DEVELOPMENT OF THE DRAFT NSW PLANNING GUIDELINES: WIND FARMS

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INTRODUCTION

On 23 December 2011 the NSW Department of Planning and Infrastructure released its *Draft NSW Planning Guidelines: Wind Farms* (the *Draft*) [1] for public consultation. The period for consultation was until 14 March 2012, which had not been reached at the time of writing this Technical Note. As you would be aware in this special edition of Acoustics Australia, there has been some reference to these guidelines. Given the deadline for this edition of Acoustics Australia predates the end of consultation period it is not possible at this time to discuss the issues raised, however at the time of writing there had been approximately 400 submissions.

The intent of this Technical Note is therefore to elaborate in more detail the science and thinking behind the development of the *Draft*. Those readers with a working knowledge of the current standards and guidelines used in Australia will recognise that the *Draft* adopts aspects of the methodologies and practices presented in the 2009 South Australian document *Wind farms - environmental noise guidelines* [2] and Australian Standard AS4959 – 2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* [3]. This document also draws on experience gained in the assessment and operation of wind farms in NSW and from community input. As a result it is believed that the process undertaken in developing the *Draft* will achieve the objective of developing a final document that meets the needs and expectations of both industry and community.

FRAMEWORK OF DRAFT GUIDELINE

The noise component of the *Draft* is based upon 6 fundamentals listed below. The reasoning and science underpinning these proposed fundamentals is discussed in some detail however it needs to be remembered that the status of these guidelines is still draft, and any final document may be subject to change.

Identification of monitoring locations

Site selection is important, particularly as these sites may be revisited for compliance over the life of the wind farm. Whilst this should be a basic consideration for an acoustician, the draft gives some guidance on positioning, particularly in relation to trees. It is generally considered that extraneous noise from foliage is not a significant problem for low scrubs and bushes, however tall trees such as eucalypts and poplar trees which seem to be common in high wind areas can cause difficulties in collection valid noise data. Whilst monitoring procedures for other environmental noise exclude periods of higher wind, this is not the case for wind farm measurements. The *Draft* therefore allows for monitoring locations to be moved away from existing or proposed trees to a position between the trees (and residence) and the wind turbine providing the noise exposure is approximately the same.

In the knowledge that it can be extremely difficult to separate wind turbine noise from the ambient when at large distances, the *Draft* allows for supporting noise data to be collected at intermediate locations where the signal-to-noise ratio is much higher. This concept is not new and has previously been accepted in similar situations in the NSW Industrial Noise Policy (INP) [4]. The *Draft* however describes in more detail how the practice can be used to supplement data collected at the sensitive receiver and can also be used to confirm compliance. It is suggested that these intermediate locations be used to confirm the presence or otherwise of any specific audible characteristics which are more easily identified in closer proximity to the turbines where the improved signal-to-noise ratio assists the data analysis.

Establishment of background noise levels

In recognition that wind farm noise will be substantially masked as wind levels at the receiver increase, the *Draft* adopts the use of regression analysis to establish the median levels at each integer hub height wind speed from cut in speed (generally around 4 m/s) to the rated power (generally around 11 m/s). Similar to the SA 2009 Guideline, the *Draft* recommends 2000 valid data points, with 500 of those to be from the most adverse wind direction. Where the adverse wind direction is one that does not occur commonly, then data from a minimum of 6 weeks of monitoring is deemed to be sufficient.

The regression line approach used to determine the background level is considered both valid and appropriate, particularly given that the threshold noise criteria are established independent of the existing background noise levels.

Development of noise criteria

When developing noise criteria, there are two aspects that need to be considered:

- What is the level of noise acceptance that is considered appropriate for the area? and;
- What is the noise amenity that one is trying to establish for the area?

In response to the first aspect, it is a general NSW objective to set where possible noise goals that will ensure at least 90% of the population are protected from being highly annoyed for

Percentages of highly annoyed

L_{den}	Road	Rail	Aircraft (revised estimate)	Industry	Windturbine
55 dB	6 %	4 %	27 %	5 %	26 %
50 dB	4 %	2 %	18 %	3 %	13 %
45 dB	1 %	0 %	12 %	1 %	6 %

Figure 1. Comparison of L_{den} values for different sources with respect to annoyance [5]

at least 90% of the time [4]. To establish the noise levels at which these impacts may be expected, reference was made to dose/response studies. In particular, the studies presented in the following three figures were used to gain a perspective of annoyance levels. Note: the noise levels in all figures are measured or predicted outside of the residence.

Acknowledging that an L_{den} noise metric incorporates an evening and night time penalty into this single noise descriptor, Table 1 shows the approximate dose response compared to a L_{eq} using a 6.4 dB reduction from the L_{den} for a constant noise source and extrapolation from the source studies. From data contained in Table 1 it can be shown that 90% of the population can be expected not to be very or highly annoyed at 40 dB(A). In examining the second aspect of noise criteria development, reference is made to the amenity noise goals established in the INP [4] for various land use classifications. From Table 2 it can be seen that 40 dB(A) is an accepted night time noise level for a rural area.

It can therefore be concluded that both contemporary dose/response relationships and acceptable amenity noise goals identify a level of 40 dB(A) as meeting NSW noise objectives for protection of the community and maintaining the amenity of a rural area. Notwithstanding, it was determined that the threshold criteria set in the *Draft* should be discounted by 5 dB to a level of 35 dB(A) to allow for any other industrial noise sources and to ensure that NSW objectives were easily met.

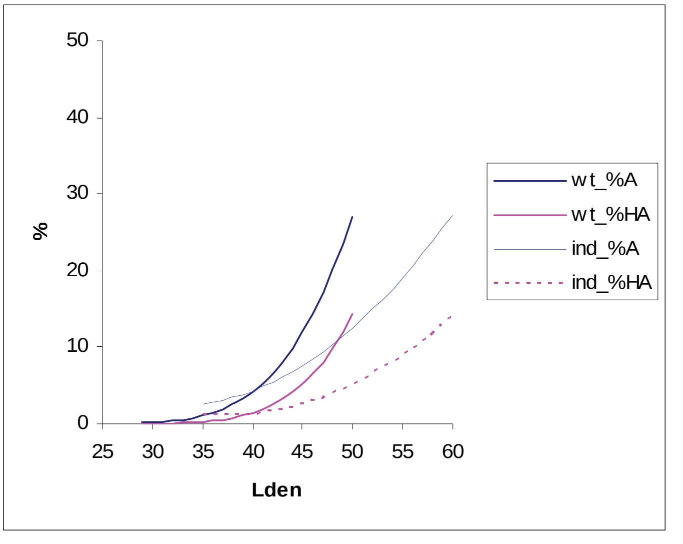

Figure 2. Comparison of the percentage (highly) annoyed persons indoors (%A indoors and %HA indoors) due to wind turbine noise (wt) and industrial noise (ind) [6]

Response outdoors	Sound pressure levels, dBA					
	<30	30-35	35-40	40-45	>45	Total
Do not notice	124 (75%)	92 (46%)	30 (21%)	7 (12%)	2 (10%)	255 (44%)
Notice, but not annoyed	34 (21%)	71 (36%)	52 (37%)	22 (37%)	5 (24%)	184 (31%)
Slightly annoyed	4 (2%)	20 (10%)	30 (21%)	16 (27%)	8 (38%)	78 (13%)
Rather annoyed	2 (1%)	13 (7%)	19 (14%)	4 (7%)	3 (14%)	41 (7%)
Very annoyed	2 (1%)	3 (2%)	9 (6%)	11 (18%)	3 (14%)	28 (5%)
Total	166 (100%)	199 (100%)	140 (100%)	60 (100%)	21 (100%)	586 (100%)

Figure 3. Response to wind turbine sound outdoors in relation to 5 dB(A) intervals of sound levels (all respondents) [7]

Table 1. Summary of dose / response studies

Study	**% Very or Highly Annoyed**				
	30 dB(A)	**35 dB(A)**	**40 dB(A)**	**45 dB(A)**	**50 dB(A)**
EEA	0	4	10	20	35
Janssen	0	3	10	20	-
Wind Perception	1	3	9	12	-

Table 2. NSW Amenity Noise Criteria [4]

Noise Amenity Area	Time of Day	Recommended L_{Aeq}. Noise Level dB(A)	
		Acceptable	Recommended Maximum
Rural	Day	50	55
	Evening	45	50
	Night	40	45
Suburban	Day	55	60
	Evening	45	50
	Night	40	45
Urban	Day	60	65
	Evening	50	55
	Night	45	50

Setting of penalties for excessive levels of specific noise characteristics

As with all types of natural and anthropogenic noise, there are identifiable levels of tonality, low frequency and modulation, NSW noise criteria are developed inclusive of a certain level of these characteristics. The objective of the *Draft* is therefore not to completely eliminate these characteristics, but to ensure that excessive levels are managed. The basis for establishing what would be considered 'excessive' levels of specific audible characteristics is given below.

Tonality

The proposed method for identifying excessive tonality is the same as that used in the INP [4] and is based on 1/3rd octave band analysis. Whilst not considered a perfect measure of tonality, a review of methods used by other States has not revealed a better indicator. The method in the INP has been established since 2000 and few, if any issues have been raised with its implementation.

To overcome difficulties with measuring 1/3rd octave bands at large distances where the signal may be compromised by local extraneous noise, the *Draft* allows for levels of tonality to be established at intermediate location points. This is based on the rational that any tonal impacts will not be enhanced at greater distances.

Amplitude modulation

The aerodynamic noise from a wind turbine's blades is sometimes referred to as 'swish' [8] or 'thump' and can be explained by the amplitude modulation of the wind turbine noise level. The modulation is generally distinct at short distances from the wind turbine generator (WTG) and may not be audible at a greater distance [9].

Whilst there has been some investigation of a modulated noise signal, there have been few recommendations on how to objectively evaluate or set management levels. Based on advice given by van den Berg (and agreed by Tonin) at the Land and Environment Court hearings into Taralga wind farm [10], the *Draft* has proposed that an excessive level will be identified as when a variation of greater than 4 dB(A) exists. It is however recognised that this is an area where contemporary studies are likely to inform future procedures for assessing and managing amplitude modulation.

Low frequency

Much has been raised regarding the level and impact of low frequency noise particularly that of infrasound (< 20 Hz). When considering the potential of wind farms to cause low frequency noise impacts, there are three important aspects that must be considered.

1. The sound power level of a turbine is only around 105 dB(A)
2. At distances of around 1km the frequencies below about 100 Hz will be inaudible [11]
3. Low frequencies are extremely difficult to measure, particularly outdoors and even more so in the presence of even small levels of wind.

An examination of detailed work by Møller and Pedersen [12] shows that wind turbines have a very similar spectral signature, regardless of the turbine capacity. When normalised, the signature band becomes even narrower and supports the work of Jakobsen [13] and Colby et al. [14] in stating definitively that wind turbines do not generate excessive levels of low frequency noise. Furthermore, the graphs show that the relationship between the lower frequencies, including the infrasound band, are such that controlling a higher frequency or range of frequencies will have the effect of controlling the lower end of the noise spectra.

When compared to the UK Department of Environment Food and Rural Affairs (DEFRA) acceptability curves [15] in Figure 7 it can be seen that most wind turbines are well below the acceptable levels for all low frequency noise, particularly below 31.5 Hz, when the outside noise is kept to around 35 dB(A).

It is therefore considered unnecessary to establish the full spectral signature of all wind turbines, but rather to rely on triggers to identify any anomalies such as a mechanical problem. To achieve this, the *Draft* recommends the use of dB(C) measurements at intermediate locations to identify a need for any further investigation. Trigger levels of 65/60 dB(C) as suggested by Broner [16] have been adopted.

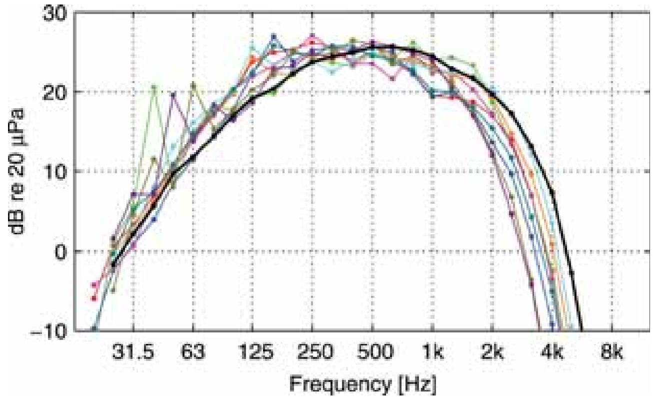

Figure 4. A-weighted sound pressure levels in 1/3rd octave bands at distances, where the total A-weighted sound pressure level is 35 dB. 2.3 – 3.6 MW turbines [12]

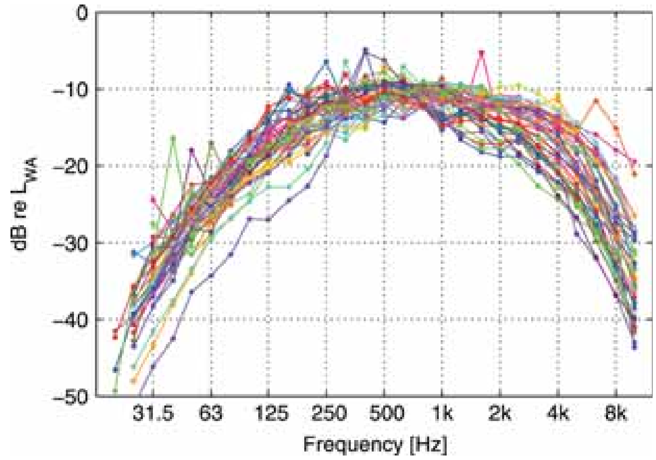

Figure 6. Normalized A-weighted apparent sound power levels in 1/3rd octave bands. 45 turbines with nominal electric power 75 kW–3.6 MW [12]

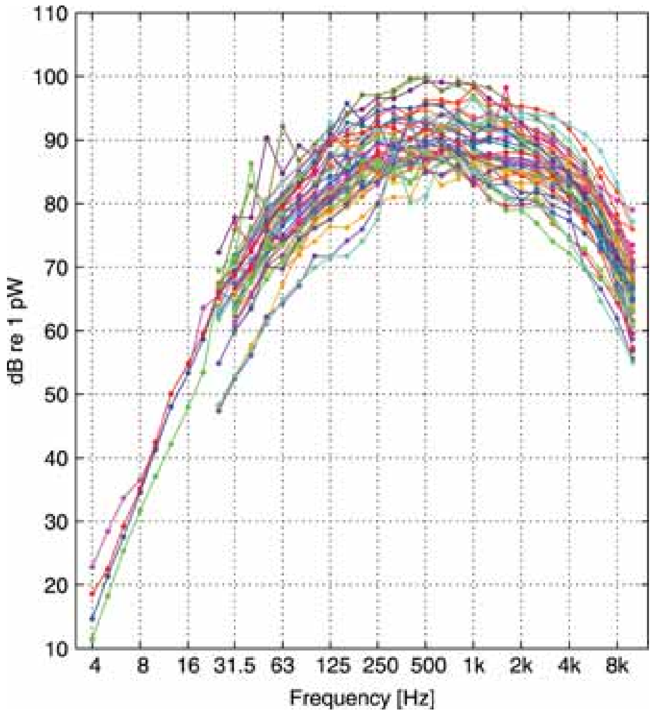

Figure 5. A-weighted apparent sound power levels in one-third-octave bands. 45 turbines with nominal electric power 75 kW–3.6 MW [12]

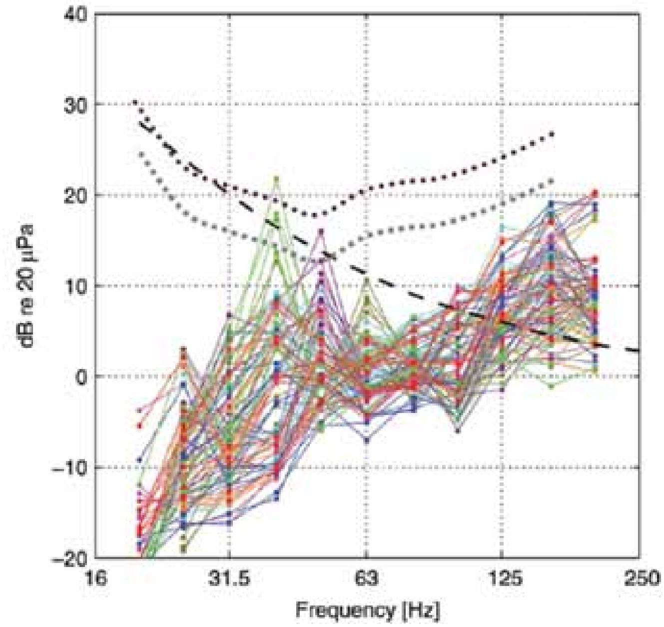

Figure 7. Indoor SPL in dB(A) where the total outdoor SPL is 35 dB(A). Adapted from [12]
ISO 389-7 (audibility) [11]
DEFRA fluctuating (acceptability) [15]
DEFRA steady signal (acceptability)

Predictions of noise impacts

Predictive noise modelling for wind farms is not considered to be overly difficult given that in most instances the noise source is highly elevated with direct line of sight to receivers. The *Draft* aims not to be prescriptive in the type of predictive noise model used and it is expected that advances in modelling will result in improved models during the lifetime of the final guideline. The focus of the *Draft* is therefore demonstrating that the particular model used can be validated for site specific scenarios.

Compliance

An important component of the *Draft* is the requirement for compliance monitoring. As with other major developments in NSW, the *Draft* sets out the procedure for establishing compliance once the wind farm is operational. It is recognised that measuring a level of say 35 dB(A) in a windy environment up to 2 km from the noise source can be difficult. Whilst it would be expected that low pass filters and possibly directional microphones would be used to improve the collection of compliance data, the *Draft* also describes how useful supporting data can be collected from intermediate locations where the signal-to-noise ratio is more favourable. The use of data collected at a proximity of say 400 m where an L_{eq} of around 45 - 50 dB(A) can be expected, may be useful in supporting receiver collected data when extrapolated to the receiver location using established relationships. Moreover, the presence of specific audible characteristics can much more easily be confirmed or denied at these intermediate locations.

Similar to AS 4959, the *Draft* allows for the conversion of some L_{90} data to L_{eq} where collection of uncontaminated L_{eq} data is shown to be problematic. The *Draft* however, differs from AS 4959 in that it prescribes the relationship between the L_{90} and the L_{eq} as being +1.5 dB.

ACKNOWLEDGEMENTS

The Department is appreciative of all the submissions it has received and particularly the advice of those with whom there has been personal correspondence.

This Technical Note does not necessarily describe sections of what will be a final guideline as these may change substantially following the input from the consultation process. Any opinions expressed are those of the author and do not necessarily reflect those of the NSW State Government.

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