Senate Inquiry Submission – *The Social and Economic Impact of Rural Wind Farms*

"Experience with Wind Farm Noise"

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Background

I have had 10 years experience working on over 20 wind farm development projects as a noise specialist (principal acoustic consultant/adviser). This has involved performing and reviewing technical acoustic studies for proposed wind farms, including noise measurements (before and after wind farm installation), noise predictions, and noise impact and compliance assessments.

I have been a Member of the *Australian Acoustical Society* (AAS) since 1997 and represent the AAS on the Standards Australia EV/16 *Committee for Wind Turbine Noise* (which developed AS 4959-2010 on Wind Turbine Noise) and EV/10 *Committee for Community Noise*. I am Australia's representative on the International Standards Organisation working group ISO/TC43/WG40 *Impulsive Environmental Noise*. I was on the expert panel that assisted in the development of the SA EPA *Wind Farm Noise Guidelines* (Environment Protection Authority, SA Government).

Discussion

In general, based on my extensive involvement with a wide range of wind farm projects across Australia, noise emission from wind turbines does not generate a significant impact to residences in rural locations. Wind farms throughout Australia are designed and developed in accordance with the methodologies and criteria given in AS 4959, NZS 6808 and/or the SA EPA Wind Farm Noise Guidelines. These standards and guidelines are among the most stringent in the world, and if followed correctly provide confidence in ensuring minimal noise impact to nearby residences.

From our studies/experience and current literature from around the world, the noise generated by wind turbine generators (WTGs) and wind farms (WFs) is predominantly and typically broadband in nature, and is generally dominated by a relatively uniform spread of mid-range frequencies. At some distance away (greater than about 500m and varies with wind conditions), this can sound like white noise that is not dissimilar to the distant sound of wind in the trees or flowing water.

In the near vicinity of a WTG, there is a slight amplitude modulation (ie. "swish") detectable due to the turbine blades cutting through the air (and the effects of associated inflow or aerodynamic turbulence), and this is a natural feature of a correctly functioning WTG (Ref: *Pederson & Waye 2005, Oerlemans & Schepers 2009*). The gearbox, generator and associated cooling fans can generate noise that may be detectable in the vicinity of a WTG (typically up to about 100 to 300m away). Note that both of these typically near-field features rapidly dissipate with distance and are generally not easily detectable or noticeable in the far field beyond about 1km.

The spectrum of noise generated by a typical WTG or WF is dominated by a smooth envelope from about 200 Hz to about 2000 Hz, with the peak of the spectrum around 500 to 600 Hz. At a distance of about 1km, the higher frequencies of the spectrum are preferentially absorbed due to atmospheric absorption. The overall A-weighted noise level (L_{Aeq}) at a receiver located 1km from a large WF will typically be around 35 to 40 dB(A), but will depend on the WTG type, number of nearby WTGs, wind speed and direction, intervening topography etc. However, note that ambient natural sounds, such as wind-induced noise in trees, generated in windy conditions often provide masking noise at a similar level. Predictions of noise performed by acoustic consultants during initial wind farm proposal phases are typically conservative (ie. over-predict) when compared with post-installation noise measurements of the fully operational wind farm.

The propagation of noise from a wind farm is dependent on a range of factors, which can vary with time and from site to site. As noise propagates away from the wind farm site, the noise level will reduce as a function of distance, air absorption, ground absorption, intervening terrain topography and meteorological conditions. Under some circumstances, such as downwind conditions (wind blowing from the wind farm towards the receiver) and stable atmospheric conditions (and associated wind shear), the noise level can increase relative to average/neutral conditions (due to downwards refraction of sound waves). Temperature inversions can also cause "acoustic focussing" down range, but given that temperature inversions typically occur in low wind conditions (< 2 m/s) this is when turbines are not operating (ie. below cut-in speed).

Recent research (Ref: *van den Bergh 2003/2008, Fowler 2005*) does suggest that Ssome sites may show variations in the vertical wind profile or wind shear between day and night (eg. due to greater atmospheric stability at night compared to day). Stable conditions and large wind shear at night can cause a quieter background wind-induced noise environment at the receiver, while higher wind speeds at turbine hub height causes higher than expected noise levels to be generated. To take this effect into account, hub height wind speed data is now used in the assessment process and consideration given to separate day/night assessments if required.

Features or characteristics in the noise from different types of noise sources, such as Special Audible Characteristics, can cause annoyance to some people. Potential types of Special Audible Characteristics (SACs) include Low Frequency Noise (LFN), Infrasound, Modulation, Impulsiveness and Tonality. From all of the available literature and studies from around the world, SACs from WTGs or WFs are an uncommon and unlikely occurrence, and there are limited confirmed reports in the literature. In addition, there have not been significant SAC incidents recorded to date with measured acoustic data at a receiver location in Australia, apart from some unverified anecdotal evidence. [Ref: *ETSU/DTI 1996, DEFRA 2003/2004, BWEA 2005, HayesMckenzie/DTI 2006, UnivSalford/DEFRA 2007, Leventhall 2003/2006, Bellhouse 2004, Styles et al 2005, Jakobsen 2005, Pederson & Waye 2005, Teague & Foster 2006, Rogers 2006, Moorhouse et al 2007, van den Bergh 2008, Sonus 2010, Draft National Wind Farm Development Guidelines 2010].*

There is not much confirmed/published data available on SACs from WFs, and given that SACs do not occur frequently or for long periods from WFs they are unlikely to be a significant issue. For example, from over 130 operating wind farms in the UK, only 4 have had complaints regarding SACs and all have been resolved (Ref: *HayesMckenzie/DTI 2006, Moorhouse et al 2007*). Also, it needs to be stressed that unqualified media reports or unverified anecdotal or subjective comments often misrepresent the likely or true nature of the noise situation.

Modern wind turbines do not generate significant amounts of Low Frequency Noise (LFN) below 100 Hz. Over substantial distances atmospheric absorption preferentially absorbs the mid to high frequencies and leaves behind more of the lower frequency content. Infrasound from WTGs (inaudible range < 20 Hz) is most unlikely to occur at levels that are detectable by humans, from the evidence in the literature. Note that infrasound is naturally occurring in the environment, due to wind noise, coastal waves, storms, ground vibrations etc. Infrasound was a feature of some older downwind turbines over 20 years ago (and some people still erroneously refer to these outdated and/or unverified internet references as though they are still currently applicable). Measured levels of infrasound at distance from modern WFs are well below (typically 20 to 30 dB or more below) the most sensitive human threshold of hearing/audibility or perception. In addition, from the peer-reviewed literature to date, there is no evidence of health effects arising from LFN or infrasound from wind farms. [Ref: *Leventhall 2003/2006, Bellhouse 2004, Pederson & Waye 2005, Jakobsen 2005, BWEA 2005, HayesMckenzie/DTI 2006, Howe 2006, Rogers 2006, UnivSalford/DEFRA 2007, Moorhouse et al 2007, Sonus 2010, Draft National Wind Farm Development Guidelines 2010*].

Amplitude modulation (AM) is the modulation or cyclic variation (over blade pass cycles of once per second or so) in the amplitude or level of the broadband aerodynamic noise from the turbine blades. Note that this is not technically classified as low frequency noise or infrasound or impulsiveness. AM is a naturally occurring part of turbine noise (usually at low levels, ie. swish) but can be increased at times producing a greater noise level variation every second or so. However, AM dissipates with distance, seems to occur rarely, requires the alignment of a number of causal factors simultaneously and there have not been many recorded or verified incidents of AM at distance from wind farms. [Ref: *Leventhall/DEFRA 2003, DEFRA 2004, Bellhouse 2004, BWEA 2005, Pederson & Waye 2005, HayesMckenzie/DTI 2006, UnivSalford/DEFRA 2007, Leventhall 2006, Moorhouse et al 2007, van den Bergh 2008, Oerlemans & Schepers 2009].*