Planning guidance

State code 23: Wind farm development

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1.0 Introduction

1.1 Purpose of the guideline

The purpose of this guideline is to assist applicants in preparing development applications for new wind farms or changes to existing approvals. The guideline will assist applicants in preparing ‘decision ready’ applications responding to the performance outcomes of State code 23: Wind farm development of the State Development Assessment Provisions (SDAP). It also includes detailed methodologies for the following technical assessments:

- ecological assessment
- noise impact assessment and noise monitoring
- electromagnetic interference impact assessment
- shadow flicker assessment.

This guideline is periodically reviewed as experience is acquired through construction of projects and updated information and technology around wind farms emerges.

This guideline is advice that only applies to a development application for a material change of use for wind farm development, applied for under the *Planning Act 2016* (the Planning Act).

Following this guideline will assist applicants to optimise project layouts and site design and to support applications with relevant reports, plans and documents. Use of this guideline by applicants will not guarantee assessment outcomes. SARA will undertake its own assessment of an application and supporting material in reaching its assessment manager decision.

1.2 Wind farm definition

The Planning Regulation 2017 (the Planning Regulation) defines a wind farm as follows:

Wind farm

a) *means the use of premises for generating electricity by wind force, other than electricity that is to be used mainly on the premises for a domestic or rural use; and*

b) *includes the use of premises for any of the following, if the use relates, or is ancillary, to the use stated in paragraph (a)—*

   i. *a wind turbine, wind monitoring tower or*

   ii. *anemometer;*

   iii. *a building or structure, including, for example, a site office or temporary workers’ accommodation;*

   iv. *a storage area or maintenance facility, including, for example, a lay down area;*

   v. *infrastructure or works, including, for example, site access, foundations, electrical works, substations or landscaping.*

A wind turbine means a machine or generator that uses wind force to generate electricity and includes the blades of the machine or generator.

1.3 SARA assessment

SARA is the assessment manager for all wind farm development applications.

Wind farms can be made as either code or impact assessment applications. A development application for a wind farm will be subject to code assessment if:

- all wind turbines for the wind farm are at least 1500 metres from a sensitive land use on a non-host lot; or
- one or more wind turbines for the wind farm is less than 1500 metres from a sensitive land use on a non-host lot and the owner of the non-host lot has, by deed, agreed to the turbines being less than 1500 metres from the sensitive land use. See section 45 of the *Property Law Act 1974* for the formal requirements for deeds executed by individuals.

If a development application does not qualify to be code assessable, it will be subject to impact assessment.

A material change of use for a wind farm is required to be assessed against State code 23: Wind farm development of SDAP. The wind farm development may also trigger assessment against other state codes within SDAP, for example State code 16: Native vegetation clearing.

1.4 Other approvals

There may be additional statutory requirements under the Planning Act, the Planning Regulation and other applicable legislation. Subsequent development applications (for example, operational works or building works applications) may also be required by a local government, SARA or another entity as prescribed under the Planning Regulation.

Further approvals or permits may also be required from a range of entities including local authorities, the Commonwealth Government, the state-owned network service provider and air services stakeholders.

Although some of these other approvals are identified throughout this guidance document, they should not be taken to be the full extent of other approvals that may be required for a specific proposal. The onus rests with applicants/proponents to determine and seek all relevant approvals prior to commencing construction of a project.

2.0 Pre-lodgement

It is highly recommended applicants seek pre-lodgement advice from SARA prior to lodging a development application.

Pre-lodgement advice can assist applicants in determining appropriate SARA triggers, understanding the requirements of the relevant SDAP codes and ascertaining SARA's preliminary views on the acceptability of site layouts. Advice on technical assessments, reports and methodologies to be used will also be provided as part of pre-lodgment advice.

Before requesting pre-lodgement advice from SARA, it is strongly recommended that the applicant consults with the following stakeholders on proposed project layouts:

- The state-owned network service provider (Energy Queensland) and the transmission provider (Powerlink Queensland). This is to ensure that the wind farm can ultimately be appropriately connected to the existing electricity grid. Refer to the Australian Energy Market Commission's (2014) National Electricity Rules Chapter 5: Network Connection, Planning and Expansion for further details. Consultation is also necessary to achieve safe setbacks from electricity lines to ensure security of strategic transmission corridors. Refer to the Energy Networks Australia (ENA) Guideline for Wind Turbines Proximity to Electricity Transmission Lines (ENA DOC 047-2022) for further details.
- Air services stakeholders (including Airservices Australia, Department of Defence, and all nearby air services aerodrome operators). This will ensure that risks to air services associated with the proposed wind farm are appropriately considered. The consultation should also include the relevant local government if they are responsible for operating any regional airports or aerodromes.
- Consultation with air services stakeholders should also consider possible electromagnetic interference impacts on existing radar, radio and telecommunication infrastructure. If the site is located within one kilometre of any telecommunications site, consultation with the infrastructure owner should also be undertaken to discuss any near-field effects on transmitting or receiving antennas.
- The relevant local government/s to ascertain views in relation to impacts of construction haulage on local roads, impacts of construction workforce accommodation and the council's views on suitability of accommodating workers in existing townships, construction supply chain capacity issues, broader social and economic issues that the project may cause on local communities. Councils can also advise on additional approvals (e.g. operational works, building works, reconfiguration of a lot, road access/driveway permits etc.) that might be required for the project and ancillary uses.
- The local community to help build social licence and community acceptance of the project. The Clean Energy Council's Community Engagement Guidelines for the Australian Wind Industry provides detailed guidance on conducting community engagement activities. One of the four local benefits principles underpinning Queensland Renewable Energy Zone development is 'genuine and ongoing engagement' and is a useful tool to help guide meaningful consultation with the community. Community stakeholders have become

increasingly critical of the fact that most wind farms are code assessable and therefore proponents have no statutory requirement to consult. Proponents are strongly encouraged to proactively engage with local communities prior to lodging a SARA application as well as during the assessment of an application.

- Department of Energy and Public Works to discuss alignment of the proposed wind farm with Queensland's energy policy objectives and longer-term infrastructure planning activities.
- Department of Resources, Land and Surveying Services to confirm the land tenure status. Under Section 199A of the *Land Act 1994*, a lease may only be used for its designated purpose. If a host lot is under a lease arrangement the wind farm use may not be consistent with the purpose of the lease for the lot and will need to be amended. Department of Resources will also advise if the project requires a S22A Relevant Purpose determination to lodge a material change of use application to SARA
- If the applicant considers that the vegetation categories or Regional Ecosystems are mapped incorrectly, it is recommended an application be made to amend the mapping prior to submitting a development application. Mapping can be amended through applying for a detailed Property Map of Assessable Vegetation (PMAV). Further information on how to apply for a PMAV is available online at https://www.qld.gov.au/environment/land/management/vegetation/maps/map-correction.

3.0 SDAP Assessment

This part of the guideline provides further details on the information that is required to support compliance with the purpose and performance outcomes of State code 23: Wind farm development.

Advice contained in this part of the guideline is the minimum required to respond to the code. Applicants are encouraged to provide additional material in support of aspects of a project that may be contentious or particularly challenging.

3.1 Meeting performance outcomes: Protecting areas of high environmental value and minimising environmental impacts

Context

The construction of wind farms necessitates the clearing and civil works construction of significant access tracks, turbine pads, laydown areas and ancillary infrastructure. Medium to large sized wind farms can involve several hundred linear kilometres of clearing and earthworks due to the spacing required between turbines. Wind farms must be designed and sited to achieve compatibility, not conflict, with habitats of threatened species and areas of high ecological value. Large scale interventions in natural landscapes should avoid these highly sensitive areas wherever possible.

Areas to be cleared for construction purposes will be required to be rehabilitated to the maximum extent possible.

The operations of a wind farm must also consider impacts on birds and bats including the migratory routes of certain bird species. The location and migratory paths of bird and bat populations or species should influence site layouts and turbine locations to minimise impacts during the operational life of the project.

Supporting action – PO1

An **ecological assessment report** must be provided to support how the project complies with PO1.

The report must identify and assess any risks to flora, fauna and associated habitat, including how highly sensitive parts of the site have been avoided and how these risks will be mitigated or managed through the design, siting and operation of the wind farm. The following information must be included in the report:

- on-site vegetation and corridors, including worst case scenario impacts to regulated vegetation and identified significant vegetation (for example, where a project layout includes a level of flexibility to allow for final micro-siting). Significant vegetation may include mapped or identified habitat for threatened species, threatened vegetation and other sensitive ecological matters such as those described as Matters of State Environmental Significance (under the Queensland *Environmental Offsets Regulation 2014*) and threatened species as outlined in the *Nature Conservation Act 1992*

- evidence as to how habitats of **threatened species** and other areas of high environmental value have been avoided
- bird and bat flight paths or behaviour and how these have been factored into the layout of turbines to minimise adverse impacts
- significant fauna habitat and potential fauna movement corridors and how impacts on these have been minimised
- the ecological assessment should include a detailed draft vegetation and fauna management plan, a detailed draft cleared vegetation management plan and a detailed draft bird and bat management plan
- the ecological assessment should include a detailed draft progressive rehabilitation plan detailing on-site rehabilitation works for the life of the development (i.e. construction until decommissioning is complete).

Methodology

Refer to **Appendix 1 – Ecological assessment methodology** for further information on how to prepare an ecological assessment for PO1.

Other approvals

Where clearing of vegetation is unavoidable, it is the applicant's responsibility to ensure all relevant approvals and permits are obtained, including under the *Planning Act 2016*, the *Vegetation Management Act 1999,* the *Nature Conservation Act 1992* and the *Environment Protection and Biodiversity Conservation Act 1999.*

Supporting action – PO2

Where SARA is of the view that an application has complied with PO1, conditions of approval will require the preparation of detailed flora and fauna management plans as well as detailed plans for managing cleared vegetation prior to commencing construction.

Supporting action – PO3

Where SARA is of the view that turbine layouts do not pose an unacceptable risk to bird and bat movements, conditions of approval will require the preparation of a bird and bat management plan prior to commencement of operations.

Supporting action – PO4

Proponents are required to replant and restore areas cleared for construction that are not required to be retained as cleared for the operations of the wind farm. This will include all areas cleared for temporary uses such as workers accommodation sites, concrete batching plants, construction site offices and construction laydown and materials storage areas. Those parts of the cross sections of access tracks that were cleared in order to establish the tracks and facilitate construction but are not required to remain cleared during operations and normal maintenance of the wind farm, will need to be replanted. This replanting will assist with the requirement to stabilise the site following construction to minimise ongoing erosion and sediment run off.

Applicants need to provide a preliminary rehabilitation/restoration plan to demonstrate how PO4 will be complied with. This plan should provide a framework outlining how the rehabilitation will be managed broadly across the site following construction. This plan should outline:

- rehabilitation principles that will guide detailed rehabilitation strategies across the different types of areas to be rehabilitated
- evidence of commitment to re-establishing native eco-systems and long term self-sustainability of restored areas
- proposed approaches to rehabilitation and replanting to be deployed over different cleared typologies including the various track cross sections, areas around turbine pads and layover, areas cleared for temporary ancillary infrastructure etc
- proposed approaches to management, monitoring and reporting of replanting and restoration efforts over time.

Conditions of MCU approval will require the preparation of detailed replanting/rehabilitation plans prior to the finalisation of construction. These detailed plans will need to be prepared having regard to the preliminary rehabilitation plan that may be approved with the MCU.

3.2 Meeting performance outcomes: Natural drainage patterns

Context

Given their extensive footprints, most wind farms impact on natural watercourses and drainage lines in the landscape. Watercourses and crossing points can require extensive modification to accommodate vertical curves required for heavy and long construction haulage vehicles. Impacts on watercourses need to be considered from a catchment perspective. Watercourse networks that feed into important rivers and waterbodies are highly sensitive, as are catchments that ultimately discharge to the coastline north of Bundaberg. Run off into these catchments has the potential to harm the Great Barrier Reef.

Site layouts need to be mindful of sensitive watercourse and crossing points and need to consider if impacts from interventions can be appropriately managed. Impacts that need to be considered include whether the watercourse is associated with sensitive, threatened and/or important species such as frogs. The realistic ability to manage erosion and run off at watercourse intervention points needs to be considered during site layout. Consideration must be given to the consequences arising from a failure of erosion management and sediment control devices associated with prominent watercourses. If such a failure would result in significant to catastrophic impacts on the watercourse, then proponents must reconsider site layouts to avoid this level of risk.

All clearing and civil works associated with wind farm construction needs to be managed to minimise adverse impacts on natural drainage patterns on site.

Supporting action – PO5

Provide a **site plan** that identifies the extent of clearing of vegetation proposed within any mapped or unmapped waterway (being a river, stream, watercourse, drainage feature or inlet of a sea).

Provide evidence that all proposed interferences with natural drainage patterns and watercourses will not result in unacceptable impacts on receiving waterways and catchments.

Conditions of approval will require the preparation of a detailed stormwater management plan prior to the commencement of operations of the wind farm. This plan will be informed by detailed post-construction site stabilisation plans and detailed replanting/restoration plans.

Other approvals

Approving a material change of use for a wind farm does not preclude the need for proponents to determine whether a separate development application under the Planning Act, or compliance with the Accepted Development Requirements for operational works that is construction or raising waterway barrier works, is required. Further information on what constitutes a waterway barrier work is available through the Department of Agriculture and Fisheries website.

3.3 Meeting performance outcomes: Protecting water quality and erosion control

Context

The construction of a wind farm and its associated infrastructure necessitates significant vegetation clearing and earthworks. Wind farms typically take several years to be constructed. During this time extensive areas of access tracks, turbine pads and laydown areas are exposed and unvegetated. To avoid detrimental impacts on watercourses and catchments it is critical that wind farms under construction manage erosion and run off to a high standard.

Consideration needs to be given to the level of risk and hazard from an erosion perspective in the preparation of site layouts. An **erosion risk assessment** should be done to inform site layouts and should also be submitted to SARA for assessment. If the project is approved, conditions attached to the material change of use will require the preparation of a detailed **erosion and sediment control plan** prior to commencing construction. This plan must then be rigorously implemented throughout construction and subsequent site activities.

Supporting action – PO6 – PO8

An **erosion risk assessment**, using the Revised Universal Soil Loss Equation (RUSLE) should be undertaken to inform the site layout prior to lodgment of an application (Renard, Foster, Weesies, McCool, and Yoder, 1997). The assessment should consider elements such as slope, soil dispersivity, erosivity and rainfall frequency. This assessment should be used to determine if parts of a site layout, even if treated with erosion control devices, pose an unacceptable risk during construction to receiving waterways and catchments. Site layouts should be modified to ensure that all proposed areas of disturbance can be appropriately managed during and after construction.

The **erosion risk assessment** submitted in support of the application should highlight any aspects of project construction that will require particular erosion and hazard management techniques and treatments. This could include soil, groundwater or surface waterbody data collection in areas that could be impacted by sedimentary movement. If supported by SARA, this assessment will form part of conditions of approval that will require a detailed erosion and sediment control plan to be prepared prior to commencing construction.

3.4 Meeting performance outcome: Natural hazards and extreme weather events

Context

Wind farms are typically located in remote areas that can be exposed to natural hazards such as flooding and bushfires and, in some cases, extreme weather events such as cyclones. The construction of wind farms involves significant numbers of people spread over large areas. Plans and strategies need to be in place to ensure the safety of workers in the event of natural hazards or extreme weather events occurring.

Supporting action – PO9

Site layouts are required to be informed by an assessment of natural hazard risk**.** This assessment should demonstrate that all parts of the site layout would be resilient to the risks posed by natural hazards and extreme weather events that could affect the site.

Conditions will be imposed on approved applications requiring the preparation of detailed bushfire management plans and safety and emergency management palns to ensure that construction and operational workforces are appropriately protected.

3.5 Meeting performance outcomes: Acoustic amenity

Context

Wind farm developments are typically sited in areas with low ambient acoustic levels. These areas typically have unique noise generating characteristics, including output that varies with wind speed and turbine location. The noise characteristics associated with wind farms are generally described within two categories:

- **Mechanical noise** which is produced from the gearbox and generator, bearings, yawing mechanism and blade pitch control mechanism in the nacelle and hub. Mechanical noise from modern wind turbines is not generally a dominant source of emitted noise.
- **Aerodynamic noise** which is noise produced by air passing over the blades of the wind turbine. Aerodynamic noise can be divided into four generation mechanisms: inflow turbulence, tip noise, trailing edge noise and blade tower interaction. Trailing edge noise is generally the most significant wind turbine blade noise source.

Noise generation associated with wind farm developments is complex. Audible acoustic emissions must be considered and modelled during the development assessment process. This guideline presents best practice noise criteria, as well as the methodology for assessment of wind farm noise. The applicable acoustic criteria have been established based on national and international best practice, including a detailed review of the various standards, guidelines and frameworks in place throughout Australia, New Zealand and abroad.

Acoustic criteria

State code 23: Wind farm development, includes separate acoustic criteria for host and non-host lots. Where reference to ‘existing or approved sensitive land uses’ is included, this is taken to be at the time of lodgement of the application.

Host lots

A host lot (also commonly referred to as host property) means a parcel of land that accommodates any part of a wind farm development. Host lots will either be owned by the proponent or will be subject to a formal agreement between the landowner and the proponent, to host the wind farm on the land. Owners of host lots will need to provide owner’s consent for the development application to be properly made and lodged with the department for assessment.

The acoustic criteria for the predicted acoustic level at sensitive land uses on host lots is listed in Table 1.

Table 1 Acoustic criteria for host lots

Noise characteristic	Time of day	Acoustic level does not exceed
Predicted[1] outdoor (free-field) A-Weighted equivalent acoustic level (L_{Aeq}), assessed at all noise affected existing or approved sensitive land use(s)	Night (10 pm – 6 am)	a. 45 dB(A), or b. the background noise (L_{A90}) by more than 5 dB(A), whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

[1] Predicted by noise modelling carried out using the sound power levels of the proposed turbines in accordance with the methodology contained in Appendix 2 – Noise impact assessment methodology.

The 45 dB(A) or 5 dB(A) above the background noise level described in Table 1 has been established to ensure the health and safety of individuals and the community, regardless of whether the landowner is receiving a financial benefit. The approach is consistent with that taken in other states and the recommendations of the World Health Organisation's (1999) Guidelines for Community Noise, which specifies 45 dB(A) outside bedrooms with windows open, to protect against sleep disturbance.

Despite the above, agreements with landowners to host turbines must be an informed consent and must specify the predicted acoustic levels at all sensitive land uses on the property, and the setbacks from turbines to sensitive land uses.

To allow the wind farm to operate for the entirety of its projected lifespan, agreements with landowners must be maintained if the host lot is sold or leased.

Non-host lots

A non-host lot (also commonly referred to as non-host property) means a parcel of land that does not accommodate any part of a wind farm development. Non-host lots will either adjoin, or be near, the host lots containing the wind farm. Sensitive land uses on non-host lots are subject to more stringent acoustic criteria, unless a deed is agreed between the owner of the non-host lot and the proponent, with the owner of the non-host lot accepting increased acoustic levels and/or reduced setbacks from turbines at their respective sensitive land uses.

The acoustic criteria for the predicted acoustic level at sensitive land uses on non-host lots is listed in Table 2.

Table 2 Acoustic criteria for non-host lots

Noise characteristic	Time of day	Acoustic level does not exceed
Predicted[2] outdoor (free-field) A-Weighted equivalent acoustic level (L_{Aeq}), assessed at all noise affected existing or approved sensitive land use(s)	Night (10 pm – 6 am)	1. 35 dB(A), or 2. the background noise (L_{A90}) by more than 5 dB(A),
		whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.
	Day (6 am – 10 pm)	1) 37 dB(A), or
		2) the background noise (L_{A90}) by more than 5 dB(A),

	whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

The prescribed acoustic criteria described in Table 2 has been developed to minimise the impact on the amenity of noise affected existing or approved sensitive land use(s). The criteria must be achieved at the sensitive land uses of non-host lots unless a deed of release is negotiated and agreed between the owner of the non- host lot and the proponent.

A deed of release allows non-host lot owners to accept a reduced setback (relating to the applicable level of assessment) and/or agreed acoustic levels at their sensitive land uses. To ensure it is an informed consent, the deed of release must clearly articulate the agreement between parties, including the following information where applicable:

- the agreed setback distance, where less than 1,500m, between turbines and sensitive land uses
- the agreed predicted day and night acoustic levels at sensitive land uses
- explanation of the proposed variation to acoustic levels (departure from the criteria stated in Table 2) and any expected or potential impacts to amenity at the non-host lot owner's sensitive land use(s).

Despite the above, and as previously outlined, an outdoor nighttime acoustic level of more than 45 dB(A) or 5 dB(A) above the background noise level at a sensitive land use is not considered suitable due to the potential for sleep disturbance (World Health Organisation, 1999) and will unlikely be accepted. Achieving this minimum level of protection is vital in protecting the health and safety of individuals and the community.

To allow the wind farm to operate for the entirety of its projected lifespan, agreements with landowners with respect to acoustic levels and setbacks must be maintained if the non-host lot is sold or leased.

Supporting action – PO10 and PO11

The following action is required to demonstrate compliance with PO10 and PO11:

- submit a noise impact assessment which demonstrates compliance with the prescribed acoustic level in Table 23.2 (for PO10) and Table 23.3 (for PO11) of State code 23: Wind farm development. The report must be undertaken by a suitably qualified acoustic consultant who is an RPEQ or is eligible for membership in the Australian Acoustical Society or whose firm is a member of the Association of Australasian Acoustical Consultants (AAAC). The noise impact assessment must:
  - consider impacts on existing or approved sensitive land uses (at the time of lodgement)
  - include noise modelling and predictions of free-field acoustic levels at all existing or approved sensitive receptors

- refer to **Appendix 2 – Noise methodologies** for further information on how to prepare a noise impact assessment.

Operational noise monitoring

Should a wind farm development be approved, SARA will apply conditions of approval in relation to the noise criteria of the code. The conditions of approval will require that the proponent undertake operational noise monitoring within the first 12 months of the wind farm being fully operational. The conditions will also require the submission of a range of associated reporting, including a noise monitoring plan, noise monitoring reports and an operational regime/strategy. The results of operational noise monitoring will be used for determining compliance with the noise criteria in the code and any conditions of approval.

Although operational noise monitoring does not form part of the assessment of a wind farm development application, it is important to understand the noise monitoring methodology to be used for operating wind farms in Queensland. This methodology is used by SARA when preparing and applying conditions of approval.

3.6 Meeting performance outcomes: Electromagnetic interference

Context

Wind turbines can block, reflect or refract electromagnetic waves affecting microwave, television, radar or radio transmissions and reception through Electromagnetic Interference (EMI). They can also on-transmit or scatter radio communication signals.

Supporting action – PO12

A preliminary EMI assessment report should be lodged to demonstrate how PO12 can be complied with. This report should outline all potential EMI impacts that could arise from the wind farm and demonstrate how these impacts can be acceptably managed through mitigation and/or management measures. Refer to **Appendix 3 – Electromagnetic interference impact assessment methodology** for further details on how to prepare the preliminary EMI impact assessment.

Conditions of approval will require the preparation of a detailed EMI report, prior to commencement of operations, outlining mitigation and operational management measures that need to be implemented to ensure that wind farm operations do not cause unacceptable EMI impacts.

Suggested further information

The Australian Communications and Media Authority database can assist in identifying communication services in a relevant area.

A search of the Australian Mobile Telecommunications Association's Radio Frequency National Site Archive database (RFNSA) provides information on Australian base stations, including electromagnetic energy reports, site locations and carrier contact details for existing sites.

3.7 Meeting performance outcomes: Shadow flicker

Context

The rotating blades of wind turbines can cast intermittent shadows that appear to flicker to an observer at a fixed ground position. Given the height of wind turbines, shadow flicker can be observed at considerable distances. Shadow flicker may occur in certain geographical positions at a particular time of day. For example, when the sun passes behind rotating blades of a wind turbine and casts a moving shadow over neighbouring areas. Shadow flicker from wind turbines can impact on the amenity of urban and rural development by creating a 'strobing' shadow effect.

- **Supporting action – PO13**

A shadow flicker assessment report should be submitted to demonstrate how PO13 can be complied with. This report should be prepared using the methodology outlined in **Appendix 4 – Shadow flicker assessment.**

3.8 Meeting performance outcomes: Social impacts

Context

The scale and nature of wind farm development results in extended construction times and typically requires a construction workforce beyond what is available in the local area. This can lead to proponents proposing large accommodation camps for construction workers on-site. PO14 is applicable where construction workers accommodation of greater than 50 beds is proposed on site during construction of the wind farm. In these situations, applicants must consider the impacts of workers accommodation facilities and have regard to implications for existing townships and communities in reasonable proximity.

Supporting action – PO14

Applications that propose construction workforce accommodation of greater than 50 beds on-site need to prepare a **construction worker's accommodation options report** to demonstrate how PO14 is proposed to be complied with. The **construction worker's accommodation options report** should outline the methodology used and options considered to justify the proposed on-site construction workers accommodation facility. The methodology used in the report needs to have regard to the relevant principles for energy transformation contained in the Queensland Energy and Jobs Plan, September 2022.

The report should include but not be limited to the following information:

- the expected number of construction workers to be accommodated during different phases of construction
- the expected construction period for the wind farm
- an assessment against selected key matters in the Queensland Government 'Social Impact Assessment Guideline' (Queensland Government, 2018), including:
    - community and stakeholder engagement – include details of the community and stakeholder engagement to be undertaken and details of the ongoing engagement proposed during construction
    - workforce management – include details of the workforce profile for the construction phases, including an analysis of the local and regional labour markets, an assessment of opportunities for local workers
    - health and wellbeing – include an analysis of the availability and accessibility to healthcare and emergency services for the proposed construction workforce
- details of any consultation and/or agreements with the local government
- an assessment of positive and negative implications of using and/or supplementing accommodation options in existing townships/communities. This analysis should explore the implications of all, or part, of the workers accommodation being located in exiting townships and should address: the availability of existing accommodation options; implications of commuting on local roads and implications of commuting distances and times from a workplace health and safety perspective
- if the options analysis recommends on-site construction workers accommodation of greater than 50 beds, further details need to be provided to demonstrate how the facility can be suitability delivered and managed on the site. These details should include:
    - a preliminary waste management plan outlining: relevant legislative requirements and how these will be met; how all waste streams generated at the facility will be managed and particular details in relation to sewage treatment. If on-site sewage treatment is not proposed, details must be provided that demonstrate that relevant local governments have been consulted and are supportive of off-site sewage disposal options
    - proposed strategy for servicing the facility with potable water. Specific details can be pursed following approval, but the lodged application needs to provide a level of confidence that, if approved, potable water can be viably supplied to the facility.

Further information on Social Impact Assessments can be found in the Queensland Government 'Social Impact Assessment Guidelines', March 2018 (Queensland Government, 2018).

3.9 Meeting performance outcomes: Areas identified by state or local government planning instruments as having high scenic amenity

Context

This performance outcome only applies to wind farms proposed in areas identified in a state or local government planning instrument as having high scenic or landscape amenity.

In order to access a suitable wind resource, wind farm developments may be located in exposed and highly visible areas (such as ridgelines and hilltops) which may be identified by a state or local government planning instrument as having high scenic amenity. The height and potential scale of wind farms and wind turbines creates an unavoidable level of visibility which may impact on appreciation of scenic amenity.

Supporting action – PO15

If the relevant state or local government planning scheme has identified the site in an area of high scenic amenity, a **visual impact assessment report** is required to demonstrate compliance with PO15.

The report must:

- include visual simulations or photomontages demonstrating the anticipated visual appreciation of the proposed turbines from key public viewpoints and viewing corridors
- an assessment of how the turbines visible from view points and/or viewing corridors does not adversely impact on the scenic amenity.

3.10 Meeting performance outcomes: Transport networks

Context

Wind farm construction involves significant volumes of heavy vehicle haulage. Turbine components such as masts and blades and transformers normally require Oversize/Overmass (OSOM) haulage from a coastal port to a construction site many kilometres inland. Turbine foundations, access roads and ancillary infrastructure also necessitate the transport of large volumes of materials to the site. The OSOM and other heavy vehicle construction haulage contributes to significant loads on local and state road networks during construction.

Some wind farms have had significant difficulties in securing feasible haulage routes after gaining MCU approvals. As a consequence, SARA now requires proponents to support applications with analysis that provides a high level of confidence that heavy vehicle haulage can be organised to support project construction after a MCU approval.

A SARA MCU approval will still require proponents to undertake detailed Traffic Impact Assessments and heavy vehicle haulage plans prior to commencing construction.

Supporting action – PO16 – PO20

Applicants are strongly encouraged to consult with DTMR and relevant local authorities on implications of heavy vehicle haulage routes during the formulation of site layouts and project design. This engagement will ensure that project componentry such as turbine heights, blade lengths and other project components can be viably constructed after gaining approvals. Gaining this confidence prior to lodging an application will provide greater confidence with other aspects of project support such as informing acoustic modelling, access track construction cross sections, erosion risk assessments etc. This increased level of construction confidence will minimise the need to seek changes to an approval that can occur if heavy vehicle haulage implications are only considered after an MCU approval is issued.

To demonstrate compliance with PO16 – PO20, applicants should accompany their application with a Heavy vehicle and OSOM construction concept strategy. This strategy should outline the:

- consultation that has occurred with relevant local authorities and DTMR in the formulation of the strategy
- proposed turbines and ancillary infrastructure key components that were used to inform the strategy formulation (for example, expected volumes and maximum weights and lengths of components requiring OSOM haulage)
- proposed vehicle types to be used for OSOM haulage (this should involve consultation will prospective haulage contractors)
- key ‘pressure points’ on proposed OSOM routes such as bridges, structures and sections of constrained horizontal geometry due to nature of the route such as tight winding roads up ranges
- details of how the proposed OSOM haulage can be feasibly achieved, at full cost to the proponent, if an MCU were to be approved.

If SARA supports the view that heavy vehicle haulage is realistically viable for the construction of a project, conditions of approval will then require the preparation of detailed Traffic Impact Assessments and detailed Construction and Heavy Vehicle Haulage Plans to be prepared prior to commencing construction.

Other approvals

It is the applicant’s responsibility to ensure all relevant approvals and permits are obtained, including under the Planning Act, the *Transport Infrastructure Act 1994*, and the *Local Government Act 2009* to confirm the suitability of the road network for the movement of Oversize/Overmass (OSOM) vehicles. The National Heavy Vehicle Regulator can assist in identifying the proposed haulage route for OSOM vehicles, however other relevant entities, such as the Ports Authority, Energy Queensland, Queensland Rail and Local Government may also require specific requirements to allow for the safe movement of items on the road network during construction.

3.11 Meeting performance outcomes: Aviation safety, integrity and efficiency

Context

Wind farms inherently involve the construction of tall structures that can be considered a potential safety risk to low-flying commercial, private and defence aircraft. Other structures (including permanent wind monitoring towers) can be erected in association with wind farms and may also be hazardous to air services given their low visibility and intrusion into airspace. The movement, material and size of wind turbines and blades, as well as the marking and lighting, also have the potential to interfere with radio communications equipment for other aircraft and the meteorological radar.

Applicants are required to determine if proposed wind turbines and wind monitoring towers will be located near areas where low-flying activities are likely to be conducted. Activities may include:

- take-off and landing routes around military and civilian airfields, airports and aerodromes
- military training in a Military Danger Area and Military Restricted Airspace
- aerial agricultural spraying
- aerial mustering
- aerial fire-fighting
- power line inspection
- helicopter operations (including search and rescue)
- recreational aviation (such as gliding, paragliding and hang-gliding).

Supporting action – PO21 and PO22

The following information is required to demonstrate compliance with PO21 and PO22:

- written evidence that the following entities (where relevant) have been consulted on the proposed development:
  - Airservices Australia
  - Department of Defence
  - the district aerodrome supervisor.

Consultation should be undertaken according to the Commonwealth Government's (2012) National Airports Safeguarding Framework – Guideline D - Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers.

Risk assessment

Guidelines to manage the risk to aviation safety from wind turbine installations (wind farms and wind monitoring towers) have been developed by the National Airports Safeguarding Advisory Group (NASAG). NASAG's wind farm guidelines (Guideline D - Managing the Risk of Wind Turbine Farms as Physical Obstacles to Air Navigation) provide information to help identify any potential safety risks posed by wind turbines and wind monitoring installations from an aviation perspective. Potential safety risks include (but are not limited to) impacts on flight procedures, and communications, navigation and surveillance assets.

For all wind farm proposals, an Aviation Impact Statement (AIS) Report is to be submitted along with the application. Further information on what information is required for an Airservices aviation assessment is provided in Air Services Australia's Developments at and around airports guide. The AIS needs to be submitted as part of the application with a copy sent to the Airports Developments mailbox (airport.developments@airservicesaustralia.com), together with any supporting documents, spreadsheets, drawings and CAD files which will assist with the assessment.

The AIS must be prepared by a suitably qualified aerodrome consultant/specialist. The report should follow the guidelines outlined in the latest version of the EUROCONTROL guidelines on how to assess the potential impact of wind turbines on surveillance sensors, and must provide a detailed analysis covering, as a minimum:

- airspace procedures
- navigation/radar

The risk assessment should consider all potential aviation activities within the vicinity of the proposed wind farm as outlined above in the context of this requirement. A database that contains all certified aerodromes, for which the operators have been granted a certificate by CASA is available through the CASA website at www.casa.gov.au/search-centre/aerodromes.

Other approvals

A Defence approval is required for wind farm applications under the Defence (Aviation Areas) Regulation (DAAR). The Defence approval is separate to the assessment under the Planning Act. The DAAR apply height controls to buildings, structures, vegetation, and construction equipment and includes controls for any object hazardous to aircraft or aviation-related communications, navigation, or surveillance, regardless of whether the DAAR height controls are infringed. Further details about the DAAR can be found at the Department of Defence Infrastructure Division.

For development in areas not subject to a DAAR, it is normal industry practice for applicants to seek Defence comments on the proposal as part of the risk assessment process prior to lodging a development application.

Airservices Australia (ASA) is responsible for recording the location and height of tall structures. The information is held in a central database managed by ASA and relates to the erection, extension, or dismantling of tall structures, the top of which is above 30 metres AGL (when within 30 kilometres of an aerodrome) and 45 metres AGL elsewhere.

Wind farm structures will meet the definition of a tall structure and the applicant will need to provide ASA with "as constructed" details. The details can be emailed to ASA at vod@airservicesaustralia.com.

The State Planning Policy interactive mapping system for transport infrastructure also includes relevant information on aviation facilities including communication, navigation or surveillance facilities and lists the aviation facilities identified by Airservices Australia and the Department of Defence for protection under the State Planning Policy. Specific location information and types of aviation facilities are provided and can assist in identifying relevant facilities in the vicinity of the proposed wind farm.

3.12 Meeting performance outcomes: Decommissioning

Context

Decommissioning a wind farm involves the removal of the wind turbines, site office and any other above-ground infrastructure from the site. Roads, parking areas and foundation pads should also be covered and revegetated to return the ground to its former state. All above ground components should be reused, recycled or repurposed to the greatest extent possible. The decommissioning of the site is the owner’s responsibility and should be considered well before the end of life of the facility to ensure adverse impacts are minimised.

Supporting action – PO23

Conditions of approval will require the preparation of an **end of operation decommissioning management plan** to be submitted to SARA before the wind farm is decommissioned.

4.0 Appendices

Appendix 1 – Ecological assessment methodology and bird and bat studies

An **ecological assessment report** should be prepared and submitted to demonstrate how PO1 is to be complied with. This report should have regard to the methodology outlined in this appendix.

The **ecological assessment report** must include:

- a desktop review of available information to identify any birds and bat species which may be impacted by the project, including obstruction of and proximity to flight paths
- two seasonal field surveys to map the vegetation and identify flora and fauna species, should be undertaken in accordance with Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 6.0 (Neldner et al, 2022) and consideration of Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland, Version 4.0 (Eyre et al. 2022), respectively
- a review of vegetation and corridors including worst case scenario impacts to regulated vegetation and locally significant vegetation (for example, where a project layout includes a level of flexibility to allow for final micro-siting). Note that micro-siting is not acceptable in laydown areas and areas designated for permanent infrastructure
- taxa-specific studies to obtain more information about threatened flora and fauna that may be at risk from the construction/operation of the development
- taxa-specific studies to obtain more information about birds and bats species that may be at risk from the operation of the development
- integrity of ecological processes, including habitats of threatened, near-threatened or special least-concern species
- integrity of landscapes and places, including identified high-value wilderness areas (e.g. World Heritage Areas) and similar natural places located within or within close vicinity to the project
- a likelihood of occurrence assessment for all threatened species derived from the desktop review
- discussion and demonstration of consideration of the proposed project layout and reducing impacts to sensitive ecological values (e.g. habitat for threatened species, threatened vegetation and riparian vegetation)
- detailed impact assessment of all threatened flora, fauna and habitat (as per the *Nature Conservation Act 1994*) identified during the desktop review and likelihood of occurrence assessment

- avoidance, mitigation and offset strategies to minimise or mitigate impacts on on flora, fauna and their habitat where required, including taxa-specific mitigation measures for threatened species as per the *Nature Conservation Act 1992.*

Methodology for preparing a Bird and Bat Management Plan

The methodology outlined below should be used in the preparation of a detailed Bird and Bat Management Plan that will need to be prepared prior to the commencement of operations of the wind farm.

Desktop assessment

A desktop assessment can be undertaken to identify whether the proposed wind farm has the potential for adverse impacts on any bird or bat species. These impacts include the risk of collision with wind turbines, and where the construction of a wind farm may affect the way species use the site.

A desktop assessment uses existing information in published reports or online databases to identify if there are known to be any bird and bat species on or adjacent to the proposed wind farm site.

The desktop assessment must encompass particular habitats that may support significant bird and bat communities, such as Ramsar wetlands which will provide habitat for waterbirds, and caves which may provide roosting and breeding sites for bats (e.g. may suggest that given the proximity to a wind farm, there may be a potential to impact seasonal migration of protected birds).

There may be restrictions on the location of turbines at a wind farm site. For example, bird and bat issues that may constrain a wind farm development include the use of the site by bird species which are at higher risk of collision with turbines, or the presence of large concentrations of bat species (e.g. cave dwelling bats) which may be at risk of collision with wind turbines.

Field studies

Outputs from the desktop review will inform the type of field studies that may be required to verify the bird and bat species at the proposed wind farm site and to explore how they use the site. At a minimum, field surveys must aim to:

- identify bird and bat habitats and habitat components, and validate the results of the desktop review
- undertake bird utilisation surveys and modelling to identify species at risk of collision or displacement (particularly listed threatened species)
- undertake bat surveys to identify any species in the area.

Field surveys must cover all planned areas of disturbance, including grid infrastructure, and should be undertaken across multiple seasons to capture variability in populations. A number of visits may be required depending on the species being surveyed and any changes in the size and layout of the wind farm.

They must provide sufficient information to determine whether any additional development applications or permits are required under other legislation.

Bird-surveys

Studies in Australia and overseas have shown that some species of birds are at a higher risk of collision with wind turbines than others. Bird utilisation surveys aim to identify the avian species on site, the numbers present, the height that birds fly, and the utilisation across the site. Utilisation studies often include a description of bird behaviour, which usually refers to activities such as feeding, resting or moving, as these can aid the understanding of potential impacts of a wind farm development. Bird utilisation surveys should be undertaken in accordance with the Protocol for initial and continuing bird utilisation surveys stated within the *Interim standards for assessing the risks to birds from wind farms in Australia* (Brett Lane and Associates Pty Ltd 2005). The bird utilisation survey data recorded and presented in the ecological assessment report must include:

- all bird species surveyed
- height bird species fly at
- bird activity (e.g. soaring, foraging etc).

The survey design should include reference (or control) points and treatment points to allow for a ‘Before and After Control Impact’ (BACI) design if the site supports significant bird species (i.e. threatened or migratory species identified as possible, likely or known to occur, as well as all raptor species). A BACI design includes reference sites placed at a sufficient distance from the proposed turbine locations to obtain data outside the zone of influence of the turbines. Data is quantitative and is collected at pre-determined fixed points. The surveys are conducted during relevant seasons with regards to the species being studied and the location of the site, and would normally involve sampling of different relevant habitats on the site. Data is usually recorded in a way that allows a collision risk model to be formulated to estimate the potential collision risk of a species.

Monitoring of the impacts of a wind farm must occur in the construction and/or operational phase of the development where there has been a specific need identified by the approving authority (i.e. through conditions on a development approval). Monitoring regimes will be aided by the earlier survey and modelling work.

Bat surveys

Similar to birds, studies in Australia and overseas have shown that some bat species are at a higher risk of collision with wind turbines or barotrauma (caused by rapid air pressure reduction near moving turbine blades, resulting in lung damage). Field surveys can be carried out to determine which bat species use the site, including for breeding, roosting, foraging or movement. Methods that can be used to identify the bat species on the site and give an indication of their use of the site include:

- harp traps placed across presumed flight paths of bats
- using bat detection systems to record and analyse the echolocation calls of bats.

Note that harp traps will require a permit to catch and handle bats from state wildlife regulatory authorities and will also require Animal Ethics Clearance. Non-intrusive methods such as bat call detecting will generally not require a permit because they do not involve the catching or handling of bats. Whichever methods are used, these must only be employed by suitably qualified and experienced ecologists.

It should be noted that bat utilisation data cannot be obtained by using the above techniques, which are only useful for species identification and to gain an appreciation of populations). Currently the only possible means of quantifying the density of bats on a site is using techniques such as radar, but even these systems have their limitations. As such, a likelihood of occurrence assessment is recommended to identify at risk species (including high flying species that are not listed as threatened under the *Nature Conservation Act 1992* or the *Environment Protection and Biodiversity Conservation Act 1999*).

Species-specific studies

The results of the field surveys may lead to additional species-specific surveys being required to assess the potential impacts of a wind farm development on significant species such as listed threatened species, or species at particular risk (e.g. birds of prey, wetland birds or bats at risk of collision with wind turbines). A species-specific study may be required to demonstrate that the wind farm is not going to have a significant impact on a bird or bat species that has been identified as at risk from the field surveys.

Bird studies

Bird studies should be undertaken in accordance with the *Interim standards for assessing the risks to birds from wind farms in Australia* (Brett Lane & Associates Pty Ltd, 2005). Collision risk for birds and bats at wind farm sites is dependent on several factors, some of which are not yet well understood. Some of these factors include species type, population densities, utilisation of the area, and the height at which a particular species flies. Risks can be reduced by gaining an understanding of how the site is used by birds and bats through the implementation of utilisation studies for particular species.

Collision risk modelling

Collision Risk Modelling (CRM) should be undertaken for all threatened species identified as possible, likely or known to occur, as well as all high flying species such as raptors. The data from either general bird utilisation studies or species-specific utilisation studies can be entered into CRMs which aim to estimate the number of birds at risk of colliding with wind turbines on a site. They are generally used for testing potential impacts on significant species. CRMs generally use bird observational data from the site and bird size, flight speed, population sizes, and avoidance rates, along with inputs about the technical specification of wind turbines (e.g. turbine height, blade length, blade dimensions) and wind direction. This data and any assumptions should be included within the ecological assessment report with justification where necessary on species included and omitted from the CRM.

CRMs can provide an indication of the magnitude of the collision risk by particular bird species at a site. In the absence of observed data, scenario modelling can be done, where a series of assumptions about bird use at a site are entered into the model to assess collision risk. The inputs can be varied to test a range of scenarios.

Bat studies

Bat studies that are particularly designed to measure whether the site is used by species of concern can also be implemented. These may include studies to assess the use of a site by concentrations of threatened species, such as bats which may use a maternity cave within the vicinity of a proposed wind farm, thereby placing greater numbers of individuals at risk of collision with wind turbines. These studies may involve the design and implementation of a study that uses the deployment of bat call detectors at several strategically located sites over the period when bats are breeding and are most active, in the spring and summer months.

Appendix 2 – Noise methodologies

This guidance material has been prepared for wind farm applicants, proponents, planners, assessment managers, and acoustic consultants to provide practical information on how to address the assessment criteria for noise impacts associated with wind farm developments.

Part 1 of this appendix details the methodology that must be adopted for noise impact assessments, prepared when modelling the acoustic impacts of a proposed wind farm.

Part 2 of this appendix details the methodology that must be adopted for operational noise monitoring, being the measurement of noise resulting from operating wind turbines.

This guidance material assumes that all acoustical assessments and monitoring relating to wind farm developments are conducted by a suitably qualified acoustic consultant with suitable acoustic experience.

Part 1 – Noise impact assessment methodology

Wind farm developments are typically sited in areas with low ambient noise levels and have unique noise generating characteristics, including output that varies with wind speed and turbine location. The assessment and modelling of noise impacts during the development assessment phase is a crucial factor in determining the potential impacts on existing or approved sensitive land use(s) in proximity to a wind farm proposal.

General

A unique characteristic of wind farms is that there is an increase in noise level emitted from each turbine as the hub height wind speed at the site increases. The increase in hub height wind speed is typically accompanied by a slightly lesser increase in ground level wind speeds which may increase the background noise level at sensitive land use receptor locations, particularly at higher wind speeds. Wind turbines typically start generating electricity at hub wind speeds around 3-4ms-1 (11 km/h) and reach maximum or ‘rated’ capacity at wind speeds of around 11ms-1 (40 km/h) at the turbine hub height.

The types of noise wind turbines produce can be classified into the following categories:

- Mechanical noise which is produced from the gearbox and generator, bearings, yawing mechanism and blade pitch control mechanism in the nacelle and hub. Mechanical noise from modern wind turbines is not generally a dominant source of emitted noise.
- Aerodynamic noise is noise produced by air passing over the blades of the wind turbine. Aerodynamic noise can be divided into four generation mechanisms: inflow turbulence, tip noise, trailing edge noise and blade tower interaction. Trailing edge noise is generally the most significant wind turbine blade noise source.

This guideline provides a framework for the assessment of noise impacts associated with wind farm developments.

Sensitive land use receptors

The code's noise criteria apply to all existing or approved sensitive land uses for which sensitive receptors may be identified. Sensitive land uses mean any of the following as defined in the code:

- caretakers' accommodation
- childcare centre
- community care centre
- community residence
- detention facility
- dual occupancy
- dwelling house
- dwelling unit
- educational establishment
- health care services
- hospital
- hotel
- multiple dwelling
- non-resident workforce accommodation
- relocatable home park
- residential care facility
- resort complex
- retirement facility
- rooming accommodation
- rural workers' accommodation
- short-term accommodation
- tourist park.

A sensitive land use receptor does not include a temporary or mobile habitable building structure sited on the land (i.e. a caravan on private property).

Wind turbine noise characteristics

The wind turbine noise criteria contained within the code take into account the fundamental characteristics of wind farm noise, including aerodynamic noise from the rotating blades, amplitude modulation, the mechanical noise of the gearbox and other hub and nacelle components, as well as other less frequent and short-term noises that may occur, such as braking or start-up procedures. Specifically, the following characteristics have been considered in determining the criteria:

- Amplitude Modulation (AM) is an expected characteristic of wind turbine noise (commonly described as a 'swish'). Enhanced amplitude modulation (EAM) has been reported from a limited number of wind farms on limited occasions. Considerable research has been conducted and is ongoing to determine and fully understand the sources of amplitude modulation generation and the conditions which may enhance amplitude modulation to a level which is considered by receptors to be an adverse noise characteristic. Current international research is aimed at defining and measuring EAM further so that suitable assessment standards can be developed, if necessary.

- Modern turbines produce broadband noise across the frequency spectrum. With large separation distances, higher frequency noise is attenuated at a greater rate, resulting in a higher concentration of lower frequency noise at residences. It is noted that the normal acoustic environment contains many other sources of low frequency sound which are commonly experienced, such as the sound of diesel engines, aircraft flyovers, blasting, mechanical plant (including pumps, compressors, air-conditioners and gas turbines), surf waves breaking on a beach, waterfalls, thunder, wind blowing the foliage of trees and shrubs, etc.

Tonality

A correctly operating wind turbine may exhibit sound with tonal characteristics. These characteristics can be minimised or avoided by careful design and/or mitigation measures. Wind farm developers should seek to avoid the installation of wind turbines that exhibit sound with tonal characteristics by specifying the supply of wind turbines from a manufacturer which guarantees that the supplied wind turbines will not exhibit tonal characteristics at the sensitive land use.

Impulsivity

Impulsive sound is a transient sound which is not a normal characteristic of wind turbine noise, but which may occur infrequently because of mechanical or aerodynamic problems with the wind turbine. Impulsive sound is best addressed during the operational phase by maintenance, when it occurs.

Noise criteria

The noise criteria apply to aspects of normal wind farm operations which can be readily predicted at the planning stage of the development. Noise modelling predictions are to be free field near existing or approved sensitive land uses. Measurements of background noise levels and operational noise levels are to be conducted at the same, or similar, locations, normally between 5 metres and 20 metres from the sensitive land use.

Wind turbine noise levels

The predicted A-weighted equivalent noise level for wind farm development, assessed as free field noise levels at all existing or approved sensitive land use receptors, at a normal height of 1.5m AGL, must not exceed:

On host lots:

- Outdoors night time (10 pm to 6 am) L_{Aeq} 45 dB(A) or the background noise (L_{A90}) by more than 5 dB(A), whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

On non-host lots:

- Outdoors day time (6 am to 10 pm) L_{Aeq} 37 dB(A) or the background noise (L_{A90}) by more than 5 dB(A), whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.
- Outdoors night time (10 pm to 6 am) L_{Aeq} 35 dB(A) or the background noise (L_{A90}) by more than 5 dB(A), whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

OR

- If a deed of release is negotiated between landowner and proponent, the agreed level and not exceeding outdoors night time (10 pm to 6 am) L_{Aeq} 45 dB(A) or the background noise (L_{A90}) by more than 5dB(A), whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

L_{Aeq} is the equivalent noise level emitted by wind turbines. L_{A90} is determined by the data collection and regression analysis procedure of this guideline (refer to below Data compilation and correlation section relating to Background noise and wind speed data).

The night time period of 10 pm to 6 am has been selected for separate analysis to provide more emphasis to the value of prevention of sleep disturbance. The limitation of the night period to 6 am provides consistency with the assessment times used by Queensland Transport and Main Roads for State-controlled roads and the commonly approved commencement time of 6 am for rural based industries, such as quarries. Restriction of the night period to 10 pm to 6 am will avoid the shoulder period between 6 am and 7 am which typically contains an increased level of road traffic noise, rural activities and natural extraneous noise (i.e. increased ambient noise levels) compared to the pre-6 am period.

The noise criteria must be applied only during the normal operating hours of each sensitive land use.

For example, day-time noise limits would generally apply to a school, commercial office, or childcare centre, whilst a residential dwelling, aged-care facility or relocatable home park would be subject to both daytime and night-time noise limits.

Staged wind farm development

The methodology in this guideline is intended to apply to greenfield sites where no wind turbines are installed. A single wind farm may be developed over several stages. Where a wind farm is proposed to be developed over several stages, the noise criteria that are applied to the initial stage of development approval will be applied to the cumulative noise level of all subsequent stages of the development.

Background noise from nearby wind farms

The wind turbine noise criteria that are applied to a new or expanded wind farm development will be based upon the same background noise scatter plot and regression analysis as used for the existing wind farm for the sensitive land uses (i.e. criteria must be based on the background noise level without the contribution of noise from existing wind farms).

Wind environment

Hub height

All wind data related to the wind environment at the site and the operating performance of the wind turbines shall be expressed in terms of the proposed hub height of the turbines.

Wind mast and monitoring instrumentation

Wind masts must be constructed to a height of not less than 60 per cent of the proposed hub height with wind measuring instrumentation installed at a minimum of two heights near the top of the mast separated by an appropriate distance (ideally greater than 20m).

Wind data must be sampled so that 10-minute samples can be measured, or post-processed from the measured data, to allow correlation/synchronisation with noise monitoring 10-minute sampling periods.

Wind data

Wind data that is not measured at hub height shall be extrapolated to the hub height using the following equations:

$$\text{Wind shear factor, } \propto = \frac{\ln\left(\frac{V_1}{V_2}\right)}{\ln\left(\frac{H_1}{H_2}\right)}$$

$$\text{Extrapolated wind speed, } V_{FHH} = \frac{V_1}{\left(\frac{H_1}{H_{FHH}}\right)^{\propto}}$$

Where:

A = wind shear factor

V_1 = wind velocity at measurement height 1 in m/s

V_2 = wind velocity at measurement height 2 in m/s

H_1 = measurement height of V1 in m

H_2 = measurement height of V2 in m/s (H1 or H2 to be at least 60% of final hub height)

H_{FHH} = final hub height in m

V_{FHH} = wind velocity at final hub height in m/s

Wind farm design

All sensitive land use receptors must be identified for a minimum distance of 3 kilometres from the nearest potential wind turbine location in the area surrounding the proposed wind farm.

As a general guide, the minimum spacing between wind turbines should be three times blade diameter in the cross-wind direction(s) and five times blade diameter for the downwind direction(s) for the dominant wind directions. If the wind farm developer proposes to use alternate spacing distances, justification for the spacing distances must be provided.

The wind farm developer should select a representative wind turbine manufacturer(s) and model(s) to be considered for the wind farm and obtain the spectral sound power level data for the selected turbines from the respective manufacturer(s). The provided sound power level data shall be related to the hub height wind speeds.

Preliminary estimates of wind turbine noise levels must be calculated using a computer noise prediction model (refer to below Data compilation and correlation section relating to Noise modelling).

The outcomes of the wind farm design preliminary noise modelling will be:

- identification of sensitive land use receptors that may be potentially impacted by wind turbine noise exceeding the noise criteria in the code
- identification of suitable representative sensitive land use receptors to be used for background noise monitoring to determine the applicable wind turbine noise criteria
- confirmation of the wind farm design, including the number of wind turbines, the type of wind turbines (i.e. standard or low noise trailing edge blade designs), the hub height, and the proposed wind turbine locations on the wind farm site.

Existing noise environment

Noise monitoring locations

The purpose of monitoring the existing noise environment is to:

- describe the ambient noise environment of the area surrounding the wind farm during the day and night period
- determine the background noise levels (L_{A90}, 10min) correlated for a range of hub height wind speeds for the day and night periods to determine the relevant outdoor wind turbine noise criteria at the selected representative noise monitoring locations.

Noise monitoring locations shall be representative of the nearest sensitive land use receptors to the proposed wind farm site and shall preferably include receptors in all direction(s) from the wind farm. Noise monitoring may be undertaken at a representative location for groups of sensitive land use receptors. The applicant shall justify the number and locations selected for noise monitoring given the:

- dimensions and scale of the proposed wind farm site
- number and location of the potentially affected sensitive land use receptors
- the topography and description of the physical environment between the wind farm and the sensitive land use receptor locations.

Generally, noise monitoring must be conducted at all sensitive land use receptors where the predicted noise level is greater than 35 dB(A).

Ambient and background noise levels shall be measured at outdoor locations with the microphone at a height of 1.2−1.5 metres above ground level, within 20 metres of the receptor dwelling and at least 5 metres from any significant vertical reflecting surfaces. The monitoring locations must be on the wind farm side of a dwelling and as far as practicable from potential sources of domestic noise (e.g. air conditioners, water pumps, etc) and a similar distance from vegetation noise sources (trees) as the façade is from those sources. The monitoring location must not be screened from the proposed wind farm site by existing or potential future building structures on the sensitive land use site, such as sheds, tanks, or other potential barrier structures.

Monitoring locations shall be described by:

- location co-ordinates (GPS Latitude/Longitude)
- photographic images of the location and the surroundings in multiple directions.

Ground level meteorological monitoring

Meteorological monitoring at ground level shall be conducted simultaneously with the noise monitoring at selected locations near to the noise monitoring locations.

The purpose of the meteorological monitoring at ground level is to determine whether there was any rainfall or high wind speeds recorded during the noise monitoring period that might affect the measured noise levels. Wind or rain affected noise samples shall be discarded from the noise data set to be used for determining the noise criteria.

The number of meteorological stations deployed during the noise monitoring will be dependent upon the dimension and scale of the proposed wind farm, and the number and spread of the proposed noise monitoring locations. The applicant shall justify the number and locations selected for simultaneous meteorological noise monitoring during the noise monitoring studies. If the meteorological mast on the wind farm site (or in the vicinity) has the capability to measure rainfall during the noise monitoring period, separate rainfall sensors at ground level may not be required.

Monitoring synchronisation and duration

The noise monitoring instrumentation, the ground level meteorological monitoring station(s) and the wind mast anemometers shall be time synchronised for the duration of the noise monitoring so that 10-minute synchronised noise and meteorological data samples may be measured for compilation and analysis. The monitoring duration must be at least six weeks to provide sufficient noise data for day and night periods. Any shorter duration must be justified.

Instrumentation

Sound

Background and ambient noise levels must be collected for continuous 10-minute intervals using sound level meters or noise loggers having Class 1 or Class 2 certification, in accordance with AS IEC−61672.1-2004 Electroacoustics – Sound level meters.

All noise monitoring equipment must have an inherent noise floor no greater than 20 dB(A). The meters or loggers must be suitably calibrated before and after measurements and if the difference is greater than 1dB, then the data must be discarded.

Windshields

Microphones must be protected with windshields which reduce wind induced noise on the microphone. Suitable windshields include those with a minimum diameter of 100mm and/or those including a double wind shield arrangement. In addition, noise samples recorded with microphone level wind speeds above 5 ms-1 for more than 90% of any 10-minute period must be discarded from the regression analysis.

Meteorology

Instrumentation to measure the required meteorological data can take many forms but must include transducers able to quantify the wind speed to an accuracy of ±1m/s or better, and any occurrence of precipitation greater than 0.2mm. Statistical wind speed (i.e. equalled or exceeded for 90% of the measurement time to match the noise measurement parameter used) is the preferred wind speed measurement parameter. However, if wind monitoring instruments do not output the wind speed statistical parameters, then reporting of average wind speed is permissible.

If rotating cup anemometers or wind vanes are used, they must be appropriately maintained and in good condition. If cup anemometers are used, noise emissions from the equipment must not significantly contribute to the measured noise levels, particularly at higher wind speeds. If the instrumentation includes cooling fans, it must be ensured that the cooling fan noise level at the noise measurement location is at least 10 dB less than the ambient noise level.

Anemometers which use ultrasonic detection methods are possible. Ultrasonic anemometers have no moving parts and can measure wind speed, wind direction and the vertical vector of wind direction.

Data compilation and correlation

Rain

Noise monitoring conducted during rain periods may be adversely affected by the rainfall.

Noise monitoring samples measured in the presence of any rain (0.2mm or more) in any 10-minute monitoring interval shall be discarded from analysis. The rainfall shall be detected by the local ground level meteorological station installed as part of the noise monitoring studies.

Extraneous noise

Extraneous noise is defined as noise that is not typical of the long-term noise environment at monitoring or receptor locations. Extraneous noise may include noise of insects (if seasonal), birds (if seasonal), frogs (if seasonal), farm animal noise, local vehicle traffic, emergency services sirens, etc. For example, insect noise can be considered extraneous noise in some circumstances if it is not typical of the long-term noise environment.

Where dominant extraneous noise contributions are identified in the noise data set then the extraneous contribution must be removed. One method of achieving this would be by use of the frequency spectrum to provide a noise data set that is more representative of periods when the extraneous noise is not present. Removal of any dominant extraneous noise contribution is to be conducted prior to the affected noise data being included in the scatter plot for determination of the background noise level. The applicant shall clearly identify whether extraneous noise was present during the monitoring samples used for the data analysis. If the extraneous noise contributions are dominant in the noise samples, then the extraneous noise contribution shall be excluded or filtered. The methodology used for adjustment or exclusion due to extraneous noise must be documented and justified in the reporting documentation.

Once the dominant extraneous noise contribution has been removed for the noise samples, the modified samples may be included in the scatter plot for determining the background noise levels.

Background noise and wind speed data

Monitored noise samples shall be correlated with the corresponding hub height wind speed (between approximate wind turbine cut-in speed and the approximate speed of rated power) and plotted to form a scatter plot of the data for each of the day and night periods.

A best fit third order regression analysis shall be carried out separately on the day and night background noise hub height wind speed data. Any alternative analysis proposed (i.e., a bin analysis) must be justified by the applicant.

The graph for each relevant receptor showing the plotted points, the fitted regression line, the polynomial describing that line and the correlation coefficient shall be included in the development application.

Figure 1 shows a typical scatter graph and regression line.

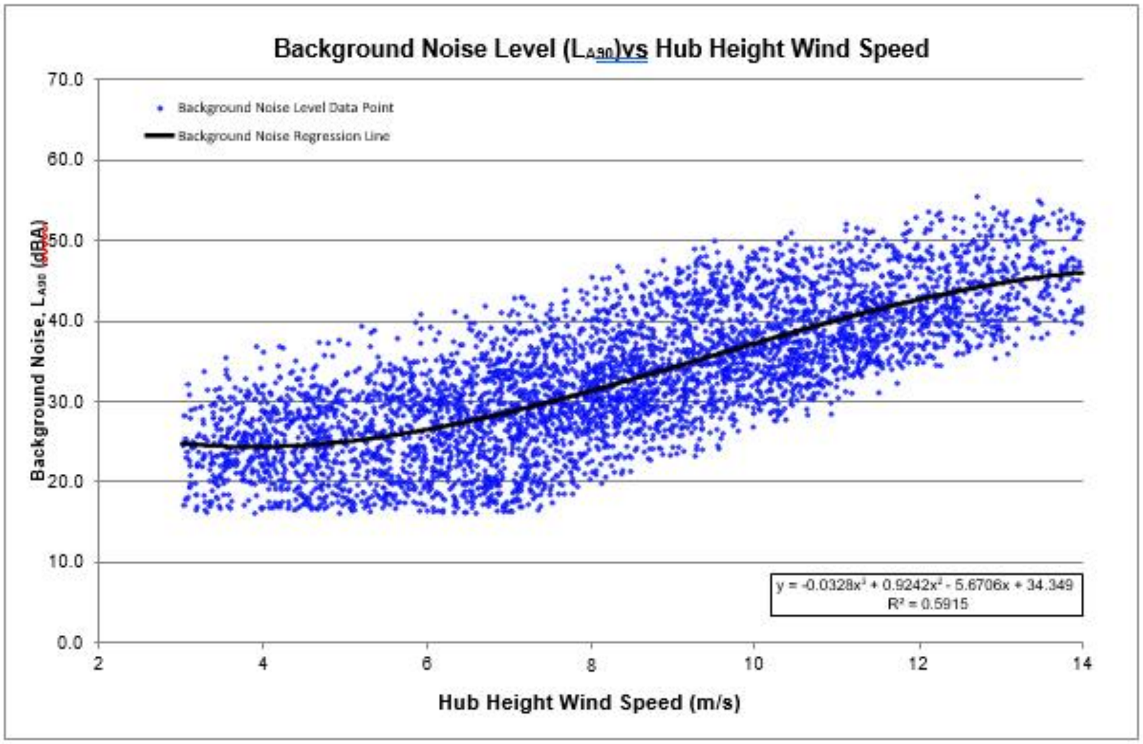

Figure 1 **Background noise level at the sensitive land use receptor vs. hub height wind speed**

Wind turbine noise criteria

The base criterion must be overlaid on the scatter graph along with a line representing the background noise level regression line plus 5 dB(A) for each of the day and night periods. The line formed by the combination of the minimum level and the background level plus 5 dB(A) line shall be the wind turbine noise criteria for the respective day or night period. Figure 2 and Figure 3 show typical wind turbine noise criteria plots for each daily period.

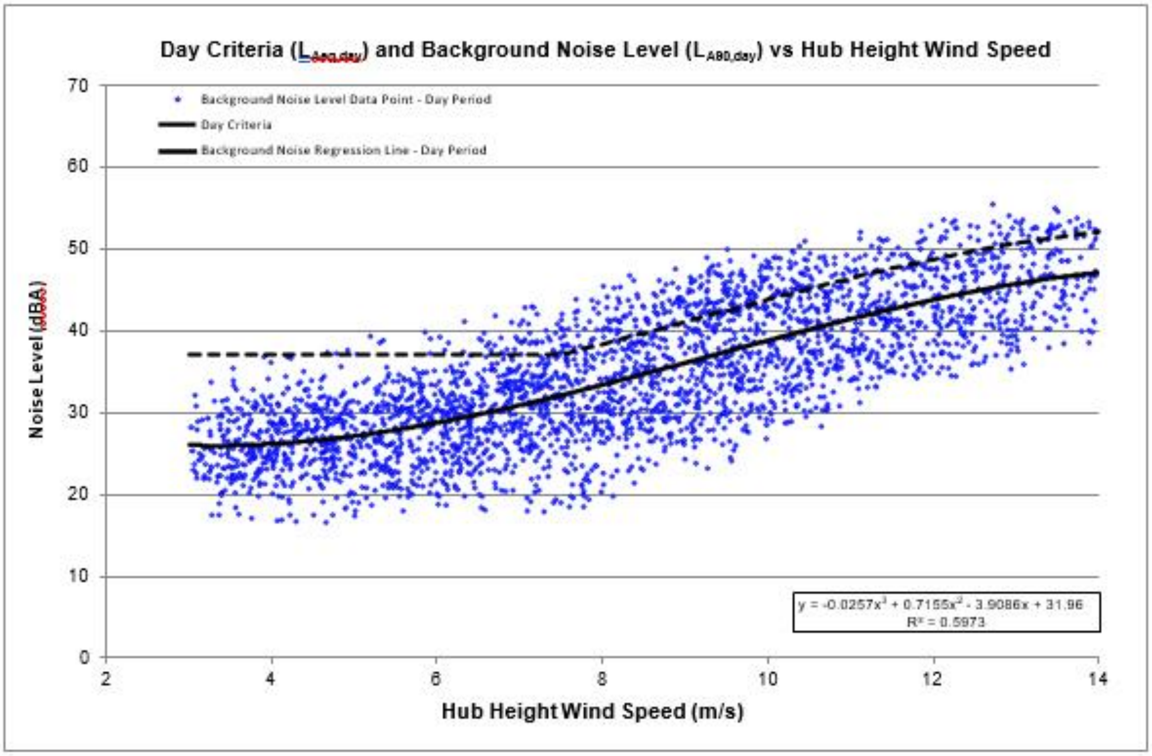

Figure 2 Wind turbine noise criteria plot for day period

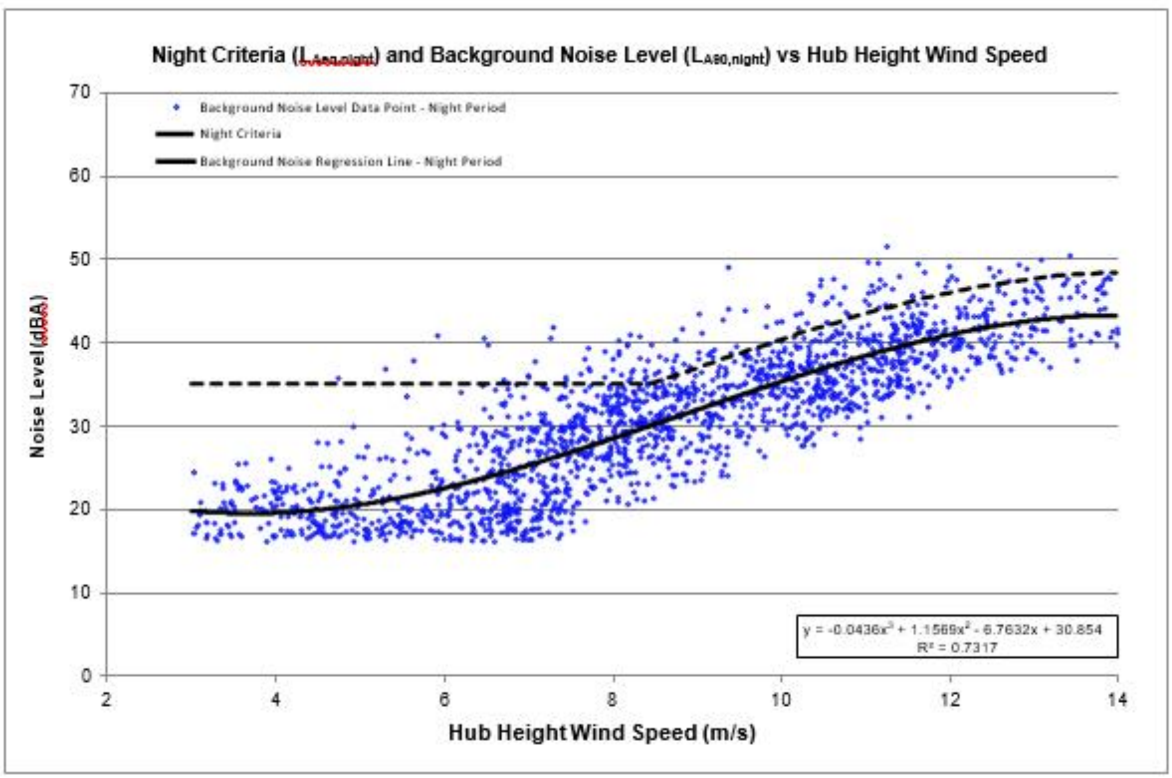

Figure 3 Wind turbine noise criteria plot for night period

Predicted noise levels

Wind turbine noise levels shall be predicted at all identified sensitive land use receptors near the proposed wind farm for integer wind speeds from wind turbine cut-in speed to the speed of the rated power, with the wind speed referenced to hub height of the wind turbines.

Noise emissions from substation transformers are not included in the assessment of noise in this section. Substation noise will be assessed using the standard industrial noise methodology in Queensland.

Noise modelling

A suitable noise model must be selected to predict the worst-case noise level at sensitive land use receptors in the minimum octave band frequency range from 63 Hz to 4 kHz.

There is no standard noise model specifically applicable to sound propagation from wind farms.

ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation is commonly used for wind turbine noise assessments and are supported by a significant amount of research confirming that with a suitable level of safety factors and consideration of ground topography, the predicted noise levels agree well with measured noise levels during operations of the wind farm after construction.

Software programs which apply noise prediction algorithms in accordance with ISO 9613-2 are recommended for noise prediction assessments under this guideline, however alternative propagation algorithms such as Nord2000 or Harmonise, may also be used, provided relevant supporting information is provided.

ISO 9613-2 specifies a method for predicting LAeq noise levels at a distance from a source under meteorological conditions favourable to noise propagation, namely downwind propagation (<5 ms- 1), or equivalently propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night. The method is conservative because it assumes that the favourable propagation conditions occur simultaneously in all directions. Where receptors are located upwind of the dominant wind directions then the noise levels are expected to be less than predicted using this method.

Topographical ground contours with a 1 m or 5 m resolution are preferred for preparation of the noise model. If a lesser resolution is proposed (such as 10 m topographic contours), the lesser resolution must be justified in the context of proximity of sensitive land use receptors to the wind turbines and the shape, or irregularity, of the ground topography between the wind turbines and the sensitive land use receptors.

The noise prediction models shall have the following inputs, with alternative values supported by relevant documentation:

ISO 9613-2:

- warranted sound power levels
- 10°C temperature
- 70% relative humidity
- 50% acoustically hard ground and 50% acoustically soft ground

- barrier attenuation of no greater than 2 dB(A)
- 4m receiver height
- application of a 3 dB(A) correction where a "concave" ground profile exists.

If concave topography is present between a particular wind turbine location and a particular sensitive land use receptor location (e.g., wind turbine located on an elevated ridge relative to receptor location) then experience has shown that ISO 9613 predicted noise levels underestimate the actual measured levels, due to reduced ground effect and the potential for additional reflection paths.

A correction of +3 dB must be added to the calculated component overall A-weighted noise level for propagation 'across a valley', i.e. a concave ground profile, or where the ground falls away significantly, between a particular turbine and the particular receptor location.

The recommended criterion for determining if the ground topography is concave is:

$$h_{mm}| \geq 1.5 \times \frac{|h_{ss} - h_{rr}|}{2}$$

Where h_m is the mean height above the ground level of the direct line of sight from the receptor to the source (as defined in ISO 9613-2), and h_s and h_r are the heights above local ground level of the source and receptor respectively.

The predicted L_{Aeq} noise levels at each sensitive land use receptor shall be determined for each hub height wind speed and over-plotted on the noise criteria curves graph to compare the predicted wind turbine noise level and the day and night criteria. Figure 4 shows a comparison of a predicted wind turbine noise levels per hub height wind speed with the noise criteria.

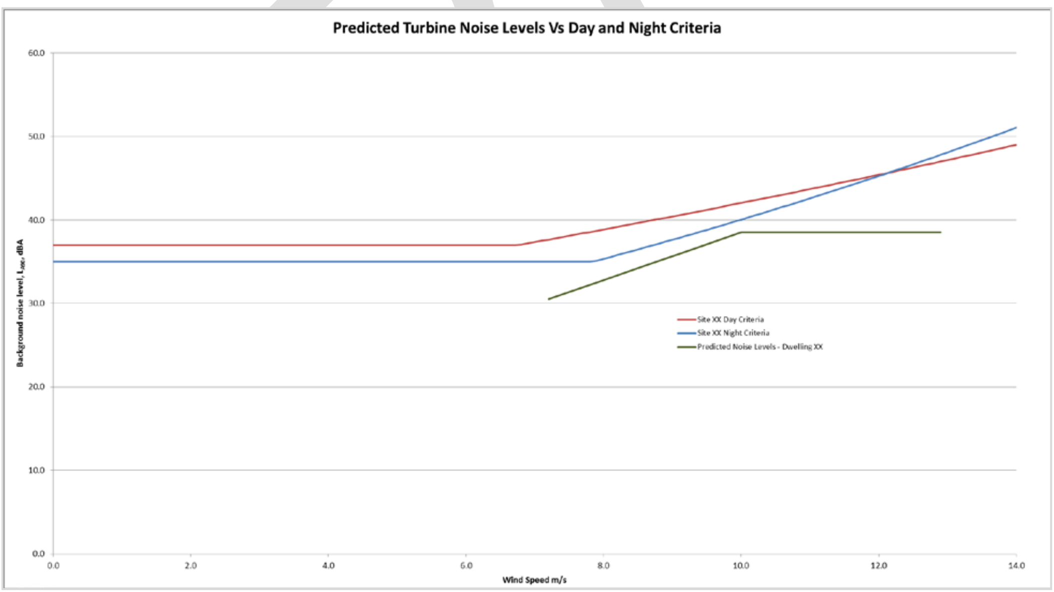

Figure 4 Predicted wind turbine noise levels vs. day and night criteria

Where alternative noise propagation algorithms or methods are used the input parameters must be documented in detail and supporting documentation regarding prediction uncertainties must be provided.

The following information shall be provided in the acoustic report supporting the development application:

- description of the noise propagation model and all input information. An electronic copy of the noise propagation model, including all noise prediction files and graphical output files shall be available for SARA upon request
- a tabulated list of worst-case predicted wind turbine noise levels at each identified sensitive land use receptor for each turbine integer wind speed for all wind turbines being considered for the wind farm
- noise contours (dB(A)) for the predicted wind turbine noise levels must be presented for the worst-case operational wind speed for the proposed wind farm development, showing predicted levels from at least 30 dB(A) contours
- the sound power levels of the proposed turbines referenced to turbine hub height wind speed, from cut-in wind speed to rated power, including the corresponding octave band sound levels from 63 Hz to 4 kHz.

Background noise levels from nearby wind farms

The noise from each individual wind farm shall meet the code noise criteria at existing or approved sensitive land uses, determined using background noise levels that existed before wind farm site developments.

Management of potential exceedances of criteria

Predicted noise levels from the proposed wind farm operation must comply with the code noise criteria for both day and night periods at all existing or approved sensitive land use receptors.

Where potential exceedances of the criteria are indicated as a result of noise prediction modelling, then modifications to the wind farm design (e.g. wind turbine layout, number of wind turbines operating, time of day for wind turbine operations, upgrade to low noise wind turbine type, etc.) must be carried out.

The development application shall comprise a proposal where the predicted wind turbine noise levels do not exceed the criteria for any sensitive land use receptor.

The noise impact assessment prepared to support a development application for a wind farm must include all necessary documentation to fully satisfy the noise criteria within the code.

Part 2 – Noise monitoring methodology

This part defines the noise monitoring methodology to be used for operating wind farms in Queensland. It provides the method for measuring the noise from operating wind turbines; the results of which will be used for determining compliance with the noise criteria included within the code and any conditions of approval.

It is noted that noise experienced at sensitive land use receptors because of a wind farm will often be similar to, or lower than, the ambient noise from other sources, such as wind in the trees. This can make the separation of wind farm noise from ambient noise very difficult. Therefore, this methodology may be supplemented with additional noise measurements to assist in determining the contribution of noise from a wind farm. The additional measurements may include noise logging at an intermediate/alternative location between the wind farm and sensitive land use receptors or on/off testing. Any variation to this methodology should be discussed with SARA prior and justified accordingly based on site-specific circumstances.

Preparation of a Noise monitoring plan

Should a wind farm development be approved, the conditions of approval will require that the proponent prepare and submit to the department a noise monitoring plan, prior to the commencement of construction. The noise monitoring plan must provide details of the proposed operational noise monitoring for the specific circumstances of the wind farm and include, at a minimum, the following information:

- the proposed residential monitoring locations (including demonstration of any necessary access arrangements/consents)
- the proposed number of noise monitoring periods and the duration of each noise monitoring period
- the proposed make and model of equipment and wind shields used for noise monitoring
- the proposed method for determining wind speed and rainfall at microphone height
- details of any additional noise measurements to assist in the determination of the contribution of noise from the wind farm
- the measured background noise levels at the proposed residential monitoring locations
- the proposed method of determining wind speed at hub height (by direct measurement or measurement and correction) and demonstration that the wind speed is equivalent to the wind speed used for background noise monitoring.

In relation to the final point, the background noise monitoring conducted for the preparation of the development application is often correlated with the wind speed measured at wind masts on the wind farm site. As the project develops, wind masts are often removed to make way for wind turbines. Therefore, wind speed measurements from another location are often required for correlation with noise monitoring.

It is critical that the wind speed used for correlation within the noise modelling is equivalent to the wind speed used for correlation within the operational noise monitoring. One method is to use an anemometer from the nacelle of a wind turbine located close to the original wind mast. When using a nacelle anemometer an adjustment must be made to the measured wind speed to account for the passing of the blades. Another method is to use a permanent wind mast. Where a permanent wind mast is used, it must be correlated against the original wind mast for a period when both masts are present. This will allow any differences in wind speed to be factored into the noise monitoring.

Noise monitoring locations

Operational noise monitoring locations must be selected from the locations where background noise measurements have occurred, be representative of the nearest sensitive land use receptors to the wind farm and include, where possible, sensitive land use receptors in all directions from the wind farm. Proposed noise monitoring locations may require demonstration of necessary access arrangements/consents (i.e., where located on private property).

The applicant must justify the locations (including the number of locations) selected for noise monitoring about the site-specific circumstances of the wind farm, including:

- dimensions, scale, and layout of the proposed wind farm
- number and location of the potentially affected sensitive land use receptors
- comparison of predicted noise levels to the criteria within the code and subsequent conditions of any approval
- the topography between the wind turbines and the sensitive land use receptor locations.

Where possible, the noise monitoring equipment must be placed in the same location as where background noise measurements have occurred. Noise monitoring locations must be described within the noise monitoring plan by:

- location co-ordinates (GPS Latitude/Longitude)
- photographic images of the location and the surroundings in all directions.

Ground level meteorological monitoring

Meteorological monitoring at ground level must be conducted simultaneously with the operational noise monitoring at locations as near as possible to the noise monitoring locations.

The purpose of the meteorological monitoring at ground level is to determine whether there was any rainfall or high wind speeds recorded during the noise monitoring period that might affect the measured noise levels. Wind or rain affected noise samples must be discarded from the noise data set to be used for correlations.

The number of meteorological stations deployed during the noise monitoring will be dependent upon the dimension and scale of the proposed wind farm, and the number and spread of the proposed noise monitoring locations. The applicant must justify the number and locations selected for simultaneous meteorological noise monitoring based on site-specific circumstances and the selected noise monitoring locations. If a meteorological mast on the wind farm site (or in the vicinity) has the capability to measure rainfall during the noise monitoring period, separate rainfall sensors at ground level may not be required.

Instrumentation to measure the required meteorological data can take many forms but must include transducers able to quantify the wind speed to an accuracy of ±1m/s or better, and any occurrence of precipitation greater than 0.2mm. Statistical wind speed (i.e. the calculated wind speed exceeded for 90% of the measurement time to match the noise measurement parameter used) is the required wind speed measurement parameter.

If rotating cup anemometers or wind vanes are used, they must be appropriately maintained and in good condition. If cup anemometers are used, noise emissions from the equipment must not significantly contribute to the measured noise levels, particularly at higher wind speeds. If the instrumentation includes cooling fans, it must be ensured that the cooling fan noise level at the noise measurement location is at least 10 dB(A) less than the ambient noise level.

Anemometers which use ultrasonic detection methods are possible. Ultrasonic anemometers have no moving parts and can measure wind speed, wind direction and the vertical vector of wind direction.

Monitoring parameters

Although the guideline requires noise modelling to be conducted using the L_{Aeq} descriptor, it is not usually practical to measure the noise from a wind farm using the L_{Aeq} descriptor because intermittent noise from sources such as wind gusts in trees, vehicles, birds and insects are included. To minimise the interference from the intermittent noise sources, the L_{A90} descriptor is used as a proxy for the L_{Aeq} for the purposes of operational noise monitoring.

Monitoring duration and synchronisation

The noise monitoring instrumentation, the ground level meteorological monitoring stations and the wind mast anemometers must be time synchronised for the duration of the noise monitoring so that 10-minute synchronised noise and meteorological data samples may be measured for compilation and analysis.

The noise monitoring duration must be a minimum of six weeks to provide sufficient noise data for day and night periods. Any shorter duration should be discussed with the department prior and justified accordingly based on site-specific circumstances.

An important aspect is to ensure that the wind speed used for the correlation within the noise modelling is equivalent to (provides the same average wind speed as) the wind speed used for the correlation with noise monitoring. It is the proponent's responsibility to demonstrate that the wind speed used for monitoring is equivalent when considering location and wake effects (when the anemometer is downwind of a turbine).

Should a wind farm development be approved, the conditions of approval will require that operational noise monitoring be conducted twice within the first year of the development being fully operational (i.e., all proposed turbines operating). This will comprise the completion of noise monitoring once within three months and once following nine months of the development being fully operational. This will provide sufficient data over a twelve-month period for the department to determine compliance or otherwise with the noise criteria included within the code and any conditions of approval.

Instrumentation

Sound

Noise measurements must be collected for continuous 10-minute intervals using sound level meters or noise loggers having Class 1 or Class 2 certification in the previous two years, in accordance with AS IEC−61672.1-2004 Electroacoustics – Sound level meters.

All noise monitoring equipment must have an inherent noise floor no greater than 20 dB(A). The meters or loggers must be suitably calibrated before and after measurements and if the difference is greater than 1 dB(A), then the data must be discarded.

Windshields

Microphones must be protected with windshields which reduce wind induced noise on the microphone. Suitable windshields include those with a minimum diameter of 100 mm and/or those including a double wind shield arrangement. In addition, noise samples recorded with microphone level wind speeds above 5 ms-1 for more than 90% of any 10-minute period must be discarded from the regression analysis.

Rain

Noise monitoring conducted during rain periods may be adversely affected by the rainfall. Noise monitoring samples measured in the presence of any rain (0.2mm or more) in any 10-minute monitoring interval must be discarded from analysis.

Extraneous noise

Extraneous noise is defined as noise that is not typical of the long-term noise environment at monitoring or receptor locations. Extraneous noise may include noise of insects (if seasonal), birds (if seasonal), frogs (if seasonal), farm animal noise, local vehicle traffic, emergency services sirens, etc. For example, insect noise can be considered extraneous noise in some circumstances if it is not typical of the long-term noise environment.

Where dominant extraneous noise contributions are identified in the noise data set then the extraneous contribution must be removed. One method of achieving this would be by use of the frequency spectrum to provide a noise data set that is more representative of periods when the extraneous noise is not present. Removal of any dominant extraneous noise contribution is to be conducted prior to the affected noise data being included in the scatter plot for determination of the background noise level. The applicant must clearly identify whether extraneous noise was present during the monitoring samples used for the data analysis. If the extraneous noise contributions are dominant in the noise samples, then the extraneous noise contribution must be excluded or filtered. The methodology used for adjustment or exclusion due to extraneous noise must be documented and justified in the Noise monitoring plan. The methodology used for the operational noise monitoring must be consistent with that used for the noise modelling.

Preparation of a Noise monitoring report

Should a wind farm development be approved, the conditions of approval will require that the proponent submit separate noise monitoring reports, outlining the results of the noise monitoring, at three and twelve months following the wind farm being fully operational.

The noise monitoring reports must outline the derived wind farm noise level at sensitive land use receptors, adjusted for any tonality. This will be used by the department when determining compliance or otherwise with the acoustic criteria within the code and the conditions of approval, for sensitive land use receptors at each integer wind speed.

The noise monitoring reports must clearly outline the results of the noise monitoring as conducted in accordance with the noise monitoring plan prepared in accordance with this methodology.

Correlation of noise and wind speed data

Monitored L_{A90} noise samples must be correlated with the corresponding hub height wind speed (between approximate wind turbine cut-in wind speed and the approximate wind speed at rated power) and plotted to form scatter plots of the data. As outlined, to minimise the interference from the intermittent noise sources, the L_{A90} descriptor is used as a proxy for the L_{Aeq} for the purposes of noise monitoring.

For monitoring locations, each of the day and night periods must have separate scatter plots. The data collected in all wind directions is used. A best fit third order regression analysis must be carried out for the noise and hub height wind speed data. Any alternative analysis proposed (i.e. a bin analysis) must be justified by the proponent.

The graph for each relevant receptor showing the plotted points, the fitted regression line, the polynomial describing that line and the correlation coefficient must be included on the plot.

The pre-construction (background noise monitoring) regression line is then subtracted from the post-construction (operational noise monitoring) regression line to determine the derived wind farm noise. It is noted that if background noise monitoring is not available, the operational noise monitoring measurement is taken as the derived wind farm noise level. Figure 5 shows a typical scatter graph and regression line analysis.

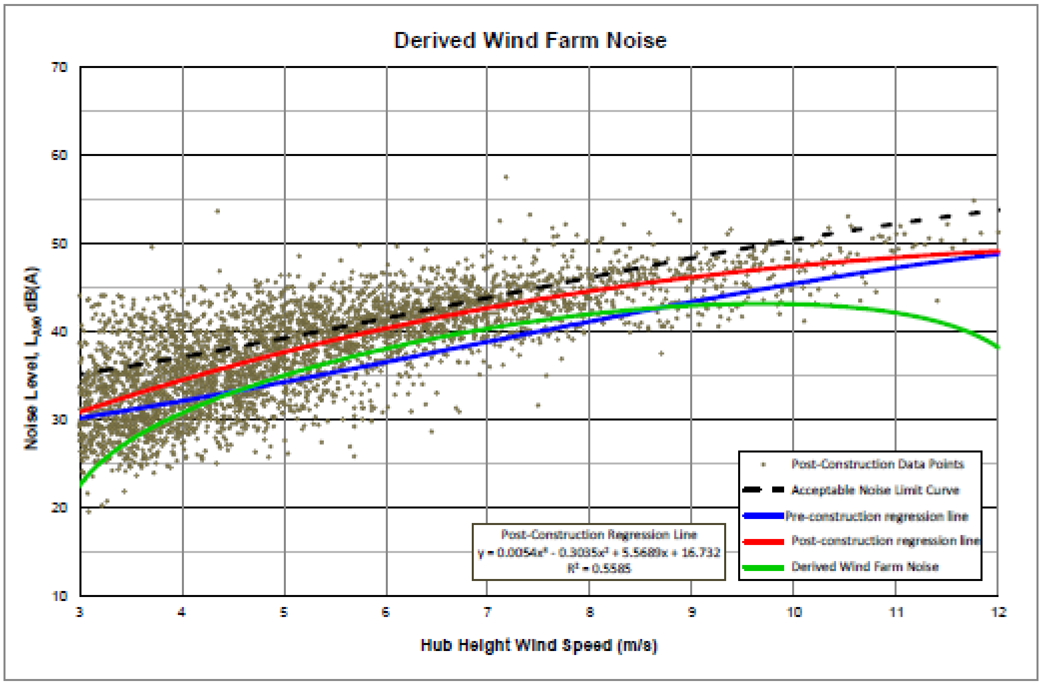

Figure 5 **Example of regression line analysis to determine derived wind farm noise level**

Tonality

Tonality must be determined by logging the (L_{Aeq}) noise in one third octave bands at the residential locations. All 10-minute L_{Aeq} noise data (i.e. without data exclusion) in one third octave bands are separated into groups of integer wind speeds ± 0.5m/s. For each 10-minute interval, where a one third octave band is 5 dB(A) above the level of both adjacent one third octave bands and there is no evidence that the noise is from another source, the 10 minute interval is potentially tonal.

Evidence that the noise is from another source could be by comparison with noise measured close to turbines or by listening to an audio recording of the sound at that time. The number of potentially tonal intervals in each wind speed group is added. Where the number of potentially tonal intervals is less than 10% in each wind speed group, it is concluded that the wind farm does not exhibit significant tonality. Where more than 10% of any wind speed group is potentially tonal at a residence, 5 dB(A) is to be added to the derived wind farm noise level at that wind speed.

Preparation of an Operational strategy

Should a wind farm development be approved, within the first twelve months of the wind farm being fully operational, proponents will be afforded the opportunity to rectify any non-compliance with the acoustic criteria within the code and the conditions of approval. This may include the implementation of turbine-specific operating measures/regimes or Wind Sector Management strategies.

At twelve months following the wind farm being fully operational, the conditions of approval will require that the proponent submit an Operational strategy. The Operational strategy must outline any specific operating measures/regimes or Wind Sector Management strategies required to ensure ongoing compliance with the acoustic criteria within the code and the conditions of approval. The proponent will be required to operate the wind farm in accordance with the Operational strategy until the development ceases operations.

Appendix 3 – Electromagnetic interference impact assessment methodology

Methodology – assessment of potential electromagnetic interference impacts

An electromagnetic interference (EMI) assessment must be prepared to demonstrate that the wind farm development is designed and sited to ensure minimal EMI to pre-existing television, radar and radio reception or transmission. The assessment must detail all potential EMI impacts, provide a preliminary impact assessment and outline any required mitigation measures.

Review of licensed radio communication services

The applicant must conduct a search of the Australian Communications and Media Authority (ACMA) Register of Radiocommunications Licences to obtain a list of all licensed radio communications services that adjoin the wind farm. A radial distance of 50–60 kilometres from the centre of the wind farm would normally capture all the potentially affected services. This search will not determine whether users of radio communications devices operating under a class licence (typically low-interference, private operators) exist in the area. Early engagement could occur with such users to identify impacts up front. It is also suggested that applicants review the Australian Mobile Telecommunications Association's Radio Frequency National Site Archive (RFNSA) database.

Identify potentially affected radio communication services

The applicant can determine which radio communication services may be affected by the wind farm development by calculating the distance between line-of-sight radio paths and the proposed wind farm. This may be specific to individual wind turbines, as any turbine (including blades) within a line-of-sight radio path or within proximity to a broadcast site may impact on the performance of a radar facility.

To calculate the distance between line-of-sight radio paths and the proposed wind farm, the Fresnel zone must first be calculated. The Fresnel zone is a volume of space between transmitting and receiving stations, through which radio waves will, if uninterrupted, travel in a straight line from the transmitter to the receptor.

Separation distances for the following categories are recommended to ensure a wind turbine will not interfere with a radio communications service:

- obstruction to radio line-of-sight path
- obstruction to radar line-of-sight
- near-field effects
- reflection/scattering.

Obstruction to radio line-of-sight path

An obstruction to radio line-of-sight path occurs when the location of a wind turbine causes radio communications signals to be partially or fully obstructed, resulting in a reduction or loss of signal. It is generally accepted that effects from obstruction by wind turbines can be avoided by placing the turbines, including blades, outside the second Fresnel zone of the line of sight path of a point to point radio link. This is considered a conservative approach.

The second Fresnel zone at any point can be calculated and is dependent upon the frequency of the signal, the length of the radio communications path, and the distance of the particular point in question along the radio communications path.

The maximum second Fresnel zone distance of a link occurs at the mid-point along the path. The formula for calculating the second Fresnel zone distance at any given point is shown in **Figure 1**.

$$F_2 = \sqrt{\frac{2\lambda d_1 d_2}{d_1 + d_2}}$$

where

F_2 = Second Fresnel zone radius

λ = Wavelength in metres

d_1, d_2 are distances from each end of radio path to the point under consideration

Figure 6 The formula for calculating the second Fresnel zone distance

Source: EPHC, 2010

Obstruction to radar line-of-sight

Radar services may be affected by wind turbines hundreds of kilometres away if they are located within the radar operating range and line-of-sight. As a guide, long range 23 centimetres (1300MHz) radars, such as those used for aircraft en-route surveillance, can have an operating range in the order of 200 nautical miles (radius of search volume in nautical miles), a 10 centimetres (3000MHz) aircraft approach radar 60 nautical miles, and a 3 centimetres (9000MHz) aircraft final approach radar 15 nautical miles. Individual radar operators will be able to advise whether a wind farm development may impact on their services.

Near-field effects

This occurs when a wind turbine is located in such close proximity to an antenna that it changes the characteristics of that antenna. Transmitting and receiving antennas have a 'near-field' zone, which requires freedom from any object that can conduct or absorb radio waves.

The near-field zone can be calculated based upon the frequency of the signal, the gain, and the orientation of the antenna. Typical calculations give the near-field zone for:

- high band Ultra High Frequency (UHF) signals, such as cellular telephones (800MHz to 1900MHz) as approximately 20 metres
- point-to-point microwave links as approximately 720 metres
- low band VHF paging systems approximately 4 metres.

As can be seen from the above examples, the near-field zone varies widely depending upon the service type. It is recommended that a wind farm applicant consider any telecommunications site within one kilometre of the proposed wind turbines as a potentially affected party with respect to near-field effects.

Reflection/scattering

Reflection/scattering occurs when radio signals are reflected (scattered) by the wind turbine blades, interfering with a radiocommunications signal.

A ratio of the scattered signal to the received signal can be used to determine the full effect of this form of interference. This can be calculated and is dependent upon the distance of the receptor and transmitter to the wind turbine tower. Some methods use worst-case Radar Cross Section (RCS) (which is conservative), or a variant on the second Fresnel zone calculation for users close to a wind turbine. RCS is relevant to all radiocommunications services, not just radar services.

Required Signal-to-Noise Ratio (SNR) for different services is variable but can be of the order of 30 decibels (dB).

An exclusion zone to meet the SNR requirement can be calculated and is dependent upon the gain and radiation pattern of the antenna, the worst-case RCS and the distances between user, transmission tower and wind turbine. Higher frequency signals generally utilise antenna patterns with higher gain.

There is no single criterion for potential impact on radiocommunications services due to scattering. It is recommended that potential impact due to reflections/scattering must be discussed with a potentially affected party if the wind farm applicant intends to locate a wind turbine within two kilometres of any telecommunications site.

It should also be noted that the accuracy of radiocommunications site coordinates in the ACMA database is variable, and it relies upon the accuracy of individuals providing the correct data when applying for a new service. It also does not guarantee that a particular service is operating, or operating in accordance with ACMA regulations. Should there be an indication that any individual services may be impacted, or are within, for instance, five kilometres of causing an impact, then it is recommended that independent verification of the radiocommunications site co-ordinates is carried out to confirm the existence of any issues.

Methodology – preliminary impact assessment

Having determined which radiocommunications services may be potentially affected by the wind farm, a preliminary impact assessment must be conducted to determine the level of risk for each of the potential impacts that are expected for each identified service. This will assist in a preliminary determination of the mitigation methods to be considered at the next stage.

If there is a low risk of impact, or the impact cannot be easily quantified, then mitigation methods may be proposed for implementation after construction, when the actual effects can be measured. There may also be the opportunity to reduce any general exclusion zones due to the specific circumstances of the development. For example, some exclusion zones are based on methods using worst-case RCS to determine signal loss due to scattering. However, while RCS can be minimised, the actual RCS is difficult to determine accurately. Using the worst-case RCS can result in overly conservative exclusion zones.

This information will inform any required mitigation strategies to ensure minimal impacts on electromagnetic interference.

Methodology – mitigation strategy

Best practice to reduce the effects of EMI involves designing the wind turbines to minimise their Radar Cross Section (RCS). This reduces the extent to which the turbines will reflect or scatter radio energy. This can be achieved by:

- careful choice of tower and nacelle shape and construction materials
- the use of absorbing (or non-reflective) materials for blade construction
- consideration of the spacing of wind turbines in relation to any affected services.

As mentioned above, RCS is relevant to all radio communications services, not just radar services.

Mitigation options may be different for each individual service affected, depending on the type of service and the level of interference expected.

Appendix 4 – Shadow flicker assessment methodology

The suggested method for assessment for potential shadow flicker impacts is as follows:

- determine the extent of shadows from turbines, based on a distance of 265 m x maximum blade chord (no assessment is required for residences beyond this distance)
- identify all existing or approved sensitive land uses within the extent of shadows from proposed turbine positions
- use modelling software with relevant modelling assumptions (as identified in tables below) to calculate the theoretical annual shadow flicker duration at each existing or approved sensitive land use, accounting for topography
- consider possible impacts of shadow flicker and identifying those impacts with negligible or significant risks

Sensitivity

Shadow flicker duration can be very sensitive to location, varying by up to approximately 0.8 hours per metre of horizontal displacement (per annum). Thus, in an extreme case, one end of a sensitive land use may experience no shadow flicker while the other end may exceed the limit. For this reason, the assessment method requires reporting of the maximum value of shadow flicker duration within 50 m of the centre of a sensitive land use. This addresses a range of other sensitivity considerations such as the offset between rotor and towers, and some minor inaccuracies in the modelling equations, as well as annual variation in shadow flicker.

Topographical variations will also need to be considered.

Recommended modelling assumptions

The assumptions or settings recommended for use in modelling shadow flicker are as follows:

Model Parameter	Setting
Zone of influence of shadows	265 m x maximum blade chord
Minimum angle to the sun	3 degrees
Shape of the sun	Disk
Time and duration of modelling	One full year representing a non-leap year 12 to 15 years after the date of DA submission
Orientation of the rotor	Sphere or disk facing the sun
Offset between rotor and tower	Not required

Time step	Ten (10) minutes or less
Effects of topography	Include
Receptor height	1.5 m – 2 m and window / balcony height where dwellings have more than one storey
Receptor location	A map must be provided and the highest level of annual shadow flicker within 50 m of the centre of a dwelling reported.
Grid size for mapping and assessment of shadow flicker at a receptor	Not more than 25 m

Means of mitigating modelled estimates

The table below contains some potential mitigation measures that may be used to reduce the modelled exposure on an existing or approved sensitive land use to shadow flicker.

Mitigation	Constraints
Cloud cover assessment	Annual limit reduced to 10 hours/year (see below for recommended method of assessment)
Vegetation blocking shadows	Where it can be shown that the view of a source turbine is completely blocked, the contribution of that turbine may be ignored.
Scheduling turbine operation	Annual limit reduced to 10 hours/year

The recommended method for assessment of cloud cover is to:

- obtain *Bureau of Meteorology* data on cloud cover from the closest site (reporting at least 9am and 3pm cloud cover) with at least three years of data
- determine monthly averages separately for the 9 am and 3 pm proportion of cloudy days
- reduce shadow flicker occurring in a given month by the proportion of cloudy days (evening shadow flicker must be reduced using the proportion from 3 pm and morning shadow flicker using the proportion from 9 am)
- sum the reduced monthly totals to determine the revised annual exposure.

5.0 Abbreviations

Abbreviation	Meaning
^{o}C	Degrees Celsius.
ACMA	The Australian Communications and Media Authority.
AGL	Above ground level.
AHD	Australian Height Datum.
AS	Australian Standard.
AS/NZS	Australian Standard/New Zealand Standard.
BCA	Building Code of Australia.
dB	Decibel. The unit of sound level.
dBA	A measured sound pressure level that incorporates A-weighting is denoted LpA, and has units of dB(A), often written as dBA.
EP Act	*Environmental Protection Act 1994*.
EPP (Noise)	Environmental Protection (Noise) Policy 2008.
Hz	Hertz.
IEC	International Electrotechnical Commission.
ISO	International Standards Organisation.
km	Kilometre.
km/h	Kilometre per hour.
L_{Aeq}	Time averaged A-weighted equivalent continuous sound pressure level.
L_{A90}	A-weighted sound pressure level which is exceeded for 90% of the measurement period. Often referred to as the Background noise level.
m	Metre.

ms^{-1}	Metres per second.
QLD	Queensland.
RPEQ	Registered Professional Engineer of Queensland.

6.0 Glossary

Term	Meaning
Ambient noise level	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source. Ambient noise levels would typically include a summary of all noise descriptors including L_{Aeq} and statistical parameters such as L_{A90}, L_{A10} and L_{A01}.
Amplitude modulation	Amplitude modulation special audible characteristics occur when there is significant amplitude modulation of the aerodynamic sound from one of more wind turbines such that there is a greater than normal degree of fluctuation as a function of the blade passing frequency (typically about once per second for larger turbines).
A-weighting	The A-weighting approximates the response of the human ear, particularly for sounds of moderate and low levels.
Background noise level	Minimum ambient noise level, evaluated as the level exceeded for 90 per cent of 10 minute sample periods ($LA_{90,10\ minute}$) during a defined time period of interest (e.g. daytime, evening or night-time).
Day	6 am to 10 pm.
dB	Decibel. The unit of sound level. A measurement of sound level expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of P_r=20 mPa, i.e. dB = 20 x log(P/P_r).
Free-field	A region in space where sound may propagate free from any form of obstruction, usually greater than 5m from any significant vertical reflecting surface.
Frequency	Frequency is the number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz). Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals.
Impulsiveness	Transient sound having a peak level of short duration, typically less than 100 milliseconds.
Hertz (Hz)	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).

L_{Aeq}	The equivalent continuous (time-averaged) A-weighted sound level.
L_{A90}	The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
Low frequency noise	Sound with frequencies between 20Hz and 200 Hz.
Night	10 pm to 6 am.
Octave band	Sound, which can occur over a range of frequencies, may be divided into octave bands for analysis. For environmental noise assessments, sound is commonly divided into 7 octave bands. The octave band frequencies are 63Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz and 4kHz.
Sound pressure level (L_P)	A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 μPa RMS) and expressed in decibels.
Sound power level (L_W)	The level of total sound power radiated by a sound source. A logarithmic ratio of the acoustic power output of a source relative to 10^{-12} Watts and expressed in decibels.
Special audible characteristics	Distinctive characteristics of a sound which are likely to subjectively cause adverse community response at lower levels than a sound without such characteristics. Examples are tonality (e.g. a hum or a whine), enhanced amplitude modulation and impulsiveness (e.g. bangs or thumps).
Tonality	Noise containing a perceptible pitch component.

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