APPENDIX 8

Environmental Noise Guidelines: Wind Farms

Environmental Protection Agency, South Australia, 2003

Wind Farms

Environmental Noise Guidelines

EPA South Australia

NOISE

Government of South Australia

Environmental Noise Guidelines: Wind Farms

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1 INTRODUCTION

This document aims to help developers, planning and enforcement authorities, other government agencies and the broader community assess environmental noise impacts from wind farms.

The core objective of these guidelines is to balance the advantage of developing wind energy projects in this State with protecting the amenity of the surrounding community from adverse noise impacts.

Wind farms need specific guidelines because wind turbines have unique noise generating characteristics and the environments surrounding wind farm sites usually have low ambient noise.

A workshop with approximately 40 participants was held to help develop these guidelines. A technical subgroup, formed from the workshop group, provided specific technical consultation during development. An earlier draft of these guidelines was distributed to the original workshop participants and their submissions were used to prepare this final document.

In addition, the Environment Protection Authority (EPA) has taken into consideration the documents listed in the Bibliography (Section 11).

Shaded boxes throughout this draft document contain explanatory comments.

Guidelines

The *Environment Protection Act 1993* requires a duty of care for the environment. This is specified under Section 25 of the Act and states:

A person must not undertake an activity that pollutes, or might pollute, the environment unless the person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm.

Guidelines published by the EPA indicate the standard of care that is likely to be required to secure compliance with the general environmental duty as outlined in s. 25 of the Act.

They have the advantage of flexibility and can be adapted to a range of circumstances.

2 NOISE CRITERIA

The general approach in setting noise criteria for new developments is to require compliance with a base noise level.

This base noise level is typically 5 dB(A) lower than the level considered to reflect the amenity of the receiving environment. Designing new developments at a lower level accounts for the cumulative effect of noise from other similar development and for the increased sensitivity of receivers to a new noise source.

The impact of a given noise is also closely linked to the amount it exceeds the background noise. For example, the same noise in a quiet rural area will generally have a greater adverse impact than in a busy urban area because of the masking effect of high ambient noise environments.

If the noise generated does not exceed the background noise by more than 5 dB(A) the impact will be marginal and acceptable.

A unique characteristic of wind farms is that the noise level from each wind turbine generator (WTG) increases as the wind speed at the site increases. As an offset, the background noise also generally increases under these conditions and can mask the WTG noise.

Comparison with a base noise level alone will therefore not be sufficient to indicate the potential impact of a wind farm: a farm could comply with this base level at lower wind speeds but exceed it when the wind speed rises.

Most international and interstate jurisdictions (see examples below) set a base noise level for low wind speeds and also ensure that the wind farm noise does not exceed the background noise by more than 5 dB(A) as the wind speed increases.

This general approach recognises the unique noise generating characteristics of wind turbines and the particular ambient noise environments of most sites and is the one used by these guidelines.

The New Zealand Standard NZS 6808 sets the predicted base level (L_{Aeq}) at 40 dB(A). This is higher than the approach of these guidelines, but the specified propagation model to be used in accordance with that standard does not account for factors such as ground absorption and topography effects that can substantially reduce the noise level in practice. In addition, the New Zealand Standard requires the criteria to be met at all receivers, regardless of their relative amenity or relationship with the wind farm development.

A comprehensive publication developed by the wind farm industry for the UK Department of Trade and Industry (1996) sets the base level (L_{A90}) at 35–40 dB(A). The actual value chosen within this range depends on the number of dwellings affected, the effect on the capacity of the wind farm of meeting the standard, and the duration and level of exposure.

Wind turbines and wind farms have been being developed in Denmark for over 20 years. Denmark has set a base noise level only (and does not consider the influence of background noise). The base noise level (L_{Aeq}) is set at 40 dB(A) for a wind speed of V_{10m} = 8 m/s. These guidelines will provide a similar result given the expected influence of background noise.

The NSW EPA has not published specific guidelines for wind farms but has assessed a number of development applications using the same base noise level and background noise approach as these guidelines.

Most wind farm sites are within or next to areas where low ambient noise levels are a significant component of that area's amenity. These might include rural living zones or zones that are not intended to be subject to any other significant ambient noise sources from adjacent premises.

The criteria in these guidelines have been established for just such a scenario and have been developed in accordance with the objects of the *Environment Protection Act 1993* (the Act).

Where the wind farm sites are within or next to areas where more intensive activity is expected, the base noise level may also be increased commensurate with the amenity of that area. It is recommended that the developer discuss such a situation with the EPA and the relevant planning authority.

2.1 Determining wind farm operating criteria

The *Environment Protection (Industrial Noise) Policy 1994* limits the noise level from non-domestic noise sources including wind farms to 40 dB(A) or the lowest typical background noise level plus 5 dB(A) (whichever is the greater) in rural areas from 2200 hrs until 0700 hrs the following day.

This limit applies to existing noise sources and does not necessarily reflect the preferred noise criterion for new (planning) development. The general approach for new development applies a night time level of 35 dB(A) to significant development in a rural location.

To prevent adverse impacts from the increased noise of WTGs under high wind conditions, the increasing noise level must also be compared to the corresponding background noise at the relevant receiver.

2.2 Noise criteria—new wind farm development

The predicted equivalent noise level ($L_{Aeq,10}$), adjusted for tonality in accordance with these guidelines, should not exceed:

- 35 dB(A), or
- the background noise ($L_{A90,10}$) by more than 5 dB(A)

whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG.

The background noise should be as determined by the data collection and regression analysis procedure recommended under these guidelines (Section 3). It should be read from the resultant graph at the relevant integer wind speed.

2.3 Agreements with wind farm developers

Wind farm developers commonly enter into agreements with the owners of private land suitable for a wind farm site. The agreement provides the wind farm developers with the appropriate siting and generally provides the landowner with a level of compensation and diversity in their income stream.

The criteria have been developed to minimise the impact on the amenity of premises that **do not** have an agreement with wind farm developers.

Notwithstanding this, the EPA cannot ignore noise impacts on the basis that an agreement has been made between the developer and the landowner. Developers cannot absolve themselves of their obligations under the Act by entering into an agreement with a landowner.

If it is shown that a development is having an 'adverse effect on an amenity value of an area that … unreasonably interferes with … the enjoyment of the area' then appropriate action can be taken under the Act.

However, the existence of an agreement will affect the consideration of whether the interference is unreasonable in a given situation. It is unlikely that there will be *unreasonable* interference if:

- a formal agreement is documented between the parties
- the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect upon the landowner's amenity
- the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance).

A risk associated with relying on such agreements still remains where the criteria in these guidelines are **exceeded**. This is because an interpretation of 'unreasonable' is required in any future assessment of the impact of wind farm noise initiated by a complaint from the landowner (or future landowners).

2.4 Staged development

The procedure and criteria presented in these guidelines are for greenfield sites but a wind farm may be developed over a number of separate stages.

A previous stage of the wind farm that is installed and operating may raise the background noise level at the relevant receivers by up to 5 dB(A).

Any subsequent stage in the development of the wind farm site should meet the criteria using the background noise levels as they existed prior to the wind farm. Therefore, the noise generated by existing WTGs from a previous stage should not be considered as part of the background noise in determining criteria for subsequent stages.

2.5 Cumulative development

Separate wind farm developments in close proximity to each other may impact on the same relevant receiver.

Therefore, as for staged development, any additional wind farm that may impact on the same relevant receiver as an existing wind farm should meet the criteria using the background noise levels as they existed before the original wind farm site development. The noise generated by existing WTGs from another wind farm should not be considered as part of the background noise in determining criteria for subsequent development.

On occasion it will not be possible to determine the background noise levels as they existed before the original wind farm development.

This may result in subsequent developers of new wind farm sites needing to provide sufficient distance from a relevant receiver (who is common to an existing site) such that the base noise level is met at that receiver for all operating wind speeds of the WTGs (V_{10m})[1] up to 10 m/s.

[1] Refer to 3.1—Background noise

3 MEETING THE CRITERIA

This section describes the steps to be taken to assess whether the wind farm noise reaching receivers at relevant locations will comply with the criteria of these guidelines.

Background noise is measured at relevant receiver locations over continuous 10-minute intervals and particularly over the range of wind speeds at which the WTGs operate. The data must adequately represent conditions at the site and cover approximately 2000 intervals.

Wind speed is measured at 10 m above the ground and in intervals that correlate with the background noise measurements. The wind speed data, together with the manufacturer's noise data for the WTG and using a suitable model, is then used to predict noise levels at each integer wind speed from cut-in to rated power, at relevant receiver locations.

The correlated wind speed and background noise data are plotted against each other to give a standard graph for background noise at each relevant receiver. This graph is then used in conjunction with the predicted noise levels to assess whether the wind farm will meet the criteria of these guidelines.

3.1 Background noise

What is background noise?

Background noise is the 'lull' in the ambient noise environment.

Intermittent noise events such as from aircraft flying over, dogs barking, mobile farm machinery and the occasional vehicle travelling along a nearby road are all part of the ambient noise environment but would not be considered part of the background noise unless they were present for at least 90% of the time.

Why is background noise important?

Background noise can mask the noise effects of new development such as a wind farm and the level of masking is a critical factor in assessing the impact of a wind farm.

Wind generated noise can provide a good masking effect, particularly as it has similar characteristics to wind farm generated noise.

Background noise measurement locations

Background noise measurements should be carried out at locations that are relevant for assessing the impact of WTG noise on nearby premises (relevant receivers).

Relevant receiver locations are premises:

- on which someone resides or has development approval to build a residential dwelling
- at which the predicted noise level exceeds the relevant base noise level for wind speeds (V_{10m}) of 10 m/s or less
- that are representative of the worst case situation when considering the range of premises, e.g. a house located among a group of nearby houses within a residential zone.

1. A proposed wind farm site with a zone in its vicinity that is primarily for residential land use and is yet to be fully developed should be discussed with the relevant planning authority and the EPA.

   These locations will probably also be considered relevant receivers and background noise levels will be required at the zone boundary.

   The relevant planning authority can then be informed about the potential impacts on any future residential development.

   Nearby areas for which the zoning intent is not clear should also be discussed with the relevant planning authority and the EPA.

2. Background noise generally increases at a greater rate than noise from WTGs at high wind speeds. If the wind farm is predicted to achieve the base noise level at the very high wind speed of 10 m/s, 10 m above the ground (V_{10m}; see Section 3.4) the wind farm noise at even higher wind speeds is expected to be masked by the increasing background noise. Therefore the impact will not be adverse and further investigation is not required.

   The only exception is a receiver within 1500 m of the wind farm site that is in an area unlikely to be exposed to a windy environment. This specific circumstance should be discussed with the EPA.

3. The worst case situation may not always be the closest receiver to the wind farm site. The closest receiver should always be a measurement position but other locations where the background noise environment may differ due to prevailing weather patterns and/or local topography should also be included as relevant receivers.

   Background noise environments likely to differ at receivers around a wind farm site should also be discussed with the EPA.

Background noise measurement position

All measurements should be made outdoors. The microphone should be positioned 1200–1500 mm above the ground and at least 5 m from any reflecting surface (other than the ground).

The property boundary of the receiving premises is not necessarily a valid measuring position (particularly for large rural properties) unless it is likely that someone would regularly be there or the Development Plan clearly envisages noise sensitive development at such a location.

In general, any area within 20 m of a house and in the direction of the wind farm would be a valid measuring position.

Background noise levels can be significantly affected by local conditions, such as the presence of trees nearby. Where this is expected then it is recommended that photographs be taken showing the noise measurement position and associated surroundings, such as buildings, trees and topography.

This will ensure that no significant physical changes have been made to the locations between the time of the initial background noise measurements and of compliance checking.

Data collection

Equipment

Background noise levels should be collected for continuous 10-minute time intervals using sound level meters or loggers of at least Type 2 certification in accordance with Australian Standard AS 1259–1990 or IEC-61672 (International Electrotechnical Commission 2002).

The meters or loggers must be calibrated on site immediately before and after any measurement period using a calibrator complying with IEC 942 and approved by the meter manufacturer.

Type 2 certified monitoring equipment provides a sufficient level of accuracy for assessing the impact of wind farms under these guidelines.

Type 1 certified monitoring equipment will probably become commercially available in South Australia in the future, possibly sooner if an Australian Standard is prepared dealing with measurement procedures for wind farm sites. The EPA intends to modify this guideline to suit technical advancements and relevant standards/policy development.

Wind

Microphones should be protected with windshields in accordance with the microphone manufacturer's instructions, and the protection should be sufficient to ensure the noise level threshold of the monitoring equipment does not adversely affect the data used in the analysis. If microphones cannot be appropriately protected then affected data should not be collected.

As part of the development application, developers may need to confirm that the reported noise levels aren't influenced by high wind speed across the microphone, particularly where average wind speeds at the noise measurement position are expected to exceed 5 m/s (a high wind speed for the purposes of noise level measurement conditions).

Affected data can be identified by monitoring the wind speed at the noise measurement position (1200–1500 mm above ground level at the relevant receiver) over 10-minute intervals that correspond with the noise level measurement intervals. This information would then be compared with both the collected data for that interval and the manufacturer's specifications for microphone performance under those conditions.

The EPA is currently sponsoring a 12-month field trial, started in January 2003, to determine typical wind speeds at a background noise level measurement site and how these speeds relate to background noise level data. When the trials are complete the data collection procedure will be reviewed.

Rain

Rain periods during monitoring may also adversely affect the collected data. If rain was recorded in the vicinity during the collection period the developer must supply evidence that the affected data has not been used in the analysis.

The nearest weather station might not provide a sufficient indication of localised conditions in remote areas. A simple method might record rain using a local gauge or collection method that is regularly checked, and discard all data in periods where rain was detected. High sensitivity tipping rain gauges have been used overseas but they are not readily available.

Data

Data not adversely affected by the effects of wind or rain should be collected for a sufficient period to cover the range of wind speeds and directions generally expected at the wind farm site.

Particular emphasis should be placed on collecting background noise data corresponding to the operating wind speed range of the WTGs.

Sufficient data is considered to be approximately 2000 measurement intervals (or the equivalent of two weeks worth of data).

The EPA field trials will also evaluate the quantity of data required to provide reliable regression analysis and to adequately represent the expected range of conditions at the site. When the trials are complete the data collection procedure will be reviewed.

Compliance checking will require the background noise level data collection process to be repeated when the wind farm is operational (see Section 4).

Background noise varies naturally throughout the year, with different prevailing wind directions, foliage on trees, atmospheric conditions and the like.

A community concern is that the developer may measure during a limited (minimum 2 week) period that is not representative of the rest of the year.

This guideline recommends that compliance checking be repeated at different periods of the year where valid concerns exist.

The developer must collect representative background noise data. Non-compliance may result in one or a number of WTGs being stopped under certain conditions.

3.2 Wind speed measurements

Manufacturers of wind turbines publish noise level data for their machines derived through a comprehensive international measurement standard.

The noise level generated by a wind turbine increases as the wind speed driving it increases. Generally data is provided for at least each integer wind speed from cut-in speed up to rated power.

Wind speeds for the purposes of the WTG noise level data are measured at 10 m above ground level.

The noise level data for each WTG is used as the basis for predicting the total noise level from a wind farm.

Wind speed 10 m above the ground at the wind farm site and background noise at the relevant receiver must be correlated so that background noise and wind farm noise can be compared. Therefore, wind speed measurements must be made in 10-minute intervals that correlate/ synchronise with the background noise data collection.

Measurement height

The wind speed should be measured at 10 m above ground level.

A developer will often measure wind speed at different heights to determine whether wind conditions at the site are suitable for an economic wind farm development. It may be acceptable to

convert the results from a different measurement height to 10 m provided the wind shear model used to do this is clearly stated and is accepted by the EPA.

All wind speeds referred to in these guidelines and within any development application referred to a planning authority should be expressed at 10 m above ground level unless otherwise stated.

All predicted noise levels should be based on noise level data derived from wind speed measurements taken at 10 m above ground level.

Measurement location

The same location should be used for measuring wind speed and direction for all of the following procedures:

- background noise measurements
- compliance checking
- noise predictions.

Therefore the wind speed measurement location at the wind farm site should not:

- be significantly affected by the operation of the WTGs in their final location
- provide lower wind speed results than other locations on the wind farm site, where those locations will house WTGs that affect the noise level at a relevant receiver.

For large or topographically diverse wind farm sites, the suitability of the wind speed measurement location may need to be confirmed as part of the development assessment process.

3.3 Noise level prediction

Prediction locations

The noise level associated with the wind farm should be predicted at all locations identified as relevant receivers under these guidelines for each integer wind speed from cut-in speed to the speed of rated power.

> WTG manufacturers generally do not test or extrapolate tested results above wind speeds of rated power.
>
> The measurement of noise levels under high wind speeds (used to determine the sound power level of a turbine model) is difficult.
>
> Where wind farms comply with the noise level criteria in these guidelines up to rated power it is unlikely that adverse impacts will occur at higher wind speeds.

Propagation model

A suitable model must be selected (or developed) to predict the worst case noise level at all relevant receivers.

The following information should be provided as part of the development application:

- the propagation model, and any variation of the model, used for the prediction
- an estimate of the model accuracy in dB(A)

- the assumptions used as input to the model, including allowances for noise absorption due to air, ground, topographical and wind effects.

The noise level at the relevant receiver locations should be predicted allowing for the propagating effect of wind (the noise sounds louder downwind than upwind) in the direction from the wind farm to that receiver at each integer wind speed. This represents a worst case situation. (In most situations there will be different wind directions and wind speeds between each WTG on a wind farm site and the relevant receiver. These effects will reduce the actual noise level when compared to that predicted under worst case conditions.)

Noise levels should be predicted by an acoustic engineer defined for the purposes of these guidelines as an engineer who is eligible for membership of both the Australian Acoustical Society and the Institution of Engineers Australia.

The New Zealand Standard NZS 6808:1998 uses a simple propagation model that does not account for wind, ground or topographical effects, and uses a simplified approach to account for atmospheric effects.

The model is expected to predict higher than actual noise levels where topography (land rise or structure between receiver and wind farm) or ground effects (heavy foliage) are important. However, on other sites it may predict with similar accuracy to more complex propagation models because it does not account for the propagating effect of the wind.

This model can be used with limited background in acoustic engineering. If it, or a similar simple propagation model, is intended to be used, this should be discussed with the EPA. Use of such a model and input by someone other than an acoustic engineer may be acceptable where the predicted levels easily meet the criteria.

Sound power data

The sound power level can be thought of as the noise signature for the WTG model proposed for the wind farm.

The sound power level data at each integer wind speed from cut-in speed to the speed of rated power should be specified in the development application as determined in accordance with International Electrotechnical Standard IEC 61400-11.

Tonality is a characteristic that can increase the adverse impact of a given noise source and it can be determined by breaking the noise signature down into discrete frequency bands.

If tonality is a characteristic of the WTG noise, 5 dB(A) should be added to the predicted or measured noise level from the wind farm.

To help determine whether there is tonality, the method and results of testing (such as in accordance with IEC 61400-11) carried out on the proposed WTG model to determine the presence of tonality should also be specified in the development application.

At the time of development application, the contractual arrangements for which particular WTG model may not have been finalised between the developer and WTG supplier. If the WTG model to be installed differs from that assumed at the time of development application, the developer should assess and discuss the effect on the propagation model with the EPA.

The wind farm developer must also discuss changes to the type, location or operation of the WTGs with the relevant planning authority.

3.4 Data analysis

Background noise and wind speed data

At the completion of the data collection period there should be a minimum of 2000 pairs of synchronised background noise and wind speed measurements at wind speeds between the cut-in speed and the speed of rated power.

The background noise should be plotted against the corresponding wind speed measurement for each relevant receiver. It is common to plot the wind speed along the x axis and the background noise along the y axis.

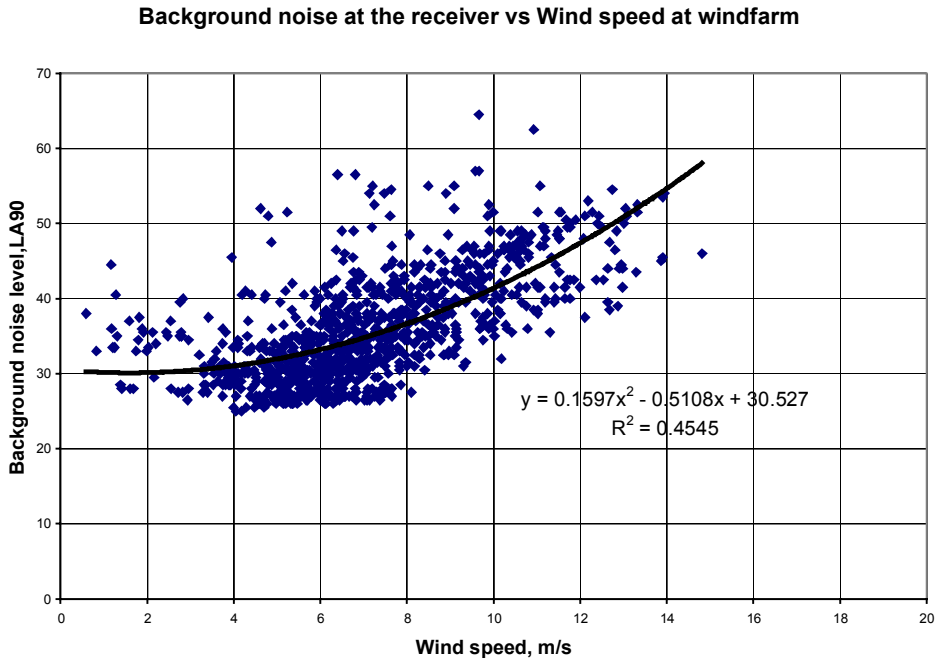
A best fit regression analysis should be carried out on the data. The polynomial order (from linear up to third order) providing the best correlation co-efficient should be used to provide the fitted regression line.

The correlation co-efficient should be specified for each polynomial order.

Data that has been collected at the extreme ends of the range of wind speeds (below and above the operating wind speeds of the WTG) can influence the slope of the fitted regression line and should not be included in the regression analysis.

The graph for each relevant receiver showing the plotted points, the fitted regression line, the polynomial describing that line and the correlation co-efficient should be included in the development application.

A typical graph is shown below for information. (In this example graph the operating speeds of the WTG are not known and thus, unlike real situations, data above and below the operating have not been removed.)



The predicted noise level should be overlaid on such a graph to determine compliance with the criteria.

4 COMPLIANCE CHECKING

It is unlikely that the worst case noise propagation conditions of the prediction procedure of these guidelines will often be repeated during operation of the wind farm. The actual impacts are therefore likely to be less than the predicted impacts.

Notwithstanding this, the prediction process relies on assumptions about a range of inputs, and the procedure given in this section for measuring the actual noise impacts is a means of confirming compliance or otherwise with the predicted impacts.

The measurement of wind farm noise is expected to be difficult due to the masking effect of the ambient noise and its influence on the base noise level descriptor (L_{Aeq}). The background noise descriptor (L_{A90}) is used to remove this effect.

In setting the compliance checking criteria, the cumulative pre-existing effect of the background noise and the wind farm noise, and the level of accuracy of the measurement procedure have been considered.

4.1 Procedure

Compliance checking follows a similar procedure to compliance prediction (Section 3).

Ambient noise levels with the wind farm operating are measured at relevant receiver locations, over continuous 10-minute intervals and over at least the range of wind speeds at which the WTGs operate. The data must cover approximately 2000 intervals.

Wind speed is measured at 10 m above the ground and in intervals that correlate with the ambient noise measurements.

Compliance checking should collect data associated with the worst case wind direction from the wind farm to the relevant receiver. A wind direction spread of 45 degrees either side of the direct line between the nearest WTG and the relevant receiver is considered acceptable (International Electrotechnical Commission 1998, 1(j) p9). This will not always be practical, given prevailing wind conditions.

Cases in which it appears to be impractical to collect 2000 data points under worst case wind direction conditions or in which all WTGs are not operating, should be discussed with the EPA.

4.2 Data analysis

Regression analysis should be repeated on the ambient noise and wind speed measurement data using the same polynomial order regression formula as for Section 3.5. The correlation co-efficient should be specified in the compliance checking report.

Data below the cut-in speed and above the speed for rated power should not be included (see Section 3.5).

A graph should be prepared for each relevant receiver showing the plotted points, the fitted regression line, the polynomial describing that line and the correlation co-efficient in the compliance checking report.

In addition, the graph should have the criteria determined in accordance with these guidelines superimposed.

4.3 Criteria

The ambient noise level ($L_{A90,10}$) measured in accordance with the compliance checking procedure and determined by the regression analysis procedure should be read from the resultant graph at

the relevant integer wind speed. It should then be adjusted for tonality in accordance with these guidelines and should not exceed:

- 35 dB(A), or
- the pre-existing background noise by more than 5 dB(A)

whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power.

4.4 Tonality

Where, in the opinion of an officer authorised under the Environment Protection Act, the wind farm exhibits tonality as a characteristic, the developer should conduct a tonality test in accordance with a procedure acceptable to the EPA.

An addition of 5 dB(A) should be made to the measured background noise level from a wind farm where tonality is shown to be a characteristic.

4.5 Annoying characteristics

These guidelines have been developed with the fundamental characteristics of noise from a wind farm taken into account. These include the aerodynamic noise from the passing blades (commonly termed 'swish') and the infrequent and short-term braking noise.

However, annoying characteristics that are not fundamental to a typical wind farm should be rectified. Such characteristics may include infrasound (low frequency noise below the audible frequency range that manifests as a rattle in lightweight materials such as glass) or adverse mechanical noise (perhaps generated as a failure of a component).

Infrasound was a characteristic of some early wind turbine models that has been attributed to early designs in which turbine blades were downwind of the main tower—the turbulence generated around the tower was cut through by the blades, generating this effect.

Modern designs generally have the blades upwind of the tower. Wind conditions onto the blades and improved blade design minimise the generation of the effect. The EPA has consulted the working group and completed an extensive literature search but is not aware of infrasound being present at any modern wind farm site.

4.6 Excessive noise

The operation of the wind farm should comply with the criteria at all relevant receivers[2]. The extent of relevant receivers should not be confined to those identified during the development assessment stage.

The EPA can require the developer to repeat the compliance checking procedure if it receives any complaint that may be valid about an unreasonable interference on those premises from noise impacts.

An Environment Protection Order as provided under s. 93 of the Environment Protection Act may be issued by the EPA to secure compliance with the criteria in these guidelines.

This may mean that the operation of certain WTGs would be restricted under certain wind speed conditions.

[2] See shaded panel

The EPA recognises that measurements in a windy environment are technically difficult and subject to variation. Exceeding the compliance checking criteria may be the result of varying background noise, rather than of excessive wind farm noise.

It is expected that there will be natural variations in background noise throughout the year[3], with different prevailing wind directions, foliage on trees, atmospheric conditions and possibly with changes to local conditions such as buildings, trees or topography that may affect compliance with the criteria. Where this may be the case, the onus of responsibility for proof resides with the developer.

A range of alternative compliance checking procedures, such as those detailed in the Clause 6 of the International Energy Agency recommended practices (1997), can remove the influence of background noise to accurately determine the wind farm noise in isolation.

[3] The EPA field trials are expected to provide information on the extent of variation of the background noise. When the trials are complete the compliance checking procedure will be reviewed.

5 DOCUMENTATION

Development applications for wind farms are often referred to the EPA by the relevant planning authority for assessment of the environmental noise impact.

The draft Planning SA Bulletin at the time of drafting these guidelines indicates that the referral may become formal by adding wind farm developments as a scheduled item in the *Development Act 1993*.

If it appears likely that the criteria under these guidelines will be approached, developers should discuss the development with the EPA before submitting the application to ensure they provide all relevant information.

All relevant information on the noise impacts must be included with the application. Possible information requirements are summarised below.

5.1 Predicted noise from the wind farm

(a) make and model of WTGs to be used, including hub height

(b) one third octave band sound power levels and associated wind speed of WTGs to be used

(c) positions of all WTGs

(d) positions of all affected premises within 1.5 km of any WTG, noting which premises are part of the development and which are not

(e) distance of all affected premises in d above from nearest WTG

(f) description of the zone category for all receivers in (d), as outlined in the relevant Development Plan under the *Development Act 1993*

(g) predicted noise levels for those premises in (d) for worst case wind direction and over the operating wind speed range of the WTGs

(h) the model used and the method for deriving the noise levels in (g)

(i) amount of noise reduction, if any, allowed for acoustic screening to estimate the levels in (g)

(j) topographical map of wind farm and affected premises showing contour lines

(k) location of wind measuring position(s) used for noise assessment and compliance purposes.

5.2 Measurement and assessment

(a) description of noise measuring equipment used, including make, model and type and including type and model of windscreen used for the microphone

(b) noise measurement position including height above ground, wind speed (at the noise measurement position) and distance to nearest building structure

(c) description and photograph of measurement position showing nearby trees and building structures

(d) atmospheric conditions at the wind farm including wind speed and direction

(e) time and duration of monitoring

(f) sampling time for wind and noise measurements

(g) number of data pairs measured (wind farm speed and background noise level)

(h) description of regression analysis method

(i) graphical plot of data in Section 5.1 (g) above and regression curve

(j) correlation co-efficient for regression curve

(k) graphical plot and corresponding tabulated data analysing predicted noise levels and criteria against integer wind speeds.

5.3 Compliance checking

(a) description of all noise monitoring equipment, including type of microphone wind protection used

(b) noise monitoring position(s)

(c) photographs of noise monitoring position taken before the wind farm was installed (at the noise modelling stage) and at the time of compliance checking, showing the noise measurement position and associated surroundings, such as buildings, trees and topography

(d) description of wind speed and direction measuring equipment used and the location on the wind farm, including height above ground level

(e) description of wind speed measuring equipment used for the purposes in Section 5.2

(f) details of which WTGs were operating during compliance check

(g) atmospheric conditions

(h) time and duration of monitoring period

(i) list of all monitored data showing wind speed, wind direction and noise level

(j) graphical plot and tabulated data overlaying line of best fit and criteria against integer wind speeds

(k) noise level at target and WTG cut-in speeds

(l) assessment of any audible annoying noise characteristics

6 GLOSSARY

A-weighted: frequency weighted as specified in Australian Standard AS 1259–1990 noise level meters or its replacement.

Authorised officer: a person appointed to be an authorised officer under Division 1 of Part 10 of the *Environment Protection Act 1993.*

Ambient noise: the total noise in a given environment.

Background noise: ambient noise, in the absence of the noise under investigation, measured using time weighting 'F', that is equalled or exceeded for 90% of the measurement time interval. Expressed as $L_{A90,T}$, where T refers to the measurement time interval in minutes.

Base noise level: means an $L_{Aeq,10}$ of 35 dB(A) unless otherwise stated.

dB(A): the noise level in decibels, obtained using the 'A' weighted network of a noise level meter as specified in Australian Standard AS 1259–1990 Noise Level Meters or its replacement.

EPA: Environment Protection Authority.

Equivalent noise level: the equivalent continuous A-weighted sound pressure level obtained using time weighting 'F', over the measurement time interval. Expressed as $L_{Aeq,T}$, where T refers to the measurement time interval in minutes.

Extraneous noise: noise from animals, excessive wind effects, insects, birds, aircraft or unusual traffic conditions or any other infrequently occurring component of the ambient noise.

Impulsive noise: noise containing impulse components as part of its characteristics, comprising a single pressure peak, or sequence of such peaks, or a single burst with multiple pressure peaks, whose amplitude decays with time, or a sequence of such bursts.

Low frequency noise: a noise with perceptible and definite content in the audible frequency range below 250 Hz.

Measurement place: a place at the receiver where the noise level is to be measured.

Noise source: premises at which an activity or process is undertaken that results in the emission of noise.

Predicted noise level: the $L_{Aeq,10}$ wind farm noise level at a receiver predicted in accordance with these guidelines.

Premises: any land, or the whole or part of a building or structure.

Prevailing background noise level: the background noise level derived from regression analysis of the background noise data.

Receiver: premises that may be affected by the noise source, other than premises on the same land as the noise source.

T: measurement time interval; taken to be 10 minutes unless stated otherwise.

Tonal noise: noise with perceptible and definite pitch or tone.

$\mathbf{V_{10m}}$: wind speed measured in metres per second (m/s) at the wind farm site at 10 m above the ground.

WTG: wind turbine generator.

Wind farm: a group of WTGs installed in the same region and all operated by the same operator. It is not necessary that all WTGs are located on the same premises.

Zone: an area of land delineated as a zone, precinct or otherwise in the relevant Development Plan under the *Development Act 1993*, that is subject to a set of land use rules under that Plan.

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[Standards Australia provides access to Australian and New Zealand Standards, and standards and guidelines from the International Electrotechnical Commission and International Energy Agency.]