Department of State Development, Infrastructure and Planning

Wind farm state code

Planning guideline - draft for consultation

April 2014

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Queensland Government

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WR14/7922

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Overview

1.1 Introduction

The Wind farm state code is intended to facilitate the development of new wind farms or the expansion of existing wind farms in appropriate locations, and to ensure potential adverse impacts on the community and environment are avoided during the construction, operation and decommissioning of a wind farm.

This guideline supports the Wind farm state code in the State Development Assessment Provisions.

1.2 Purpose

The purpose of this guideline is to assist a proponent to prepare a development proposal for a new or expanded wind farm.

1.3 Using the guideline

A proponent proposing to develop a new wind farm or expand an existing wind farm should use this guideline to inform the planning, construction, operation and decommissioning stages of a wind farm development.

This guideline is presented in two parts:

- Part 1 provides an overview of the development approval process for wind farms, an explanation of the types of development to which the code and guideline apply and advice about pre-lodgement processes.
- Part 2 provides advice about how to comply with the performance and acceptable outcomes of the Wind farm state code.

It is not possible to address all the potential variables that could occur on a proposed wind farm site. Accordingly, the use of this guideline alone will not necessarily enable compliance with all planning and environmental management requirements. A proponent should refer to the code and ensure compliance with the prescribed provisions that apply to a development application.

Part 1 Assessment framework

2.1 Development approval process

2.1.1 Application of the Wind farm state code

The Wind farm state code (the code) applies to all new wind farm developments that comprise one or more wind turbines - including any existing wind turbines at the site - with a generation capacity of over 500 kilowatts. The code also applies to the associated infrastructure and works, such as site access (including internal roads), foundations, buildings (construction and operational) and electrical works.

The code does not apply to a wind turbine used for domestic, industrial or agricultural purposes where the generation capacity of the turbine is less than 500 kilowatts. A proposal for such a turbine is subject to assessment by the relevant local government.

The code does not have retrospective effect. A wind farm proposal that is already under assessment will continue to be subject to that assessment process.

2.1.2 State Development Assessment Provisions (SDAP)

The code is part of SDAP which is used to assess a wind farm development proposal submitted to the State Referral and Assessment Agency (SARA).

SDAP is a statutory instrument made under the *Sustainable Planning Act 2009* (SPA), and prescribed in the Sustainable Planning Regulation 2009 (SPR). SDAP contains the matters of interest that the chief executive administering SPA, may have regard to when assessing a development application as either the assessment manager or a referral agency.

The SPR will prescribe that a material change of use for a wind farm is assessable development requiring code assessment by the chief executive administrating SPA. The code will be a Module under Part C: State Codes in SDAP.

2.1.3 SARA assessment process

SARA is the agency that assesses all development applications for which the state has a jurisdiction under SPA. A proponent for a wind farm will make an application to SARA in accordance with the process set down in the Integrated Development Assessment System (IDAS). This process is depicted in **Figure 1**.

According to SPA, the chief executive may assess such an application having regard to the relevant provisions of SDAP and is required to assess the application against any:

- State planning regulatory provisions;
- the regional plan for the designated region;
- the State Planning Policy;
- any applicable codes in a temporary local planning instrument (TLPI); and
- a preliminary approval to which section 242 applies and the local government planning scheme.

This ensures an application is assessed against the relevant criteria under SDAP, and in the broader context of the planning framework.

Once a wind farm development proposal has been assessed, SARA may determine that:

- an application is approved or refused; or
- only part of the development is approved or is only subject to preliminary approval; or
- an approval of an application is subject to certain conditions.

2.1.3 Pre-lodgement

Before a development application for a wind farm is made to SARA, the proponent will need to obtain owner's consent, obtain the specialist reports referred to in the code and confirm the relevant application fees and forms with SARA. A proponent should undertake consultation with the community and other key stakeholders prior to the lodgement of a development application. A pre-lodgement meeting with SARA will assist a proponent to determine if they are ready to lodge a properly made development application.

2.2 Pre-lodgement consultation

As stated in the editor's note under the purpose of the code, stakeholder consultation plays a key role in promoting understanding and acceptance in a local community of a proposed wind farm development. As previously stated, a proponent is advised to undertake this consultation prior to the lodgement of a development application.

As part of the development assessment process, the proponent should demonstrate that there has been effective consultation with the local community. It should be noted that the wind farm proponent is responsible for the management and administration of stakeholder participation activities and information sessions and evidence of consultation undertaken will need to be provided as part of the assessment. Further details on pre-lodgement consultation are outlined in **Appendix 1**.

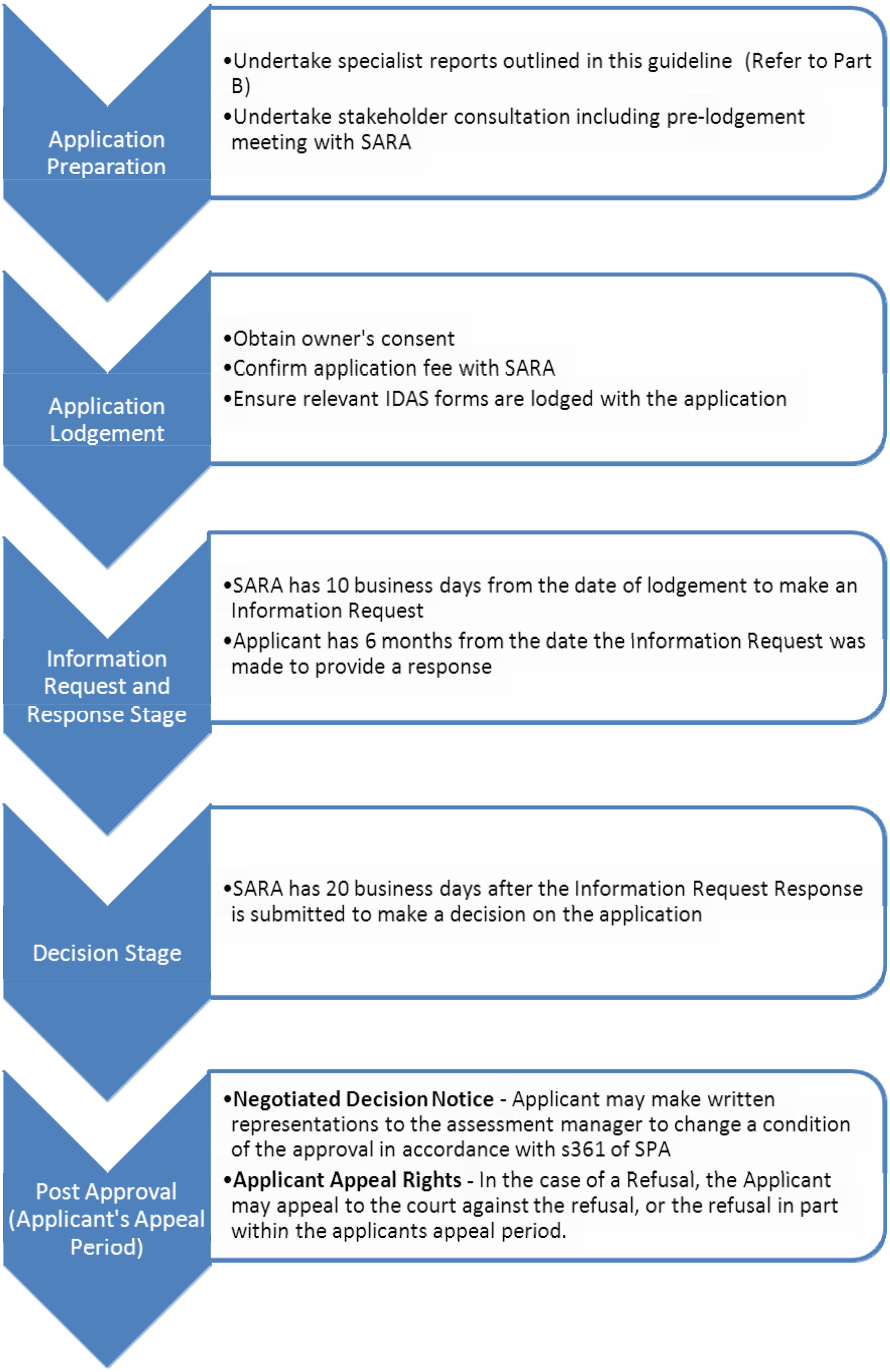

Figure 1 – Assessment Framework for wind farms

Part 2 Assessment criteria

This section of the planning guideline provides additional information to assist proponents with meeting the performance outcomes or acceptable outcomes of the Wind farm state code. The supporting actions provide useful ways of responding to the performance outcomes and acceptable outcomes; however, they may be modified to suit individual project and site circumstances as appropriate.

3.1 Meeting assessment requirements: Connectivity

3.1.1 PO1 Connection to electricity supply networks

Context

The transmission of electricity via underground or overhead power lines is required to connect a wind farm to the users of the electricity generated. The extension of transmission and distribution networks can create significant additional cost for project proponents and require additional environmental and planning approvals with associated impacts. Wind farms should be located so that they readily connect to the existing electricity supply network.

Supporting actions

The following actions support PO1:

- An assessment of the local electricity transmission or distribution system by the applicant. This would be based on a discussion with the network service provider/owner as well as the lodgement of a 'Connection Enquiry' to determine whether an electrical connection to the site is technically or commercially feasible, particularly in terms of network capacity. The Australian Energy Market Commission's National Electricity Rules indicate the required information to be provided to the Network Service Provider as part of the 'Connection Enquiry'.
- Documentation demonstrating the proposed route to connect the wind farm to the electricity network and detail through supporting reports (such as ecology, traffic, environmental management plan) how any impacts will be minimised and/or mitigated is provided by the applicant.

Suggested further information

- Chapter 5: Network Connection, Planning and Expansion of the Australian Energy Market Commission's *National Electricity Rules*.

3.2 Meeting assessment requirements: Location

3.2.1 PO2 Air safety

Context

The development of a wind farm in the vicinity of an airport and aviation facilities must not adversely impact on aircraft and airport operations. As wind farms inherently involve the construction of tall structures (often exceeding 110m in height) they are considered as a potential safety risk to low flying commercial, private and defence aircraft in the vicinity of the wind farm. Also, the movement and size of turbine blades as well as the material they are made of may interfere with radio communications equipment including aircraft and meteorological radar.

Supporting actions

The following actions support PO2:

- An assessment should be undertaken on all potential aviation activities within the vicinity of the proposed wind farm, including those operations relating to commercial, civil (including for farming related use) and military operations.
- Potential air traffic issues identified in the assessment should be discussed with the Civil Aviation Safety Authority (CASA) prior to the application being lodged. The district aerodrome supervisor should also be contacted for advice where there are potential impacts from a wind farm on aviation activities within their jurisdiction.

Suggested further information

- The *National Airports Safeguarding Advisory Group Aviation Facilities supporting Guideline - Managing the Risk of Wind Turbine Farms as Physical Obstacles to Air Navigation*.

3.2.2 PO3 Electromagnetic interference (radio and television)

Context

Microwave, television, radar or radio transmissions may be affected by the presence of wind turbines in the form of electromagnetic interference. This occurs as wind turbines can interfere with electromagnetic (or radio communications) signals either by blocking, reflecting or refracting electromagnetic waves emitted from a source. In addition, they can also on-transmit or scatter radio communication signals.

Supporting actions

The following actions support PO3:

- An assessment report of the potential electromagnetic interference should be undertaken. This may include undertaking surveys of pre-existing communications signals as well as an assessment of potential impacts and how they will be mitigated and/or managed.

Further information detailing electromagnetic interference identification and reporting, as adopted from the Draft National Wind Farm Development Guidelines, is included in **Appendix 2.**

Suggested further information

- The *Draft National Wind Farm Development Guidelines – Draft July 2010*
- The Australian Communications and Media Authority database can also assist to identify any communication services in a relevant area.

3.2.3 PO4 Environmental and ecological matters

Context

Wind farm developments have potential impacts on the ecology of the immediate and surrounding area of a proposed development site. The potential impacts of a wind farm include bird and bat strike along with potential cumulative impacts on the migratory routes of certain bird species. In addition, there are also the potential impacts on ecological processes and/or sustainability of fauna populations where wind farms are located within areas of ecological value.

The location of vegetation and the impacts associated with the clearing of the native vegetation may influence the selection of the site for a potential wind farm development. Specifically, the clearing of vegetation and the effects thereof, have the potential to impact on threatened or near threatened protected plants or animal breeding places, for example, where it results in soil erosion.

Supporting actions

The following actions support PO4:

- An ecological assessment is undertaken, which considers any risk to protected native vegetation and to fauna, particularly endangered or threatened species, and how they will be mitigated and/or managed in the siting, design and operation of the development. **Appendix 3** provides further guidance on preparing an ecological assessment.
- Should the ecological assessment identify potential risks to flora and fauna, an evaluation of site-specific wind conditions and consideration of alternative localities to support the justification of the development in the proposed location.
- Where clearing of native vegetation is unavoidable a detailed description and plans are to be supplied, along with mitigation measures (rehabilitation) for implementation during design, construction and operation of a wind farm.

Suggested further information

- The Environmental Impact Statement processes detailed in legislation such the Environmental Protection Act 1994, SPA and State Development and Public Works Organisation Act 1971.
- *Best Practice Guidelines – For Implementation of Wind Energy Projects in Australia,* prepared by the Clean Energy Council (refer specifically to Appendix 10 of the Guidelines).
- *Measuring Network of Wind Energy Institutes Evaluation of Site-Specific Wind Conditions 2009*
- The Vegetation Management Act 1999 - for further information regarding the clearing of native vegetation.

3.2.4 PO5 Wind farm transport and access

Context

The construction of a wind farm requires access by over-dimensional and heavy vehicles to the site. The construction, maintenance and decommissioning of wind farms represent the key stages at which large vehicles are typically needed to support a wind farm.

As a consequence of the types of vehicles and machinery needed to construct and maintain a wind farm, their temporary impacts on the road network need to be assessed and understood.

The route for onsite access roads between turbines should avoid steep gradients in the transportation of turbine components.

Supporting actions

The following actions support PO5:

- An assessment report of the traffic impacts associated with the construction and operation of the wind farm should be prepared by the applicant. It should include consideration of the potential impacts on the local and regional road network such as:
  - details of traffic volumes (both light and heavy vehicles) and proposed transport routes (including site access) during construction and operation;
  - an assessment of the potential traffic impacts of the project on road network function (including intersection level of service) and safety;
  - an assessment of the capacity of the existing road network to accommodate the type and volume of traffic generated by the project (including over-dimensional traffic) during construction and operation, including full details of any required upgrades to roads, bridges, site access provisions or other road features;
  - details of any potential road upgrades or special traffic control arrangements that may be required during construction;
  - details of measures to mitigate and / or manage potential impacts, including construction traffic control, road dilapidation surveys and measures to control soil erosion and dust generated by traffic volumes; and
  - details of access roads within the site including how these would connect to the existing road network and ongoing operational maintenance.

Suggested further information

No further reference material is suggested.

3.3 Meeting assessment requirements: Amenity

3.3.1 PO6 Visual amenity

Context

In order to access a wind resource, wind farm developments may need to be located in areas that impact on the landscape values of an area. The height and potential scale of wind farms means that an impact on landscape values is often unavoidable. However, an assessment needs to be undertaken that clearly identify aspects of landscape value

as relevant to the unique characteristics of a wind farm project. These values should be identified through engagement with the local community and subsequently mitigation measures should be considered where possible.

Supporting actions

The following actions support PO6:

- A landscape visual assessment report of the immediate and surrounding areas should be prepared by the applicant. The assessment should include consideration and include:
  - A detailed description of the potential impacts (including the cumulative impacts) on the locally, regionally and nationally significant viewscapes;
  - Accurate visual simulations or photomontages illustrating the development in the context of the surrounding areas and from key public view points;
  - Any mitigation measures such as materials, finish and/or colour required to minimise visual impacts. Where possible, connections between wind turbines and substation/s are located underground within internal access roads, along with other co-located services.

The landscape visual assessment may be prepared in accordance with the *Wind Farms and Landscape Values National Assessment Framework 2007.*

Suggested further information

- The *Wind Farms and Landscape Values National Assessment Framework 2007* - for further information regarding undertaking a landscape visual assessment.

3.3.2 PO7 Shadow flicker

Context

Shadow flicker may occur under certain conditions of geographical position and time of day, 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 potentially impact on urban and rural development by creating a 'strobing' shadow effect.

Supporting actions

The following actions support PO7:

- A shadow flicker assessment and outline of the potential impacts and how these impacts are to be mitigated and/or managed should be detailed in a report by the applicant. This assessment should consider the potential impacts on neighbouring properties and ensure that any modelled blade shadow flicker impacts do not exceed 30 hours per annum and 30 minutes/day.

Appendix 4 provides guidance on addressing the risk of shadow flicker based on the recommendations of the *Draft National Wind Farm Development Guidelines – Draft July 2010*

Suggested further information

- The *National Wind Farm Development Guidelines – Draft July 2010.*

3.3.3 PO8 and PO9 Noise impact

Context

The noise characteristics of wind farms mean that both audible and low-frequency noise emissions need to be considered during development assessment.

The National Health and Medical Research Council (NHMRC) interpret sound as composed of frequency, expressed in hertz (Hz) and pressure, expressed as decibels (dB). In terms of frequency sound can be categorised as audible and low-frequency (also referred to as inaudible).

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

- Mechanical noise which is produced from the motor of motor or gearbox; if functioning correctly, mechanical noise from modern wind turbines should not be an issue.
- Aerodynamic noise which is produced by wind passing over the blade of the wind turbine. Aerodynamic noise can be divided into three classifications: low frequency noise, inflow turbulence noise and airfoil self-noise.

Low-frequency sound is commonly defined as sound which is inaudible to the human ear (below 16 Hz). Despite this commonly used definition, low-frequency noise can be audible. Human sensitivity to sound, especially to low frequency sound, is variable and people will exhibit variable levels of tolerance to different frequencies.

With respect to low-frequency noise, the NHMRC is a national expert body promoting the development and maintenance of public and individual health standards. In early 2014, after a review of scientific literature, NHMRC concluded that there is no reliable or consistent evidence that wind farms directly cause adverse health effects in humans.

The NHMRC will continue to investigate and monitor health issues and wind farms. As the NHMRC is the key expert body on health effects of wind farms, the Queensland Government will monitor any new findings and incorporate findings from NHMRC reviews, into potential future amendments of the Wind farm state code.

Supporting actions

The following actions support PO8 and PO9:

- A noise impact assessment report, by a qualified acoustic engineer is provided. **Appendix 5** contains guidance for undertaking a noise assessment.

Suggested further information

- *Best Practice Guidelines – For Implementation of Wind Energy Projects in Australia* prepared by the Clean Energy Council.

3.3.4 PO10 Environmental management plan

Context

An environmental management plan (EMP) is the most appropriate means of addressing all significant lifecycle aspects of the construction, operation and decommissioning of a wind farm.

Supporting actions

The following actions support PO10:

- The EMP should, at least achieve the following:
  - nominate the objectives of the EMP and criteria by which performance can be assessed.
  - describe the roles and responsibilities of those involved in the construction, operation and decommissioning.
  - define the site included in the EMP and provide a description of the activities covered by the EMP (i.e. construction works such as access track construction and operation activities such as turbine maintenance).
  - identify all potential negative environmental impacts associated with the project (e.g. sedimentation of nearby waterways during construction, bird strike during operation).
  - describe the processes by which potential negative environmental impacts can be successfully mitigated and the project can meet its commitments and obligations (this is often achieved by including sections or sub-plans in the EMP for each potential impact together with specific management measures).
  - define the procedures for monitoring and reporting, if required, to ensure processes implemented are effective and to provide a mechanism for demonstrating compliance.
  - set out the audit process for the implementation of the EMP and develop a procedure for managing non-conformances and providing for continual improvement in environmental performance.
  - document the environmental commitments and obligations associated with the project. Should the development be approved, these would include commitments required by the approving authorities (e.g. in conditions contained in the project approval) and obligations determined by the relevant Acts and regulations.
  - establish stakeholder consultation and complaint management procedures.
  - provide a timeline for the implementation of the plan or period of currency prior to review.
- For decommissioning, the EMP should specifically contain commitments by the proponent to rehabilitate the wind farm site, regarding how:
  - the wind farm infrastructure is removed from the site;
  - the site is suitable for other uses compatible with the locality as stated in the planning scheme;
  - the visual amenity and the sustainable ecological functioning of the site is maintained and where possible improved.

Suggested further information

- *Best Practice Guidelines – For Implementation of Wind Energy Projects in Australia* prepared by the Clean Energy Council.

Appendices

Appendix 1 - Community and stakeholder consultation

To ensure effective and responsible community engagement, the proponent should:

- Commence community and stakeholder engagement early in the development process, preferably prior to the lodgement of the development application. Proponents should consult with neighbours and others likely to be directly impacted, specifically in the site selection and preliminary design phases.
- During consultation, provide opportunities for feedback and input and full consideration of community concerns. It is strongly encouraged that proponents maintain open and regular communication channels with relevant stakeholders.
- To demonstrate that a proponent has taken this approach, the development application could include community consultation assessment documentation that includes the following:
  - Clear presentation of details and evidence of the consultation process undertaken including the stakeholders and government bodies (such as federal, state and local governments) consulted;
  - Clear identification and tabulation of all issues raised during the consultation process;
  - A description of how the identified community issues have been addressed, and how they have informed the proposal; and
  - Review of a social baseline study.

A social baseline study involves conducting research to understand the social context of an area where a wind farm might be developed. This includes researching a community's background, demographics and attitudes - so as to inform decision-making, identify opportunities and avoid potential risks.

The social baseline study provides data that proponents can use to analyse change in the community as a consequence of the future wind farm development. This can help proponents understand their contribution and potential impacts on the community.

Suggested further information

- For further information regarding consultation approaches refer to the *Community Engagement Guideline for the Australian Wind Industry.*

Appendix 2 - Electromagnetic impact assessment

The material contained in these appendices is drawn from the *National Wind Farm Development Guidelines – Draft July 2010.*

An electromagnetic impact assessment report is to be prepared to demonstrate that the wind farm development is designed and sited to ensure minimal electromagnetic interference (EMI) to pre-existing television, radio reception or transmission. The assessment report should detail the outcomes of:

an assessment of potential EMI service;

- a preliminary impact assessment; and
- the necessary mitigation strategy.

A2.1 Methodology – assessment of potential EMI impacts

Review of licensed radio communication services

Conduct a search of the Australian Communications and Media Authority (ACMA) Register of Radiocommunications Licences to provide a listing of all licensed radiocommunications services within a specified area around the wind farm. A radial distance of 50-60km from the centre of the wind farm would normally capture all of the potentially affected services in the area.

It is not possible to determine whether users of radiocommunications devices operating under a class licence exist in the area. Such users would need to come forward during the community consultation process.

Identify potentially affected services

Applicants are required to determine which services may be affected by the wind farm development through the calculation of the distance between line-of-sight radio paths and the proposed wind farm. This may come down to individual wind turbines if necessary, for any turbine (including blades) within a line-of- sight radio path or within close proximity to a broadcast site or if it may impact on the performance of a radar facility.

To calculate this distance, 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 receiver.

The following categories detail the circumstances in which certain separation distances are required to ensure a wind turbine will not interfere with a radiocommunications service:

- Obstruction to radio line-of-sight path
- Reflection/scattering
- Near-field effects
- Obstruction to radar line-of-sight

Obstruction to radio line-of-sight path

This is when the location of a wind turbine causes radiocommunications 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 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 radiocommunications path, and the distance of the particular point in question along the radiocommunications 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 as follows.

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

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 2 – The formula for calculating the second Fresnel zone distance

Source: [National Wind Farm Development Guidelines – Draft July 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 23cm (1300MHz) radars, such as those used for en-route surveillance, can have an operating range in the order of 200 nmiles (radius of search volume in nautical miles), a 10cm (3000MHz) approach radar 60 nmiles, and 3cm (9000MHz) final approach radar 15 nmiles. Individual radar operators will need to evaluate the development and advise whether there may be any potential 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, and is dependent upon the frequency of the signal, the gain and 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 20m.
- For point-to-point Microwave links as approximately 720m.
- For Low Band VHF paging systems approximately 4m.

As can be seen from the above examples the near-field zone varies widely depending upon the service type. It is recommended that a conservative criterion for discussing potential impact due to near-field effects with a potentially affected party is if the wind farm proponent intends to locate a wind turbine within, for instance, 1km of any telecommunications site.

Reflection/scattering

This occurs when radio signals are reflected (scattered) from the wind turbine blades and interfere with a wanted 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 receiver and transmitter to the wind turbine tower. Some methods use worst-case radar cross section (RCS), which is very conservative, or a variant on the second Fresnel zone calculation for users close to a wind turbine. Note, 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 30dB.

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.

As there is no single criterion for potential impact on radiocommunications services due to scattering, it is recommended that the criterion for discussing potential impact due to reflections/scattering with a potentially affected party is if the wind farm proponent intends to locate a wind turbine within 2km of any telecommunications site.

In summary, the recommended criteria for discussions with a potentially affected party are, if the wind farm proponent intends to locate a wind turbine:

- Within the maximum second Fresnel zone of a point-to-point radio link.
- Within 2km of a radiocommunications site or a receiver.
- Within 250 nmiles of Aeronautical and Weather Radar operations.

It should also be noted that the accuracy of radiocommunications site coordinates in the ACMA database is variable, and also that 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. Therefore, should there be an indication that any individual services may be impacted, or are within, for instance, 5 km 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.

A2.2 Preliminary impact assessment

Having determined which services may be potentially affected by the wind farm, a preliminary impact assessment should be conducted to determine the level of risk for the potential impacts 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 may be a subject for discussion with the individual organisations affected at the next stage.

Following the risk assessment, a preliminary determination of which organisations or individuals require consultation can be made and undertaken as part of the consultation.

A2.3 Mitigation strategy

Best practice to reduce the effects of EMI involves designing the wind turbines to their minimise 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 available construction materials
- the use of absorbing (or non-reflective) materials from those available for blade construction
- consideration of the spacing of wind turbines in relation to any affected services

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

In addition, there is a hierarchy of mitigation options that can be explored with the individual affected parties, to eliminate any specifically identified EMI effects. They are:

- Re-location / removal of individual turbines
- Replacement of the existing radiocommunications service equipment with another less affected type (e.g. UHF link → Microwave link; Analogue TV → Digital TV)
- Re-location of radiocommunications services to another existing radiocommunications site
- Re-location of radiocommunications services to a new telecommunications site. (Such a site may need to be established to provide telecommunications services to the wind farm itself, and provide a dual purpose solution)
- The use of underground or overhead optical fibre as a telecommunications medium in lieu of a radiocommunications service, thereby avoiding the wind farm interference effects
- Enhanced radar filters (able to remove the returns from wind turbines, careful spacing of turbines in relation to the radar service can also assist with this solution)

The mitigation options selected may be different for each individual service affected, depending on the type of service and the level of interference expected. For example, there may be several point to point radio links that are affected. It may be agreed to relocate one turbine for one of the links, and move the other to another site which is then linked by optical fibre.

Where the effects cannot be easily quantified, and are intended to be dealt with after construction, the mitigation process could be:

- Baseline testing prior to construction
- Post-construction monitoring
- Validation of any issue and mitigation

For example, where the proposed wind farm development is within close proximity to houses, for instance within 10km, it is recommended that baseline testing of television signals is carried out prior to construction, for picture quality and signal level. This may also apply to other broadcast and point to multipoint services such as mobile phone, commercial radio etc.

Should post-construction monitoring identify an issue, the following mitigation options are available after commissioning:

- For general broadcast services, including analogue or digital television:
  - Review and improve the receive antenna orientation and state of repair
  - Installation of a more directional and/or higher gain antenna
  - Relocation of the antenna to a less affected position
  - Installation of an appropriate amplifier
- For analogue or digital television:
  - Installation of a digital TV translator for an affected area
  - Provision of satellite TV services.

A2.4 Glossary - Electromagnetic impact assessment

ACMA: The Australian Communications and Media Authority

Fresnel zone: Is an ellipsoid around and forming a path between the transmitting and receiving stations based on transmission, frequency, distance and local atmospheric conditions. If unobstructed, radio waves will travel in a straight line from the transmitter to the receiver. But if there are obstacles near the path, the radio waves reflecting off those objects may arrive out of phase with the signals that travel directly. A Fresnel zone is the ellipsoid surface from which reflected signals will arrive at the same time later than the direct radio signal.

2nd Fresnel zone: Is the ellipsoid zone within which a reflected signal will arrive up to 270 degrees out of phase with the direct signal.

nmiles: Nautical miles

Suggested further information

- *National Wind Farm Development Guidelines – Draft July 2010*

Appendix 3 - Ecological assessments

The material contained in these appendices is drawn from the *National Wind Farm Development Guidelines – Draft July 2010.*

In accordance with the Wind farm state code, this section details the recommended methodology for undertaking the ecological assessment of:

- vegetation communities
- flora
- terrestrial fauna and their habitats
- birds and bats.

Assessments are necessary where wind farms can potentially affect ecological values through:

- bird and bat collisions with wind turbines
- the clearing of native vegetation for the construction of roads and turbine hardstands
- the construction of roads and turbine hardstands impacting on important flora species and fauna habitats
- indirect effects (such as noise or potential alienation at a site), where wind farms change the use of habitats by birds and bats on or near a wind farm.

The results of the ecological assessments are used to describe the existing environment and to assess the potential impact on flora and fauna. This information will support an application for development approval and will be included in the assessment whether the wind farm is likely to have an unacceptable impact on ecological values.

The results of an ecological assessment could also inform a referral to the Australian Government Minister of the Environment for consideration under the Environment Protection Biodiversity Conservation Act 1999 (EPBC Act) if one is made for the assessment of potential impacts on matters of National Environmental Significance.

A3.1 Approach

The ecological assessment should include:

- a desktop review of available information to identify any potential issues that may prevent the project being approved
- field surveys to map the vegetation and identify flora and fauna species
- species-specific studies to obtain more information about significant flora and fauna particularly birds and bats) that may be at risk from the development or to avoid them or develop mitigation strategies
- development of avoidance, mitigation and offset strategies to minimise or mitigate impacts on species if required; and
- development and implementation of monitoring programs for the construction and operational phases of the wind farm development.

The ecological assessment guidelines have been separated into two parts, birds and bats, and vegetation and terrestrial fauna. The assessment of bird and bat issues tend to form a major part of ecological impact assessments for many wind farm projects because of the potential for collisions with wind turbines.

A3.2 Birds and Bats

Desktop review

The aim of the desktop review is to identify if there is the potential for significant impacts to any listed bird or bat species that use the site. These impacts include the risk of collision with wind turbines or where the construction of a wind farm may affect the way species use the site. This could also apply to unlisted species that are important for other reasons, however the desktop review should focus on bird and bat species that are covered by state, territory and Australian Government legislation.

A desktop assessment uses existing information in published reports or online databases, to identify if there are any significant bird and bat species on or adjacent to the proposed wind farm site that may constrain, impede or prevent the approval of a wind farm. Significant species are those listed as threatened under relevant legislation and those for which there is evidence that they are at risk from wind farm developments.

The desktop review should encompass an area around the wind farm which includes 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. Examples of online databases are the EPBC Act Protected Matters Search Tool as well as Queensland's Matters of State Environmental Significance.

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

The desktop review can benefit from a site visit to validate and inform the results of the database. This could include the presence of important potential habitat features for birds and bats such as forest with old trees with hollows which may provide potential nesting, roosting breeding and habitat.

Field studies

The desktop review will inform the type of field studies that will 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 should aim to:

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

Field surveys should aim to cover all planned areas of disturbance, including grid infrastructure, and may require a number of visits depending on the species being

surveyed and any changes in the size and layout of wind farm. They should provide sufficient information to support an application for development approval and to assess whether a referral under the EPBC Act might be appropriate.

Bird surveys

Studies in Australia and overseas have shown that some birds are at risk of collision with wind turbines, with some species of birds shown to be at higher risk than others. Bird utilisation surveys aim to identify the avian species on site, the numbers present, the height that birds fly, and describe 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 wind farm effects.

The survey design may need to 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. 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 are quantitative and are collected at pre-determined fixed points. The surveys are conducted during relevant seasons (for the species being studied and the location of the site), and would normally involve sampling of different relevant habitats on the site. Data are usually recorded in a way that allows them to be input into a collision risk model for estimating the potential collision risk of a species.

Monitoring of the impacts of a wind farm should only occur in the operational phase of the development, and only where there has been a specific need identified by the regulators. Monitoring regimes will be informed by the earlier survey and modelling work.

Bat surveys

Similarly to birds, studies in Australia and overseas have shown that some bat species are at risk of collision with wind turbines or barotrauma. Field surveys can be carried out to determine which bat species use the site and includes those species that breed and roost on the site and those that do not live on the site but forage and/or move across the site. Methods that can be used to identify the bat species on the site and give an indication of their use of the site include:

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

Note that mist nets and harp traps will require permits to catch and handle bats from state wildlife regulatory authorities and will also require Animal Ethics Approval. 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.

It should be noted that bat utilisation data cannot be obtained by using the above techniques (i.e. they 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.

Species-specific studies

The results of the field surveys may lead to additional species specific surveys being required to assess the potential effect of the wind farm 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

Collision risk of 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 whether a particular species flies at rotor height. 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

The data from either general bird utilisation studies or specific species utilisation studies can be input into Collision Risk Models (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. 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 input 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 at sites. These may include studies to assess the use of a site by concentrations of threatened species, such as those that may use a maternity cave within the vicinity of a proposed wind farm which may place greater numbers of individuals at risk of collision with wind turbines. These studies may involve the design and implementation of a study that employs the deployment of bat call detectors at a number of strategically located sites over the period when bats are breeding and are most active, in the spring and summer months.

Population viability analysis

Population Viability Analysis (PVA) was developed as a modelling tool for determining the viability (extinction probability) of populations of threatened species, where information was available on a range of population variables. It provides a means of organising and analysing information about the population of a threatened species. PVA is a useful modelling approach to explore a range of scenarios that may arise from the impacts of a wind farm (particularly collision risk) on bird populations.

It is a well-researched, formalised approach and its information requirements are well-documented. However, for most threatened species there is an absence of measured

population and demographic variables that are required as inputs into a PVA and the results of the PVA need to be interpreted with consideration of the limitations of the data that have been used.

Suggested further information

- *Terrestrial Vertebrate Fauna Survey Guidelines, August 2013*
- *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Version 3.2 August 2012)*
- *The National Wind Farm Development Guidelines – Draft July 2010*

Appendix 4 - Shadow flicker assessment

The material contained in these appendices is drawn from the *National Wind Farm Development Guidelines – Draft July 2010.*

The rotating blades of wind turbines can cast intermittent shadows that appear to flicker for an observer at a fixed ground position. Since wind turbines are tall structures, shadow flicker can be observed at considerable distances but usually only occurs for brief times at any given location. The most common effect of shadow flicker is annoyance. These impacts are most closely associated with the duration of shadow flicker experienced above a certain level of intensity.

The duration of shadow flicker, its intensity and the locations it affects are most strongly determined by the relative position of the Sun, the turbine, and the receptor. The relative position of the Sun varies with latitude, time of day and time of year. Other influential factors include:

- the size of the wind turbine rotor and height of the tower;
- surface topography;
- intervening vegetation;
- direction of the wind (and hence the rotor plane of the wind turbine);
- weather (particularly cloud cover); and
- general visibility (including presence of mist, smoke and other particulates).

This Appendix discusses the shadow flicker phenomenon and presents a best practice methodology to assess and mitigate against its affects. Specifically, the Appendix provides:

- Consideration of suggested impacts of shadow flicker, identifying impacts with negligible risk and impacts with significant risk.
- An explanation of the shadow flicker assessment method with practice note.
- Specify wind farm design methods necessary to minimise the impact of shadow flicker on wind farm stakeholders.

A4.1 Methodology – Limiting shadow flicker on amenity of residents

Assessment of proposed layout

The optimum method of assessment is as follows:

- Determine the extent of shadows from turbines being a distance of 265 x maximum blade chord (no assessment is required for residences beyond this distance).
- Identify all residences within the extent of shadows from proposed turbine positions.
- Use modelling software with relevant modelling parameters, as identified below, to calculate the theoretical annual shadow flicker duration at each residence, accounting for topography and cumulative effects.

The approach to addressing cumulative impacts is common to many aspects of wind farms. This section addresses requirements specific to shadow flicker, and in particular defines the information to be provided by a developer in order to assess potential cumulative impacts in the future. Cumulative impacts from shadow flicker are generally unlikely; however, there are a number of practical instances where they can occur and so the potential for such impacts to arise should be addressed.

If necessary, modify turbine layout and repeat calculations, or introduce mitigation measures, to achieve compliance with the specified limits in below.

Impact	Measure	Assessment Procedure	Acceptable Level
Annoyance	Hours / year (Hr/yr)	Modelled*	30 hours / year modelled
		Measured*	10 hours / year actual

**Calculation of shadow flicker in an ideal model (with the assumptions specified here) will provide a conservative estimate of the actual shadow flicker. In most circumstances where a dwelling experiences a 'Modelled' level of shadow flicker less than 30 hours per year, no further investigation is required. However, if this level is exceeded in the modelled scenario, mitigation measures may be introduced and the 'actual' or 'measured' level of shadow flicker will need to be determined. The modelling approach includes a number of assumptions and, as such, the 'Modelled' exposure limit is set higher to account for these conservatisms. The assumptions used in the modelling approach should produce an outcome equivalent to 10 hours per year actual exposure.*

Sensitivity

Shadow flicker duration can be very sensitive to location, varying by up to approximately 0.8 hours per metre of horizontal displacement. Thus in an extreme case, one end of a house 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 dwelling. 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 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 should 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 25m

Means of mitigating modelled estimates

The mitigation measures identified below may be used to reduce the modelled exposure to shadow flicker.

Mitigation	Constraints
Cloud cover assessment	Annual limit reduced to 10 hours/year Use recommended method of assessment described below
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 should 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.

Suggested further information

- *The National Wind Farm Development Guidelines – Draft July 2010*

Appendix 5 - Noise impacts

The material contained in these appendices is drawn from the *Wind farms environmental noise guidelines.*

The following appendix comprises two parts. Part A relates to audible noise and Part B relates to low-frequency noise. Both aspects must be satisfied in order to meet the relevant performance outcome.

Part A

A5.1 Audible Noise

The predicted equivalent noise level (LAeq, adj,10min), including tonality adjustment, does not exceed, whichever is the greater of:

(1) 35dB(A) at relevant sensitive receptors, or

(2) the background noise (LA90,10min) by more than 5dB(A);

for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.

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

Meeting the criteria

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

Background noise is measured at relevant receiver locations at continuous 10-minute intervals and particularly over the range of wind speeds at which the Wind Turbine Generator's (WTG) operate. The data must adequately represent conditions at the site and cover approximately 2,000 intervals.

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

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

A5.2 Background Noise

What is background noise?

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

Why is background noise important?

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

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

Background noise measurement locations

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

Relevant receiver locations are premises:

- where someone resides or has development approval to build a residential dwelling;
- where the predicted noise level exceeds the base noise level for the area [35dB(A)] for wind speeds up to the speed of the rated power;
- that are representative of the worst-case situation when considering the range of premises, e.g. a house located among a group of nearby houses within a residential zone.

The only exception is a receiver within 1,500 metres of the Wind Farm site that is in an area unlikely to be exposed to a windy environment. This specific circumstance should be discussed with relevant referral agency.

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

Background noise environments likely to differ at receivers around a Wind Farm site should also be discussed with the relevant referral agency.

Background noise measurement position

All measurements should be made outdoors. The microphone should be positioned 1.2−1.5 metres above the ground and at least 5 metres from any reflecting surface (other than the ground).

The property boundary of the receiving premises is generally not considered a valid measuring position for large rural properties unless a house is located near the boundary or the development plan clearly envisages noise sensitive development at such a location.

In general, any area within 30 metres of a house and in the direction of the Wind Farm would be a valid measuring position. Care should be taken to ensure that the area is not screened from the Wind Farm by house, shelter or other elements.

Background noise levels can be significantly affected by local conditions, such as the presence of trees nearby. Photographs from multiple directions are to be taken showing the noise measurement position and associated surroundings, such as buildings, trees and topography. This will ensure that no significant physical changes have been made to the locations since the time of the initial background noise measurements.

Care must be taken when using a measurement position to represent other receivers in the locality. Trees, grass and shrubs should be representative of the local area that is being assessed. Background noise measurements should represent the natural background in the immediate vicinity of the relevant receiver; extraneous noise sources (water pumps, air conditioning units, electrical transformers, etc.) should not influence the data. In case selection of the representative point is not straightforward a conservative approach should be taken by placing the microphone in the quieter location.

Data Collection

Equipment

Background noise levels should be collected for continuous 10-minute intervals using sound level meters or loggers of at least Class 2 certification in accordance with Standard AS IEC−61672. The lower limit of the instrument measurement range must be chosen to provide accurate measurements which might be limited by the noise floor of the data acquisition device.

The meters or loggers should be calibrated on site immediately before and after any measurement period using a calibrator which is suitable for the class of the instrument and complies with AS IEC−60942.

Wind

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

As part of the development application, developers should confirm that the reported noise levels are not influenced by high wind speed across the microphone, particularly where wind speeds at the noise measurement position are expected to exceed 5 m/s (a high wind speed for the purposes of noise level measurement conditions). It is permitted to report noise measurement data at higher wind speeds if they have been taken with special windshields. The windshield performance should be confirmed by sufficient technical information proving accuracy of such measurements.

Affected data should be identified by monitoring statistical wind speed (i.e. equalled or exceeded for 90% of the measurement time) at the noise measurement position (1.2−1.5 metres above ground level at the relevant receiver) over 10-minute intervals that correspond with the noise level measurement intervals. Not all wind monitoring instruments can provide the wind speed statistical parameters. In this case reporting the average wind speed to identify validity of the noise measurements is permissible. Accuracy of the wind speed measurements should be ±0.5m/s or better.

If wind data from the single wind speed monitor are not representative for all of the noise monitoring locations, the wind speed should be measured separately at each of the locations.

This information would then be compared with both the collected data for that interval and the manufacturer's specifications for the windshield performance under those conditions:

- Where manufacturers' specifications indicate that wind induced noise on the microphone is

- 10dB(A) or more below the background noise, the data is acceptable.
- Where manufacturers' specifications indicate that wind induced noise on the microphone is
- 10dB(A) to 4dB(A) below the background noise, the affected data may be retained with the wind induced noise subtracted from the measured background.
- Where manufacturers' specifications indicate that wind-induced noise on the microphone is within 4dB(A) of the affected data, the affected data should be discarded and the data should be re-analysed. If the procedure causes the regression curve to change significantly, then additional data will need to be collected within an improved wind screen.

If it is not possible to obtain manufacturers' data for the windshield used, then data above 5 m/s should be discarded.

Rain

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

The nearest weather station might not provide a sufficient indication of localised conditions in remote areas. A simple method might record rain using a local gauge or collection method that is regularly checked, and discard all data in periods where rain was detected.

Data

Data not adversely affected by the effects of wind or rain should be collected for a sufficient period to cover the range of wind speeds and directions generally expected at the Wind Farm site. Particular emphasis should be placed on collecting background noise data corresponding to the operating wind speed range of the WTGs.

Sufficient data is considered to be approximately 2,000 measurement intervals (or the equivalent of two weeks' worth of data) where at least 500 points are collected for the worst- case wind direction. Compliance checking will require the similar noise data collection process to be repeated when the Wind Farm is operational.

Background noise varies naturally throughout the year, with different prevailing wind directions, foliage on trees, atmospheric conditions and the like. It is advised to use the collected wind statistics and weather forecast to perform the background monitoring during periods when the percentage of the worst-case wind direction data is sufficiently high to collect the required number of data. If collection of the noise statistics under the worst-case wind direction requires an unreasonably long monitoring time, less data that still provides a robust correlation between the background noise and wind speed may be acceptable (generally a few hundred points).

A community concern is that the developer may measure during a limited (minimum two weeks) period that is not representative of the whole year.

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

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

A5.3 Wind Speed Measurements

Generally, as the wind speed increases the noise level generated by a wind turbine increases. Manufacturers of wind turbines publish noise level data for their machines derived through a comprehensive international measurement standard. Data should be provided for at least each integer wind speed from cut-in speed up to the speed of the rated power.

Wind speeds (in m/s) should be measured at the WTG hub height. For the purpose of the guidelines it is permitted to report wind speeds at other heights where wind speed at the hub height can be accurately calculated (refer to the text below). The noise level data for each WTG is used as the basis for predicting the total noise level from a Wind Farm.

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

Measurement height

A developer will often measure wind speed at different heights to determine whether wind conditions at the site are suitable for an economically viable Wind Farm development. It may be acceptable to convert the results from a different measurement height (for example meteorological tower sensors) to the hub height provided the wind shear model used to do this is clearly stated and accepted by the EPA. Atmospheric stability conditions should be taken into account to assure accurate conversion of the data from the different height.

All wind speeds referred to in these guidelines and within any development application submitted to a planning authority should be expressed at the WTG hub height.

All predicted and measured noise levels should be based on noise level data derived from wind speed measurements referring to the WTG hub height.

Measurement location

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

- background noise measurements
- noise predictions
- compliance checking

Therefore the wind speed measurement location at the Wind Farm site should not:

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

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

Wind measurements at the WTG nearest to the relevant receiver should be used for compliance/complaints checking if it is not possible to perform measurements at the same location as it was used for the background noise data acquisition.

Evidence that the wind speed and direction sensor is certified for the accurate determination of wind parameters is to be supplied as a part of the report. Accuracy of the wind speed measurements should be ±0.5m/s and wind direction measurements ±3º or better.

A5.4 Noise Level Prediction

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

All noise sources associated with the Wind Farm operation (e.g. substations, switch yards) should be taken into account and results of the prediction compared with the noise criteria.

WTG manufacturers generally do not test or extrapolate tested results above wind speeds of rated power.

The measurement of noise levels under high wind speeds (used to determine the sound power level of a turbine model) is difficult.
Where Wind Farms comply with the noise level criteria in these guidelines up to rated power, it is unlikely that adverse impacts will occur at higher wind speeds.

Propagation model

A suitable model must be selected (or developed) to predict the worst-case noise level at all relevant receivers. There is no standard procedure directly applicable to sound propagation from Wind Farms. It is recommended to use noise prediction methods in accordance with ISO9613−2 or CONCAWE2.

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

A conservative approach should be used for predicting Wind Farm noise by calculating noise levels in octave bands from at least 63 to 4,000Hz to determine an overall predicted level and using the following inputs:

- atmospheric conditions at 10ºC and 80% humidity
- weather category 6 (if CONCAWE method is utilised)
- hard ground (zero ground factor)

If another prediction method and modelling inputs are employed to carrying out the noise level prediction, the details of the model should be clearly stated. The following information should be provided as part of the development application:

- the propagation model, and any variation of the model, used for the prediction
- an estimate of the model accuracy in dB(A)
- the assumptions used as input to the model, including allowances for noise absorption due to air, ground, topographical and wind effects

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

Sound power data

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

The sound power level data at wind speeds from cut-in speed to the speed of rated power and each integer speed in between should be specified in the development application as determined in accordance with International Electrotechnical Standard IEC 61400−11. The sound power level determined in accordance with other relevant standard or procedure might be acceptable for the purpose of the guidelines.

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

The wind farm developer must also discuss changes to the type, location or operation of the WTGs with the assessment manager.

Tonality

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

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

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

A5.5 Data analysis

Background noise and wind speed data

At the end of the data collection period there should be a minimum of 2,000 pairs of synchronised background noise and wind speed measurements where at least 500 points are collected for the worst-case wind direction. The data should be collected at wind speeds between the cut-in speed and the speed of rated power.

A best fit regression analysis should be carried out on the data. The polynomial order (from linear up to third order) providing the best correlation coefficient should be used to present the fitted regression line to calculate background level Lb. The correlation coefficient should be specified for each polynomial order. If a higher order of polynomial is used, a justification for its utilisation should be provided. Generally background noise demonstrates an incremental trend if the wind speed increases.

The graph for each relevant receiver showing the plotted points, the fitted regression line, the polynomial describing that line and the correlation coefficient should be included in the development application. The predicted noise level should be overlaid on such a graph to determine compliance with the criteria.

A5.6 Noise assessment procedures

Wind farm noise screening measurements follow a similar procedure to background noise monitoring. The LA90, 10 is measured with the wind farm operating at relevant receiver locations, over continuous 10- minute intervals and over at least the range of wind speeds from the cut-in speed to the speed of the rated power of the WTGs. The data must cover not less than 2,000 intervals where at least 500 pairs of data correspond to the worst case wind direction.

Wind speed is measured in intervals that correlate with the ambient noise measurements as previously described.

Compliance checking should be based on data associated with the worst case wind direction from the wind farm to the relevant receiver. A wind direction spread of 45° either side of the direct line between the nearest WTG and the relevant receiver is considered acceptable. This will not always be practical, given prevailing wind conditions. Data measured during known extraneous noise events should not be included in the analysis.

Cases in which it appears to be impractical to collect 500 valid data points under worst case wind direction conditions should be discussed with the local government or assessment manager.

Choice of the nearest WTG may be ambiguous. For example, two or more WTGs are located at the similar distances from the receiver and the worst case scenario for the noise propagation is not obvious. It is not expected that such situation is frequently encountered in practice. In this case data post- process should be carried out and reported for each of the possible worst case wind directions.

If data adjusted for tonality (if needed) is below the criteria it should be reported as such and no further data analysis or additional noise measurements are required.

A5.7 Data analysis of wind farm noise measurements

Regression analysis should be repeated on the ambient noise LA90,10 and wind speed measurement data. If a higher order of the polynomial is used, justification for its utilisation should be provided. The correlation coefficient should be specified in the compliance checking report.

Data below the cut-in speed and above the speed of the rated power should not be included. A graph should be prepared for each relevant receiver showing:

- the plotted points,
- the fitted regression line indicating combined wind farm and background noise level LR,
- the polynomial describing that line and the correlation coefficient in the compliance checking report.

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

A5.8 Correction for background

This is the preferable method for calculation of the wind farm noise. It should be employed when noise monitoring of the wind farm is done at commissioning and subsequent compliance checking procedures. The method is based on the logarithmic subtraction of the acquired background noise level Lb (for the worst case wind direction) from the combined noise level measurements LR.

The wind farm noise level LWF is to be adjusted for tonality in accordance with these guidelines and compared with the criteria. Results of the calculations should be reported in the supplied documentation.

The compliance checking report should contain confirmation that the background noise data based on the previous background measurements (if any) are still valid. Otherwise background data acquisition procedure should be repeated with WTGs parked or offline with WTG rotor revolutions below 2r/min. Otherwise alternative compliance checking methods as outlined below can be discussed with the local government or assessment manager.

A5.9 Alternative compliance checking procedures

Recent advancement in acoustic data acquisition (such as directional noise monitors) has introduced a method to separate wind farm noise contribution from other sources. If the methods above cannot be used for the compliance checking, alternative techniques may be employed.

Attended measurement procedures can be used for compliance measurements at a single receiver. The monitored noise is to be accurately recorded and extraneous noise should be excluded from the data analysis either during the data acquisition or post-acquisition data processing. Attended monitoring should include at least four site visits with each visit including eight hours of monitoring or more and equally including day and night time periods. Measurements should be taken when the wind direction corresponds to the worst case scenario. It might require periodical shut down of WTGs to enable a determination of the noise contribution associated with operation of the wind farm.

If an alternative technique enables reliable monitoring of the wind farm noise using LAeq descriptor, it should be measured and reported as such. Comparison of the noise criteria with the wind farm noise should also be performed using LAeq magnitudes. Details of the alternative monitoring program should be discussed with the local government or assessment manager.

A5.10 Tonality

Where, the wind farm exhibits tonality as a characteristic, the developer or wind farm operator should conduct a tonality test in accordance with a procedure acceptable to the local government or assessment manager.

An addition of 5dB(A) should be made to the measured noise level from a wind farm where tonality is shown to be a characteristic. It should be noted that the tonal characteristic penalty applies only if it is audible at the relevant receiver. Absence of tone in noise emission if measured close to the WTGs and/or other relevant Wind Farm elements is sufficient proof that the tone at the receiver is not associated with the Wind Farm operation.

A5.11 Excessive noise

The operation of the wind farm should comply with the criteria at all relevant receivers. The extent of relevant receivers is confined to those identified during the development assessment stage (including proposed developments near the wind farm which have approved development applications).

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

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

The assessment manager recognises that there will be natural variations in background noise throughout the year, with different prevailing wind directions, foliage on trees, atmospheric conditions and possibly with changes to local conditions such as buildings, trees or topography that may affect compliance with the criteria.

Where this may be the case, the onus of responsibility to prove this resides with the developer or current operator of the wind farm.

A range of alternative compliance checking procedures can remove the influence of background noise to accurately determine the wind farm noise in isolation.

Where measurements of the ambient noise indicate that excessive noise from the Wind Farm may exist, it is likely that the assessment manager will restrict operation of the Wind Farm subject to proof of compliance with the criteria.

A5.12 Documentation

Development applications for wind farms are referred to the referral agency (SARA) for assessment of the environmental noise impact.

If it appears likely that the criteria under these guidelines will be used for assessment purposes, developers should discuss the development with the relevant referral agency at the pre-lodgement stage before submitting the application, so as to ensure they provide all relevant information.

All relevant information on the noise impacts should be included with the application, including relevant information on:

- Predicted noise from a wind farm
- Measurement and assessment of background noise
- Compliance checking

Predicted noise from a wind farm

Relevant information could include:

- make and model of WTGs to be used, including hub height, cut-in wind speed and speed of the rated power
- positions of all WTGs shown in topographical map
- table of WTGs and relevant receivers coordinates including distances and angle directions between the receiver and nearest WTG
- predicted noise levels for those premises in (e) for worst-case wind direction for wind speeds from cut-in speed to the speed of the WTG rated power
- the model used and the method for deriving the noise levels in (f)

  indication of accuracy of the wind farm noise prediction
- amount of noise reduction, if any, allowed for acoustic screening to estimate the levels in (h)

- topographical map of Wind Farm and affected premises showing labelled noise contour lines
- location of wind measuring position(s) used for noise assessment and compliance purposes.

Measurement and assessment of background noise

Relevant information could include:

- a description of noise measuring equipment used, including make, model and type and including type and model of windscreen used for the microphone, data demonstrating valid calibration for all equipment at the time of measurements
- noise measurement position including height above ground, wind speed (at the noise measurement position) and distance to nearest building structure
- description and photograph of measurement position showing nearby trees and building structures
- angle direction between the line connecting the noise measurement point and the nearest WTG and North (measured clockwise)
- atmospheric conditions at the Wind Farm including wind speed and direction, description of wind speed and direction measuring equipment used
- wind speed data at the noise measurement site
- time and duration of monitoring
- sampling time for wind and noise measurements.
- total number of data pairs measured (Wind Farm speed and background noise level) and number of data pairs measured at the worst wind conditions between the cut-in wind speed and speed of the rated power
- description of regression analysis method
- graphical plot of data and regression curve
- correlation coefficient and equation for the regression curve.

Compliance checking

Relevant information could include:

- description of all noise monitoring equipment, including type of microphone and wind protection used, data demonstrating valid calibration when measurements were taken
- noise measurement position(s) including height above ground, wind speed (at the noise measurement position) and distance to nearest building structure and WTG
- photographs of noise monitoring position taken before the wind farm was installed (at the noise modelling stage) and at the time of compliance checking, showing the noise measurement position and associated surroundings, such as buildings, trees and topography
- angle direction between the line connecting the noise measurement point and the nearest WTG and North (measured clockwise)
- description of atmospheric conditions, wind speed and direction measuring equipment used and the location on the wind farm, including height above ground level

- make and model of WTGs monitored, including hub height, cut-in wind speed and speed of the rated power
- details of which WTGs were operating during compliance check
- time and duration of monitoring period
- list of all monitored data showing wind speed, wind direction and noise level
- presence of any audible annoying noise characteristics
- graphical plots of relevant data
- conclusions highlighting correspondence to the criteria.

Part B

A5.13 Low-Frequency noise

A Noise Assessment Report will be required to be submitted which includes the assessment of potential impacts of low frequency noise, and details mitigation measures to be incorporated in design and construction of the development including:

- Measurement of low-frequency noise levels indoors and outdoors pre-wind farm development at the nearest representative sensitive land uses;
- Determination of suitable low frequency noise criteria for annoyance due to wind turbines (as spectra and/or overall noise level);
- Development of a detailed noise prediction methodology identifying:
  - sound power levels used,
  - the noise prediction standard used;
  - the atmospheric conditions used in the noise model.
- Determination of suitable noise amelioration measures, if necessary.
- Development of a detailed methodology for measuring the low-frequency noise levels indoors and outdoors during commissioning at the nearest sensitive land uses, including:
  - Measurement locations;
  - Instrumentation requirements including sampling duration, minimum measurement periods (e.g. 10 minute periods), suitable windscreen specification and microphone frequency response requirements;
  - Synchronisation of noise data with appropriate meteorological data and turbine operating conditions;
  - Total duration of measurement required (e.g. more than 2 weeks or greater than 1440 periods);
  - Acceptability criteria, including a determination of the uncertainty of measurement.

A5.14 Noise glossary

A-weighted: Frequency weighted as specified in Australian Standard AS 1259−1990 Noise level meters or its replacement.

Acoustic engineer: A person eligible for membership of both the Institution of Engineers Australia and the Australian Acoustical Society.

Ambient noise: The total noise in a given environment.

Background noise: Measured ambient noise, in the absence of the noise under investigation, measured using time weighting 'F', which is equalled or exceeded for 90% of the measurement time interval. Expressed as LA90,T, where T refers to the measurement time interval in minutes

Base noise level: Means an LAeq,10 of 35dB(A)

Calculated background noise: Background noise level Lb at a receiver calculated by the regression analysis from the measured background noise data in accordance with these guidelines.

Combined wind farm and background noise: Total wind farm and background noise level LR at a receiver calculated by the regression analysis from the measured data in accordance with these guidelines.

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

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

IEC: International Electrotechnical Commission.

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

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

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

Predicted noise level: The LAeq,10 wind farm noise level at a receiver predicted in accordance with these guidelines.

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

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

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

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

V10m: Wind speed measured in metres per second (m/s) at the wind farm site at 10 metres above the ground.

WTG: Wind turbine generator.

Suggested Further Information

- The *Wind farms environmental noise guidelines*

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