Technical Note

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WIND FARM NOISE – AN ETHICAL DILEMMA FOR THE AUSTRALIAN ACOUSTICAL SOCIETY?

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Not since the opening of the Third Runway at Sydney Airport has there been so much publicity in Australia concerning noise – in this case wind farms. Putting aside the issue of noise versus inaudible noise there is a question being raised as to Members of the Society breaching the Code of Ethics. This is not the old question of Professional versus Learned Society. Reliance upon criteria contained in Guidelines or Standards may be an excuse by consultants that in turn places the "fault" on the SA EPA and the New Zealand Standard. However, if people making complaints to no avail and leave their homes because of the wind farm "noise" what is the responsibility of Members of the AAS to the community?

INTRODUCTION

The April 2012 edition of the Australian Acoustical Society's journal (Acoustics Australia – Vol 40, No. 1) provided a series of papers and technical notes relating to wind farm noise [1]. However, the articles supporting wind farms did not discuss the acoustic impact of the wind farms. The articles referred to criteria and compliance with the criteria. The articles did not identify the basis of the criteria or the acoustic impact of wind farms even when they complied with the nominated criteria.

It is evident from the recent public forums conducted by Senators Madigan and Xenophon in South Australia, Victoria and New South Wales that wind farm "noise" is an issue in the community [2,3]. The degree of claims for and against wind farm noise is reminiscent of the aircraft noise debate (with the introduction of jet aircraft to Australia) [4] and the third runway at Sydney Airport [5].

Examination of the aircraft noise debate finds acoustic and socio-acoustic research undertaken in Australia by Members of the Society. Examination of the wind farm noise issue finds a different position.

Members of the Society had been at the forefront of preparing acoustic and vibration Guidelines and Standards in Australia [6] to protect the community from a wide range of noise sources and invariably rely upon overseas experience/standards that are then compared or evaluated with Australian situations.

For example with respect to road traffic noise, we had Standards/Guidelines that originally followed the UK Department of Environment [7] recommendations (rather than US Department of Transport criteria). Work undertaken by the ARRB and Dr Stephen Samuels (and others) lead to a modification of the British criteria to account for Australian road conditions.

AIRCRAFT NOISE IMPACTS IN AUSTRALIA

In the initial stages for aircraft noise assessment Australia adopted the US NEF system [8]. As a result of community concerns about aircraft noise, and a Commonwealth government inquiry (HORSCAN report) [4] led to the noise study by the National Acoustics Laboratory [9] to then result in the ANEF system used for aircraft noise assessments in Australia. Changes have been proposed to the aircraft noise standard, citing the community's response to aircraft noise and the need for supplementary acoustic metrics. However the use of the N60, N70 or N80 descriptor [10] has not been presented in terms of any socio-acoustic surveys and therefore there is a fundamental problem of implementing N60/N80 criteria without any basis to support that criteria.

In the original NAL report on aircraft noise there is the dose response curve for ANEF versus affected people which is slightly different to the curve in Australian Standard AS 2021 [11]. Contained in the NAL report is a dose response for the N70 that can be placed in the context of the unacceptable/acceptable limits for the ANEF system and in turn the building site acceptability tables in AS 2021.

The NAL report does not provide any regression curves showing a basis for N60 or N80. Therefore, as presented previously [12-15], there are issues as to substantiating the number of events that may be applied to the N60 and N80 for an acceptable aircraft noise impact.

In undertaking research work with Fergus Fricke at Sydney University [16] most postgraduate students became aware that Fergus pulled/pushed you sideways to look into different aspects of your subject which required further investigation and a broadening of the material that was the subject of the research. It is such an approach that students of acoustics (of which all members of the Society can still said to be students) can benefit in their daily use of acoustics to have in the back of their mind when there is a problem the quote of Professor Julius Summer Miller "Why is it so?".

This is the exact situation when faced with the challenge of measurements from helicopter operations not agreeing with the international computer modelling led to investigating the matter of lateral attenuation. Investigation found that the attenuation

algorithms in the computer model [8] were wrong, had been wrong for many years, and people were unaware of that fact. Investigations, including going back to the original reference documents [17,18] to uncover the problem, which was verified with additional testing leading to that material being presented to the US Aircraft Standards Committee in 2003 [19], accepted and two years later INM was amended to overcome that issue.

Similarly in seeking to validate military aircraft operations with the computer model we kept on getting incorrect results for high frequency noise which under the same investigative concept lead to querying the results. Testing over a number of years led to identification that the original model for determining atmospheric attenuation coefficient per hundred metres was not carried out in any vast chamber or airfields, ovals or similar. The attenuation coefficients were determined from a stainless steel sphere of 1.68 m diameter on a theoretical basis [20].

Utilising measurement data for aircraft operations under different atmospheric conditions found the universal attenuation coefficients [8,21] did not agree with field measurement for aircraft [22] and monitoring at industrial sites.

These results revealed that if one utilises the atmospheric attenuation contained in various International and American standards in computer models there can be errors. And in particular there can be significant errors if one is dealing with high frequency noise, particularly with respect to the discharge of high velocity steam where there is a significant component of the noise source occurring above 2000 Hz.

It is in light of the above background material and the fact that throughout Australia there are hundreds of residents in proximity to wind farms who claim to be adversely affected, and in some cases so affected that they leave their properties, that must be of concern to members of the Society where there are repeated responses that these people are imagining the problem.

It would appear that the reaction of the community to wind farms is not that dissimilar to communities that were subject to the aircraft noise following the introduction of the jet engine that ultimately led to the famous NAL study. The number of people affected by wind farms is not as great as that affected by airports simply because wind farms are not located in suburban areas. However, in taking into account the percentage of people affected in the area covered by the nominated noise level criteria it would seem to be more than 10% of the population are seriously affected.

MEASUREMENT OF WIND FARM NOISE FOR THE COMMUNITY

I and a number of acousticians in Australia have been requested to undertake reviews of wind farm applications and/or conduct measurements of wind farms. This is not dissimilar to requests for peer reviews of acoustic reports for Development Applications or Compliance Tests for a range of typical noise sources, domestic, road, rail, air traffic, and industrial developments.

These reviews and testing have raised a number of issues as to the adequacy of the original assessments, the accuracy of the measurements and question the acceptability of noise limits which are simply matters that an appropriately qualified and experienced acoustic engineer/consultant would undertake.

Such investigations and assessments have raised concerns as to the adequacy of the guidelines and also the results of compliance testing undertaken by various organisations that include Members of the Australian Acoustical Society.

As a result of undertaking the assessments and providing those reports in the public domain I and other consultants have been labelled by wind farm power entities as being "anti-wind farm" or having close ties to "anti-wind farm lobby groups".

Having discussed this very fact with other Members of the Society who have been so labelled and do not accept such accusations, I have stated a number of times that I am not anti-wind farm but have been simply presenting the facts as to what has been generated by such installations that requires further investigation.

If one is to be labelled as anti-wind farm when simply presenting the facts of what is occurring as a result of undertaking work for the community, then it must be the case that the acoustic consultant/engineer who undertakes work for wind farm applicants should equally be labelled by the wind farm industry as "pro-wind farm".

Both the "anti-wind farm" and "pro-wind farm" acousticians who are Members of the Society would undoubtedly disagree with such labelling and should identify the fact that they are truly independent in carrying out such assessments. Furthermore, if those persons are Members of the Society then they could bring to their defence that there is an obligation to abide by the Code of Ethics of the Australian Acoustical Society [23].

So how can persons undertaking assessments "for or against" wind farms of the noise impact of wind farms be a dilemma for the Australian Acoustical Society you may ask.

CODE OF ETHICS

From the Code of Ethics, that appears on the Society's website, one can see there is the Responsibility for the members of the Society:

The welfare, health and safety of the community shall at all times take precedence over sectional, professional and private interests.

The explanatory notes in the Code of Ethics in referring to Responsibility requires members of the Society to:

- conform to acceptable professional standard and procedures, and not act in any manner that may knowingly jeopardise the public welfare, health, or safety.
- endeavour to promote the well-being of the community, and, if over-ruled in their judgement on this, inform their clients or employers of the possible consequences.
- contribute to public discussion on matters within their competence when by so doing the well-being of the community can be advanced.

The explanatory notes in the Code of Ethics in referring to Work within Areas of Competence requires members of the Society to:

- report, make statements, give evidence or advice in an objective and truthful manner and only on the basis of adequate knowledge

- reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in technical matters.

NOISE IMPACT

A significant number of wind farm assessments follow a generic format. Whether there is identification of primarily the South Australian EPA Wind Farm Guidelines [24,25] or the New Zealand Wind Farm Standard [26,27], the assessment in terms of those guidelines uses the ambient noise level to provide regression line curves, use of a criterion of 35, or 40 dBA and background +5 dB, whichever is the greater value.

The acoustic assessment generally provides the results of computer predictions using the A-weighted value to then indicate compliance with the criteria contained in Guidelines/ Standard.

The noise assessment in relation to the application provides predicted levels in terms of the substation and construction activities that are related to relevant guidelines, and may include an assessment of noise from power lines to indicate significant separation distance to residence to not present at an issue. In some cases there is identification of the acoustic impact of the substation, construction activities, and power lines [28-31].

However in the generic wind farm assessments there is no actual noise assessment of the wind farm, i.e. the assessment simply states compliance with the relevant guidelines and that is it.

The generic wind farm "noise assessment" considers the noise outside residences and does not identify to the community the audibility of the wind farm, the relationship of the guideline criteria with respect to the acoustic environment of the area, the percentage of time in which there will be audible noise as a result of weather conditions, or conversely a reduction in noise as a result of weather conditions.

The generic wind farm "noise assessment" does not report the situation of residents hearing the noise inside their homes or having sleep being disturbed or that some residents experience disturbance even when there is compliance with the guidelines noise limit. The "noise assessment" does not indicate situations in Australia where residents (host and non-hosts) leave their homes to live elsewhere.

The question is now being asked in the community, and invariably will be asked in courts of law, whether the absence of that material in the "noise assessment" is a Breach of Code of Ethics.

The Association of Australian Acoustical Consultants (AAAC), of which firms become members of that Association, have a Code of Professional Conduct [32] which goes one step further than the AAS in the section on Professional Standards:

- To maintain the standards of business and personal conduct reasonably expected of a professional
- To act with professional responsibility and integrity in my dealings with the community and clients, employers, employees and students
- To provide professional opinions in an objective and truthful manner, avoiding statements that may be demeaning, misleading or unethical
- Not to misrepresent one's skills and experience
- To undertake work only in areas of competence, unless the client is informed of the member's limitations
- To maintain a proper sense of responsibility to the client, broader community, employees, the profession and the environment.

In attending various rural dwellings to undertake wind farm noise measurements questions have been raised by the occupants as to the conduct of members of the AAAC and the AAS in relation to monitoring and reporting of the results/impact.

RURAL NOISE ENVIRONMENTS

Acousticians in Australia that are aware of the origins of Australian Standard AS 1055 [33,34] will be well aware that it follows that the general scenario outlined for other standards and its primary function as per its original title was "Noise Assessment in Residential Areas".

Accordingly AS 1055 is not really a document that is appropriate for rural areas and the background levels that were suggested for various categories may be appropriate in suburban areas. However for areas removed from traffic the lowest background level in AS 1055 would not necessarily apply in such areas.

Rural areas removed from main roads and the like, and being areas nominated for wind farm developments can experience background levels less than 20 dBA in the day and night, and can also experience ambient L_{eq} levels less than 30 dBA during the day and less than 25 dBA at night.

A fundamental question that communities exposed to wind farms raise is how can the guidelines substantiate 35, or 40 dBA as an acceptable base level at night in rural areas?

The SA EPA Guidelines refer to an indoor sleep disturbance level of 30 dBA by reference to a WHO Guideline [35]. However there is a failure to correctly identify that the WHO guidelines were referring to suburban areas impacted by traffic noise and did not provide criteria for rural areas or consider wind farm noise. The draft New South Wales Wind Farm Guidelines [36] specifically clarified the WHO guideline sleep arousal related to noise in suburban areas from traffic [37].

The situation of background levels in residential bedrooms which are between 10 dBA and 20 dBA, even with turbines operating, must be a fundamental issue of concern for the Members of the Society for a guideline that suggests 40 dBA is an acceptable level at night (as an external level) or 30 dBA as an internal level.

If the "pro-wind farm" acoustician's defence to inadequate reporting assessment or consideration of the community's health relies upon Guidelines or Standards that have been issued for wind farms, then apparently blame may be to the authors of the Guidelines or the Standards committees which include Members of the Society.

It could well be argued that when the first version of the guidelines were prepared by the South Australian EPA they did not have the benefit of an existing wind farm to undertake measurements and determine the appropriateness of the draft guideline and then the guideline.

It would appear historically that the original SA EPA guidelines were based upon overseas material in part. However, there does not appear to be any reference in the document to identify where the base criteria have been substantiated for use in Australian rural communities, i.e. socio-acoustic study to support the limits.

OUTCOMES

The current public debate as to noise impact from wind farms would appear to be more complex than just the "Learned Society of Professional Institution" question raised by Fergus Fricke [38] in the same 1982 AAS Bulletin that reported on the NAL 1982 Aircraft Noise Report.

If further work finds there is a health issue as a result of "noise" generated by wind farms and there are "acoustic assessments" that state there are no health impact no sleep impacts, and no infrasound, then what happens?

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AAS CODE OF ETHICS

1. Responsibility
The welfare, health and safety of the community shall at all times take precedence over sectional, professional and private interests.

2. Advance the Objects of the Society
Members shall act in such a way as to promote the objects of the Society.

3. Work within Areas of Competence
Members shall perform work only in their areas of competence.

4. Application of Knowledge
Members shall apply their skill and knowledge in the interest of their employer or client, for whom they shall act in professional matters as faithful agents or trustees.

5. Reputation
Members shall develop their professional reputation on merit and shall act at all times in a fair and honest manner.

6. Professional Development
Members shall continue their professional development throughout their careers and shall assist and encourage others to do so.

EXPLANATORY NOTES

1. Responsibility
In fulfilment of this requirement members of the Society shall:

- Avoid assignments that may create conflict between the interests of their clients, employers, or employees and the public interest.
- Conform to acceptable professional standard and procedures, and not act in any manner that may knowingly jeopardise the public welfare, health, or safety.
- Endeavour to promote the well-being of the community, and, if over-ruled in their judgement on this, inform their clients or employers of the possible consequences.
- Contribute to public discussion on matters within their competence when by so doing the well-being of the community can be advanced.

2. Advance the Objects of the Society
Appropriate objects of the Society as listed in the Memorandum of Association are:
Object (a)
To promote and advance acoustics in all its branches and to facilitate the exchange of information and ideas in relation thereto.
Object (e)
To encourage the study of acoustics, highlight excellence in acoustics and to improve and elevate the general and technical knowledge in any manner considered appropriate by the Society.
Object (g)
To encourage research and the publication of new developments relating to acoustics.

3. Work within Areas of Competence
In all circumstances members shall:

- Inform their employers or clients if any assignment requires qualifications and/or experience outside their fields of competence, and where possible make appropriate recommendations in regard to the need for further advice.
- Report, make statements, give evidence or advice in an objective and truthful manner and only on the basis of adequate knowledge.
- Reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in technical matters.

4. Application of Knowledge
Members shall at all times act equitably and fairly in dealing with others. Specifically they shall:

- Strive to avoid all known or potential conflicts of interest, and keep employers or clients fully informed on all matters, financial or technical, that could lead to such conflicts.
- Refuse compensation, financial or otherwise, from more than one party for services on the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
- Neither solicit nor accept financial or other valuable considerations from material or equipment suppliers in return for specification or recommendation of their products, or from contractors or other parties dealing with their employer or client.

5. Reputation
No member shall act improperly to gain a benefit and, accordingly, shall not:

- Pay nor offer inducements, either directly or indirectly, to secure employment or engagement.
- Falsify or misrepresent their qualifications, or experience, or prior responsibilities nor maliciously or carelessly do anything to injure the reputation, prospects, or business of others.
- Use the advantages of privileged positions to compete unfairly.
- Fail to give proper credit for work of others to whom credit is due nor to acknowledge the contribution of others.

6. Professional Development
Members shall:

- Strive to extend their knowledge and skills in order to achieve continuous improvement in the science and practice of acoustics.
- Actively assist and encourage those under their direction or with whom they are associated to advance their knowledge and skills.

Technical Note

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EFFECT OF A 35 dB(A) MINIMUM CRITERION ON A WIND FARM DEVELOPMENT

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INTRODUCTION

Environmental noise criteria for wind farms in Australia are normally determined individually for nearby receiver locations. The criteria take the form of a minimum criterion or the background $L_{A90,10min}$ noise level plus 5 dB(A), whichever is the greater, for each integer wind speed between turbine cut-in and rated power.

At low wind speeds, the minimum criterion typically applies due to the lower background noise levels than during periods of higher wind speeds. A minimum criterion of 40 dB(A) is specified in the following standards and guidelines that are typically applied in Australia:

- New Zealand Standard 6808:1998 *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZS 6808:1998) [1]
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) [2]
- South Australian *Wind Farms Environmental Noise Guidelines* 2009 (2009 SA Guidelines) [3].

In Western Australia and New South Wales, the 2003 version of the South Australian *Wind Farms Environmental Noise Guidelines* (2003 SA Guidelines) [4] has been adopted for the majority of recent wind farm projects, and this version applies a 35 dB(A) minimum criterion.

It is important to note that both NZS 6808:2010 and the SA Guidelines also consider a 35 dB(A) minimum criterion, although the application of this is limited to particular situations. NZS 6808:2010 states that a 35 dB(A) minimum criterion may be applied in "high amenity areas" which is to be considered only where a district plan promotes a higher degree of acoustic amenity protection to an area, and where the wind speed and measured background noise levels are low enough to justify the application. The SA Guidelines apply a minimum criterion of 35 dB(A) to receivers located in areas primarily intended for rural living, as defined by the relevant Development Plan. However, this is not commonly applied in our experience, as most wind farms are located in zones intended for primary production.

This technical note investigates the effect of applying a minimum criterion of 35 dB(A) based on AECOM's database of background noise measurements at 60 separate receiver locations adjacent to 10 different wind farm developments. Noise criteria are determined for both a 35 and 40 dB(A) minimum criterion, and the difference in criteria between the two cases investigated for three different wind turbine models.

This is also relevant to the recently released *Draft NSW Planning Guidelines: Wind Farms* (Draft NSW Guidelines) [5]. These guidelines propose a minimum criterion of 35 dB(A) and suggest that, because of the 5 dB(A) reduction in the minimum criterion, turbines will be sited approximately twice as far away as would be required in other Australian states.

BACKGROUND NOISE LEVELS

Background $L_{A90,10min}$ noise level measurements undertaken by AECOM at over 60 sites have been collated to determine a mean background noise level at hub height wind speeds for the measurement set. All of the noise level measurements are correlated against hub height wind speeds at the meteorological mast at the proposed wind farm site (a height of approximately 80 metres), and periods of rain and extraneous noise have been removed from the data set. After removal of these data points, the majority of the measurement sites include over 2000 data points, with 12 sites including between 1400 and 2000 data points.

The average background noise level at each integer wind speed for each site was determined by a best fit regression analysis. A mean background noise level for the entire dataset was then determined by averaging the background noise levels at each integer wind speed across the sites. Finally, a best fit regression analysis was conducted on the average background noise levels to determine a background noise level at each integer wind speed for the 60 sites.

The above analysis has been conducted in accordance with the method prescribed in the 2009 SA Guidelines, with the exception that all wind speeds have been considered and not just those between turbine cut-in and rated power. This has been done intentionally to provide an indication of the lower wind speeds at which the 35 dB(A) criterion may affect the end compliance result. This method is similar to the 2003 SA Guidelines except that it considers wind speeds at hub height rather than at 10 metre height. The use of hub height wind speeds is preferable as it minimises the potential effects of air stability which can result in variations in the relationship between wind speeds measured at hub height and those at 10 metres.

Figure 1 presents the mean background noise levels (with bars shown corresponding to one standard deviation), the best

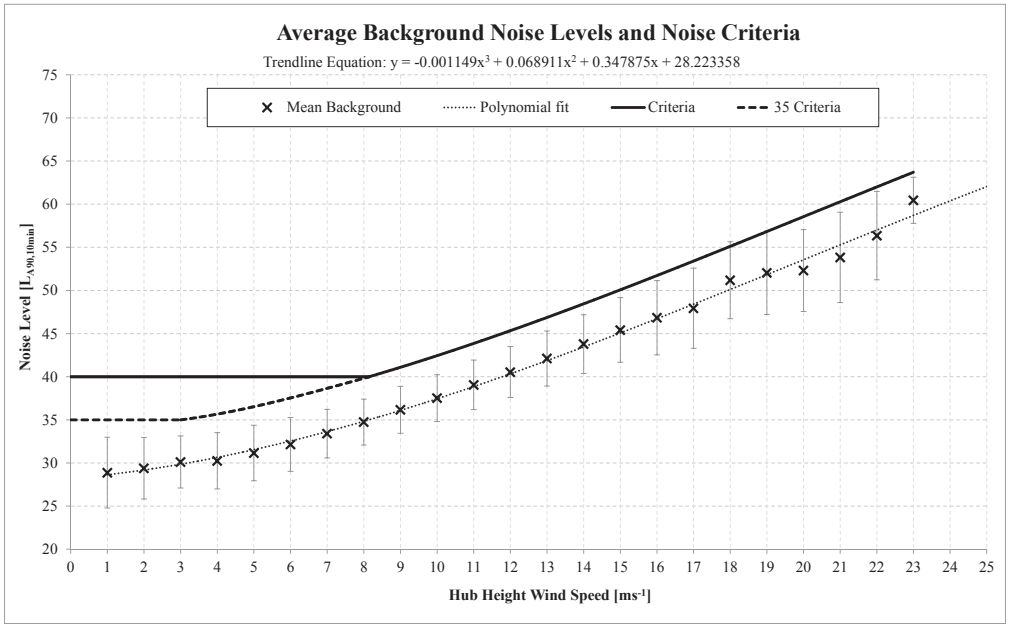

Figure 1. Average background noise levels and noise criteria

fit regression curve and the corresponding noise criteria for a both a 35 dB(A) and 40 dB(A) minimum criterion.

The results indicate that a 35 dB(A) minimum criterion would typically control the noise criteria at hub height wind speeds of approximately 3 to 4 m/s before the background noise level starts to increase with higher wind speed. The criteria determined under both situations would typically be identical at wind speeds of approximately 8 m/s or greater.

WIND FARM NOISE LEVELS

Wind farm noise levels will also increase with increasing wind speed, as the turbine sound power levels increase between cut-in and rated power. Evans and Cooper [6] found that the increase in turbine noise level against hub height wind speed at a receiver location closely matched the increase in the sound power level of the turbines at the wind farm.

Therefore, to approximate the wind farm noise level at a receiver location for comparison with the noise criteria

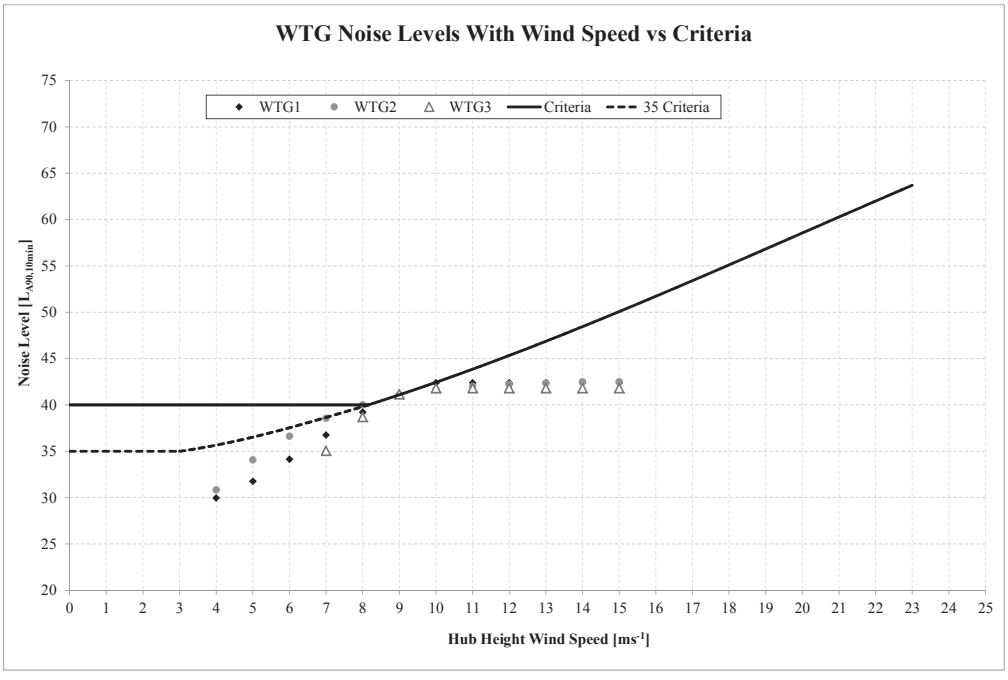

Figure 2. WTG noise levels with wind speed vs criteria

presented in Figure 1, the sound power levels of three modern wind turbines against hub height wind speed were sourced from manufacturer data available online. The three turbines, each from a different manufacturer, are:

- WTG 1: Vestas V112-3.0MW [7]
- WTG 2: Nordex N90 2.5MW [8]
- WTG 3: GE 2.5MW-103 [9].

The sound power versus wind speed profiles for the three turbines were scaled so that compliance with a 40 dB(A) minimum criterion would just be met, emulating noise levels at a location where the wind farm had been designed to comply with a 40 dB(A) minimum criterion. The turbine noise levels are plotted against the previously determined noise criteria in Figure 2.

The results in Figure 2 indicate that the application of a 35 dB(A) minimum criterion has minimal effect on the compliance of a proposed wind turbine layout with the noise criteria, for the turbine models considered. This is as the peak noise levels occur at hub height wind speeds above 8 m/s.

Table 1 summarises exceedances of the criteria that would occur when incorporating a 35 dB(A) minimum criterion at each of the 60 measurement sites based on a turbine noise level just compliant with the 40 dB(A) criteria. It can be seen that the majority of the receivers remain compliant with the more stringent criteria. For 90% of the receiver locations, there would be no noticeable reduction in noise levels (i.e. 2 dB(A) or less) due to the application of the 35 dB(A) minimum criterion, whichever of the three turbine models were selected.

Table 1. Percentage of receiver sites at which exceedance of criteria with 35 dB(A) minimum criterion would occur

Exceedance	WTG 1	WTG 2	WTG 3
0 dB(A)	80%	60%	78%
1 dB(A)	12%	22%	12%
2 dB(A)	3%	7%	5%
3 dB(A)	2%	8%	2%
4 dB(A)	3%	3%	3%
5 dB(A)	0	0	0

DISCUSSION

Based on an analysis of background noise measurements at 60 sites adjacent to 10 different wind farm developments, and manufacturer's data for three different wind turbine models, it appears that a turbine layout designed to comply with a 40 dB(A) minimum criterion would still comply with a 35 dB(A) criterion in the majority of cases. At 90% of the considered receiver locations, there would be no noticeable reduction in noise levels required to achieve compliance with the more stringent criteria (i.e. 2 dB or less). This appears to contradict the assumption that a 35 dB(A) minimum criterion would result in turbines being sited significantly further away from residences.

A further suggestion from this analysis is that Regulatory authorities that currently apply the 2003 SA Guidelines could consider the adoption of the updated 2009 SA Guidelines, with minimal changes to noise levels at residential locations. The 2009 SA Guidelines provide other advantages such as updated noise level measurement, prediction and assessment techniques. The use of hub height, rather than 10 metre height, wind speeds is one example.

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