensate those seriously affected residents who have had to abandon their homes in a last desperate attempt to maintain their health?

Manage the future development of new wind farms with appropriate, safe, set-back distances?

Approach the issue of new technology developments with respect to potential adverse health outcomes?

Create such legislative frameworks as to protect public health free from the pressure of commercial interests?

Facilitate public and professional education with respect to adverse health effects of wind farms.

Stop the wind industry's current propaganda engine that is predicated on falsehoods and lies that support their commercial position?

Support the Precautionary Principle in practice?

Counteract the propaganda from the AMA that has stepped outside their area of knowledge, expertise and mandate in supporting the wind industry by their public statements?

Prevent the ACNC from removing the charity status of the Waubra Foundation as a result of pressure from the commercial wind industry?

Introduction

Wind turbines are a useful source of energy, in the right place – albeit costly and not all that efficient. Some reports state that modern wind turbines have a working life of 20 years, while taking 18 of those years to break even financially.

It is the siting near residences that is the problem for large, industrial turbines – small ones do not seem to have the same problems, or at least of the same magnitude.

The emissions from a large wind turbine include very low frequencies that cannot be measured using the A-Frequency Weighting – the metric used in all wind turbine noise standards to date. As a consequence, there are very many reports of adverse health by local residents. It is low frequencies that are the major cause of their distress.

There is considerable controversy regarding these claims of harm as a result of low-frequencies and infrasound. The common mantra quoted in such circumstances is: **What you cannot hear, doesn't affect you**. Some acousticians, and certainly the wind industry, are quick to refute any possibility that low-frequency and infrasound could be the causal agent. However, they have a commercial interest to protect by upholding this stance. If industry were to admit to harm caused as a direct result of their technology, the commercial consequences could be severe.

The most common response from the wind industry and their consultants is that the low-frequency and infrasound emissions from industrial-scale wind turbines are sub-audible, therefore cannot be causing harm. ***This is completely untrue and shows a poor understanding of the science involved***. In part, it is based on the concept that only large quanta of energy are harmful, weak immissions "cannot hurt you". This is patently wrong in many other fields, such as radiation biology. Ultraviolet light cannot be perceived, yet it can burn skin and cause cancer. X-rays cannot be 'felt', but they can harm, which is why gonad shields are used on patients requiring x-rays and the protocol not to x-ray pregnant women due to the potential damage to the developing foetus, except in the most extreme circumstances. Accordingly, acoustic energy does not need to be of high energy in order to be consciously perceived, experienced or cause biological reactions (conscious or subconscious).

Due to the relative newness of industrial-scale wind turbine farms, there has not been sufficient time for the science to be conducted with regard to health and safety of nearby residents. For example, Chinese water torture utilises such a small impact of energy, when repeated many times, can cause extreme mental and physiological stress. The sound from wind turbines does just this, causing sleep disturbance. From this lack of sleep a plethora of other adverse health effects can eventuate. There is also the problem of flicker during the day, again another slow torture. Only by going away from the area where they live are they able to obtain relief, pinpointing the wind turbine installation, and not natural low frequency sounds in the environment, as the root cause of the problem. **Naturally occurring low-frequencies and infrasound is *not* the problem**.

Use of wind in ancient times

From the earliest records of human history, Man has sought to utilise the power of the wind. The first known use of wind was an Egyptian sailing ship,

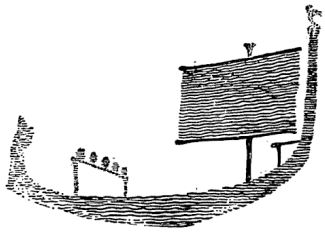


Figure 1: Earliest known ship

The next major advance was Heron of Alexandra's wind-powered organ that utilised a 'wind-wheel' to pump the bellows circa 50 AD.

Figure 2: Heron of Alexandra

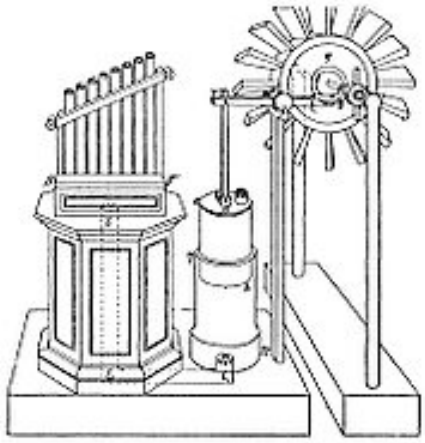


Figure 3: Heron's wind wheel

Figure 4: Earliest known Iranian windmill

The first practical wind mills were built in Sistan, Iran, around the 7th century. These were vertical axis windmills with a long vertical drive shaft and rectangular blades. The sails, of which there were either 6 or 12, were constructed of reed matting or timber slats, sometimes with cloth coverings. They were used for the arduous tasks of grinding corn and

Figure 5: Earliest known Iranian windmill

Horizontal axis wind mills were not invented until the 12th century in Europe. The first known Dutch wind mills were built around 1180 and used to grind grain into flour. They were also brought into service to pump water out of the polders (low-lying tracts of land surrounded by embankments known as dikes). Various incarnations evolved: post mill, trestle mill, smock mill. So in their earliest incarnations, wind mills harnessed the 'free' energy of the wind to provide motive power for mundane, otherwise labour-intensive work.

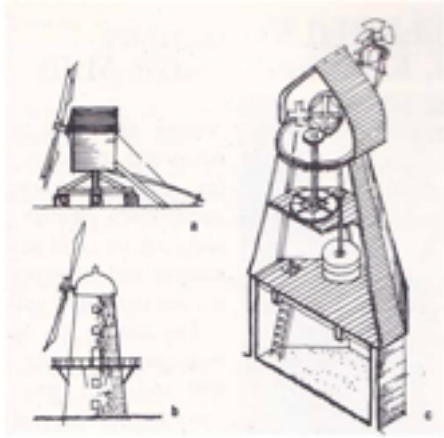


Figure 6: First Dutch windmill

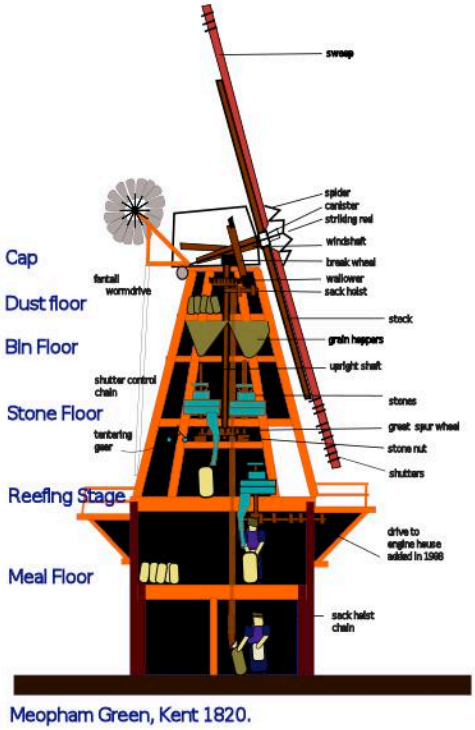


Figure 7: Diagram of a Smock

Figure 8: A working Smock Mill

The first use of wind to generate electricity was the invention of Professor James Blythe of Anderson's College, Glasgow (the forerunner of Strathclyde University). Blyth built a 33 foot high 'contraption' to produce electricity for his holiday cottage at Marykirk in Kincardineshire, Figure 9. There it was used to charge accumulators for use in lighting. Blyth later offered his excess power generated to the citizens of Marykirk for powering street-lamps in the main street. This kind offer was turned down by the good folk of Marykirk, many of who believed electricity to be "the work of the devil" perhaps demonstrating the first public resistance to wind-generated electricity!

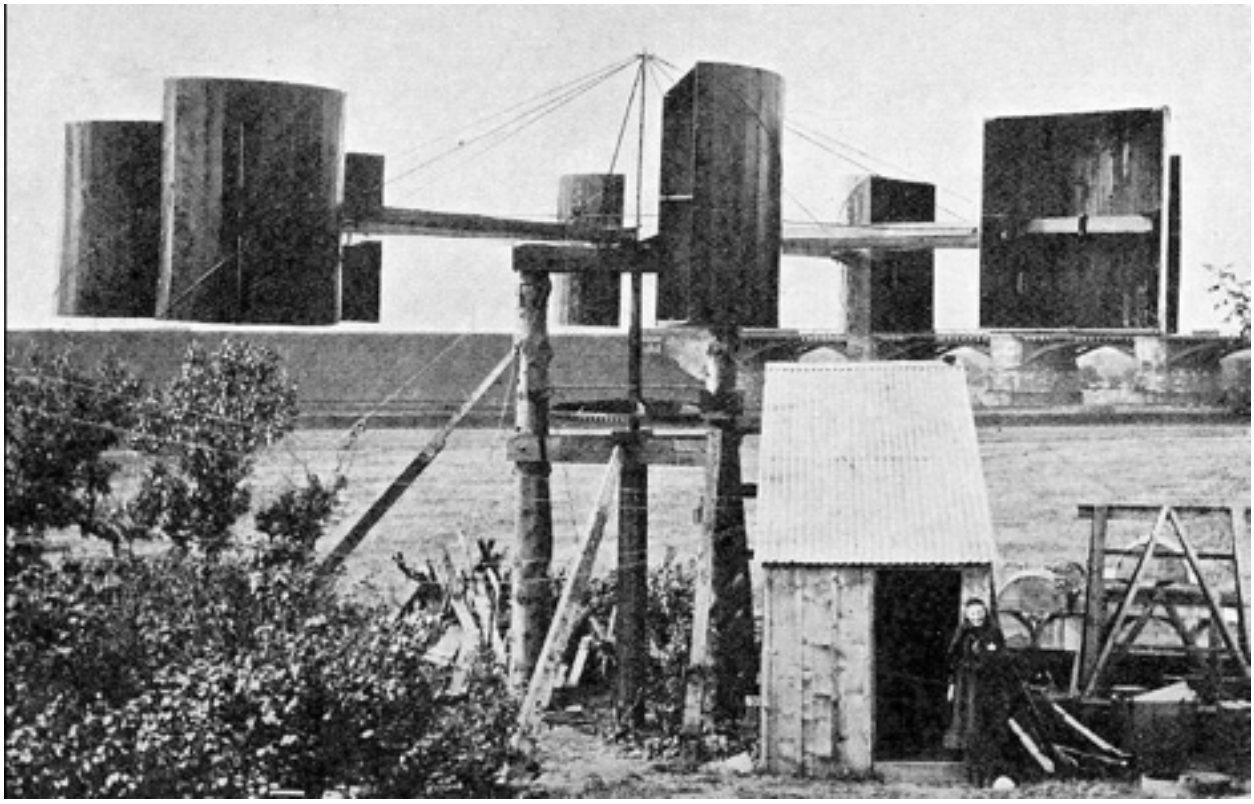


Figure 9: James Blyth's Cottage at Marykirk with its wind-powered electricity generator.

As Europeans expanded their territory, colonising the Americas, their vast tracts of farm land in the Mid-West were ideally suited to harness wind power. The primary use was to pump water from deep wells for irrigation. The wind mills were also to provide electricity for these remote farms, creating a considerable business opportunity for the manufacture and sale of 12 volt home appliances.

The electrification of the United States throughout the 20th century lead to less reliance on wind turbines for electricity generation. Many were still used for pumping water, but their numbers continue to dwindle slowly. It was not until the oil shock of the 1970s that the idea of using large-scale wind turbines for electricity generation moved into high gear. The trend for designing and building larger turbines continues to the present day. A brief timeline can be found in the Appendices.

Figure 10: Steel-bladed water pumping windmill - America Mid-West late 1880s.

Modern wind turbines

With the oil crisis of the 1970s and hysterical claims in the media about 'peak oil', the general public were being primed for a new technology. Add to this the threat of Global Warming, although that now seems to have been down-graded somewhat to the lesser Climate Change, the public were primed for a crisis. With the ever-increasing threat of pollution, the stage was set for the Green movement to capture much of the popular vote.

Many constituents, while couch-sitting and largely ignoring the real issues and what contribution they could make to cleaning up the planet, instead chose to exercise their Green Vote to ease their conscience. By voting Green, they were 'doing their bit'. And so it is against this socio-political backdrop that the stage was clear for the wind industry to offer a solution: **Free energy from the wind**.

While the concept of 'free energy' was to strike a cord amongst most people, the concept was flawed on first principles: **There is no such thing as 'Free Energy'**. With everything there is a cost, and the cost of building the infrastructure to harness this 'free energy' comes at a considerable price. Yet no one considered there might be adverse health effects, sometimes severe, on those living in the near vicinity of wind farms.

The thrust of this document is not to examine the economics of wind energy, rather its focus is on the sensible regulation of such technology and the protection of public health and well-being through Standards.

Figure 11: Modern wind turbines.

The Purpose of Standards

What is a standard?

"A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose" [7].

The definition above is provided by the **International Organization for Standardization**[8] (ISO) and neatly encapsulates the concept and purpose of standards. Today one can find standards on just about every conceivable topic and, by and large, they provide useful information and protocols so that goods and services can be 'fit for purpose'. It should therefore come as no surprise that there is a standard for wind turbine emissions.

First New Zealand Noise Standard for Wind Turbines

The first New Zealand Wind standard was created in 1998. As the number of turbines began to increase, Standards New Zealand decided to review the standard in 2010. The result is NZS6808:2010.

The Standards Committee for NZS6808:20101

For any standard to be worth its salt, the committee charged with the responsibility must be highly qualified in the appropriate areas and free from bias or other industry pressure. Was this the case for NZS6808:2010? The reader is advised to formulate that opinion for themselves based on the list of committee members overleaf.

Those who have a strong association with the wind industry or have worked for the wind industry in the past are highlighted in **RED**. Those who have at least some claim to represent human health concerns are highlighted in **GREEN**. One member represents the community and is highlighted in **PURPLE**.

[7] http://www.iso.org/iso/home/standards.htm

[8] http://www.iso.org/iso/home/standards.htm

Committee Member	Employer	Representing	Potential Conflicts
Stephen Chiles: Chair	URS NZ Ltd.	New Zealand Acoustical Society	Currently advising Meridian Energy on Hurunui Wind Farm.
Nevil Hegley	Private Consultant	Energy Efficiency and Conservation Authority	Consulted for Mighty River Power and Genesis Energy.
Malcolm Hunt	Malcolm Hunt Associates	NZ Institute of Env. Health	Worked for Mainpower.
Milkin Halstead	Marshal Day Acoustics	NZ Acoustical Soc.	Acted for many Energy companies.
Paul Botha	Meridian Energy Ltd	NZ Wind Energy Association	Worked for Meridian Energy.
Fraser Clark	NZ Wind Energy Association	NZ Wind Energy Association	CEO NZ Wind Energy Association.
Philip Dickinson	Massey University	Prof. of Acoustics and Human Health	No known conflict of interest.
George Dodd	University of Auckland	Senior Lecturer in Acoustics	No known conflict of interest.
Matthew Borich	Wellington City Council	Local Govt NZ	Compliance Advise Officer WCC.
Vern Goodwin	Southern Monitoring Services	Ministry of Health & Res. Man. Law Assn.	The Ministry of Health and Resource Management Law Association have different objectives.
Rachel Tretson (replacing B. Rouse.)	Ministry of the Environment	Ministry of the Environment	No known conflicts of interest.
Ruth Paul	Makara & Ohariu Community Board	Executive of Community Boards	Supported the standard not the wishes of the Makara residents.

It is sobering to realise that fully two thirds of the Standards Committee have now, or have had, a strong link to the wind industry. Only 25% can claim some interest in the health aspects of the standard and only one member is a community representative, Figure 12.

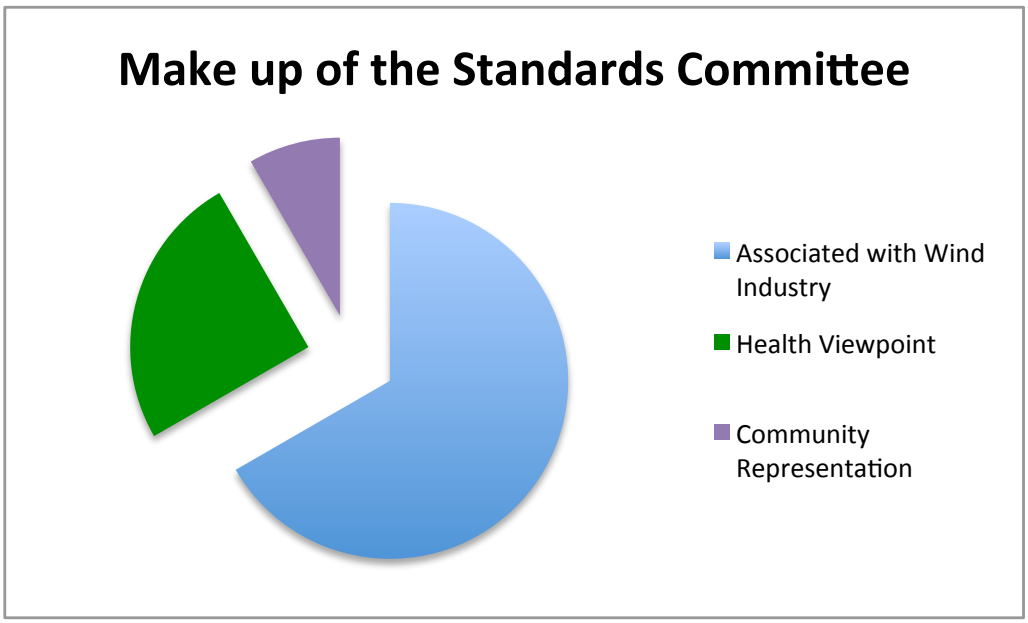


Figure 12: Makeup of the Standards Committee.

That the committee was stacked in favour of the wind industry appears to be an incontrovertible fact. The question of whether or not these members were able to work in a totally unbiased manner remains an unanswered question and one surrounded by much controversy and public concern.

If stacking the Standards Committee with 2/3 of the members strongly linked to the very industry that sought to benefit the most from the standard, then who funded the committee is even more enlightening.

The Standards Committee was funded by the Wind Energy Association and Energy Efficiency Conservation Authority.

It remains to be seen how such a committee could operate without the undue influence of the very bodies that had a 'vested interest' in the outcome. Fully 2/3 of the committee would clearly benefit from a positive outcome, that is, one that would facilitate the proliferation of wind farms unencumbered by statutory guidelines regarding nuisance noise and adverse health impacts.

A red flag from a committee member

While the Standards Committee successfully produced an updated noise standard for wind turbines, albeit based on the original 1998 standard, there was not universal agreement about the detail.

Of that committee, one lone member, Professor Dickinson, who can claim more than 60 years in the acoustics industry with a focus on human health, openly withdrew his support from the final standard. On page two of the standard, the following sentence appears:

> **"The representative of Massey University, while recognising the revised Standard is an improvement on the original, does not support the standard."**

This must surely ring alarm bells. The Professor of Acoustics and Health at one of New Zealand's major universities felt strongly enough about the shortcomings of the Standard that he chose to withdraw his support.

His reasons for doing so was that the ***"new Standard was based on nothing more than scientific nonsense".*** His contention was that the use of the LA_{90} was not supportive of public health and contravened the World Health Organization guidelines for safe noise limits for uninterrupted sleep. As an engineer and mathematician responsible for many of the world's noise standards, this is a damning indictment. It is also interesting that Dr. George Dodd, representing Auckland University, also refrained from the final vote. The reasons have never been divulged to explain why.

Either of these occurrences should have rung alarm bells, but the committee appeared hell-bent on producing a standard that would not only prove to be ***hard to measure compliance with but also would not protect the very people it was designed to look after.*** Further, it was based on faulty science, faulty assumptions and in direct contravention of the World Health Organization guidelines on sleep. The tragic consequences that followed for some families are an indictment on both the committee members and the process for allowing this miscarriage of natural justice to occur.

As is the case with many things, those that make the decisions rarely have to shoulder the consequences of their actions. Without this vital feedback mechanism, it is easily understood why so many adverse effects result. If those who make the rules had to live by them and were directly affected by them, for example by salary, then perhaps they would not be so keen to reach a decision that supported corporations rather than fostering the general public health of individuals and the community.

What NZS6808:2010 actually says

The critical heart of the standard is expressed in section 5 Noise Limits, under 5.1 General.

Specifically 5.1.1 states:

5.1.1 Limits for wind farm sound are required to provide protection against sleep disturbance and maintain reasonable amenity at noise sensitive locations.

> **C5.1.1 "Wind farm sound may be audible at times at noise sensitive locations. Effective, ongoing consultation with the community, beginning at the early planning stages of a wind farm, is important to encourage good communication among all the interested parties. This can help to identify and address any community concerns, and can reduce the likelihood of adverse effects such as annoyance from audible sounds at different wind speeds and wind directions when the wind farm begins operating."**

Critical to the standard is the concept that it should "provide protection against sleep disturbance". It further states that "reasonable amenity at sensitive noise locations" be maintained. Any reasonable person would think that this is a very fair and reasonable ruling. Wind turbines should not disturb sleep and the noise they generate should be maintained at a reasonable level.

As usual, the devil is in the detail. When 'woolly words' are used such as "REASONABLE', this is obviously going to be a point of contention as there is no single definition of 'reasonable'. Here is the first failing of the standard: woolly language that can provide wiggle-room for the industry.

Just what is reasonable? Perhaps it can never be defined as all people have different perceptions, likes and dislikes. As such, this provides a great opportunity for lawyers to

increase their income as the matters come to court for debate. It is a truism that once lawyers become involved, nobody wins.

So in the absence of a meaningful, legal definition of "reasonable", let us examine the more specific goal of protection against sleep disturbance. Here 5.1.2 provides the answer:

5.1.2 To provide a satisfactory level of protection against sleep disturbance, this Standard recommends a limit of wind turbine sound levels outdoors al noise sensitive locations of 40 dB $L_{A90(10\ min)}$ (see 5.2).

C5.1.2 This is based on an internationally accepted indoor sound level of 30 dB L_{Aeq} to protect against sleep disturbance (refer to Berglund, Lindvall, and Schwela[9]). This assumes a reduction from outdoors to outdoors of typically 15 dB with windows partially open for ventilation. The typical reduction of 15 dB would reduce an external level of 40 dB L_{A90} to 25 dB L_{A90}. Given that the internal target is 30 dB LAeq this allows for the difference between LEQ and L90, and for variations in the outside to inside reduction.

The intention of wind turbine standards needs to be understood against the science on which they should be based. One authoritative source regarding the effects of noise on sleep is Birgitta Berglund. Some of her work is the basis for the WHO stance on noise and sleep: see overleaf.

[9] Berglund, B, Lindvall, T, and Schwela, D. (eds). Guidelines for community noise. World health Organization. 1999. http://www.who.int/docstore/peh/noise/guidelines2.html accessed 26 January 2010.

Berglund *et al*. on sleep disturbance

The document referred to by NZS6808:2010 on page 5 is: Berglund, B, Lindvall, T, and Schwela, D. (eds). Guidelines for community noise. World health Organization, 1999. This document has much to say about the effects of noise on health. Section 4.2.3 can be found in the Appendices. The key points are:

Continuous and intermittent noise affects sleep[10]:

- Sleep disturbance correlates with increasing sound levels
- Measurable sleep disturbance begins at 30 dB L_{Aeq}.
- Effects on sleep include changes in sleep patterns and reduction in REM sleep
- Subjective effects include: difficulty falling asleep; poor sleep quality; headaches; tiredness
- Sensitive groups have been identified including shift workers, elderly, and people with physical or mental disability
- Of significance is the reference to 'continuous noise'. In such circumstances, as would be the case with wind turbine noise, sound pressure levels should not exceed 30 dB_A inside a dwelling.

Even more significant is the statement:

> **"When the noise is composed of a large proportion of low-frequency sounds a still lower guideline value is recommended"**

because low-frequency noise (e.g. from ventilation systems) can disturb rest and sleep even at low sound pressure levels.

Berglund *et al*. note that the adverse effects depend on the nature of the noise source. Noise can not only disturb sleep but create other health effects in very vulnerable babies. The question arises: What are the effects of wind turbine emissions on the sensitive populations, including: the elderly, those suffering from various illnesses (physical or psychological) and young babies?

In the case of continuous noise, Berglund *et al*. recommend the L_{Amax} or SEL measures. Specifically, sleep disturbance has been observed at 45 dB_{LAmax} or less. The advice is to limit the maximum allowable noise to 45 dB L_{Amax}. But for real protection against sleep disturbance a combination of metrics is required:

[10] Scientific studies include electrophysiological and behavioural methodologies.

> **"guidelines should be based on a combination of values of 30 dB $L_{Aeq,8h}$ and 45 dB L_{Amax}"**

In the circumstance where naturally occurring background levels are low, such as rural locations, Berglund *et al*. recommend:

> **"To protect sensitive persons, a still lower guideline value would be preferred".**

Another scientific observation is that:

> **"sleep disturbance from intermittent noise events increases with maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep".**

Hearing is the only sense that does not 'sleep'. This is an evolutionary protective mechanism predicated on survival. Sleeping animals are vulnerable to predators, hence those that survived were the ones who were able to maintain hearing vigilance during sleep. This is why alarms are commonly audible, such as fire alarms. Light would not work as well unless it was very intense. Light also has the disadvantage that if you are not looking in that direction (in the absence of strong reflection) you could miss the signal.

The thrust of this submission is not to provide chapter and verse on the effects of sleep deprivation. There are thousands of very well-documented papers in the scientific literature and decades of clinical observations that more than prove how damaging the effects can be. A short list of references in provided in the Appendices to assist the reader.

Suffice it to say that the effects of sleep deprivation and reduced sleep quality affect virtually every aspect of human biology and function. Tiredness, loss of cognitive function, memory, physical motor skills, gene expression in the brain, reduction of natural killer cells and reduced cellular immune responses, pain perception, weight gain - the list goes on. Sleep is a natural, restorative function that is essential to human health. One of the most sinister and less well known problems of sleep deprivation is the reduction in immune system response. This can have a critical effect on cancer, allowing the proliferation of abnormal cells in the absence of reduced function of the natural killer cells whose job it is to seek out and destroy cancer cells. This process functions at maximum efficiency during sleep. Without adequate sleep, including sufficient REM sleep, the human body is unable to function properly and attack cancer cells.

Failure of the Standard to protect against sleep deprivation.

NZS6808:2010 fails to fulfil its own criteria to "provide a satisfactory level of protection against sleep disturbance" for two major reasons.

Firstly it relies on the 40 dB $L_{A90(10\ min)}$.

Secondly because it makes a false assumption that "reduction from outdoors to outdoors of typically 15 dB with windows partially open for ventilation".

World Health Organization recommendation:[11]

If negative effects on sleep are to be avoided the equivalent sound pressure level should not exceed 30 dBA indoors for continuous noise.

> "If the noise is not continuous, sleep disturbance correlates best with LA_{max} and effects have been observed at 45 dB or less. This is particularly true if the background level is low. Noise events exceeding 45 dB_A should therefore be limited if possible.
>
> For sensitive people an even lower limit would be preferred. It should be noted that it should be possible to sleep with a bedroom window slightly open (a reduction from outside to inside of 15 dB being maintained). "
>
> "To prevent sleep disturbances, one should thus consider the equivalent sound pressure level and the number and level of sound events. Mitigation targeted to the first part of the night is believed to be effective for the ability to fall asleep."

[11] Night Noise Guidelines for Europe ISBN 978 92 890 4173 7

Anatomy of failure - the false assumption

The fact that NZS6808:2010 fails to meet its own criteria with respect to sleep deprivation involves both the 40 dB $L_{A90(10\ min)}$ and the assumption of a 15 dB reduction in sound pressure level through a partially open window is an egregious failure. The two problems are linked.

While the attenuation factor of 15 dBA would bring the indoor sound pressure level below the WHO recommendation of 30 dBA, the fact that this does not occur, certainly in typical New Zealand and Australian homes, is a matter of considerable concern. It should be noted that the WHO document relates to Europe where the construction of homes may be different to those in New Zealand *and is based on studies of transportation noise*.

NZS6808:2010 assumes that people will never sleep with their bedroom windows open, thus facilitating a 10 to 15 dB attenuation from outside to inside. This is most unlikely to be true in all but the most rare and limited occasions. For this assumption to be met in reality would require that the person sleeping in the room was situated at exactly the right position in a symmetrical and uniformly furnished room - that is - in a spatial average position and then only if the window's opening slightly is a very small percentage of the wall area.

In New Zealand, many rural people regularly sleep with the windows partly open, if not fully open, due to the warm summer nights of a temperate-zone country. They are also likely to sleep within a metre or so of that open window. Sometimes this opening can be up to 90% of the external wall area, as may be the case with ranch-sliders. In this instance, attenuation will be near zero. As many New Zealand homes lack air conditioning, common in some countries, it is not unusual for people to sleep on verandas or with the bedroom windows fully open.

Another failing of the standard is that the attenuation is assumed to be equal for all frequencies. This is demonstrably not the case. Dickinson[12] provides the following table: Sound attenuation for an open window in a typical New Zealand house as a percentage of the wall area.

[12] The sounds from wind turbines - theory, practice, assumptions, and reality.

Octave band Centre Hz	Percentage of wall opening											
	3	5	7.5	10	20	30	40	50	60	70	80	90
	Attenuation in dB											
31.5	12	11	10	9	6	5	4	3	2	1	1	0
63	11	10	9	8	6	5	4	3	2	1	1	0
125	12	11	10	9	6	5	4	3	2	1	1	0
250	15	13	11	10	7	5	4	3	2	2	1	0
500	15	13	11	10	7	5	4	3	2	2	1	0
1000	15	13	11	10	7	5	4	3	2	2	1	0
2000	15	13	11	10	7	5	4	3	2	2	1	0
4000	15	13	11	10	7	5	4	3	2	2	1	0
8000	15	13	11	10	7	5	4	3	2	2	1	0

Table 1: Sound attenuation through an open window.

This is based on a free-field sound level outside compared to the resulting spatial average sound level in a fully furnished room, which latter is assumed to give a reverberation time of 0.5 seconds. For this example, the attenuation of the remaining part of the glass window is assumed to be the same as that of the wall construction. It will likely be less, so the total attenuation predicted will likely be overstated.

The type of construction, typical of a New Zealand or Australian house is: Walls: 4m x 2.7m weatherboard, on 100 x 50 studs, 10mm plasterboard, 75mm batts in cavity. In this case, the data is not based on a spatial average within the room - the microphone was situated approximately where the inhabitant would be sleeping (1 metre from the window, 1.2 metres above the floor). The measurements were not consecutive and were taken at random times when wind turbine sound was predominant outside.

Clearly, for the assumption of a reduction of 15%, the window opening would have to be of the order of < 3% - an extremely unlikely value given the construction of New Zealand and Australian homes and their lack of ventilation and air conditioning systems.

The other issue is attenuation across the spectrum through glass. Again, Dickinson provides the following information on the sound of wind turbine attenuation through a closed window. The values are averages of four, 10 minute Leq measurements through 4mm glass in a weatherboard home.

Octave Band Hz	16	31.5	62	125	250	500	1000	2000	4000
Attenuation dB	3.4	3.6	5.1	10.1	11.2	12.7	15.3	14.3	16.1

Table 2: Attenuation of wind turbine noise through a CLOSED window.

The salient point is that a single pane of 4mm glass is only reasonably effective at attenuating sounds above 125 Hz. Low frequency sounds (below 125 Hz) are only slightly attenuated. Given that the majority of the sound power of a spectrum from an industrial wind turbine is in the lower region, the assumption that any significant attenuation can be expected through a standard 4mm glass window would be minimal.

NZS6808:2010 is flawed on first principles with regard to the expected attenuation of industrial wind turbine emissions through the walls of a standard-construction New Zealand or Australian home. Therefore, the current allowable sound pressure level of 40 dB $L_{A90(10\ min)}$ will not comply with the World Health Organization guidelines of 30 dBA continuous inside sound pressure level.

Given that the Standards Committee was appraised of this failure, and the fact that they chose to ignore the recommendation of the WHO with respect to the actual attenuation factor of real New Zealand-built houses, it can only be assumed that the standard was engineered to facilitate the wind industry who stand to make substantially more money if the sound pressure level is allowed to be higher.

In its current form, NZS6808:2010 can in no way protect those who live in standard New Zealand (or Australian) homes in close proximity to industrial wind turbines (less than 10 km). Given also that many homes are within less than 5 km of industrial wind turbines, it is easy to understand why so many complaints of adverse health effects have been lodged. The same situation is mirrored throughout the world, wherever industrial wind turbines have been built in close proximity to dwellings. Accordingly the author cannot support the following statement in NZS6808:2010 as it is demonstrably incorrect:

5.1.3 The wind farm noise limit of 40 dB $L_{A90(10\ min)}$ outdoors recommended for protection of sleep is also appropriate for protecting the health and amenity of residents for most noise sensitive activities.

Low-frequency sound - the missing link

NZS6808:2010, like many similar standards, assumes that wind turbines do not generate low frequency sounds of any significance. Based on this erroneous assumption, the standard need not even consider the potential adverse health effects from low-frequency and infrasound. Accordingly, the standard relies upon the A-Weighting. But what is the real emission spectra of an industrial wind turbine?

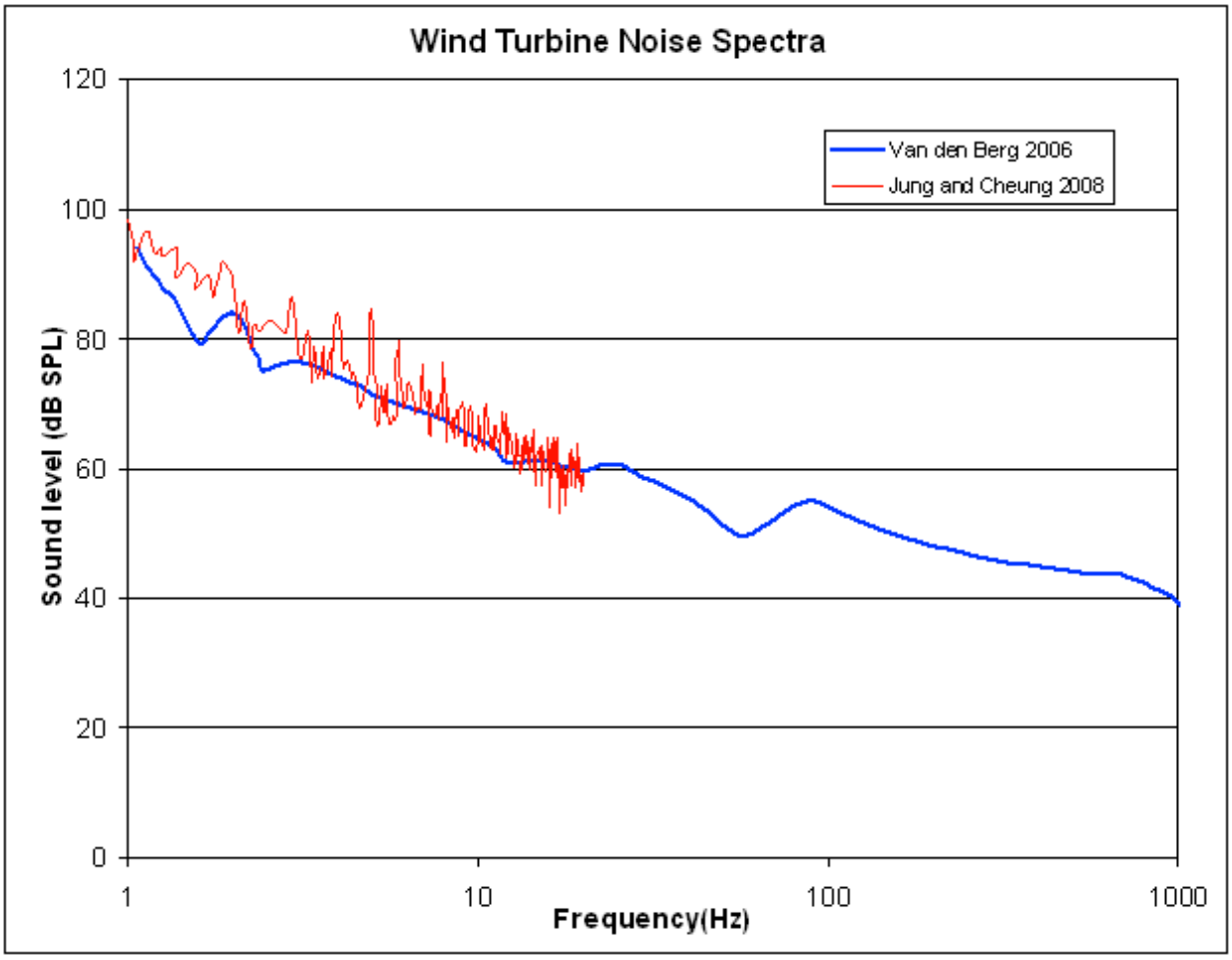


Figure 13: Noise spectra of a wind turbine.

Clearly the majority of the power in the acoustic spectrum is concentrated towards the low end. **The egregious error that NZS6808:2010 makes is the assumption that this portion of low-frequency and infrasound has no effect on human receivers. Nothing could be further from the truth, yet many standards for wind turbine noise continue to perpetuate this myth.**

To fully comprehend the significance of the A-Weighting, consider Figure 14, overleaf:

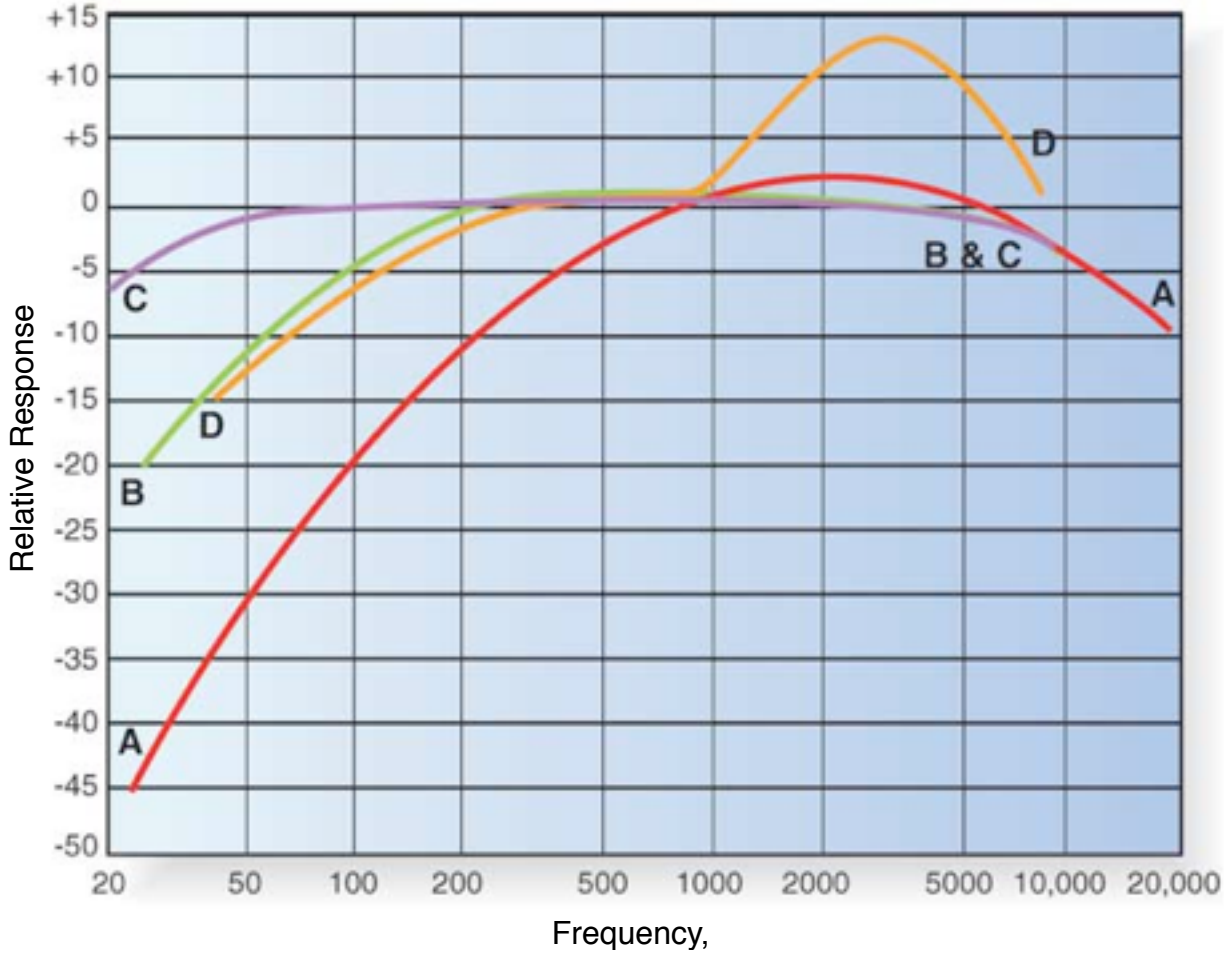


Figure 14: Sound weighting curves.

The most commonly-used sound level weighting is the A-Frequency Weighting. This out-dated concept comes from the work of Fletcher and Munsen in 1920s and 1930s. Fletcher and Munsen were investigating the differential response of the human ear to different tones (frequencies). They determined this experimentally using single, continuous tones played to the subjects through headphones (described as occluded). Using rather primitive, by today's standards, equipment and a small sample of only 23 people, they were able to determine what they referred to as EQUAL LOUDNESS CURVES.

They published their results for equal loudness curves in 1937. Their original results are shown in **blue** in Figure 15. The curves were updated by Robinson and Dadson in 1956 which became the basis for the ISO 226 standard: **red**.

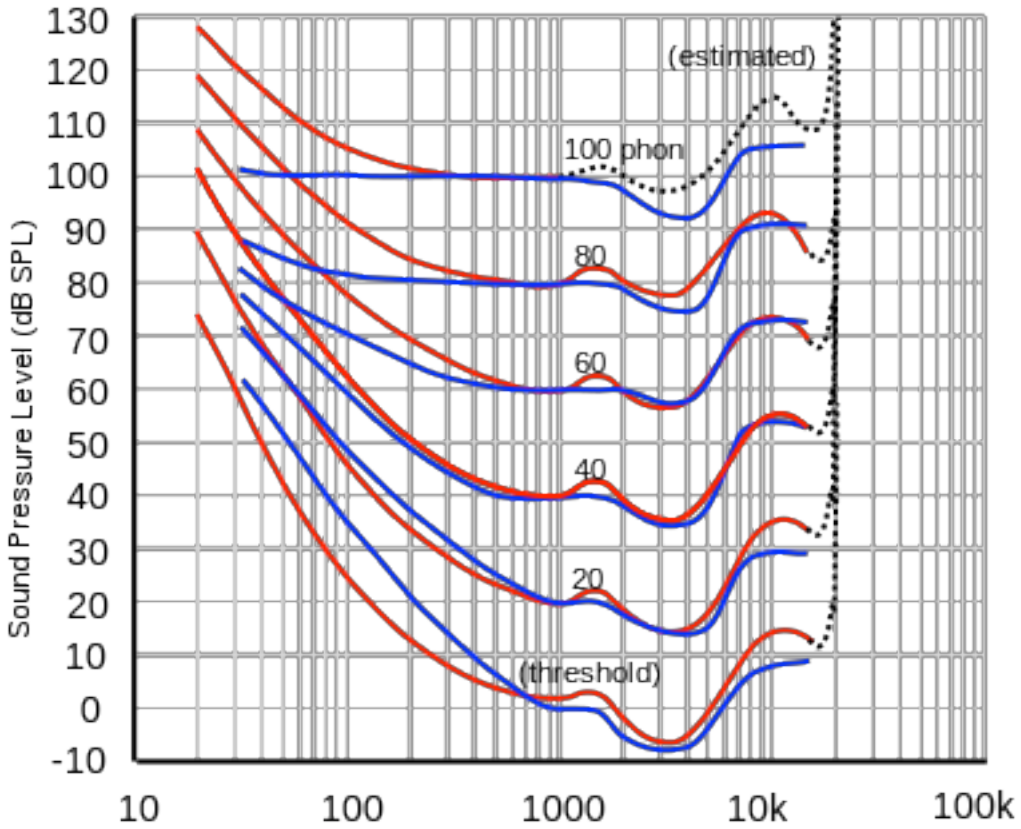


Figure 15: Equal Loudness Contours.

Each of the pair of curves above relate to the differential hearing response of a 'normal young adult's ear' at various different sound levels. Note that the curves change, indicating the sensitivity of hearing changes with loudness. *Note that the A-Weighting is based on the 40 Phon curve.*

The point is that it is common practice to use the A-Weighing for measuring sound pressure levels in the majority of environmental surveys. The common belief is that this is the best way to represent the soundscape by a single number that has some correlation to the human hearing response. It has been forgotten that the tests carried out to determine the equal loudness curves on which the A-Weighting is based were carried out with single tones using an occluded headset. This is not a very natural way to hear sound, and in the real world, single tones do not really exist. It is an artificial construct, one that has led acoustics into deep water. Sound in the real environment is always a combination of frequencies, not individual pure tones.

Many ordinances around the world prescribe the A-Weighting, despite its shortcomings, except in the case of where there is evidence of a 'significant' component of low-frequency sound. In this case, the C-Weighting curve is preferred. The anomaly that exists is that even though wind turbine emissions are clearly skewed towards the lower frequencies, where the A-Weighting severely underestimates the sound pressure levels,

the various standards still specify the A-Weighting. This essentially underestimates this low-frequency component, giving the wind farm operators far more 'wiggle-room' to create nuisance noise.

That standards still doggedly insistence on the use of the obviously inadequate methodology of the A-Weighting is an indictment on the system. The A-Weighting is an acknowledged anachronism that is still in use by wind turbine standards only because it allows wind turbine operators to create more noise. The point is, this low-frequency noise is the most likely cause of the adverse health effects reported around the world. And the fact that the same symptoms are reported world-wide should be a clear indication of a common underlying mechanism. Dr. Paul Schomer pointed out in his support of the work of Steven Cooper:

> **"This study finds that . . . people sense the operation of the turbine(s) via other pathways than hearing or seeing, and that the adverse reactions to the operations of the wind turbine(s) correlates directly with the power output of the wind turbine[s] and fairly large changes in power output."**

This is simple cause and effect shown through a case series crossover design, a very powerful epidemiological tool where the subjects are used as their own controls. What Cooper shows is that there is a cause and effect relationship that correlates adverse health effects with turbine output power. This effect persists in the absence of either audible or visual clues as to the turbine's operations.

Further, Dr. Schomer explains:

> **"It really does not matter what the pathway is, whether it is infra-sound or some new form of rays or electro-magnetic field coming off the turbine blades."**

If Cooper had simply relied upon the A-Weighting, he would have found no correlation between wind turbine emissions and biological effects. But it was his use of low-frequency, narrow-band spectral analysis that was able to mine the data and reveal the causal influence. This is analogous to using a microscope to examine bacteria and tissue samples. If you do not look deep enough, without sufficient detail, you will likely miss important features. After all, it was Pasteur's use of the microscope that allowed him to see bacterial infection in wine that had gone sour. Without the microscope, it is hard to know how the process of spoiling of wine could be understood and avoided.

There is much agreement amongst acousticians that the A-weighting is inappropriate for use with industrial wind turbine emissions. But science is not about numbers. Science is

not a democracy where the most votes carry the day. Rather science is about attempting to establish the facts, based on careful observations combined with a theory of causation (the mechanism). Such scientific understanding of phenomena is termed a theory. And as Sir Karl Popper pointed out, a theory is only good while it cannot be refuted. No amount of additional support will 'cut the mustard'. While more corroborating evidence ***strengthens*** a theory, it only takes one falsification to cause scientists to go back to the drawing board. Only after long periods of time without falsification does a theory become somewhat elevated to the status of a Natural Law. Examples would include the law of gravitational attraction, and the conservation of momentum.

That the A-Weighting is so inadequate as an environmental noise measurement strategy, yet still used almost universally, defies logic. Its continued use baffles this Author and acoustical consultants across the world. The only reason for it remaining the predominant approach to environmental sound analysis is that it hides the real issue: large quanta of low-frequency sound. In point of fact it also underestimates high-frequency sounds above 5,000 Hz. To continue using an anachronistic measure that deliberately hides acoustic exposure is to transgress against humanity, facilitating human suffering. Further, this is an example of a failure of professional ethics and an abdication of the principle of "duty of care". It is time that acoustical consultants were brought to task for these egregious breaches of ethics by their professional bodies.

At the end of the day, wind farm consents are about politics and commerce, not public health. That NZS6808:2010 flagrantly refuses to acknowledge the WHO guidelines with regard to noise levels for sleep should be a key indicator that politics and commerce are in fact in control, at the expense of public health. However, the A-weighting is not the only gremlin in the works. A basic ignorance of the scientific method is also to blame. To further explain this concept, a brief outline of the scientific method will be presented, with relevance to wind turbine emissions.

The Scientific Method

The Scientific Method is a much-talked about concept, but understood by few. Indeed it is the inappropriate use of investigative procedures, euphemistically referred to as scientific, that is the cause of much misunderstanding of phenomena. So what is the scientific method?

The scientific method, in its purest form, originated some 2,500 years ago with the ancient Greeks, such as Socrates, Plato and Aristotle. Following the death of Aristotle, his knowledge was to live on in the absence of his processes and methodologies. Accordingly, science languished in the dark ages until circa 1600 AD when two philosophers, Gilbert and Harvey took centre stage. Harvey was to accurately describe the circulation of the blood while Gilbert was to postulate that the earth was, in fact, a giant magnet. From these two humble discoveries, all of modern science began to flow.

The last 500 years has seen a considerable maturation of the process of discovery about the natural world that has now become what we call “Science”. In essence the steps in the process are quite simple:

1. Observe a phenomenon
2. Ask a question, such as: How did that happen?
3. Formulate a theory of how the phenomenon manifested. This is called the hypothesis.
4. Conduct an experiment to test the ‘hypothesis’ to see if it explains the original observation.
5. Analyse the results and see if the hypothesis is supported by the experimental results and if it fits in with what is already known. This is known as external consistency.

By way of explanation, a set of experimental results that contradicted a basic law, such as the conservation of momentum, would require extraordinary proof for it to be supported. If experiments support the existing theory, then that adds weight to its validity. It does not ‘prove’ it. It adds support. If the experimental results cast doubt on the hypothesis, then another theory must be devised and tested to see if a better explanation can be found to explain the observations.

In this way, science proceeds as a never-ending series of experiments, getting closer and closer to the truth, each experiment with a positive outcome adding support to the hypothesis. It is important to understand that nothing in science is ever settled. Rather theories just become stronger and better supported, or they are refuted and discarded.

The concept of an “Ultimate Truth” is a mythical construct - an aim, if you like. Nothing is ever ‘proven’ in absolute terms, although this is often the cause of considerable unease and misunderstanding of the scientific process. Humans like everything to be neatly explained and put into ‘boxes’ - a very Aristotelian approach. In the real world, it is never that simple.

And so it is the misunderstanding of the scientific method that is somewhat to blame for the situation we find ourselves in now. Wind turbine proponents continually try to deny any adverse effects, ignoring the empirical observations, at times going to extreme lengths to press their case, such as labelling those who complain as NIMBYs (Not In My Back Yard) or simply deluded people who have succumbed to the Nocebo effect. The fact that the nocebo effect is even raised is an indication of a basic misunderstanding of the term. You cannot have a nocebo (or placebo, for that matter) when there is some palpable difference between conditions. Sound is a palpable phenomenon, so it cannot, by definition, a nocebo. That simple logic still does not stop the pro-wind turbine lobby from trying to hoodwink the general public into believing in their delusion.

To return to the matter of industrial wind turbine emissions, the simple observation that adverse health effects are reported, from around the world, and that these follow a very distinct pattern, should be a major clue that there is some hitherto unknown phenomenon underpinning the effects. If people from around the world were reporting very different phenomena in relation to wind turbine emissions, then there would be reason to doubt the veracity of the observations. But the very fact that the reports all share much in common is a big hint that there is something yet to be discovered by way of a causal mechanism. This is how science advances.

One of the cornerstones of the scientific method is external validity, that is, does what we think fit in with everything else that we ‘know’? That new knowledge needs to coexist with current knowledge is a vital part of a rational and logical understanding of the real world. And so it is also from the real world that we can draw much information to assist us in devising new hypotheses to increase our understanding of the world we live in. That this knowledge may alert us to an unforeseen hazard is an added bonus. With knowledge comes power. For example, we make great use of electrical energy, only because we understand it so well. That is why we can use it safely and provide useful motive power to all manner of devices from light bulbs to DVD players. And yet, the path to that knowledge is lined with the deaths of many who were struck down in the course of their research. Indeed, this is a common theme with much new science. It is often dangerous until the phenomenon is better understood. For example, Marie Curie, co-discoverer of radioactivity after noticing that photographic plates would mysteriously fog when various mineral samples were stored next to them, actually died of radiation poisoning.

Another example of a researcher dying as a result of their work is the French scientist Vladimir Gavreau who died as a result of empyema caused through internal infection as a result of being subjected to large amplitude, low-frequency sound. While there is much misinformation about Gavreau's death in the popular media and on the internet, the author is fortunate in having worked with a scientist who actually knew Gavreau personally and was in his laboratory not long before the low-frequency sound exposure caused his premature death. It took 24 hours for Gavreau to die as a result of septicaemia (blood poisoning) after his internal organs were abraded against their connective tissue integuments resulting in empyema.

Damage is not restricted to the human species. In 2014, 1,600 miscarriages were reported at a mink farm in Denmark that was built within 328 metres of four large wind turbines: Figure 16. Many of the still births showed deformities: Figure 17.

Figure16: Danish mink farm.

Figure 17: Premature mink births.

No only were there a large number of miscarriages, but many of the stillborn foetuses were deformed: Figure 18. Significant aggression was observed and many animals were injured since the wind farm began operating. Figure 19.

Figure 18: Deformed mink foetus.

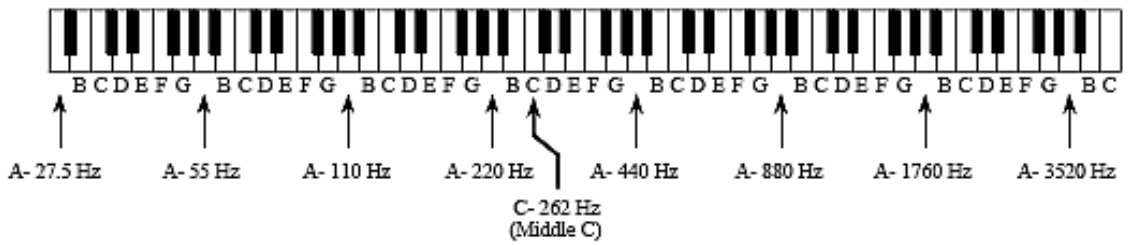
Figure 19: Injured mink

The failure of NZS6808:2010 can, in part, be linked to a lack of known mechanisms of action. But just because we do not understand how something happens, that is no reason to deny the existence of the observed phenomenon. We simply have yet to understand all the parts of the equation. And it is the recent discovery of some of the 'missing links' that have led scientists to better understand how low-frequency sound and infrasound may cause the effects observed. That these new discoveries are derided by the pro-wind turbine lobby who prefer to use force of personality to win the argument only serves to prolong the suffering of those who are victims of the effects. Therefore, a brief explanation of the missing parts of the puzzle will be undertaken to provide the reader with a greater understanding of how emissions from industrial wind turbines may cause adverse health effects.

That the New Zealand Standards committee was not appraised of such information is simply a failure of process. Or was it by intention? If the new knowledge from neurophysiology is ignored, that would make it far easier to deliver a standard that favours the wind farm developer. It would also disadvantage those who are unfortunate enough to live in close proximity to these industrial sites, thereby suffering the consequences. Remember, science is about the **GESTALT** - there must be internal consistency within the theory and also external to it, integrating the results with what is already known. Knowledge is power, and without sufficient knowledge, we would not be able to utilise the natural force of electricity, or avoid the natural hazards of radiation. Food poisoning may be far more common. In cases where there is reasonable doubt, the Precautionary Principle should be adopted until such time as the safety of the technology can be verified.

The neurophysiology of sound

Sound consists of a series of alternating pressure pulses in air. The normal human hearing range is considered to be between 20 cycles per second (Hertz - Hz) and 20,000 cycles per second. To provide some relevance to this frequency range, consider a piano keyboard: Figure 20.



The Piano keyboard. The keyboard of the piano is a *logarithmic* frequency scale, with the fundamental frequency doubling after every seven white keys. These white keys are the notes: *A, B, C, D, E, F and G.*

Figure 20: Piano frequency spectrum.

Of course, humans can hear outside of this range, and everybody has slightly different hearing. What is particularly interesting is the area of the acoustic spectrum generally referred to as infrasound. For the purpose of this document infrasound is defined as any frequency of vibration below 20 cycles per second: 0>20 Hz.

While humans can clearly hear below 20 Hz, as the frequency gets lower it has to be louder in order to be perceived as sound. Tonality, that is, the perception of a particular frequency as a continuous “tone” is lost somewhere between 15 to 18 Hz. Thereafter, the sound is perceived as a series of pulses. This is due to the integration time of the ear. It is very similar to the integration time of the eye. When a series of still images is presented in rapid succession, faster than 20 frames per second, they are no longer perceived as a series of individual images, rather they are perceived as a ‘moving image’. The slow frame rates of old films look rather ‘jerky’, like the Keystone Comedy Cops, or Charlie Chaplin.

The human ear can certainly hear some of the infrasound spectrum, particularly if it is loud enough. When the frequency is too low, it can be perceived as pulses or puffs. But the salient point is that acoustic energy (sound) is not only ‘heard’ or perceived by the ear, as any rock concert audience can attest. Rather, other sensors are also able to respond to acoustic energy. Of most relevance to this paper is the VESTIBULAR SYSTEM: Figure 21. This is the series of organs in the inner ear that are principally responsible for motion detection and balance. They consist of three semi-circular canals which act like accelerometers, detecting movement (acceleration). Also there are two

small bulges known as the saccule[13] and utricle[14]. Together, this system senses how we move and what our orientation is.

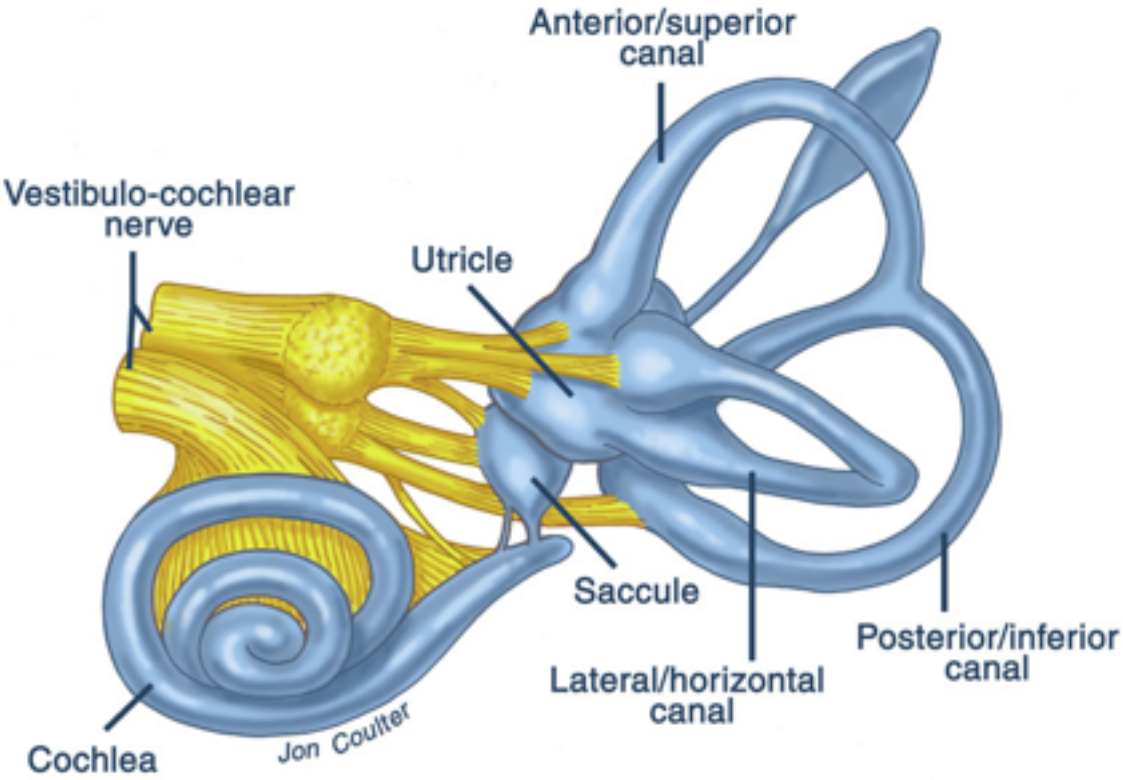


Figure 21: The human vestibular system.

The neurophysiology of the perception of sound is a very complex topic, however, a simple explanation will be attempted in order to provide an understanding of why NZS6808:2010 fails in its role to protect the health of those who live in close proximity to industrial wind turbine farms.

The principal organ of hearing is the cochlea; the spiral, snail-like organ in the inner ear. The ear drum detects changes in air pressure and conveys these through three small bony linkages (levers) to the oval window of the cochlea. This sets the fluid inside the cochlea moving and it can bulge out at the round window. The cochlear is actually three tubes in one, Figure 20.

[13] The saccule detects linear accelerations and head tilts in the vertical plane.

[14] The utricle detects head tilt.

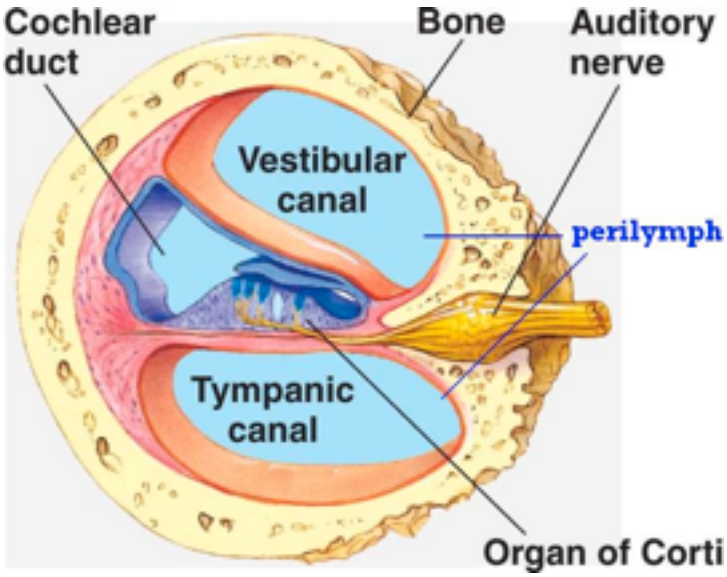


Figure 22: Cross section of a human cochlea.

The pressure waves from the three bony structures (ossicles) enters through the vestibular canal, travels all the way to the end of the spiral and passes through a small aperture, the helicotrema. These waves then pass back along the tympanic canal to exit at the round window[15]. It is a closed system. In between the two major canals is the third cavity, the cochlea duct, wherein lives the sensory mechanism known as the organ of corti. This consists of a series of small cellular 'switches' that respond to the travelling waves in the fluid passing this information to the brain as nerve impulses via the vestibulo-cochlear nerve.

The surprising fact in all of this is that what we ***HEAR***, that is, ***PERCEIVE***, is not actually the variations of pressure waves in the air, rather it is a ***RECONSTRUCTION*** inside the brain's auditory cortex. Think of it like a fax machine. What is sent down the wire is not actually the individual letters, rather it is a representation of those letters in binary form (ones and zeros) that is reinterpreted at the other end and essentially ***TYPED OUT*** onto paper. And so it is with the perception of sound. What you hear is the result of changes in air pressure impacting on the eardrum then passed to the cochlea to be encoded into nerve impulses and sent to the brain where it is interpreted as sound. What you hear (perceive) is a *facsimile* or *reproduction* of the original sound, a reconstruction if you will.

What you hear is what you perceive in response to varying air pressure at the eardrum. The main thrust of the argument is that humans can only hear in the range of 20 to 20,000 Hz. Of course, we know that this is a generalisation, but it is taken as gospel. The contention that if you cannot hear it, it cannot affect you is just another myth

[15] This causes the round window to 'bulge' out. It is a closed fluid system.

perpetrated by those who would seek to pull the 'wool over our eyes' and it is simply not true.

It is hard to determine where this concept came from, but N. Broner[16] wrote in a paper entitled: 'The effects of low frequency sound on people - a review', published in the Journal of Sound and Vibration (1978) 58(4), 483-500:

"As regards a threshold level for annoyance, both **Johnson** [31, 321 and **Leventhall** [33] expressed the thought that **"if you can't hear it, you can't feel it"**, and this led Johnson to the criterion shown in Figure 21. The L,, of 55 dB was set as a limit for audio frequencies [34] and was extrapolated down to low frequencies. The limit of 120 dB was chosen for frequencies below 5 Hz to avoid middle-ear pressure build-up and damage to or rattling of structures."

> **"However, people who show extreme sensitivity to higher frequency noise may not be wholly protected by this criterion."**

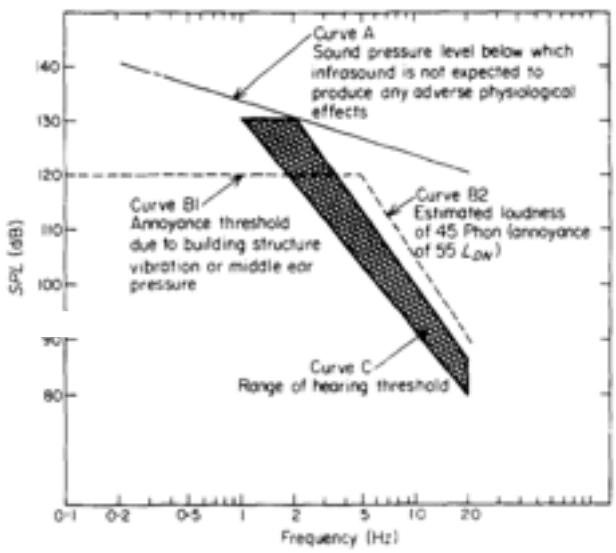


Figure 2. Infrasound criteria proposed by Johnson [31, 61].

Figure 23: Broner's infrasound criteria as proposed by Johnson.

Broner continues:

> **"Auditory system response has long been a criterion for measuring the acceptability of noise exposure, and much work has been done in this regard for low frequency noise, and in particular, infrasound."**

[16] Quoted from Broner's paper, page 485.

Somehow this has morphed into popular culture as **"if you can't hear it, it can't hurt you"** - ***a supposition that has never been proven.***

This is another blatant failure of the application of the scientific method and logical, rational thinking processes. Just because something cannot be perceived does not mean that it cannot affect or harm you. Take x-rays for example. You cannot perceive them, yet they can harm you. Ultraviolet light is the same. You can't feel or perceive it yet it can still cause severe skin burns and promote cancer. Few people would disagree with either of these last two statements, but for some reason, hearing appears to be different.

So just what can you 'hear' or perceive, and how is this achieved? While the neurophysiology of hearing is very complex, a simple overview will be presented to assist the reader in understanding this topic.

Classical Understanding of the Hearing Apparatus

The classical understanding of the hearing function in humans is best described by the following diagram: Figure 22[17].

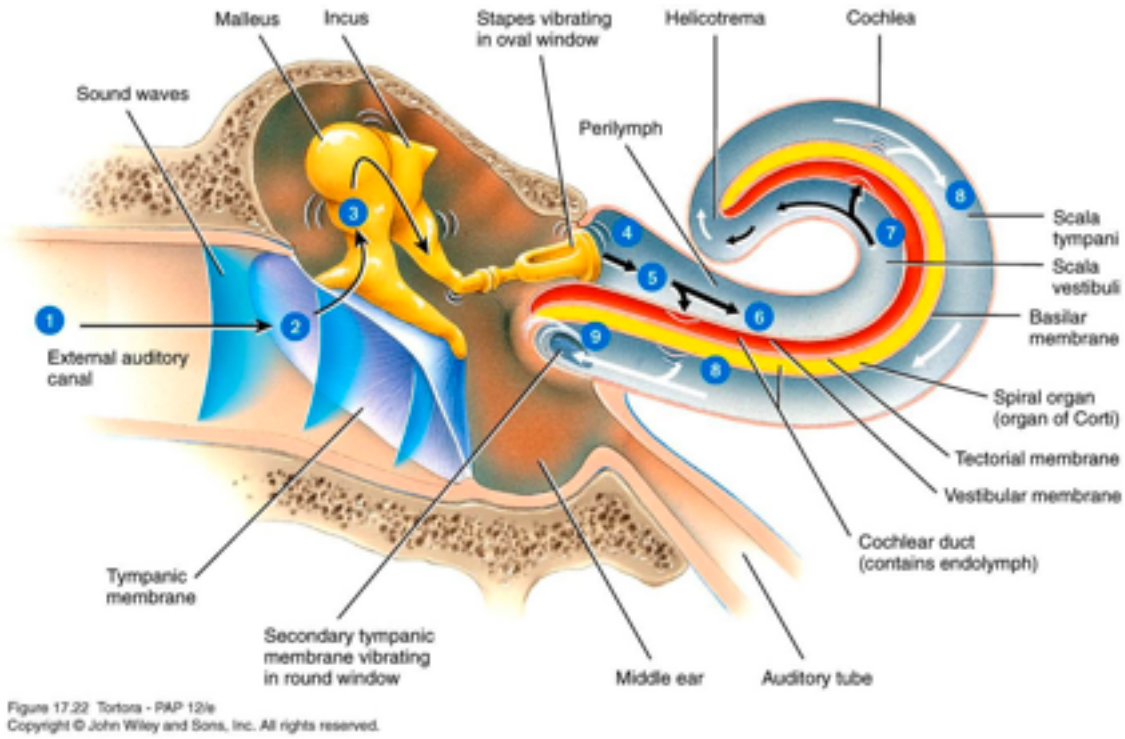


Figure 24: Artist's impression of the human ear.

Sound in the form of alternating waves of air pressure are funnelled in the ear canal by the pinna. These pressure changes press on the ear drum that is connected to the cochlea, the organ of hearing, via three small bony levers - the ossicles. The action of the ossicles is to amplify the pressure, amplifying the incoming mechanical forces by some 29 dB. The purpose of this is to impedance-match pressure waves in air to pressure waves in a fluid (perilymph).

Once the air pressure variations are converted into liquid pressure waves, these waves proceed from the oval window to the distal end (apex) where there is a small opening, the helicotrema, that allows the pressure to move back down the other side of the cochlea to 'exit' at the round window. It is important to understand that the cochlea is a fluid-filled, 'closed system'. When mechanical forces from the ossicles depress the oval window, the fluid extends the round window - like a pressure release valve.

[17] Copyright John Wiley and Sons, from Tortora.

The way that different frequencies (pitch) are determined is best described by the theory of place, Figure 25[18] and 26.

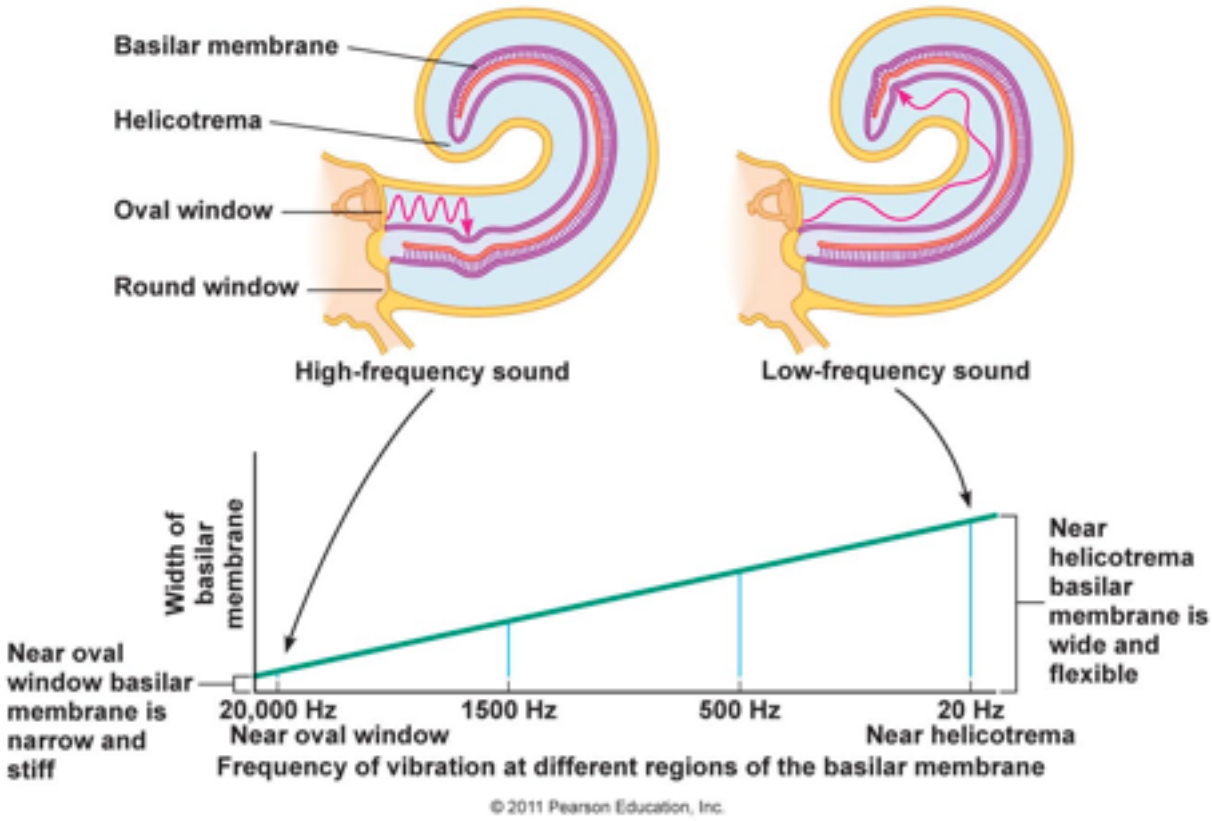


Figure 25: Cochlear - theory of place.

High-frequency sounds have a shorter wavelength, triggering the sensors in the cochlea (hair cells) close to the oval window, while lower frequencies travel further towards the apex, triggering the hair cells nearer the helicotrema.

The classical understanding of the range of frequencies a human can perceive through the cochlea is best described by the following diagram: Figure 26.

[18] Copyright Pearson education.

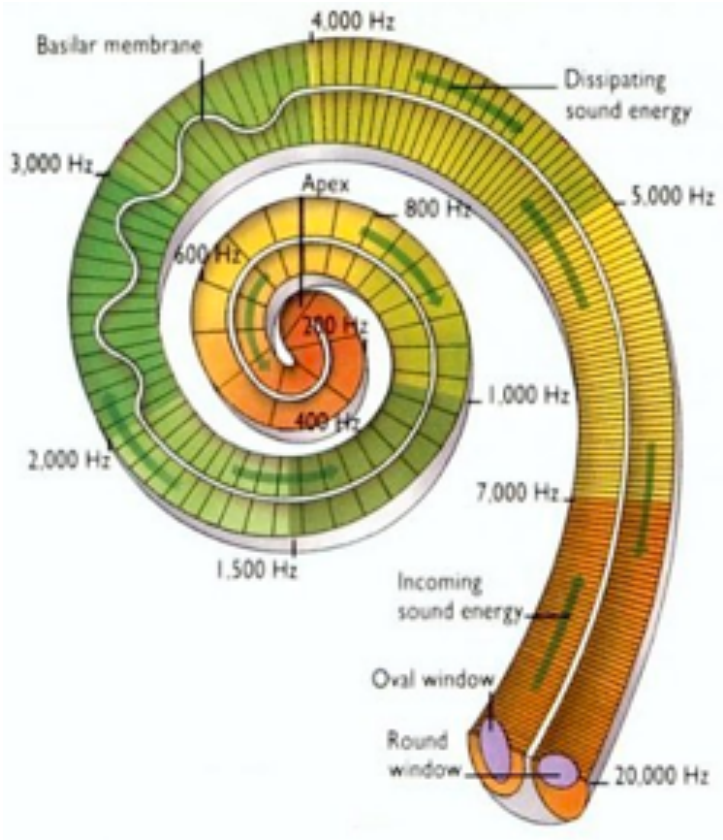


Figure 26: Cochlear frequency response in the human.

This simplistic artist's representation clearly shows the path of the waves in the fluid of the cochlear and where on the structure each frequency is detected. High frequencies are perceived close to the entry and exit point (oval window) while lower frequencies are perceived towards the far end, the apex (helicotrema).

While a basic knowledge of the hearing apparatus has been known for decades, it is the new knowledge regarding the micro anatomy and neurophysiology of processing acoustic-derived nerve impulses that is critical to understanding how low-frequency and infrasound can impact the human body. The old paradigms have to be released in order to embrace the latest science regarding the neurobiology and psychophysiology of hearing. A brief outline of this new knowledge and how it impacts on the wind turbine debate and the inadequacy of the the A-Sound Weighting will be presented.

New research in neurophysiology of hearing

And for a long time, the preceding section described where our knowledge stood. A simple organ of detection with little cellular sensors (switches) spaced along its length, somewhat like a piano keyboard. But, as with all things, the devil is in the detail.

As anatomical science progressed, taking advantage of the increasing technology and methodologies available to researchers, a clearer understanding of the minute structure of the cochlea was achieved. The biophysics of the cochlear is best illustrated in Figure 27[19]:

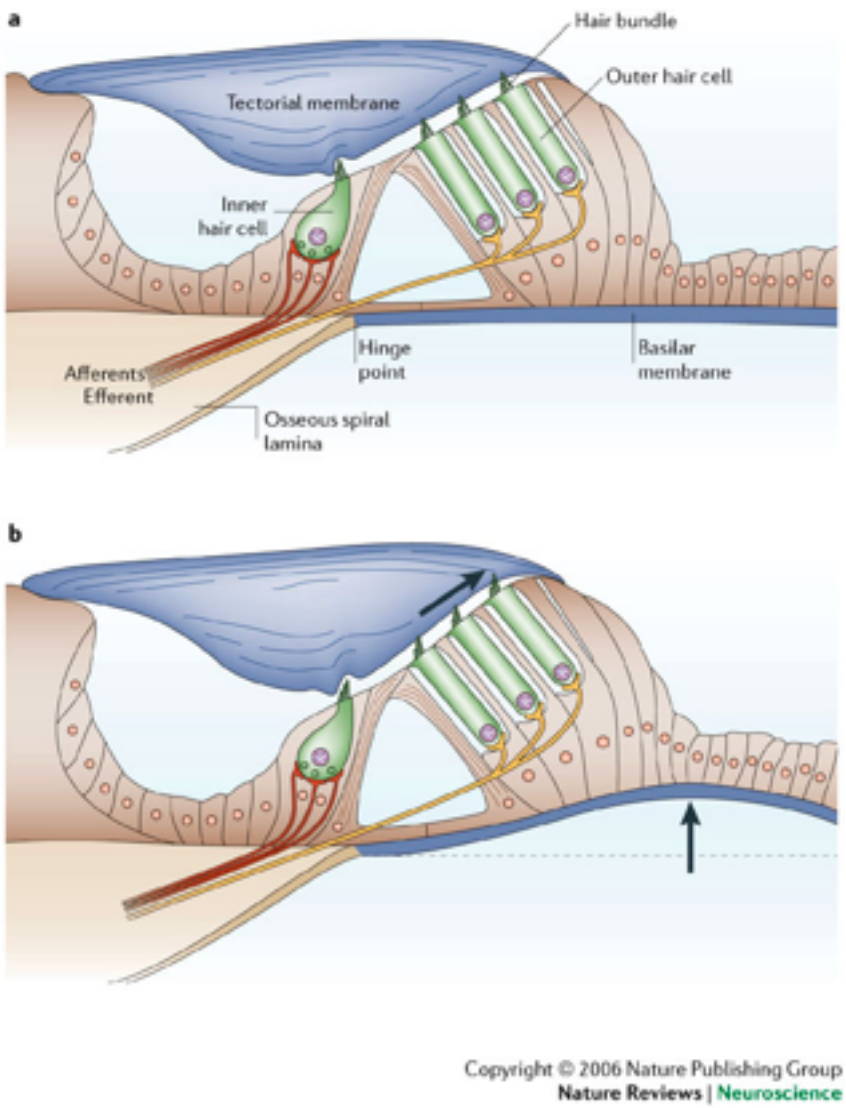


Figure 27: Micro anatomy of the cochlea.

[19] Copyright 2006 Nature Publishing Group - Nature Reviews - Neuroscience.

Figure 25 shows the cochlea in two different states, the upper diagram (a) shows the resting state of the organ with effectively no sound waves in the fluid. The lower image (b) shows how the basilar membrane bends in response to the wave in the fluid travelling along the cochlea, see arrows.

As the pressure wave moves down the cochlea, the basilar membrane is distorted, pressing against the stiffer tectorial membrane in the region correlating to the wavelength of that particular frequency (frequencies) of sound. An analogy might be striking the keys on a piano keyboard. The basilar membrane is the equivalent of the microphone diaphragm.

The critical physiology is that the outer hair cells actually touch the tectorial membrane above them. In fact, the longest hairs (stereocilia) are actually embedded into the base of the tectorial plate. The inner hair cells do not touch the tectorial membrane and are activated by waves moving through the fluid as a result of bending of the basilar membrane. This may seem to be minute detail, but it is the very heart of the most recent discoveries with regard to human hearing and is one of the critical reasons why NZS6808:2010 fails in its purpose.

Much of our hearing is facilitated by the inner hair cells. However, low frequencies and in particular, infrasound, ***is detected*** by the outer hair cells that are in direct, physical contact with the tectorial membrane. In this way, very low frequencies can be turned into nerve impulses and sent to the brain for analysis. The critical fact is:

Nerve impulses encoding infrasound information are not interpreted in the brain as sound.

The point is, you don't consciously *hear* infrasound. But you can perceive it.

The prevailing and unsupported myth that "**what you can't hear, can't hurt you**" is the concept we need to address. Some very low frequency sounds can be perceived as sound if they are loud enough, but normally they are only transmitted to the brain via the outer hair cells and thus may not necessarily be registered as 'normal sound' by the conscious brain. Other senses can pick up large infrasound waves and this is perceived often as a feeling of 'pressure' or 'fullness'. Just because the brain fails to recognise

very low frequencies (and infrasound) as 'audible' sound does not mean that the neural information is not transmitted to the brain or that it is not processed and acted upon. *There is yet another pathway that transmits this infrasound information to the brain*.

The vestibular system is mainly concerned with movement (perceived as acceleration) and position, but can also respond to low frequency sound. This has been proposed as the biophysical mechanism by which people who are subjected to infrasound exhibit the symptoms of vertigo and dizziness. In a similar way, the reason we become sea sick, or suffer from motion sickness, is because the brain has difficulty processing what appears to be conflicting information. Our eyes are telling us a different story to our balance system. The end result of this confusion is frequently the triggering of a primitive survival response: vomiting. While this might save a life if some poisonous substance is being ingested, it is inappropriate and unhelpful if we are simply being rocked while on a boat.

The landmark work of Steven Cooper in studying the effects of wind turbines at Cape Bridgewater has shown that **the symptoms residents are reporting are correlated to the output power of the turbine**. This is good, scientific evidence in support of our theory that also has external validity, mirroring what we observe in other situations where people live in close proximity to turbine farms. It is always good when observations are similar, adding weight to our hypothesis.

The fact that we are not yet certain as to the precise nature of the interaction, in other words, how it works precisely, the evidence is now extremely strong to show that there is some biological effect that is somehow correlated to turbine emissions. The seminal work over the past decade by Professor Alec Salt and his team at Washington University, St. Louis, is providing the neurophysiological details to fill in the picture. What we know from his team's work is that the outer hair cells do actually transmit infrasound information to the brain. It is just that the brain handles them differently, thus not interpreting it as 'normal' sound. Salt and his team have measured the nerve impulses in the laboratory using animal models.

The combination of infrasound information reaching the brain via the nerves of the outer hair cells, plus the potential data stream from the vestibular system, is thought to be sufficient to cause a plethora of hitherto unexplained symptoms. The fact that the symptomology is very consistent across the world is strong evidence that the phenomenon is not only real but indicative of the basic functioning of the human organism. Only now are we beginning to understand this complex system, thanks to people like Salt, Lichtenhan, Balaban and Cooper.

Professor Salt's team have made one other landmark contribution to our knowledge in this area. That is concerning amplitude modulation. Amplitude modulation is likened to

listening to a sound through a stereo amplifier which is having that volume control turned up and down. See Figure 28.

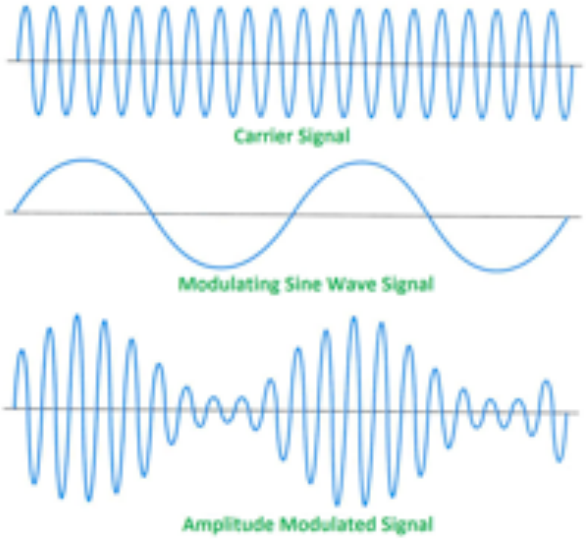


Figure 28: Modulation of a simple sine wave.

This top figure shows a single, high-frequency tone (termed the carrier wave). The middle signal is a very much lower frequency with a correspondingly longer wavelength. When we add the first and second wave forms together, the result is the lower wave form. What we would 'hear' is the original tone (top figure) being made louder and softer in time to the modulating signal (middle signal).

Amplitude modulation is a well-understood physical phenomenon and is actually how AM radio is transmitted. A carrier wave, usually in the kHz region, is modulated (made louder or softer) by the actual sound information we are wanting to transmit. The radio receives this information and removes the carrier wave, the very high transmission frequency, and what we are left with is the lower-frequency audible sound we wanted to transmit and receive in the first place.

So what has amplitude modulation got to do with the neurophysiology of hearing? We now know that the outer hair cells have a number of functions, one is to detect low frequencies (including infrasound). Another important function that we have only recently come to understand is that they are able to change the tension between the tectorial membrane and the basilar membrane. Each bundle of outer hair cells have some fibres that can expand or contract vertically, thus changing the tension on the basilar membrane. This effectively damps (reduces) or facilitates the sensitivity of the membrane. In essence, the role of these outer hair cells is to act as a ***volume control*** for the cochlea. It is believed that this is a 'safety' mechanism, able to protect the sensitive inner hair cells from repetitive, loud sound.

It appears that incoming infrasound can stimulate the outer hair cells that respond by modulating the sensitivity of various regions of the cochlea. The effect of modulating the sensitivity of the cochlea is that other frequencies appear to be amplitude modulated! This unnatural manipulation of sound levels can have a very disconcerting effect on the listener. It also means that the infrasound is being encoded by way of amplitude modulation of higher audible frequencies (equivalent to the carrier wave in the previous diagram) so that the brain is then subjected to the infrasound.

In essence, this apparent cyclic change in sensitivity (loudness) of the ear is creating an unnatural sound that is actually 'not there' in the original ambient sound. It is what we call an ***ARTEFACT***. What we perceive is not actually the original sound but a permutation caused by the mechanics of the system. It is the result of a built-in biofeedback control system between the cochlea and the brain that is changing the nature of what we perceive as audible sound. The effect of this distortion of perception is not well understood, although it does appear that this process is actually facilitating another channel though which infrasound can impact on the brain. If this unnatural manipulation of the hearing mechanism continues for extended periods (as may be the case for people living in close proximity to wind turbines) from hours to days, the effect on the physiology is not yet known.

The salient point is that NZS6808:2010 does not take any of this neurophysiology into account. By the continual use of the (anachronistic) A-Weighting, acousticians are deliberately removing acoustic data that may be critical in terms of biological effects.

While the effect of this modification of hearing sensitivity is not known, the use of the A-Weighting in measuring environmental sound is throwing the baby out with the bathwater by deliberately discounting the low-frequency component.

Now that we understand more of the neurophysiology, it is nothing short of criminal not to take this knowledge into account when dealing with noise emissions from wind turbines and the creation of standards ostensibly to protect public health and amenity.

There is one last aspect that we need to consider: behavioural science and the endocrine system. The following section will briefly discuss how this is relevant to wind turbine emissions.

The endocrine system and wind turbine emissions

The brain is arguably the most complex structure in the human body, certainly the most difficult to understand. It remains one of the greatest medical mysteries man has ever, or is likely to face. Unlike the heart that clearly pumps blood, or the lungs that exchange oxygen and carbon dioxide, the brain seems to be rather more esoteric in function. It is just a huge bunch of nerve cells all connected together. Somehow this complex structure monitors all incoming nerve signals via afferent nerves and controls the entire body using the efferent nerves.

Radio transmission is a good example of the practical use of amplitude modulation. Now we need to apply that understanding to how nerves sense and 'choreograph' the human body's functions. There are some equally useful analogies from other sciences and technologies that will assist us in getting to grips with this concept.

The first concept is that of a filter. A filter is a device that selectively lets some objects through, while constraining others. We use this simple system to strain our vegetables from the cooking water, remove the grounds from our coffee, or filter contaminants out of our car's lubrication oil. In the membranes of our cells, proteins perform the very same function. They form channels which are selective for certain chemical species, allowing some in, while keeping others out. This is not always a passive process, rather it frequently requires energy, usually in the form of ATP[20].

Figure 29: Coffee Filter

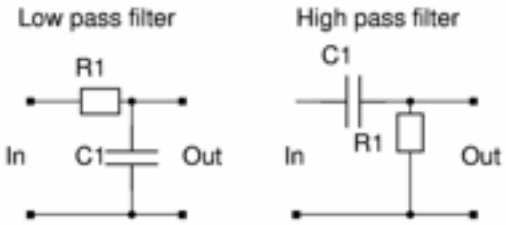


Figure 30: Electronic Filters

In electronics, filters are used in a myriad of applications. One example is the tone controls on stereos. These electronics mechanisms, often simply a resistor and a capacitor wired together, effectively allow some frequencies to pass by while blocking others. A graphic equaliser is just an extreme example of multiple narrow-band tone filters across the spectrum. Sound engineers use this technology to create (master) music onto CDs (or records for the older generation). Some frequencies are enhanced, or amplified, others attenuated or damped. It is interesting to note that the brain works exactly like this also.

[20] Adenosine TriPhosphate

In essence, the brain is what we call a ***difference engine***. One that works on ***binary information***. That is, ones and zeros, ***just like a computer.*** This is a weird concept to have to come to terms with, but it is nonetheless true. The concept of a difference engine was created by an engineer in the Hessian army, J.H. Muller, and later built by Charles Babbage in 1823. A working example is on display at the London Science Museum, Figure 31.

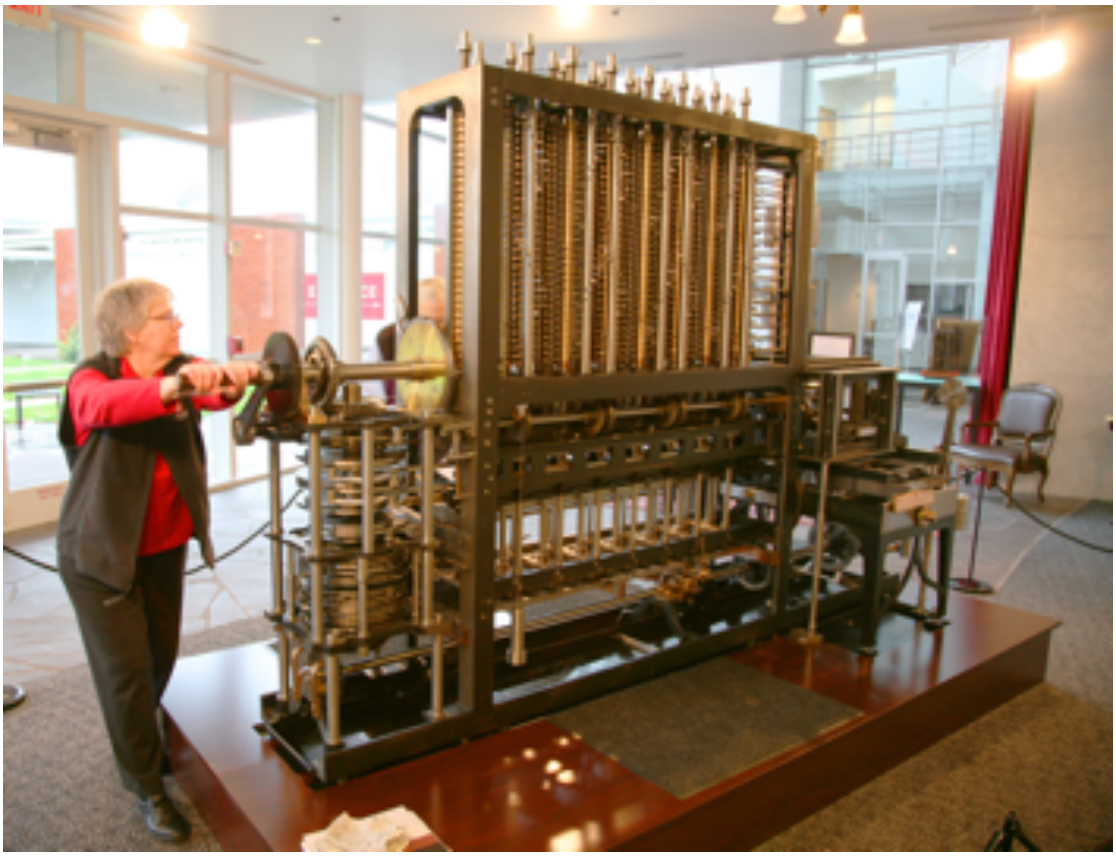


Figure 31: Model of the Babbage Difference Engine, London Science Museum.

A difference engine is a mechanical calculator designed to tabulate polynomial functions, the name derived from the method of divided differences, a way to interpolate or tabulate functions by using a small set of polynomial coefficients. What is fascinating is that the brain works in a very similar manner!

Every nerve impulse is the same as any other. There are no strong or weak nerve impulses. There are no loud or soft nerve impulses. A nerve impulse is just a nerve impulse. The equivalent of a “1” in binary numbers and computer technology. Every piece of input from the environment and every control impulse is simply transmitted in ***BINARY CODE***. The implication is simple: **The brain is a binary, difference engine.**

Nerve impulses are all remarkably similar, Figure 32.

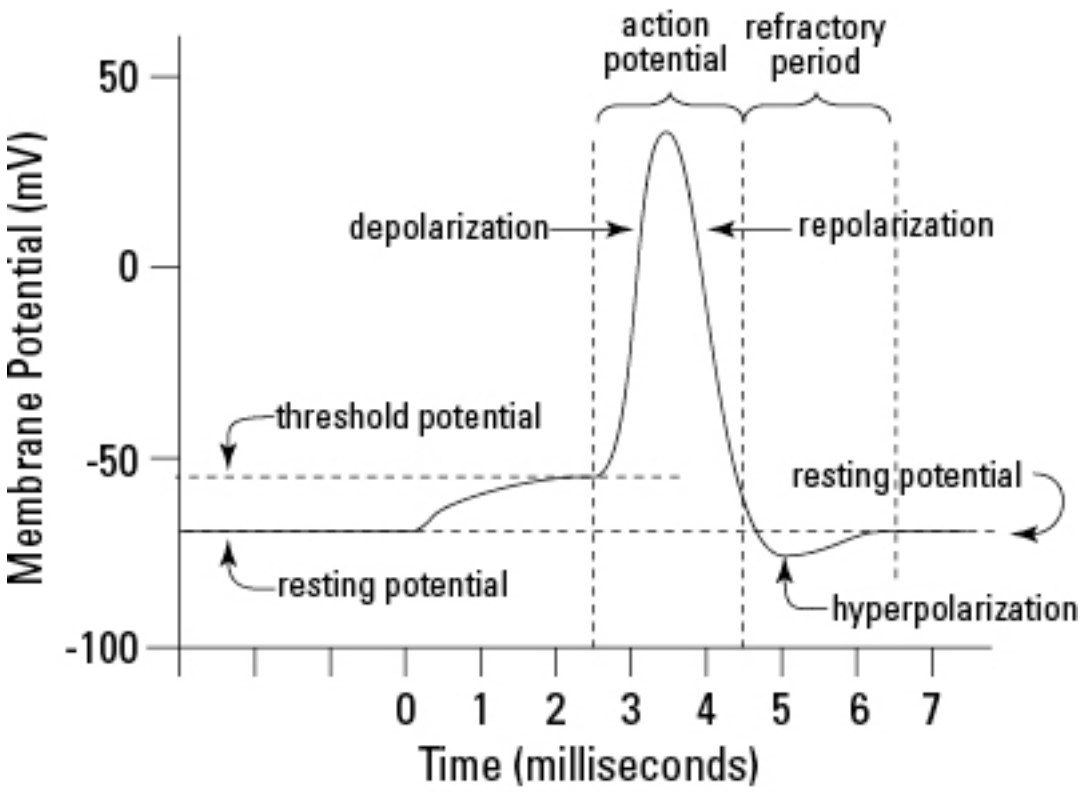


Figure 32: Electrical characteristics of a nerve impulse.

This immediately provides us with a conundrum: How can we represent colour, or loudness, in binary terms? Well, your computer does this, and, in point of fact, so does your brain. In essence, all neural information is ***frequency modulated***. Ergo, the brain is a frequency-modulated difference engine. The number of nerves firing at one time, or in quick succession, and the length of the gaps in between the pulses, is how the brain encodes information and 'sees' the world and also 'controls' the body.

Thinking about how the cochlea functions, the piano keyboard is not a bad analogy. When a particular sound frequency is received at the ear drum, that results in the vibrations being transferred to the cochlea via the ossicles. These cause pressure waves to impact on the basilar membrane of the cochlea effectively 'pushing' the switches (hair cells) to tell the brain, "Hey, I detected this frequency".

The precise mechanism of how the cochlear works and how the brain interprets these trains of pulses is well beyond the scope of this submission. However, it is important to understand at least a little of the biology that relates to the people that NZS6808:2010 is trying to protect with regard to wind turbine emissions. If NZS6808:2010 does not consider how the human receiver of the wind turbine emissions functions, including all the neurophysiological responses, then it cannot guarantee to provide a scheme to control those emissions in relation to adverse biological responses, upholding the principles of public health.

Now that we understand the nerve's process of transferring information in binary code, we return to our topic of the brain as a difference engine. Within the brain there are 'circuits' that are specifically designed to respond to certain inputs. We call such mechanisms: **Filters**. These filters are preprogrammed into the brain as the result of millions of years of evolution. (Or at the clever whim of a Divine Creator - if you prefer.) These filters are understood to exist in the auditory cortex in connection with the limbic system. Together, these parts of the brain process incoming, binary nerve impulses from the ear, including both the cochlea and the vestibular system.

Specific filters have different signature frequencies that result in different output information. **Some of these filters are designed to respond to: INFRASOUND.** The ability to detect and respond to infrasound has an evolutionary advantage. In the natural environment, infrasound is usually a harbinger of danger. This can take the form of stormy weather, an avalanche, a rock slide, a tree falling, an earthquake or the approach of a predator. In most circumstances, each of these natural phenomena is distinguished by its **infrasound signature that often manifests at relatively low sound pressure levels**. When mammals hear infrasound it triggers these ancient biological filters in the brain, triggering a fear response.

In an article in the New Zealand Listener, March 7-13, 2015, by Health Correspondent Nicky Pellegrino, quotes Dr. David Welch, Head of the Audiology Discipline in the Department of Public Health at the Faculty of Medical and Health Sciences, Auckland University. The article is entitled "Noises off - please: Those with sensitive ears can suffer a range of sound-induced health effects".

> . . . Part of the problem is we're wired to react to sound.
>
> "The auditory system has evolved to act as a warning system for our bodies," says Welch. "It's a way of alerting us to potential environmental threats. Sound is transmitted through the brain stem and it gets into the limbic system of the brain, which is where emotions are processed. If you go back a few hundred years, it's what stopped us getting eaten."

This natural fear response is what biologists refer to as the ***Fight or Flight Response***. Basically, when these ominous infrasound signals are perceived by the filters in the brain, they initiate a neurological cascade that, in turn, creates a cascade of hormones (including adrenalin and cortisol) to be released throughout the body. Together, the

nerve impulses and the hormones create what is referred to as ***Sympathetic Dominance***.

The Autonomic Nervous System is the auto-pilot of the human body. These nerve pathways control all the background activities such as digestion, blood distribution, muscle tone, sweating, energy distribution, etc. etc. etc.

Essentially there are two states that the autonomic nervous system operates in, each the opposite of the other: **Sympathetic** and **Parasympathetic**.

In the **parasympathetic** state, blood supply is directed to the digestive organs, cellular repair is activated, mood is quiet and contemplative.

When the **sympathetic** state is dominant the pupils of the eyes dilate, blood is directed away from digestion and towards to the muscles. The skin begins to sweat, heart rate increases and a state of absolute alertness takes over cognitive function. This is the state where the classic choice is either stay and fight or run for your life.

The latest scientific research is now beginning to show that the acoustic emissions from industrial wind turbines can '*flip the switch*' causing the autonomic nervous system to operate in **sympathetic** mode. In the short term, this is ok, it gives the body the best functionality to fight or flee. If that state continues for more than a short period of time however, the consequences can be very dangerous, if not fatal. The long-term medical consequences of stress can be all-encompassing. Risk of heart attack rises, fatigue and irritability increases, there is often loss of memory function, general degradation of cognitive function, adrenal fatigue, poor digestion and lower mineral absorption, reduced immune function, increased risk of cancer, reduced motor control, headaches, nausea, vertigo, blurred vision, loss of ability to focus the eyes - the list goes on. . .

The important fact to take notice of is that ***the acoustic emissions of industrial wind turbines are unique***. They are unlike any other form of infrasound, with the possible exception of ventilation fans and HVAC[21] systems. Accordingly, emissions from industrial wind turbines somehow manage to trigger the primitive acoustic filters in the brain that initiates a cascade of nerve impulses in the limbic system, including the parabrachial nucleus and the amygdala. In essence, this reaction puts the organism into the best state for fighting or fleeing danger. The involvement of the amygdala triggers memory of fear. If this state continues for extended periods it can even cause death.

In a normal environment, the function of sympathetic dominance of the autonomic nervous system is to save the life of the organism. It is the equivalent of the panic button - **RED ALERT**. This provides the organism with the best chance to deal with the source of the threat or flee. If the threat cannot be identified, as is the case for low-

[21] Heating And Ventilation Systems.

frequency and infrasound that appears to “come from everywhere”, the brain is then put into a state of utter confusion. There is something that needs to be fought, but where is it? There is some danger in this geographical location, but in the absence of an absolute location of the threat, where does one run to if you cannot see what to fight?

This state of confusion, if allowed to continue for a prolonged period, as would be the case with constant emissions from industrial wind turbines that could continue from hours to days to weeks, the effect this has on the physiology and cognitive functions of the human body can be extreme.

NZS6808:2010 fails to protect the health of those living in close proximity to wind farms because it fails to consider all the biological responses of humans to low-frequency and infrasound stimuli.

The acoustic emissions from wind turbines are unique, as are the biological responses of individuals. This explains why some people will be more affected than others. It is also important to note that physiological habituation to low-frequencies and infrasound is virtually impossible. This is of evolutionary advantage as one might not tend to live too long if environmental danger signals are ignored. But it is no way to live a ‘normal’, healthy life.

Sympathetic tonus is a life-saving mode, not a cruising mode. If the stimulus continues for extended periods of time, the individual will become seriously impacted by the biochemical and neurological cascades. Adverse health effects are the only possible outcome. There is no other option.

What we know so far . . .

Large industrial wind turbines used for electricity generation are a relatively recent phenomenon, originating post 1970s in response to the international oil crisis and the resulting call for new green energy initiatives.

The past three decades have seen a steady increase in size of industrial wind turbines and their generating capacity. This increase has been mirrored by the number of adverse health effects that are reported world-wide, wherever large turbines have been installed.

There have been numerous industrial wind turbine noise standards produced, yet none seem to address the problem of reported adverse health effects. Why is this?

The wind industry response has been largely negative, first denying the existence of any problem, and when that failed, turning their attention to blaming the residents for making false complaints or being influenced by the so-called Nocebo Effect. Accusations go so far as to label complainants as NIMBYs: Not In My Back Yard.

The Nocebo Effect is a scientific non-sequitur. You cannot have a Nocebo (or Placebo) Effect if the phenomenon is palpable, that is, able to be observed, detected or perceived. The emissions of industrial wind turbines are readily sensed so the Nocebo Effect is not possible - by definition! To continue to promote this idea shows a remarkable lack of scientific rigour.

The wind industry continues to buy out and silence objectors with gagging clauses that only serve to make the whole business far more suspicious and clandestine.

The question that must be asked is: Why are industrial wind turbine noise standards not protective of nearby residents?

The answer to this question is relatively simple:

- Wind turbine noise standards rely on the anachronistic and inappropriate A-Weighting;
- These standards use the $L_{A90(10\ min)}$ statistic, citing 40 dB or the background plus 5dB, whichever is the greater, as the limit at noise sensitive locations. This is **not protective of sleep**;
- These standards also assume that there will be an attenuation of 15 dB between outside to inside noise of typical New Zealand (and Australian) dwellings. **This assumption is completely untrue, hence the level of sleep disruption reported**;

The standard, in assuming a 10 to 15 dB attenuation through an open window and using a design level of 40 dB (LA90) at the property or an increase of 5 dB over the background sound level, whichever is the greater, is assuming that if the background sound is over 40 dB (giving more than 30 dB at the person sleeping or trying to sleep) then it is all right to increase the noise by 5 dB as no one will notice.

The resulting sound pressure level is contrary to the World Health Organization recommendation that 30 dB should not to be exceeded and is not sustainable management as defined under the Resource Management Act. Taking an analogy from an Environment Court judge, this is equivalent to hitting someone over the head with a hammer and saying it is all right to hit them 7 times as hard (5 dB) as they won't notice the difference. It is also greater than the noise allowed for even short term construction in the New Zealand Standard for Construction Noise (NZS 6803).

The result of using an inappropriate measurement statistic and other false assumptions has ensured that NZS6808 cannot be protective of residents in close proximity to industrial wind turbine installations (possibly out to 10 km). The number of affected people, world-wide, now numbers in the thousands. In the opinion of this Author, to continue to deny the evidence of adverse human effects is bordering on criminality. If the same approach, ignoring reported symptoms, was taken by medical practitioners, such practitioners could be taken to task for a breach of medical ethics. Yet it is ok for the wind industry to continue to do this in the face of overwhelming evidence to attest to adverse health effects.

The wind industry constantly states that there is insufficient evidence to support a link between wind turbine emissions and adverse human health. It seems as if affected residents are being forced to 'prove' their condition, rather than the alternate process that would require a manufacturer to prove the safety of their product first.

If a similar quantum of adverse reactions were reported for a new pharmaceutical drug it would be removed immediately from the market and warning statements issued.

This bizarre and hypocritical attitude is fuelled by the Green Agenda and a call for energy generation systems that are not reliant on fossil fuels. Add to this the other myth that wind energy is essentially free, and you have a disaster in the making of epic proportion.

Only those who are adversely affected by wind turbines fully appreciate the enormity of the problem. So while industry moguls and health organisations call for

"more research", many people continue to suffer. If this were any other product, an electrical appliance, an automobile or a pharmaceutical drug - the onus on proving safety and fitness-for-purpose would be on the manufacturer. Why are we allowing the persecution of innocent people whose only crime has been that they live in close proximity to industrial wind turbines and they are now suffering the consequences.

The fight gets dirty - bring in the big guns

This debate has become dirty, with the wind industry wheeling in pseudo experts to flood the media with their propaganda. The landmark work of Steven Cooper at Cape Bridgewater has shown strong evidence of a cause and effect relationship between the output power of industrial turbine emissions and reported sensation. For his efforts he has been pilloried in the public press/media. That this is likely to result in legal action underlines the seriousness of this campaign by the wind industry which appears to be totally focussed on destroying any person or group that threatens their commercial imperatives. Enter the Australian medical Association.

That the AMA (Australian Medical Association) has publicly come out in support of the industrial wind turbine developers is yet one more example of how corrupt the system has become. In stating:

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

they have overstepped the authority of their profession and should be held responsible for it.

When the AMA then states:

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

they are again stepping outside of their area of expertise and knowledge base.

To continue, the AMA say that:

> **"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."**

This suggests that the AMA consider that low-frequency emissions from wind turbines are nothing new in the environment and no different to existing sources. The contention of the AMA that such low-frequency and infrasound has no effect on public and personal health is simply a ludicrous notion, demonstrating how little the medical profession understands acoustics or, it is suggested, is willing to ignore some facts for some nefarious, political reasons. Why did the AMA step outside its area of expertise to support the wind industry to the detriment of

members of the general public? The very public that the AMA is ethically bound to protect.

There are numerous scientific references in the literature that clearly state that wind turbine emissions are a unique addition to the natural soundscape. As medical students are required to be able to read to enter medical school, the only conclusion is that once qualified, they choose not to read scientific journals, unless they present a viewpoint consistent with their own or current medical dogma.

It is hard to understand how a group of highly qualified medical professionals could act in such an unprofessional way. In their statement regarding wind energy they claim:

> **"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."**

That downwind turbines have been known for more than 30 years to be a source of problematic noise emissions does not address the actual issue of the emissions from upwind turbines and whether or not these levels could be harmful to residents living in proximity. By making the above statement, the AMA appears to be admitting that wind turbines generate low-frequency and infrasound. The AMA displays not only their ignorance but also their bias when they opine:

> **"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 only way that such a nonsensical conclusion could be reached is by actively cherry-picking the data and ignoring anything that contradicts their chosen position. This is not the way that science works. Sir Karl Popper pointed out that all we have in science is a series of models to explain observations. While evidence that supports the model can make us think that the model is more likely to be correct, it takes only one example to the contrary to destroy a long-cherished 'belief'.

That a professional organisation, the AMA, has come out with public policy statements that are well beyond their area of expertise and knowledge base is indicative of a system in crisis. As one of the many scientists who wrote to the AMA to question their

position, this Author was simply one more voice that was ignored by the association while they continued to support an industry that is becoming more questionable every day. That they cannot even respond to serious, scientific criticism is reason enough to question their basic tenets and professional ethics. This Author's letter to the AMA can be found in the Appendices.

The philosopher, Arthur Schopenhauer, once said that all truth passes through three stages:

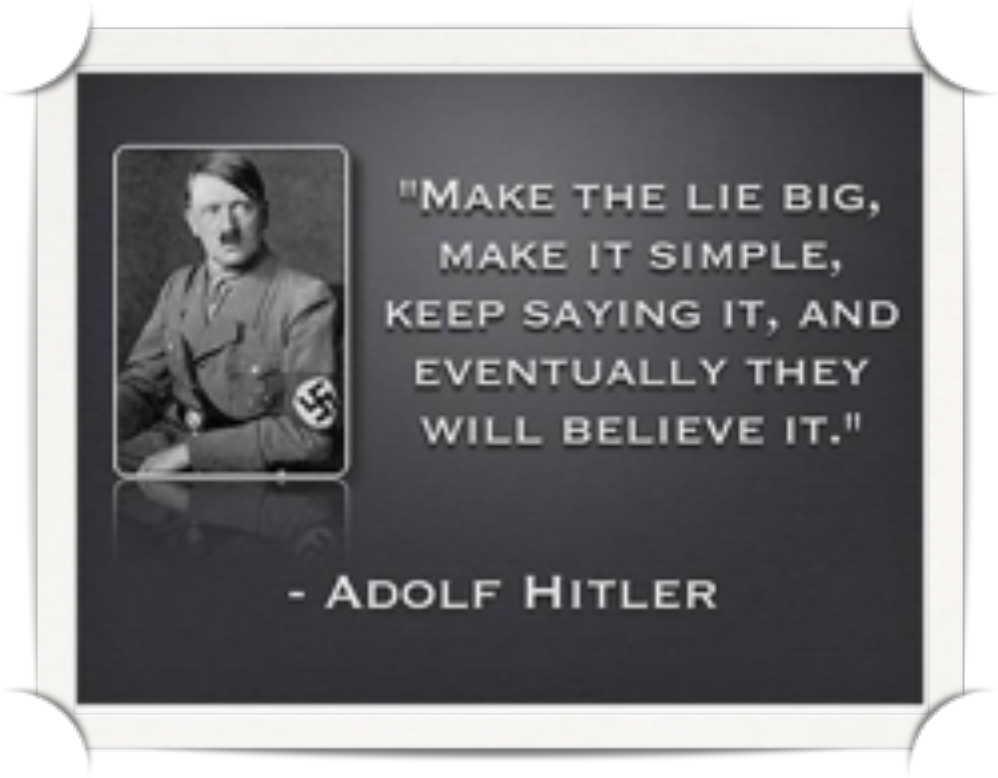
- First, it is ridiculed.
- Second, it is violently opposed.
- Third, it is accepted as being self-evident.

Clearly the industrial wind turbine debate has only reached stage two as at the time of writing.

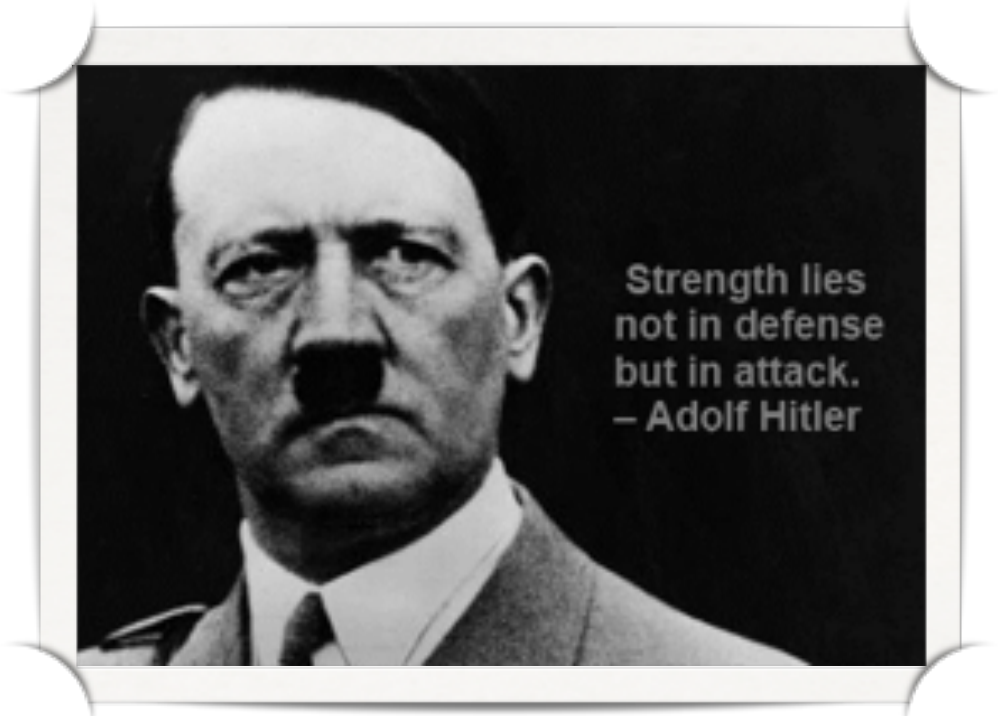
That there is a sizeable conspiracy involving the wind industry is now becoming abundantly clear as the only explanation for what is unfolding. The recent actions of the Australian Charities and Not-for-profits Commission (ACNC) to remove the charity status of the Waubra Foundation is yet one more piece of evidence indicative of the depth of the corruption. (This Author's letter to the ACNC can be found in the appendix.)

In the final analysis, science is not a numbers game. It is a not a democracy where the most popular vote wins. Rather science prides itself on its basis in logical, rational thought processes and protocols, and use of empirical observations. That the scientific method is so misunderstood, so misapplied and so easily hijacked for commercial gain, is an indictment of human society.

A growing number of scientists, engineers and acousticians around the world are slowly coming together to fight the corrupt practice of the wind industry and their associated henchmen. How long will it take before common sense prevails? How many more people must suffer because of the fiscal bottom line of an industry unconcerned with human health? It is harrowing to realise that Adolf Hitler was correct when he asserted:



More evidence of Hitler's beliefs is evident in the wind industry's *modus operandi* as they continue to attack anyone who would question their viewpoint:



What we are left with is the quotation from the Irish statesman, author, orator, political theorist and philosopher: Edmund Burke (1729-1797):

> **"The only thing necessary for the triumph of evil is for good men to do nothing."**

The Australian Senate now has an awesome task to perform: to consider the public health issues associated with the industrial wind turbine industry, to agree on and suggest appropriate technical requirements to regulate it appropriately to minimise human suffering. No longer can the science be ignored, or the empirical evidence denied until 'sufficient' proof is obtained. As Rob Rand, an acoustician in the United States stated in response to the recent Australian Media Watch debacle:

> **"It would be unethical of me as a member of Institute of Noise Control Engineering to wait for the years required for such careful medical research work to be completed. I have sufficient correlation already from the neighbours' reports and affidavits and the measurements done thus far to inform others for designing properly to be good acoustic neighbours."**

In no other industry would the burden of proof be placed on the victim, rather it is the responsibility of industry to guarantee safe, fit-for-purpose products. The Senate now has the job of finding a way through this crisis to minimise the adverse public health outcomes before many more people are harmed by this folly of obtaining 'free energy' from wind. To fail to act at this time is to condemn many more people to a life of illness and virtual torture, not to mention the many who have been forced out of their homes.

Politicians have a duty of care, and now that they have been so advised, any future decisions they make must be seen against the evidence of palpable harm from industrial wind turbine installations ***of which they have now been made aware***. Therefore, any subsequent harm as a result of their decisions will be undertaken in the full knowledge of the consequences. Politicians must take responsibility for their actions in the execution of their public duty.

Unanswered Questions

There is an old adage that what we learn from history is that we do not learn from history. This cliche is nonetheless true, but how can we change our collective behaviour?

An equally useful Chinese proverb goes something like this:

"IF YOU WANT TO KNOW WHERE YOU ARE,

YOU MUST FIRST KNOW WHERE YOU HAVE BEEN."

In an attempt to assist the reader in answering this question, a timeline of major events in the modern history of wind turbines is presented in Appendices. Perhaps this time we may learn from the past before it is too late.

From this timeline it will be clear that the problem of wind turbine emissions has been known for decades.

There can be no excuse that "we didn't know that", the reported adverse health problems coming out of 'left field'.

All wind turbine developers in recent times should have known the potential adverse health consequences. ***It has been in the literature for decades***. Ignorance is no longer a plausible excuse.

It can only be assumed that although recent wind farms were built by developers cognisant of the public health impact, they simply chose to ignore the consequences and proceeded to "make hay while the sun shines", the commercial imperative overriding public health.

A pathway to the future

The situation in which we currently find ourselves is the result of a number of factors. The lack of 'sufficient' scientific evidence is a major concern, although there is evidence in the scientific literature going back 30 years that spells out the dangers of industrial wind turbines' noise emissions. When is there ever 'enough' scientific information? As is frequently the case, enforcement lags scientific knowledge.

A critical failing of process regarding NZS6808:2010 was the over-representation of industries on the standards committee. Those with a vested commercial interest should not be in such a powerful position to decide matters that involve public health. In the opinion of this Author, there is no place for industry involvement on standards committees where public health is involved due to the obvious conflict of interest. That commercial interests should continually overrule public health is an egregious crime of the 20th and 21st century.

Public health initiatives should never be at the behest of the commercial imperative. Without looking after the health of both workers and the broader community, no standard should be acceptable that does not place health first and foremost as the number one priority.

Since the Industrial Revolution, society has progressed along a dangerous path, the technological advantages coming at considerable social cost. That we have failed, as a society, to learn from history does nothing to affirm our humanity. While commercial greed is used as the sole basis for industrial development, the human race is in danger of destroying its environment that may, one day, lead to the very extinction of mankind.

In respect of public health with regard to nuclear radiation, there is no debate about the safety aspects and stringent rules apply. The same is true of X-rays, asbestos, lead and other chemical pollutants. Even cigarette smoking is now accepted as carcinogenic - after nearly half a century of battling over the concept. If we can get it right with these environmental hazards, why are we unable to apply the same logic to harmful noise?

The World Health Organization has recognised the seriousness of noise pollution in the modern urban environment and the profound effects it can have on quality of sleep. Without sufficient quality and quantity of sleep, the human organism is put under excessive physiological and psychological stress. That a multitude of adverse health effects are related to excessive noise is not news. Countless textbooks exist that discuss the topic and scientific papers abound in the literature. What is missing is the legislative control and the policing of safe environments without undue influence from industry that is only concerned with the fiscal bottom line.

This Author suggests that all standards involving commercial gain which include public health aspects should be reviewed. It is vital that all undue pressure from industrial and commercial interests be excluded from that process. Health must take priority over the commercial imperative. An independent body needs to be established that will have the authority to close down or modify the functioning of any industrial organisation that fails to operate within the legislated, safe boundaries. Such an organisation could be funded, in part, by way of costs from the very industries that are operating outside the law, just as police fines do now.

When a complaint, for example, Noise Trespass, is registered, the offending industry should be responsible for the cost of an independent investigation by the controlling authority that then has the power to insist on mitigation of the problem or closure of the site. ***While there is no consequence of action, industry will continue to operate for profit at the expense of public health.*** Those responsible for 'pollution' should be responsible for cleaning it up. This is so in the oil industry, why should this not applyto the wind-power industry?

One of the major reasons that human society finds itself in such a state of disarray is that in many instances, consequences of action are divorced from those that cause it. If there was no consequence for breaking the speed limit, there would undoubtedly be far more casualties on our roads. We do not allow open speed limits on our roads. Similarly there should be appropriate noise limits to preserve public health.

That the wind industry continues to hold fast to the false assumption that "what you can't hear can't hurt you", or that there can be no consequences from infrasound, is to remain in a state of profound ignorance. Or is it by design? The science is now able to describe in minute detail how acoustic energy manifests in the human body. That includes low-frequencies and infrasound. ***To continue to deny the scientific research as well as the plethora of commonly observable effects on those living in close proximity to industrial wind developments is inexcusable, deliberate ignorance that is resulting in serious adverse health consequences.***

It is no longer ok to continue the proliferation of such obvious lies as "the sound from wind turbines is similar to the rustling of leaves or the babbling of a brook". That wind turbine emissions are unique in the sound environment cannot be contested. Wind turbine emissions cannot be compared to other naturally existing sources of infrasound, either in quantity (SPL) or in quality (timbre). The sounds are totally different.

The Green Dream of a free and safe source of energy is but another example of false hope based on a paucity of information. Wind turbine energy is not free from economic cost to society nor is it free from creating serious health effects. Yet the industry still blusters on with publicity based on naive assumptions and demonstrably incorrect science. Another viewpoint is that the industry continues to proliferate "false and

misleading statements that they know to be incorrect at the time they make them". Not only is the current situation the fault of a deceitful industry, but it is also the fault of intelligent people who have allowed commercial interests to dominate regulation of environmental noise, to the commercial benefit of the very noise polluters who have known about the adverse health impacts for thirty years. As Abraham Lincoln once said:

> **"You can fool all of the people some of the time, and some of the people all the time, but you cannot fool all the people all the time."**

As the list of casualties of the Wind Industry continues to grow, world-wide, when will legislators finally muster the courage to act and stop this abuse of public health?

The Australian legislature, through this Select Committee, has the opportunity of giving a strongly ethical example to other legislatures around the world by rationally dealing with a difficult problem.

A cautionary warning about future research

While it is always true that there is never 'enough' science, the research that needs to be conducted in the near future should concentrate on correlating the wind turbine emissions with adverse human reactions. What is urgently needed is a study design that focuses on obtaining objective as well as subjective evidence from sensitive individuals who are already severely impacted by wind turbine emissions. Naturalistic observational studies need to be conducted utilising non-invasive physiological monitoring together with diary records of individuals that are already severely impacted. Without multiple measures and careful analysis, little progress can be made. Without that attention to detail, the end result will likely be that the number of severely-impacted people will continue to grow, world-wide.

Limitations of laboratory studies

There are those who would propose that laboratory studies be undertaken as the next logical step. However this could be a very dangerous assumption. There are many reasons why laboratory studies are of limited use. The very artificiality of the laboratory environment does not lead to realistic exposure conditions that would be comparable to the real environment. Physiological and psychological factors come into play here, and while laboratory studies have the advantage of significantly more control of the independent variables, the artificiality of the study remains the biggest failing.

Previous laboratory studies that had disastrous outcomes

One last point. Laboratory studies have been carried out on the effects of low-frequency and infrasound as far back as the 1960s. One such study resulted in the death of two researchers in the early 1970s. Another researcher was badly impacted in a UK study being rendered unconscious during an infrasound experiment, suffering permanent destruction of facial nerves resulting in a prominent facial droop to this day. That the military in the United Kingdom, France and the United States have permanently banned research on the production of low-frequency weapons should ring warning bells regarding the potentially fatal consequences of continuing with laboratory research. The Influence of the Infrasound on the Immunological Properties of Rats Blood by S.T. Tuleuhanov, O.S. Desouky and M.A. Mohaseb bpublished in Romanian Journal of Biophysics, Vol. 20. No.3. P245-255, Bucharest, 2010, recommends "caution for people dealing with these low frequencies."

The bigger picture

In conclusion, it is vital that the research proposed above be carried out in a variety of other locales and circumstances where there is demonstrable evidence of human harm due to low-frequency and infrasound emissions. Such locations would include but not be restricted to: coal-fired power stations; mining operations; heavy industrial

manufacturing, transportation and any other source where there is the potential to create adverse health effects as a result of acoustic emissions.

PART II

Inconvenient facts beyond the A-Weighting: The human consequences of inappropriate regulation.

The truth about the A-Weighting - a reprise

The A-Weighting is an archaic concept that grew out of the early studies of human hearing in the first three decades of the 20th century.

Based, as it is, on the 40 Phon curve, it is only a very broad approximation of human hearing that was determined using pure tones and occluded headsets and 23 young adult subjects in the late 1920s.

Biology is never that simple. Each person has unique hearing as a result of their genetics, their physiological hearing apparatus (ear), and their cognitive engine i.e. the human brain, and their state of health.

The A-Weighting severely underreports frequencies below 1,000 Hz and as such is an entirely inappropriate 'yard-stick' to use for determining the emissions from industrial wind turbines whose output is predominantly in the low-frequency and infrasound region.

The fact that the A-Weighting appears in noise standards for industrial wind turbines is a testament to that industry's strong and far-reaching influence.

Infrasound and human hearing: a primer

The concept that humans cannot 'hear' below 20 Hz is a myth. The human hearing apparatus can hear down to single Hz, if the amplitude is high enough.

The human ear ***can*** and ***does respond*** to frequencies down to the low Hz.

Recent research has discovered the pathway by which low-frequencies and infrasound are transmitted to the human brain. This pathway involves the outer hair cells of the cochlea as well as the vestibular (balance) system of the inner ear.

Human conscious awareness does not necessarily interpret very low-frequencies and infrasound as consciously-audible 'tones' (sounds).

Tonality is lost somewhere around 15 to 18 Hz. Thereafter the acoustic energy is perceived as a series of individual pulses as a result of the integration time of the human ear in association with mental processing in the auditory cortex.

Low-frequencies and infrasound do not enter the human body only as 'pure' tones, rather they can also be transferred to the brain as the amplitude modulation frequency of other, higher frequencies.

Beyond noise-induced hearing loss

Much of environmental noise regulation, occupational health and safety regulations are predicated on avoiding noise-induced hearing loss. This includes single loud events such as explosions (mining) or weapons.

The damage caused to the human hearing apparatus body as a result of acoustic energy is not only restricted to high-energy sound high SPLs).

Acoustic energy can also cause other effects including loss of cognitive function, memory loss, inability to focus, annoyance, loss of sleep quality and quantity and cardiac effects.

Loss of sleep can directly cause a plethora of adverse physiological and psychological effects.

Inconvenient facts about sleep loss

Loss of adequate amounts and quality of sleep can directly cause:

- accidents through fatigue or loss of cognitive function, such as focus
- difficulty in learning - insufficient sleep 'dumbs you down'
- increased skin ageing as a result of high cortisol levels in the blood that attack collagen
- loss of libido and sexual function
- reduced production of human growth factor (hormone)

Serious health problems associated with loss of sleep include:

- heart disease
- heart attack, heart failure
- irregular heartbeat
- high blood pressure
- stroke
- diabetes
- directly increased mortality rates as shown by population studies of cardiovascular disease

Abnormal psychological functioning such as:

- depression and anxiety
- impaired judgement, memory and recall
- insomnia
- elevated levels of ghrelin that normally suppress leptins (to regulate satiety) that can stimulate appetite leading to weight gain

Vibroacoustic Disease - 'new' kid on the block

A new disease was identified in 1987 as the result of the autopsy of a deceased aircraft manufacturing worker in Portugal: **Vibroacoustic Disease (VAD)**.

Continuing scientific research over the past 25 years has resulted in a new understanding of how exposure to low-frequency sound and infrasound can adversely affect the human body.

The agent of this disease has been identified as Low-Frequency Noise (**LFN**) otherwise referred to as **LPALF** (**L**arge **P**ressure **A**mplitude **L**ow **F**requency).

Specific LFN effects have already been well defined by[22]:

> **"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."**

LFN has also been shown to result in genotoxicity[23] (via the mechanism of sister chromatid exchange) in both human and animal models.

Elevated levels of annoyance in response to noise may be a sign of previous, excessive LFN exposure.

The emerging field of scientific understanding known as BIOTENSEGRITY provides a new understanding of anatomy and the structure of life and can be used to understand the whole-body response to LFN. Biotensegrity has been under development since the 1970s, building on the previous concept of Tensegrity[24].

The new condition, Vibroacoustic Disease, is well-defined in the literature and a series of diagnostic criteria and methods have been determined:

- Echocardiography to visualise thickened cardiac structures (including the pericardium);
- $P_{0.1}$ (CO_2) index to measure the dramatically reduced respiratory drive, and

[22] Vibroacoustic Disease. Castelo-Branco and M. Alves-Pereira, Noise & HEALTH 2004, 6;23, 3-20

[23] Genotoxicity describes the property of an agent, often a chemical, that damages genetic material in a cell causing mutations that may lead to cancer.

[24] Tensegrity, tensional integrity or floating compression, is a structural principle based on the use of isolated components in compressions inside a net of continuous tension, in such a way that the compressed members (usually bars or struts) do not touch each other and the prestressed tensioned members (usually cables or tendons) delineate the system spatially.

- evoked potentials that disclose important topographical changes and increased latencies in the P3 and N2 components, both indicative of cognitive impairment.

Vibroacoustic Disease has been classified as a multi-stage process that was first clinically observed in 1999[21] after analysing 140 cases of LPALF noise exposure in industry:

Stage 1 - Mild Signs - after 2 years of occupational exposure

Mood swings as noticed by family, friends and co-workers.

Increasing irritability followed by self-imposed isolation.

Memory lapses reported by family, friends and co-workers.

Corroboration by evaluation of medical records revealing non-specific stomach aches, flatulence and colic.

Frequent complaint of oropharynx infections and bronchitis.

Stage II - Moderate Signs - after 5 years of occupational exposure

Chest pain, predominantly the left thorax, resembling pleurodynia.

Behavioural changes become more pronounced.

Frequent complaint that hearing is too sensitive (sic “hearing too much”).

Some signs of hearing loss (in spite of negative Metz[25] test results).

Increased isolation and loss of social contact - often related to hearing deficit.

Overreactive to sound associated with social activities (e.g. dislike of music).

Back pain of undisclosed origin.

[25] The first practical impedance bridge for measurement of the acoustic reflex described by Metz in 1946.

Bone and disk pathology (detected by imaging) in the absence of radiological lesions.

In the absence of an explanatory diagnosis, sufferers are often labelled as '*malingerers*'.

Stage II - Moderate Signs - after 7 years occupational exposure

Sufferers report considerable unexplained fatigue.

Sufferers may begin to exhibit unexplained weight loss or anorexia.

30% of sufferers report an increase in skin infections, simultaneously having both fungal and viral components.

Increased dyspepsia including inflammatory and peptic lesion of the stomach and duodenum (confirmed by radiology or endoscopic examination).

Stage II - Moderate Signs - after 8 years occupational exposure

Increase in urinary complaints including pain, disuria[26], renal colic.

Pain disappears with vacation or rest.

Urinalysis reveals microscopic hematuria[27] in 80% of cases in the absence of other infection including both alcohol and acid-resistant bacilli.

Increased incidence of kidney stones (predominantly calcium with few uric acid salts).

Microscopic hematuria without infection.

Stage II - Moderate Signs - after 9 years occupational exposure

Increase incidence of conjunctivitis, non-responsive to conventional treatment. Some short-term relief from administration of steroids but with frequent relapses.

Symptoms tend to disappear in the absence of occupational exposure to LFN.

Increased skin reactions including rashes, urticaria and allergic rhinitis.

[26] Disurea - painful urination.

[27] Hematuria - presence of blood in the urine.

Stage III - Severe Signs - after 11 years occupational exposure

50% of sufferers require psychiatric counselling following diagnoses of anxiety and depression, some involving suicidal tendencies.

Failed suicides cannot account for their behaviour and are not ashamed of it, showing frequent memory lapses and associated cognitive deficit.

Sufferers often display overt reactions to loud sounds, sometimes reacting violently and aggressively to sudden intense noise.

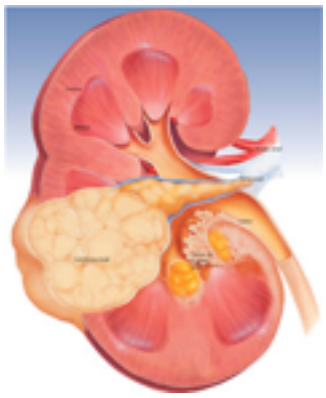


Figure 33: Renal carcinoma

Stage III - Severe Signs - after 12 years occupational exposure

Increased incidence of nasal, digestive and conjunctival mucosal haemorrhages.

Beyond haemorrhagic lesions, vascular pathology with a constitutional component is frequent.

50% of sufferers will develop varicose veins.

Onset of major gastrointestinal pathologies including duodenal ulcers and spastic colitis.

Other pathologies include: esophagitis, esophogeal diverticula, appendicitis, colon diverticula and gall bladder dyskinesia[28].

Stage III - Severe Signs - after 13 years occupational exposure

50% of sufferers report a decrease in visual acuity that is uncorrectable in some cases.

50% of sufferers report difficult to characterise headaches that are frequently resistant to conventional treatment.

Predominantly unilateral osteoarticular pain in the large joints (scapulo-humeral, elbow and knee). Most sufferers present radiological lesions.

[28] Dyskinesia - category of disorders that are characterised by involuntary muscle movement.

Stage III - Severe Signs - after 14 years occupational exposure

50% of sufferers report intense muscular pain many of whom show severe neck stiffness. Large muscle contractions are sustained and very painful.

Neurological changes are noted in approximately 50% of sufferers, the most common being retention of the archaic palmo-mental reflex.

Other neurological problems include facial dyskinesia triggered by auditory stimulation. (Indicative of inhibition of the upper cortical control on the lower pontine centres.)

15% of sufferers develop late-onset epilepsy.

50% of sufferers display balance disturbance ranging from dizziness to vertigo.

Subjects may lose the ability to stand on closing their eyes.

Subjects examined using MRI displayed asymmetry of the brain stem evoked potential that correlated to hyper intensities in the T2 location, deep in the white matter of the basal nucleus.

A small percentage of subjects who experienced sudden episodes of non-convulsive neurological deficit were subsequently diagnosed with cerebral ischemic vascular accidents that are compatible with imaging studies.

Subjects with non-convulsive neurological deficit present with considerable changes in the power of EEG and multi-modal evoked potentials.

Approximately 20% of sufferers have respiratory insufficiency, only half of whom were smokers. Even light physical exercise would produce symptoms. This is indicative of airway flow limitation.

50% of subjects display endocrine disorders the most common being thyroid dysfunction and diabetes. (The rate for diabetes is twice that of the normal population.)

20% of subjects present with malignant tumours with peculiar characteristics.

Death can result from cardiac tamponade[29] from ruptured myocardial infarct.

[29] The accumulation of blood or fluid in the pericardium, the sac surrounding the heart. This prevents the heart ventricles from expanding fully. The excess pressure from the fluid prevents the heart from working properly. As a result, the body does not get enough blood.

One autopsy revealed the existence of two previously unsuspected malignant tumours: a Grade I microsystic astrocytoma and a Grawitz[30] tumour on the left kidney.

Some subjects present with simultaneous tumours of different types, frequently Grawitz. Some subjects presented with malignant gliomata while other subjects had tumours in the colon, rectum, stomach, lung, larynx, soft tissue and bladder.

The mutagenic effect of prolonged exposure to LFN resulted in an increase in sister chromatid exchange[31] as observed in lymphocytes.

Pathologies that may appear at any time in LFN exposure

Echocardiology reveals thickening of cardiac structures including both large and small vessels in 100% of the sample population that have been exposed to LFN in occupational circumstances. No correlation has been found between cardiac thickening and age in these subjects.

Some susceptible individuals show marked thickening after only 2 years of occupational exposure to Large Pressure Amplitude Low Frequency noise (LPALF).

97% of the subjects presented with pericardial thickening with a small number exhibiting thickening of the mitral and aortic valves.

Hearing Loss

One of the unique features of occupational exposure to LPALF noise is that it induces low-frequency hearing loss in the 250 - 400 Hz range. Only 10% of sufferers exhibit losses at 4,000 Hz[32].

Another finding is that the Metz test failed to confirm that the noise intolerance was due to recruitment.

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[30] Renal cell carcinoma (RCC, also known as hypernephroma, renal adenocarcinoma) is a kidney cancer that originates in the lining of the proximal convoluted tubule, a part of the very small tubes in the kidney that transport waste molecules from the blood to the urine. RCC is the most common type of kidney cancer in adults, responsible for approximately 90-95% of cases

[31] The exchange of genetic material between two identical sister chromatids. Usually indicative of mutagenic effects caused by environmental exposure to radiation. Understood to be a very primitive survival mechanism in response to adverse environmental conditions.

[32] High-frequency hearing loss is commonly associated with exposure to occupational noise (Noise-induced Hearing Loss - HIHL). Also associated with aging.

A positive correlation has been found between auditory deficit at 250 Hz and mitral valve thickening, while 500 Hz deficit correlates to aortic wall thickness.

Disabilities resulting from on-the-job accidents

75% of sufferers experienced one accident that required sick leave.

71% of sufferers had more than one accident.

50% of sufferers had more than 3 accidents.

No association was found between frequency of accidents and clinical stage of VAD, although sufferers displayed a greatly increased risk of accidents compared to a control population.

The Senate now has the opportunity to demonstrate Australia's commitment to the science, and in doing so, uphold the health and well-being of its citizens.

The Australian Government's duty of care must extend to those unfortunate, affected people who have had their health compromised through no fault of their own as a result of the imposition of industrial wind farms built too close to their homes.

Before VAD

Although much of the knowledge regarding the clinical stages of VAD, the diagnostic criteria and investigation methodologies are the result of intense research in Portugal since the 1980s, the same symptoms have been observed in a large number of different occupations going back decades. Significant examples include the aircraft industry in America and concrete factory workers in the Soviet Union. Since then, many other industrial manufacturing facilities have experienced the same symptomology in relation to LPALF.

Common to all these observations is the presentation of respiratory function deficit and changes to the vegetative nervous system. Other pathologies include hypoacusis, neurodynamic and neurocircuitry changes, cardiovascular and central nervous system disorders. Common findings include death in industrial plant workers due to acute respiratory failure and cardiovascular pathology.

Workers in LPALF environments frequently report chest wall vibration, gagging sensation, coughing, choking and respiratory difficulty after as little as 20 minutes of exposure.

It is sobering to realise that many of the symptoms, such as pulmonary haemorrhages, have also been found in animal studies. Morphofunctional changes in the myocardium and problems due to blood flow and widening of capillaries have commonly been observed also.

Where is the science?

Due to the relative newness of the pathology of VAD, and a reluctance to investigate the disease as it is not seen as a high priority, the much-needed large-scale epidemiological studies have not been undertaken. The skeptical may also conclude that such research may be considered financially problematic for industry and that may explain the significant absence of grants for research.

There is an urgent need for more case-control studies of individuals occupationally exposed to LPALF noise.

As a direct result of the lack of support and funding for research, VAD is not yet widely acknowledged as a pathological entity, despite the clear evidence that has been collected over the past 27 years. While VAD may be the 'thick end of the wedge' as far as adverse health effects as a result of exposure to LPALF noise, it is useful in that it defines what can happen at the extreme end of such exposure to low-frequency, acoustic energy.

The 'thin end of the wedge' may well relate to wind farm emissions. The enormous amount of evidence that is being accumulated, world-wide, points to real biological effects that urgently need to be researched. In the absence of that research initiative, the wind industry's continual insistence that 'there is no problem' or that there is 'no direct effect' can only be described as 'hiding one's head in the sand'. All such displacement activity has proved to be disastrous in the cold light of history. It took over 100 years before smoking was finally acknowledged as a health hazard, somewhat less for asbestos. How long must we wait for the inevitable realisation that adverse health outcomes are associated with exposure to low-frequency and infrasound energy, including that from sources such as industrial wind turbines.?

This Author contends that to maintain the *status quo* is unsustainable, egregiously unethical and downright obscene.

The time for the precautionary principal is right now.

The time for a major review of planning decisions in respect of wind farm placement is right now.

The time for serious research is right now.

The time for honesty on the part of the wind industry is right now. Prolonging the lie will only increase the severity of the final outcomes, including moral, ethical, public credibility and financial aspects.

Denouement

Science is an evolutionary discipline. It is not a democracy where the most votes win. Rather it is a system of logical, rational investigation that is predicated on empirical observation, hypothesis generation, testing and analysis. Science provides us with an ever changing understanding of the world around us. Every observation or experiment adds to this understanding. Accordingly, as our observations increase, so does our knowledge about the world. **Science is the search for 'Truth'**. No one knows the limits to knowledge and what can or cannot be known.

Science is a journey - not a destination.

The adverse biological effects of large, industrial-scale wind turbines have been known for at least the past 30 years. The early work with downwind turbines revealed adverse biological effects, resulting in a change in turbine design - to upwind blades. While this reduced some of the emissions, it did not, unfortunately, totally eliminate all of them.

The international oil crisis of the 1970s has given much impetus to the development of energy generation systems that do not rely on fossil fuels. As a result, wind farms have been fast-tracked in many countries - most often involving heavy government subsidies. As a result, little attention has been paid to the resulting adverse effects on the human population. This approach is neither responsible nor reasonable.

As science relies upon empirical evidence, it is vital that the reported adverse reactions to wind turbines are thoroughly investigated before more harm is facilitated. That the wind industry has initially denied the possibility of low-frequency and infrasound emissions, let alone harm from them, only to deride those honestly reporting such effects is simply unjust, unethical and unacceptable in today's world. That the wind industry buys out property owners and insists on gagging clauses in the contracts is *prima face* evidence that there is a real problem and that they do not want to acknowledge or deal with it.

The wind industry continues to mount an ever-increasing attack on those who are so affected by wind farms that they are forced to speak out in order to maintain their health. By bringing in paid 'experts' to support their case, the wind industry is simply providing

more evidence of their egregious, unethical behaviour. By utilising, as mouthpieces, such organisations as the Australian Medical Association to press their claim, they simply display the depths to which they will stoop in order to preserve their commercial bottom line. This practice is totally unethical and demeans the practice of medicine. Further, this action damns both parties and destroys public confidence.

Science does not progress by sweeping evidence under the rug. Knowledge can only flourish in a system which is free from bias and commercial agendas. Problematic observations need to be fully investigated without the shackles of commercial gain at the expense of public health. That so many residents, world-wide, report the same range of effects is indicative of a real phenomenon. The world did not progress by simply choosing to ignore radioactive emissions from ore samples. Rather, the tragic death of scientists was simply more grist to the mill for expending greater efforts to understand the phenomenon. Such painful research has resulted in us being able to use radioactivity not only safely, but to the advantage of humanity (for example, in cancer treatment).

What is needed now is total transparency on the part of the wind industry advocates and a genuine desire to find the answer to the puzzling questions that we now face. Ignoring the symptoms is no guarantee to avoid a train wreck. Ask any medical doctor. To ignore symptoms can be, and is frequently, met with fatal outcome. The medical fraternity are forever urging the public to seek medical advise at the earliest possible opportunity so that an appropriate diagnosis can be made in time before premature death is the only possible outcome. So why does the wind turbine industry work so hard to bury the evidence? Why is there social pressure on those adversely-affected by wind turbines not to seek medical help. Why are such genuine complainants ridiculed by the wind industry? Why are the subjected to gagging clauses?

As a society, we can no longer ignore the adverse health effects of large, industrial-scale wind turbines, in the hope that the complainants will simply shift away, give up or shut up. The number of complainants at this time is simply the tip of the iceberg. Simple, unbiased empirical observations tell us that there is something serious to address here. By not cooperating with the scientific community in an open manner, the wind industry is deliberately acting against the best principles of science - to the detriment of humanity. Research must be undertaken so that this whole debate can move forward on more solid ground. The landmark work of Steven Cooper is certainly a good place to start. The wealth of new information from Professor Salt and his team at Washington University, School of Medicine St. Louis, Missouri, is heading in the right direction and more research should be facilitated with all due speed.

The world can no longer afford the luxury of the Green Dream, particularly when it is actually causing real, demonstrable harm to people (and animals). To deny the obvious,

ridicule those who honestly report adverse effects, then ultimately seek to gag them is an egregious crime. One that will no doubt go down in the history books for our grand children to read about and learn from. Shooting the messenger is never a good idea. Further Green-Washing[33] is also inappropriate.

There is no more time. The harm is happening now: every day. It is time for those in authority to take control of this situation, reign in the corporate greed and facilitate serious, independent, scientific research so that we might be able to utilise this technology while minimising the harm to people.

The wind industry must become partners in this research, not antagonists. They must cooperate without obstruction. It is in their own best interests to know the truth. If only the West German pharmaceutical company, Chemie Grünenthal, had known back in 1957 about the terrible side effects of their drug, Thalidomide, this Author is sure they would have acted differently.

There are many more examples and the very process of science in not without collateral damage. But when you have an enormous amount of evidence pointing to serious harm, it is insane to try to whitewash (or greenwash) the truth in order to maximise profits through corporate greed, citing a Green argument in mitigation. **This commercial rape of humanity by large corporations must stop or else we will all have lost our last shred of human decency.**

Senators, the ball is in your court . . . .

[33] "Greenwashing" describes the actions of a company or organization that spends more time and money claiming to be "green" through advertising and marketing than actually implementing business practices that minimize environmental impact.