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Draft Wind Energy Guideline



Technical Supplement for
Noise Assessment

November 2023



Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Cover Page Crudine Ridge Wind Farm, Squadron Energy

Glossary of key terms

Applicant	The applicant of an SSD project seeking consent for a development application or modification application.
Decibel (dB)	A measure of sound level. The decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage, intensity or other parameters. In the case of sound pressure, it is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure squared to a reference sound pressure squared.
Decibel (A-weighted; dB(A))	Unit used to measure ‘A-weighted’ sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.
Decibel (C-weighted)	C-weighting is an adjustment made to sound-level measurements that takes account of low-frequency components of noise within the audibility range of humans.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of running water sounds while talking in a busy kitchen.
Receiver	The noise-sensitive land use at which noise from a development can be heard.
Residence	A lawful and permanent structure erected in a land-use zone that permits residential use (or for which existing use rights under the EP&A Act apply) where a person/s permanently reside and is not, nor associated with, a commercial undertaking such as caretakers’ quarters, hotel, motel, transient holiday accommodation or caravan park.
Low frequency	Noise containing major components in the low-frequency range (10 hertz [Hz] to 160 Hz) of the frequency spectrum.
Tonality	Noise containing a prominent frequency and characterised by a definite pitch.
Passive recreation areas	Designated walking trails, campgrounds, scenic lookouts.
SA Guidelines	Wind farms – environmental noise guidelines, South Australian Environmental Protection Authority (issued July 2009, updated November 2021).

1 Introduction

This document provides additional guidance for applicants, consent authorities, acoustic specialists and the community using the Wind Energy Guideline to understand the process and requirements for assessing noise impacts of wind energy development in NSW.

1.1 Purpose

This technical supplement provides a detailed description of the noise assessment process and includes practical guidance on how to measure and assess environmental noise impacts from wind energy projects. It ensures acceptable amenity for people living near proposed wind energy projects by establishing clear standards and noise limits.

The technical supplement aims to provide greater interpretation, clarity and rigour for the assessment and regulation of wind energy development noise, including low frequency noise, tonality and auditing and compliance issues. The objective is to ensure that the noise impacts of wind energy projects are appropriately identified, mitigated and managed.

This document should be read in conjunction with the more general assessment requirements outlined in the *Draft Wind Energy Guideline (2023)*. It will be reviewed from time to time as required, such as to reflect changes in technology and contemporary assessment methods.

1.2 Characteristics of wind turbine noise

Wind energy projects require reliable wind resources which are typically found in quiet, rural areas. Noise generated by wind energy development is often raised as a concern for people living in these areas.

To ensure acceptable noise levels for people living in the area surrounding a proposed wind energy project, the NSW Government has adopted clear standards for conducting a noise impact assessment to accurately predict noise levels at surrounding dwellings.

The assessment of noise impacts arising from wind energy development is unique in three key ways. Firstly, wind turbines operate under very different conditions to other industrial noise sources. Wind turbines only function when there is wind, and the noise level from each wind turbine rises as the wind speed increases. The increase in wind speed also results in an equal or greater increase in the background noise level due to aerodynamic and foliage noise which can mask turbine noise. The increase in background noise with wind speed is generally site specific and needs to be determined in the assessment process.

Secondly, the height of the noise source centre (the machinery inside the enclosure at the top of the tower, called the nacelle) is highly elevated compared to other noise sources such as roads, railways, mines and most industrial facilities. As a result, there is less opportunity to mitigate or shield the propagation of wind turbine noise.

Lastly, activities in rural areas, such as farming and agricultural practices, can generate significant noise resulting from sources including road traffic and farm machinery. Whilst noise from wind turbines is not likely to be dominant, the characteristics of wind turbine noise may be perceived as being different to these existing noise sources.

Given the unique characteristics of noise generated by wind turbines, specific guidance is warranted.

2 Assessment framework

The NSW Government has adopted the South Australian EPA's *Wind farms environmental noise guidelines* (published in 2009 and updated in 2021) (the SA Guidelines) as the basis for assessing and managing noise from wind energy projects in NSW.

The SA Guidelines set out the methodology that applicants are required to follow when assessing the noise impacts associated with a proposed wind energy project, and the documentation requirements for a noise impact assessment.

However, in recognition that the regional areas of NSW with high quality wind resources are more populated than the equivalent regions in South Australia, there are some variations specific to the NSW context that are outlined in detail throughout this document.

2.1 Scoping and preliminary assessment

Applicants of wind energy projects are required to consider the potential noise impacts of a wind energy project at all stages of the project, including during the site selection and project design phase.

As part of the project scoping stage, applicants should undertake an indicative noise impact assessment of noise levels expected at all receivers. The indicative noise assessment must be included in the Scoping Report and request for the Secretary's Environmental Assessment Requirements.

While the design of a project may change during the preparation of an Environmental Impact Statement (EIS) and at the development application stage, it is important to provide early indicative noise predictions using simple modelling techniques and conservative assumptions. Such assumptions would include using the maximum sound power level of the likely turbine proposed and calculated under the worst-case noise propagation conditions. These indicative predictions should be compared against the base criteria adopted in NSW of 35 dB(A), unless detailed studies support more elevated criteria on the basis of prevailing background noise levels.

2.2 Environmental Impact Statement

The applicant must prepare a report detailing the noise assessment undertaken and include it in EIS that is submitted to the Department of Planning and Environment (the department) with the SSD

application. The report should be prepared by a competent person as defined in section 2.2 of the NSW Environment Protection Authority's (EPA) *Approved methods for the measurement and analysis of environmental noise in NSW* (2022 or latest version). By this stage, the applicant will need to have undertaken monitoring to determine the background noise levels and modelling of the predicted noise levels of the proposed turbines.

The applicant's EIS should clearly identify the expected noise levels at all non-associated receiver locations to ensure that affected persons are appropriately informed regarding the development proposal. As a minimum, the noise impact assessment must include the following:

- the model used to predict the wind energy project noise levels and input assumptions and factors used in the model, noting that noise management mode or sector management (i.e. stopping individual turbines or combinations, or operating in low noise mode, during identified meteorological conditions) should not be used in the primary modelling or predicting of noise levels. Any modelling and predictions which incorporate noise management mode or sector management must be reported separately
- background noise measurement locations including time and duration of the background noise monitoring program
- wind speed monitoring locations within the project area, heights above ground and a graphical plot of hub height wind speed versus background noise level data
- a summary of the environmental noise criteria for the project at each integer wind speed based on the above relationship
- likely performance specifications of the wind turbines along with their location
- predicted noise levels at the closest non-associated dwellings to the wind energy project at each integer wind speed that are expected to exceed the base objective of 35 dB(A)
- a comparison of the predicted noise levels against the criterion at each integer wind speed for the most affected non-associated dwellings to the wind energy project that are expected to exceed 35 dB(A), and
- modifications or operating strategy that would be employed to address any unforeseen non-compliances. The error margins of the noise model used should be considered in developing such modifications or strategies.

The department and the EPA will assess the noise impact assessment to determine whether it has been undertaken in accordance with the requirements of the SA Guidelines and this technical supplement, and whether the predicted noise levels comply with the applicable criteria (see Section 3.1).

2.3 Determination and post approval regulation

Following assessment of a wind energy SSD application, the consent authority will determine whether the project should be approved. The consent authority will consider the noise impacts of the project alongside the other environmental, social and economic considerations, including the public interest. If consent is granted, it will be subject to conditions which will include a requirement to monitor noise generated by the operation of wind turbines to ensure it does not exceed the

relevant criteria. The conditions of consent will also require the applicant to prepare a specific compliance assessment methodology and to undertake noise compliance monitoring.

If noise compliance monitoring indicates that noise from turbines exceeds the approved noise limits, the applicant must identify feasible and reasonable noise mitigation and management measures to achieve compliance with the noise limits, including a timetable for implementation. These measures will be dependent on the nature of the issue and implemented on a case-by-case basis.

If consent is granted, the applicant will also need to obtain an environment protection licence (EPL) from the EPA before commencing construction. The EPL will typically include noise performance requirements.

3 Noise limits

The purpose of setting noise level objectives for wind turbines is to retain noise levels that are compatible with surrounding land uses and to ensure that noise levels do not significantly affect the living experience of people residing in the area.

3.1 Noise limits for residences

Under the SA Guidelines, a higher base noise level is permitted in land use zones associated with high intensity farming practices and a lower base noise level applies in land use zones associated with residential uses. Excursions above the base criterion are allowed provided this level does not exceed the ambient background noise level + 5 dB(A).

The NSW Government recognises that rural land use zones in NSW are often more densely settled than those of South Australia and that there is a relatively high density of rural residential living in parts of regional NSW with reliable wind resources.

Therefore, only the lower base noise criteria in the SA Guidelines will be applied in NSW. This criterion applies to all residential receivers and is defined as follows.

Noise limits for residential receivers

The predicted equivalent noise level (LAeq,10 minute)¹, adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed **35 dB(A)** or the **background noise (LA90(10 minute)) by more than 5 dB(A)**, whichever is the greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.

Note: While the noise criteria is established on the basis of a 24-hour period, noise readings are taken at 10 minute intervals.

¹ Determined in accordance with Section 4 of the South Australian *Wind farms environmental noise guidelines*

Figure 1 shows the average distances at which compliance with different noise standards is expected to occur, using other Australian and International standards as examples.

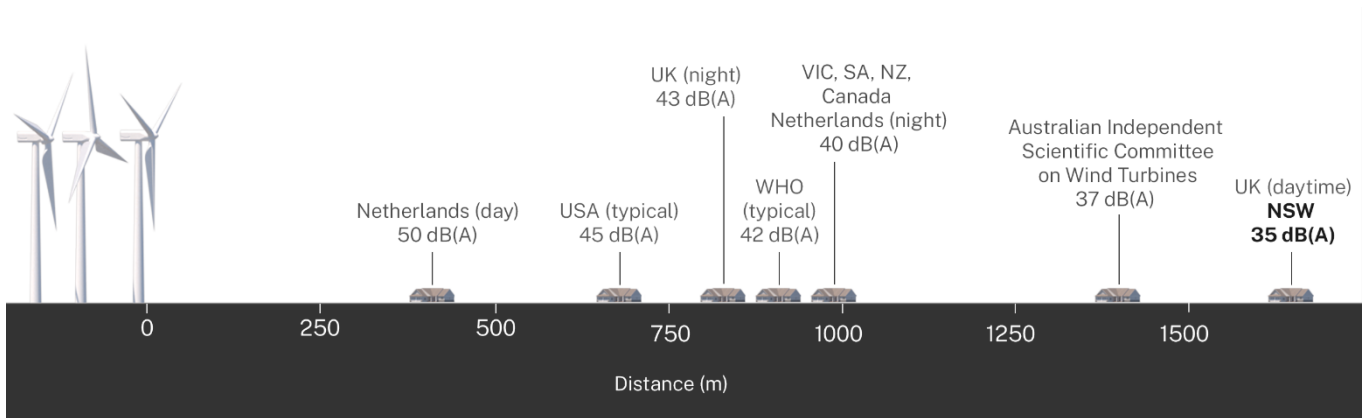


Figure 1 – Distances at which a range of residential noise limits may be achieved²

3.2 Noise limits for other land uses

Wind energy projects can be located in close proximity to National Parks given the location of high-quality wind resources in NSW. This has the potential to impact the amenity of passive recreation areas including designated walking trails, campgrounds and scenic lookouts. To manage noise amenity in these areas, the following criterion applies.

Noise limits for National Parks

The predicted noise level, adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed **Leq 50 dB(A)**, at passive recreation areas within National Parks (when in use) for wind speed of 4m/s or cut-in speed, whichever is the greater.

This criterion will typically be achieved at setback distances of 500 metres.

It is rare that wind energy projects impact on other non-residential receivers. In cases where other sensitive receivers are impacted, then Table 2.2 of the NSW EPA *Noise Policy for Industry* can provide guidance on the acceptability of such noise to those receivers.

3.3 Special noise characteristics

While the main noise assessment criteria for wind energy projects is the base noise level, there are alternate special noise characteristics which need to be considered as part of the noise assessment process of any wind energy project.

² Comparison of inter-jurisdictional wind energy noise criteria is complex. The setback distances are indicative only and do not account for site-specific conditions which may increase or decrease the noise level, such as topography. Modelled using ISO 9613.2 algorithm for three typical 6 MW turbines (with a hub height of 170 m) directly upwind of receivers.

Tonality

In addition to sound pressure level (measured in decibels, dB), the way sound is perceived is partially determined by its pitch or frequency (measured in Hertz, Hz). Human hearing covers frequencies from 20 Hz to 20,000 Hz and is less sensitive at low and high frequencies. Sounds which have unusually high levels of energy in a relatively narrow band of frequencies may be referred to as being tonal.

Audible tonal sounds from wind turbines are generally related to rotational equipment in the turbine nacelle and can have a specific pitch dependent on the speed of rotation. This can cause the noise to be more noticeable. These tonal characteristics (as defined below) typically do not occur in well designed and well-maintained wind turbines. If present, they are usually caused by a turbine maintenance issue³.

The SA Guideline suggests that the tonality assessment procedure detailed in the International Standard IEC 61400-11 is appropriate for measurement in close proximity to a turbine or that it can be modified for assessing wind farm associated tones at distant receivers. However, the NSW EPA assesses tonality with reference to the ISO 1996.2 standard.

For consistency in NSW, assessment, prediction and compliance of tonality objectives should be undertaken in accordance with ISO 1996.2: 2017 *Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of sound pressure levels* using measured or similar representative data. The survey method described in Annex K (comparison of 1/3rd octave levels) assessed at integer wind speeds provides an acceptable screening test. It defines tonality as when the level of a one-third octave band⁴ exceeds the level of the adjacent bands on both sides by:

- 5 dB or more if the centre frequency of the band containing the tone is in the range 500 Hz to 10,000 Hz;
- 8 dB or more if the centre frequency of the band containing the tone is in the range 160 Hz to 400 Hz; and/or
- 15 dB or more if the centre frequency of the band containing the tone is in the range 25 Hz to 125 Hz.

If tonality is found to be a repeated characteristic of the wind turbine noise, 5 dB(A) should be added to measured noise levels from the wind energy project. The tonal characteristic penalty applies only if the tone from the wind turbine is audible at the relevant receiver. Absence of tone in noise emissions measured at an intermediate location is sufficient proof the wind energy project noise is not tonal at a receiver location. The assessment for tonality should only be made for frequencies of concern from 25 Hz to 10,000 Hz and for sound pressure levels above the threshold of hearing (as defined in ISO 389.7:2019 *Acoustics – Reference zero for the calibration of audiometric equipment – Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions*).

³ Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3), EPA, Ireland (2011).

⁴ The descriptor shall be in accordance with Section 4 of the SA Guideline

Note: Narrow band analysis using the engineering method in ISO1996-2:2017, Annex J may be required by the consent / regulatory authority where it appears that a tone is not being adequately identified, for example where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.

Low frequency noise

Low frequency noise is present in all types of environmental noise and is particularly difficult to measure in the presence of wind due to the increased level of background noise. Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise when it complies with the A-weighted criteria outlined in Section 3.1.

In the unlikely event that excessive low frequency noise is found to be a repeated characteristic (i.e. noise from the wind project would be repeatedly greater than 60 dB(C)) of the wind turbine noise, 5 dB(A) should be added to the predicted or measured noise level from the wind energy project.

Note: Appropriate care needs to be taken when measuring C-weighted and low frequency noise levels as wind at microphone height can influence the measured levels. The performance of the selected microphone / wind screen combination needs to be considered so that data potentially affected by wind induced noise across the microphone can be excluded.

However, at the discretion of the applicant, a more detailed assessment can be carried out to demonstrate that low frequency noise is not a repeated characteristic. This assessment must be undertaken using Fact Sheet C of the *Noise Policy for Industry* (NSW EPA, 2017). Minor modifications to this approach are required for wind energy projects. The modified approach is:

- the assessment must be undertaken for a 24-hour period, rather than the trichotomy of day/evening/night reported in the Noise Policy for Industry.
- where any of the one-third octave noise levels in Table C2 (reproduced below) are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dB(A) positive adjustment to measured/predicted A-weighted levels applies.
- where any of the one-third octave noise levels in Table C2 (reproduced below) are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies.

Table C2: One-third octave low frequency noise thresholds

Hz/dB(Z)	One-third octave $L_{Zeq,15minute}$ threshold level												
Frequency (Hz)	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB(Z)	92	89	86	77	69	61	54	50	50	48	48	46	44

Notes: Table C2 is reproduced from the Noise Policy for Industry (NSW EPA, 2017)
 dB(z) = decibel (Z frequency weighted)

Penalties for special noise characteristics

A special noise characteristic is defined as a repeated and excessive characteristic if it occurs for more than 10 per cent of an assessment period. This equates to being identified for more than 144 minutes in any day (24 hours).

The SA Guideline applies an addition of 5 dB(A) to the measured noise level only where tonality is identified. In NSW, the wind energy project noise level must be adjusted where excessive levels of tonality, low frequency noise, or a combination of both is identified in accordance with this technical supplement to a maximum adjustment of 5 dB(A). Results of the calculations should be reported in the noise monitoring report.

Typically, monitoring campaigns designed to identify special noise characteristics would be not greater than one week.

3.4 Noise from ancillary sources

Noise from ancillary operation sources such as electrical substations and battery energy storage facilities should be assessed against the *NSW Noise Policy for Industry*.

4 Management and Mitigation

Noise management and sector management

Noise Management Mode and Sector Management are operating strategies that may be employed by applicants to meet noise criteria and optimise turbine performance. If these strategies are intended to be used, applicants must provide the Department, the EPA and any potentially impacted residents with the parameters and meteorological conditions which trigger their use and an auditable process by which compliance can be independently confirmed.

Private Agreements

Applicants commonly negotiate agreements with private land holders as a measure to manage impacts where noise limits may not be achievable. Where such an agreement is in place, the nature, extent and duration of the agreement will factor into the consent authority's consideration of the assessment. Further information, including a template agreement and advice for landholders, can be found in the *Draft Private Agreement Guideline (2023)*.

5 Noise monitoring

Use of alternative / intermediate noise monitoring locations

Once operational, measurement of the operational noise of a wind energy project will be required as a condition of consent. During typical operating conditions, wind turbine noise may be fully or partially masked, or substantially contaminated by wind or other extraneous noises. Measurement of wind turbine noise in these conditions is often difficult, and in some cases not possible. To improve the ability to undertake compliance measurements, NSW regulators may accept alternative techniques. Such alternate techniques will need to be assessed individually and on their merits.

Techniques may include the use of alternative or intermediate locations between the wind energy project and the relevant receiver where the signal-to-noise ratio is much higher, and for which there are well established theoretical and empirical relationships to the relevant receivers. Data from such sites may be used to supplement and support conclusions obtained at the receiver locations. In most cases, it is expected that intermediate locations will be chosen from predicted noise contour maps. Intermediate locations that would return Leq levels of around 45-50 dB(A) under down-wind conditions would expect to be found at around 400 metres from the nearest turbines. At such levels, the signal-to-noise ratio should be high enough to allow valid data to be collected under a wide range of meteorological conditions and extraneous background noise.

Where the use of an intermediate assessment location is proposed, a robust transfer function between the intermediate noise monitoring point and the sensitive receivers it represents needs to be established. Any intermediate noise monitoring locations should be identified in the site / project specific compliance assessment methodology required by conditions of consent along with details of the transfer function. Where possible, intermediate noise monitoring points should be at an easy to access public location. Such intermediate assessment locations provide regulators with the added benefit of being able to make their own indicative short-term measurements in response to complaints or queries.

Duration of monitoring

The SA Guideline's noise compliance checking procedure requires the collection of 2,000 data points including a minimum of 500 from the worst-case wind direction for operational wind energy projects. Experience has shown that for some locations in NSW, the worst-case wind direction rarely occurs. Therefore, it may be impractical to collect 500 valid data points under the worst-case conditions. Consequently, data collection should continue for up to six weeks and the valid data collected in this period shall be deemed to be an acceptable quantity in terms of worst-case wind direction. However, 2,000 valid data points should be obtained in all cases as part of the noise assessment procedure undertaken to demonstrate that the operating wind energy project complies with the applicable noise criteria and the conditions of the consent.

As with all statistical methods that graphically represent the relationship between a dependent variable against independent variables, the wind speed bin analysis method can also produce unexpected results when there is a low number of data points within an individual wind speed bin.

Whilst the SA Guideline does not nominate a minimum number of data points, it is noted that International Standard IEC 61400-11 requires a minimum of 10 data points in a wind speed bin to form a valid assessment. NSW also adopts this requirement unless otherwise justified.

6 Health impacts

High levels of noise are associated with adverse health outcomes. To examine this potential relationship, the National Health and Medical Research Council (NHMRC) undertook a comprehensive assessment of the scientific evidence on wind farms and human health.

In 2015, the NHMRC concluded that “there is no direct evidence that exposure to wind farm noise affects physical or mental health”, and there is currently no consistent evidence supporting a link between wind energy projects and adverse health outcomes in humans relating to infrasound. More specifically, they stated that, “while exposure to environmental noise is associated with health effects, these effects occur at much higher levels of noise than are likely to be perceived by people living in close proximity to wind farms in Australia”.

In 2018, the World Health Organization (WHO) released their *Environmental noise guidelines for the European Region* which comprised a suite of recommendations including “reducing noise levels produced by wind turbines below 45 dB Lden, as wind turbine noise above this level is associated with adverse health effects.” The WHO recommended level of Lden 45 dB(A) is a minimum of 3.5 dB higher than the base NSW criterion and would typically be expected to equate to a level measured in NSW of around Leq 42 – 50 dB(A).

The NSW Government’s position on potential health impacts of wind energy projects continues to be informed by the scientific findings of the NHMRC and the advice of NSW Health. The National Wind Farm Commissioner and the Independent Scientific Committee on Wind Turbines was established by the federal government in 2015 to provide advice on the potential impacts of wind turbine sound on health and the environment.

This work resulted in several publications including *Wind turbine sound limits: Current status and recommendations based on mitigating noise annoyance (2018)*. This concludes that a level of LA90,10 min (equal to 37 dB), is an approximate maximum level of noise to which residents should be exposed.

The criteria adopted in this guideline is significantly lower than the WHO recommended level and slightly below the levels recommended by the Independent Scientific Committee on Wind Turbines.

The NSW Government will continue to monitor contemporary scientific research outcomes to ensure its position reflects robust evidence on any health effects.