**Submission to Federal Senate inquiry into the 'Social and economic impact of rural wind farms'.**

**Professor Peter Seligman, PhD, DEng.**

**My credentials**

I am a biomedical and acoustic engineer with a PhD from the Department of Electrical Engineering at Monash University. My thesis topic was “Auditory Pattern Transmission”. Before my recent retirement I worked for 30 years firstly in the Department of Otolaryngology at the University of Melbourne and then for Cochlear Ltd, manufacturer of the Australian Bionic Ear. I was a member of the original team that developed the Australian Cochlear Implant with responsibility for speech processing and human perception of sound. At Cochlear I directed the development of seven generations of sound processor for the Cochlear Implant.

**Summary of the problem**

It is held by some that wind farms are detrimental to the health of those living in the vicinity. In some cases this includes people living as far away 5 km of the wind farm. These problems have been mostly attributed to infrasound, i.e. very low frequency sound which is inaudible. It is pointed out that UV light is invisible but can nevertheless damage people and this is analogous. However UV light at low intensity is not dangerous. It is a question of the level of exposure.

**Attempts to resolve the issue**

A number of studies have been conducted in which infrasound levels have been measured at various distances from wind farms. These levels have been compared with background noise levels due to both natural (eg ocean) and man-made sources. A summary is provided in Fig. 13 of http://www.pacifichydro.com.au/media/192017/infrasound_report.pdf

In that document, it can be seen that beyond 360 metres, the level of infrasound between 1 and 20 Hz is below the ambient levels near a beach and below that in the CBD of a city.

**The arguments for and against damage or annoyance at a distance**

It has been argued that infrasound does not propagate and attenuate with distance in the same way that normal sound does. This was not borne out in Fig 7 of the above document, which shows that infrasound does indeed attenuate at 6 dB per doubling of distance. At 5 km (4 doublings), a distance at which it is claimed infrasound is still problematic (Dr. Michael Nissenbaum), the level would be some 24 dB below background level, undetectable by man or machine.

It is exactly this claim of adverse effects at 5 km which detracts from the argument. If ill effects are being claimed at that distance one might assume that the problem is a nocebo (opposite of placebo) effect rather than physical.

Aside from the issue of an adverse response to something which cannot be measured, it is worth noting that apart from external sources, the hearing and vestibular systems are subjected to very high levels of body generated noise. These include, walking, breathing, heartbeat, chewing and head movement. Body noises generated in this way were a problem in the Cochlear Ltd project to develop a fully implantable cochlear implant. In this case the microphone was implanted subcutaneously

behind the ear. The level of infrasound picked up from the body by this microphone was a major problem and far exceeded all infrasound from external sources. In fact it was some ten times greater.

So it is being held that levels that cannot be measured and cannot be heard, are problematic. In contrast, everybody is subjected to far higher internally self-generated natural infrasound levels which clearly, are not a problem

Another argument that has been put up (Dr Alec Salt) is that infrasound stimulates the outer hair cells of the cochlea. These cells are said to be inhibitory and thus do not create any perceivable sensation. It is held that because wind turbine infrasound is air-borne rather than conducted through the body, it has different effects on the auditory system and also the vestibular system. The explanation given is that these systems have not evolved to deal with air-borne noise. Even if that is the case, the former point stands; that beyond a few hundred metres, airborne infrasound is below the level of natural and other man-made noise.

It is also claimed that the body picks up airborne infrasound, amplifies it and transmits it to the auditory and vestibular systems. The "Wind turbine syndrome, Report for clinicians" p77 by Piermont quoting Hedge 2007 states that "Vibrations between 4 and 6 Hz set up resonances in the trunk with amplification up to 200%" This may sound significant but in the normal units of sound measurement, it is 6dB, equivalent to halving the distance from the source. The much greater loss in transmission from the air to the thoraco-abdominal system is not mentioned. If the sound from wind farms is transmitted in this way, so is sound from the numerous other sources of infrasound.

The sound of wind farms has been reported some kilometres away from the site. This could occur occasionally through atmospheric effects as detailed in a report by Terrock Pty Ltd http://terrock.com.au/vibration/blasting.html - see appendix. My personal experience relates to a tram line. We live some 2 km from a tram line and although normally we cannot hear trams, on odd occasions, presumably through such an effect, a tram can clearly, although not loudly, be heard. If I were passionately against trams, I might consider this to be intrusive although it may only occur very occasionally.

The other reports in the submissions relate to feeling vibrations at a distance. Submission #1 by Helen White, states "I went to Blaney to look at their wind farm and I was 2 Kms at least from the farm and the vibrations shook the car and this is a small farm and quite a long way from a town."

In attempting to determine whether this was possible and if so what the mechanism might be, I contacted the school of earth sciences at the University of Melbourne. There are two relevant studies, i.e. reporting seismically detectable responses at 1.7 HZ up to 11 km for the Italian case (a 4 x 2Mw farm) . See
http://www.earth-prints.org/bitstream/2122/6754/1/PP_BSSA_Saccorotti_etal_2010.pdf
also a Guralp report on a Scottish study
http://www.guralp.com/articles/20060316-casestudy-windfarm/support

Although in both studies, vibration is detectable by sensitive instruments at distances over 10 km, the Italian experiment involves detecting gravitation waves and the other study relates to seismic

measuring stations. It must be noted that these are special installations which are hypersensitive to vibrations at levels far lower than would normally be measured or perceived.

Fig. 5 in the Saccorroti report shows that the ground is moving at about 0.05 mm/s directly under the turbine. Both on and off conditions are recorded. The Terrock Pty Ltd report referred to earlier on annoyance through blasting, states that vibration is perceptible at between 0.2 mm/s and 0.5 mm/s. This is a factor of 10 greater than directly under a turbine. The American National Standards Institution (ANSI) S3.18-1979 standard for a Critical Structure (eg. hospital): is 0.05 mm/s.
So even directly under a turbine, the standard would be met for a hospital.

The Terrock Pty Ltd report, which is primarily concerned with blasting, also makes the statement "Air vibration also attenuates with distance. The ground vibration attenuates to below perception levels faster than air vibration so, at distances further than about one kilometre from the blast, people may only be aware of the air vibration". Thus the sound could be perceived as vibration.

From the engineering and physiological perspectives, there is no mechanism for consistent adverse effects of noise from wind farms beyond the distance at which the noise falls below background levels. This is typically a few hundred metres for modern equipment. However it is accepted that under some atmospheric conditions, wind farms are audible at a distance. Salt states that his study "*raises the POSSIBILTY that the dislike / disturbance of individuals by wind turbine noise may be related to the long-term stimulation of the outer hair cells with infrasound*." However the atmospheric effect mentioned above is exceptional and not long-term. Apart from that, as is often mentioned by the critics of wind farms, the wind doesn't blow all the time.

In conclusion, it is not doubted that under some conditions wind farms can be heard at a distance. It is unlikely that any vibration can be felt at a distance. As far as infrasound is concerned, the body is naturally exposed to high levels from internally generated sources.

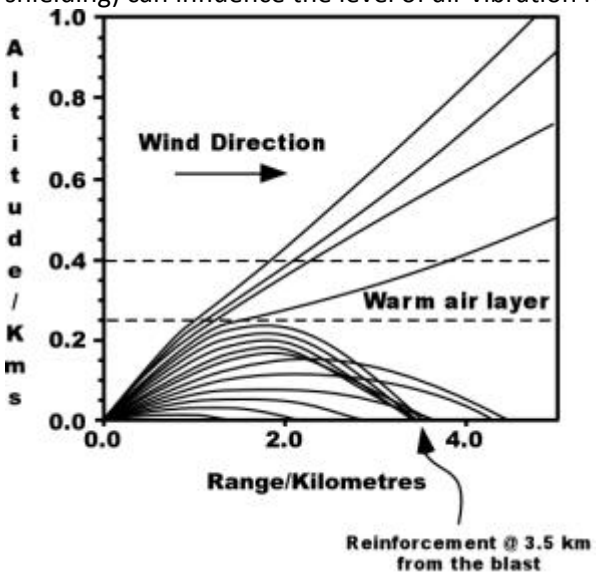
Finally, for those who are violently opposed to wind farms any sign, visual or auditory may be sickening. As one of the submissions stated "made me nauseous and feeling very anxious, when I looked at them."

Professor Peter Seligman
Associate, Melbourne Energy Research Institute
Also consultant at the Bionic Ear Institute

**Appendix**

**Meteorological Effects**

Atmospheric conditions (meteorological reinforcement) and the degree of shielding (topographical shielding) can influence the level of air vibration resulting in the area surrounding a blast.




Atmospheric conditions can, on occasions, concentrate or focus air vibration in certain directions and distances from the blast. Weather conditions that include an 'inversion' or a layer of warm air between colder air layers, such as exists on smog pollution days, can cause an increase of up to 10 or more decibels at distances from 2-5 km from the blast. The reinforcing mechanism is demonstrated on the left.

Similar effects may be caused by increasing wind speed with altitude, especially when accompanied with a change of wind direction or wind shear. For meteorology to have a significant influence on air vibration levels, the inversion layer or wind shear must be at levels less than about 200-250 metres above the blast. The prediction of meteorological conditions requires accurate local data that is generally not freely available for use. The practical effect of meteorological reinforcement is that, on occasions, blasts may be noticed in locations distant from the operation where they are normally imperceptible. Elevated airblast levels due to meteorology are usually below regulatory limits because at the distance from the blast at which they characteristically occur (>2 km), the basic emission levels are low following natural attenuation.