UNION FENOSA
WIND AUSTRALIA

gasNatural fenosa

PALING YARDS WIND FARM

CHAPTER 10

# NOISE IMPACTS

# 10 Noise Impacts

## 10.1 Introduction

UFWA engaged SLR Consulting Australia Pty Ltd (*SLR*) to assess the potential noise impacts of the project. The noise impact assessment report can be found at **Appendix 7**.

The report analyses:

- the acoustic criteria;
- the background noise measurements;
- the predicted noise level at all potentially impacted receivers from the operation of the project; and
- the acoustic impact of the project during the construction phase, including blasting and traffic noise.

## 10.2 Methodology

The methodology and criteria used in the noise impact assessment was based on the South Australian Environmental Protection Authority *Environment Noise Guidelines for Wind Farms* (February 2003) (SA EPA Guidelines), the World Health Organization (WHO) limits, construction noise guidelines (*DECC Interim Construction Noise Guideline* 2009) and blasting impact guidelines.

The methodology and acceptability limit criteria that were applied in the noise assessment are based upon the SA EPA Guidelines. The principal acceptability limit criteria in the SA EPA Guidelines are that the project LA90 (10 min) noise should not exceed the greater of:

- an amenity limit of 35 dBA; or
- the pre-existing background noise by more than 5 dBA (for any given wind speed).

The WHO noise guidelines have also been used in the noise impact assessment in order to ensure that the project does not result in an 'unreasonable interference' with the amenity of these areas or cause any adverse health effects, as outlined in the WHO guidelines.

The appropriate WHO guideline noise limits are listed in the table below.

For the assessment of the project involved residences, the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

**Table 18** WHO Guideline values for environmental noise in specific environments

| Specific environment | Critical health effect(s) | LAeq (dBA) | Time base (hours) | LAMax (dBA, Fast) |
|---|---|---|---|---|
| Outdoor living area | Serious Annoyance, daytime & evening<br>Moderate annoyance, daytime & evening | 55<br>50 | 16<br>16 | - |
| Dwelling indoors<br>Inside bedrooms | Speech Intelligibility & moderate annoyance, daytime & evening<br>Sleep disturbance, night-time | 35<br>30 | 16<br>8 | |
| Outside bedrooms | Sleep disturbance – window open, night-time | 45 | 8 | 60 |

The noise impact assessment has considered the requirements of the *Draft NSW Wind Farm Planning Guidelines* (Draft Guidelines) which were released in December 2011, particularly Appendix B: NSW Wind Farm Noise Guidelines. This included consideration of separate daytime and night-time periods and alternative methods of evaluation for Special Audible Character.

The noise impact assessment conducted noise monitoring and wind monitoring at eight locations during the period between 7 June 2011 to 24 June 2011 to determine baseline conditions and establish criteria for surrounding residential receivers. The names and locations of all the identified residential receivers are listed in the report.

The noise emission model used to predict project noise levels at sensitive receptors is based on ISO 9613, as implemented in the SoundPLAN computer noise model.

In general, the assessment procedure was based on the following steps:

- Predict and plot the L Aeq 35 dBA noise level contour from the project under reference conditions.
- Establish the pre-existing background noise level at each of the relevant assessment receivers within the L Aeq 35 dBA noise level.
- Predict project noise levels at all relevant assessment receivers for the wind range from cut-in of the turbines to approximately 10 m/s.
- Assess the acceptability of project noise at each relevant assessment receiver to the established limits.

Noise predictions were made for receptors within a 6km radius of the indicative location of each wind turbine model currently proposed for the project.

Where modelling was conducted for the purposes of the noise impact assessment, the modelled hub height represents the maximum height in the range being considered.

Should an alternative selection of turbines be ultimately made and/or the final layout of the project differ from that assessed in the noise impact assessment, then a revised

noise impact assessment prediction will be completed prior to construction commencing.

The predicted noise levels are considered to be conservative due to the noise modelling assuming 'hard ground', average downwind propagation from all turbines to each receiver or a well-developed moderate ground based temperature inversion.

In addition, the noise assessment included an assessment of turbines P2, P6 and P7 which are no longer proposed as part of the project (although they may form a subsequent stage which will be subject to separate approval at that time), increasing the conservatism in the assessment.

## 10.3 Results

10.3.1 Operation noise levels

A three-dimensional computer noise model was used to predict LAeq noise levels from all turbines at all surrounding residential dwellings.

For the purposes of the noise impact assessment, the turbine noise levels from the proposed turbine layout was calculated for a wind condition of 8 m/s at 10m AGL.

Furthermore, noise levels from the proposed wind farm were calculated for all integer wind speeds in the range of 5 to 10 m/s (at 10m AGL) at all surrounding assessment receivers within 6 km of a turbine.

Whilst the rated wind speed of the turbines is typically 13 to 14 m/s, published manufacturers sound power level test data has only been generated as high as 10 m/s.

It should be noted that noise produced by turbines begins to 'plateau off' at higher wind speeds.

10.3.2 Background levels and noise limits

The locations for the background noise measurements were selected based on the potential for acoustic impact to the nearest receivers. The SA EPA Guidelines recommend that the measurement locations should be located at least 5 metres from a reflecting surface (other than the ground) and within 20 metres of a residence.

Background noise monitoring has been conducted at one representative location and was considered indicative of other similar locations, due to the relative proximity of some receiver locations to one another and their similar wind exposure and surrounding environment.

Accordingly, background noise monitoring was commenced at eight locations around the site.

It is important to note that that further baseline background noise monitoring is anticipated to be conducted before the project is commissioned in order to obtain further comprehensive data.

At each location, the noise monitoring equipment was placed in the vicinity of the residence and the position and location of the equipment was photographed.

A reduced data set was created for the night period analysis (10:00 pm to 7:00 am).

### 10.3.3 Acoustic impact assessment

Once the existing background noise levels and noise limits were assessed and determined in accordance with the relevant guidelines, an assessment of the predicted project noise levels was undertaken for all receivers located within a distance of 6km of a wind turbine.

Turbine noise was predicted using the indicative turbine layout and the turbine models currently being considered and assessed against relevant criteria prescribed by the SA EPA Guideline and WHO based noise criteria where appropriate.

SLR Consulting found that predicted noise levels at all non-project involved receptors (including all locations of buildings not identified as an official dwelling) were found to be below the relevant noise criteria.

Accordingly, the adopted noise limits will be met for all non-project involved receptors.

Furthermore, all receptors (including the project-involved receivers) would achieve their respective criteria with consideration to the night-time only regression line based limits. Refer to **Figure 42 – Predicted Noise Levels Contour Map**.

The noise impacts on some project-involved secondary dwellings are predicted to slightly exceed the WHO noise criteria. These secondary dwellings are used for a very limited part of the year only. It is proposed to enter into a noise agreement regulating the use of these secondary dwellings so that they will not be used should post construction noise testing show an exceedance of the criteria.

The table below shows the predicted noise exceedances at the project-involved residences.

**Table 19** Project involved residences' predicted noise exceedances

| Location | Exceedance of WHO Noise Criteria at Hub Height Wind Speed | | | | | | | | | | MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.3 | 5.7 | 7.2 | 8.6 | 10.0 | 11.5 | 12.9 | 14.3 | 15.8 | 17.2 | |
| 7A | | | | 2.4 | 3.4 | 3.3 | 3.1 | 3.0 | 2.0 | 0.6 | 3.4 |
| 9A | | | | | 0.8 | 0.6 | 0.4 | 0.4 | 0.4 | 0.1 | 0.8 |
| 9B | | | | | 0.7 | 0.5 | 0.4 | 0.3 | 0.3 | 0.1 | 0.6 |
| 8 | | | | | 0.3 | | | | | | 0.3 |
| 8A | | | | | 0.2 | | | | | | 0.2 |
| 9 | | | | | 0.1 | | | | | | 0.1 |
| 7 | | | | | 0.1 | | | | | | 0.1 |

For locations 7, 8 and 9, the exceedance occurs only at one wind speed and is less than 0.5 dB in magnitude. The noise impact assessment found that this is a minor exceedance and unlikely to cause any additional effect on the amenity of the area or health of the residents.

Locations 7A, 8A, 9A and 9B are project-involved secondary dwellings and the proposed noise agreements will make specific provision for these dwellings to ensure that no adverse noise impacts to any person.

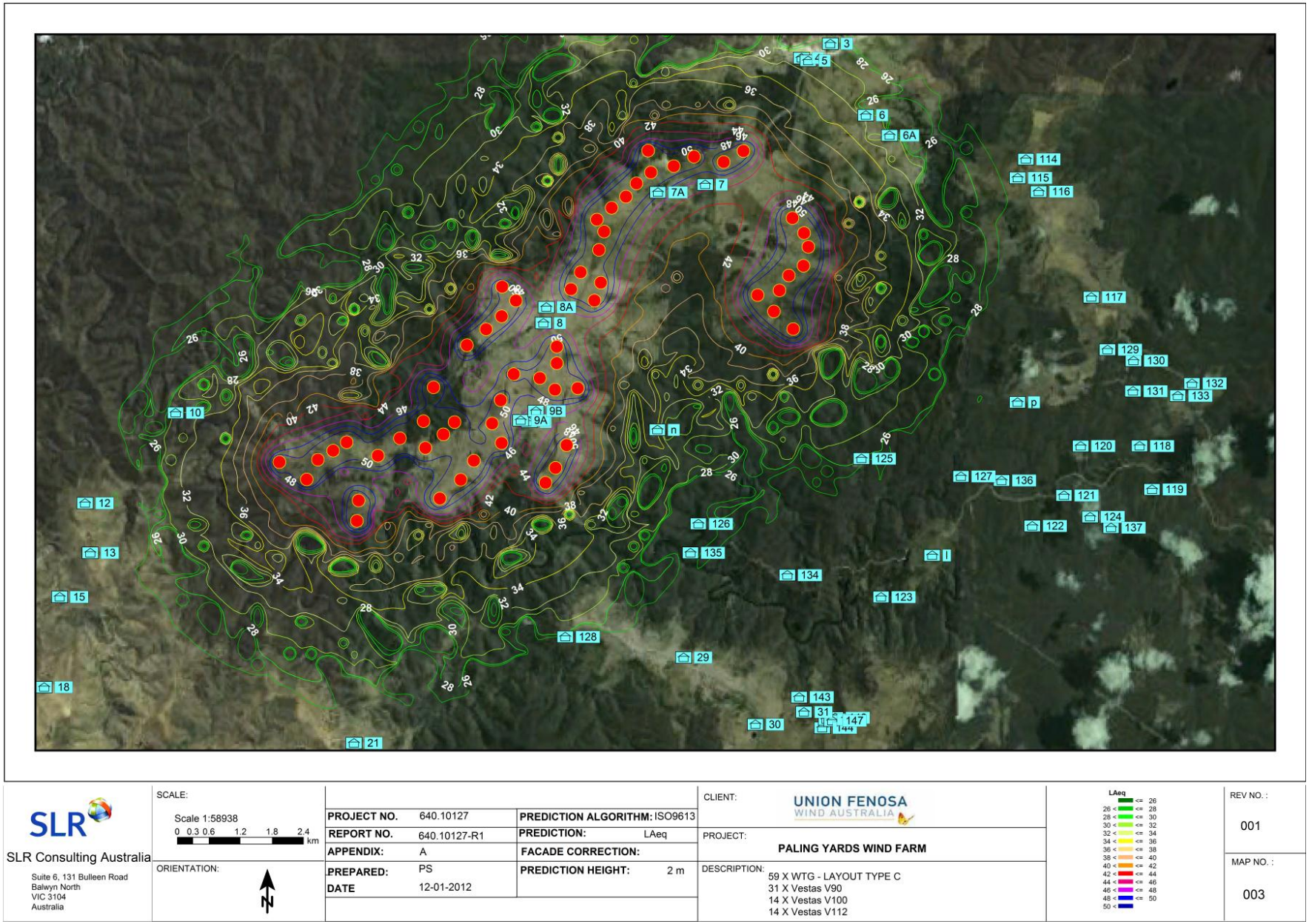



**Figure 42** Predicted Noise Levels Contour Map

***Source:*** *SLR Consulting Australia*

Under the SA EPA Guidelines, project involved residences are not required to comply to the 35 dBA or 'background + 5 dBA' limits. However, in order to ensure that the project does not result in an 'unreasonable interference' with the amenity of these areas or cause any adverse health effects, the noise limits outlined in the WHO guidelines will be met for project involved residences.

Accordingly, external criteria of 45 dBA (as per the WHO guidelines) or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

The noise agreements with these project involved residences will be entered into prior to construction.

Upon finalising the layout and turbine models a revised noise prediction and assessment will be completed to demonstrate compliance with the project noise criteria.

It should be further noted that *"all predicted noise levels are considered to be conservative with the model assuming 'hard ground', average downwind propagation from all turbines to each receiver or a well-developed moderate ground based temperature inversion, a scenario which is not able to be re-created in reality"*.

Predicted external noise levels will be further mitigated by the shielding effects of the building, with the anticipated internal noise levels similarly reduced by the façade of the dwelling.

10.3.4 Construction noise

The construction noise and vibration impacts assessment conducted by SLR Consulting found that the 'worst case' scenarios modelled were found to be generally acceptable.

10.3.5 Blasting

The blasting impact assessment conducted by SLR Consulting concluded that noise impact was found to be acceptable. The airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear for all existing residences, and vibration levels are anticipated to be well below the acceptable criteria.

10.3.6 Traffic noise

The construction traffic noise impact assessment undertaken by SLR Consulting found that the 'worst case' maximum construction traffic generated scenario would increase existing traffic noise levels along local roads by up to 4-7 dBA. However, due to the typically large setback of dwellings from the road network, SRL concluded that the predicted traffic noise impacts would be acceptable.

10.3.7 Substation noise

Australian Standard AS 60076 Part 10 2009: *"Power Transformers – Determination of sound levels"* has found that a 200 MVA substation may produce sound power levels up to 99 dB.

Noise predictions for transformer substations have been made using CONCAWE algorithms assuming an absolute 'worst case' meteorology enhancement condition of downwind 3 m/s and Pasquill Stability Class F temperature inversion, which found that the predicted noise levels are within the noise limits.

10.3.8 Transmission line noise

Transmission line noise, also known as 'corona noise' is *"caused by the partial breakdown of the insulation properties of air surrounding the conducting wires"*. It generally only occurs in humid conditions, as provided by fog or rain.

It is noted that *"a minimum line potential of 70 kV or higher is required to generate corona noise depending on the electrical design"*.

It is expected that the proposed transmission line will traverse largely remote and uninhabited land.

It is anticipated that sufficient buffer distances between the transmission line and receivers will result in the occasional corona noise being inaudible at residential receivers.

## 10.4 Draft NSW Wind Farm Planning Guidelines (December 2011)

SLR Consulting has addressed a number of additional requirements of the Draft Guidelines. Refer to Chapter 10 of the noise assessment found at **Appendix 7** of this report for full details and results of the assessment.

10.4.1 Daytime and night-time background noise

The background noise data was reprocessed to define background noise curves for the daytime period (7.00am to 10.00pm) and night-time period (10.00pm to7.00am), in accordance with the Draft Guidelines.

The new background noise curves were used to update the noise limit curves for all receptors and all predicted results were assessed against these criteria. The set of assessment graphs are presented in the noise assessment at **Appendix 7**.

The assessment found that there were no exceedances of the daytime-only or night-time-only criteria for non-project involved receivers.

The maximum exceedance for project-involved receivers was determined by the 45 dBA criteria, rather than the Background+5 criteria.

The table below shows the exceedances for project involved locations for the night-time criteria.

**Table 20** Noise exceedances at project-involved households for the night-time criteria

| Location | Exceedance at Hub Height Wind Speed | | | | | | | | | | MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.3 | 5.7 | 7.2 | 8.6 | 10.0 | 11.5 | 12.9 | 14.3 | 15.8 | 17.2 | |
| 7A | | | | 2.4 | 3.4 | 3.3 | 3.1 | 3.0 | 3.0 | 1.4 | 3.4 |
| 9A | | | | | 0.8 | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 | 0.8 |
| 9B | | | | | 0.7 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.6 |
| 8 | | | | | 0.3 | | | | | | 0.3 |
| 8A | | | | | 0.2 | | | | | | 0.2 |
| 9 | | | | | 0.1 | | | | | | 0.1 |
| 7 | | | | | 0.1 | | | | | | 0.1 |

As discussed in **Chapter 10.3** above, the proposed noise agreements will make specific provision for these project-involved dwellings to ensure that no adverse noise impacts to any person.

Overall, the assessment found the predicted noise exceedances to be acceptable.

10.4.2 Special Audible Characteristics

SLR Consulting assessed the predicted levels of levels of swish, modulation, discrete tones and low frequency noise, otherwise known as 'Special Audible Characteristics', for the project.

The noise impact assessment found that:

- *"The results from the SoundPlan model [low frequency noise] predict that wind turbine noise would only exceed 60 dBC for one receiver location, Location 7A, the predicted exceedance was 0.8 dBC. This is a relatively small exceedance of the criteria, however, as post-construction monitoring is already planned for this location."*
- *"The tonality tests showed no presence of tonality in the predicted results."*
- *"There currently is no means to predict the eventuality, severity or frequency of occurrence of excessive amplitude modulation… excessive amplitude modulation has only been confirmed at a small number of wind farm sites and when it occurs it is relatively infrequent."*
- *"Nevertheless, should excessive amplitude modulation be found to be a problem with the wind farm, it would be possible to limit the impact on the residents through adaptive management techniques."*

Therefore, it is found that the predicted Special Audible Characteristics for the project are acceptable and manageable.

## 10.5 Mitigation

If undue turbine noise impacts are identified during operations due to temperature inversion, atmospheric stability or other reasons, then adaptive management' measures may be implemented to mitigate or remove the impact. This process may include:

- Receiving and documenting noise impact complaint through 'hotline' or other means.
- Investigating the nature of the reported impact.
- Identifying exactly what conditions or times lead to undue impacts.
- Operating turbines in a reduced 'noise optimised' mode during identified times and conditions (sector management).
- Providing acoustic upgrades (glazing, façade, masking noise etc) to affected dwellings.
- Turning off turbines that are identified as causing the undue impact during identified times and conditions.

Upon finalising the layout and turbine models a revised noise prediction and assessment will be completed in which the noise impact mitigation techniques will be investigated thoroughly in order to ensure a fully noise compliant turbine layout.

### 10.5.1 Agreements

The noise impact assessment notes that UFWA proposes to enter into noise agreements with the owners of the project-involved properties prior to construction. These agreements would specify that:

- *UFWA would ensure that the properties met the World Health Organisation noise guidelines; and,*
- *UFWA would implement an adaptive management approach which could include the use of building treatments and turbine operation/management strategies if operational noise causes significant impact to the amenity of involved residents.*

In addition, it is proposed that the noise agreements will make specific provision for the project involved secondary dwellings so as to ensure that no adverse health impacts result to any person as a result of turbine noise impacts.

UNION FENOSA
WIND AUSTRALIA

gasNatural fenosa

PALING YARDS WIND FARM

CHAPTER 11

# HEALTH IMPACTS

# 11 Health Impacts

## 11.1 Introduction

Health concerns are often cited by the public in relation to wind farm development, including concerns as to potential adverse impacts on the health and wellbeing of people in the immediate vicinity of the wind farms. These health concerns relate to a range of issues including noise pollution (including infrasound noise), vibrations, shadow flickering, electromagnetic interference, blade glint, blade throws, ice shedding, tower failure, and the risk of fire due to the introduction of electrical devices and mechanical components.

The World Health Organisation (WHO) defines health as *"a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"*.

This chapter draws on Australian and international research to detail the potential impacts on human health associated with the construction and operational phase of wind farm developments, and assesses the likely health related risks arising from the project, including those on residents within 2km of a turbine. In particular, this chapter draws on the landmark study published by the National Health and Medical Research Council in July 2010, *Wind Turbines and Health* (NHMRC Report), which presents a current review of the evidence from literature on wind turbines and any impacts on human health.

The NHMRC Report tested the hypothesis that "*there are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines"*, and found that *"there is no published scientific evidence to support adverse effects of wind turbines on health"*.

This chapter also outlines key mitigation measures that should be employed for wind farms to reduce the risk of any adverse physical and mental impacts occurring.

UFWA recognises that it is important to address any health concerns held by local residents at the early stages of a wind farm proposal, regardless of whether any impacts eventuate.

## 11.2 Key Claims

### 11.2.1 Wind Turbine Syndrome

US paediatrician Dr Nina Pierpont has conducted research into the impacts of wind farms on human health. Her study is based predominantly on survey and anecdotal data, as well as existing research. Dr Pierpont refers in her 2006 paper, *Health Effects of Wind Turbine Noise*, to a 'Wind Turbine Syndrome' that incorporates a number of health impacts claimed to be the result of wind farms sited in close proximity to dwellings and public spaces. The symptoms of this syndrome include:

- *"Sleep problems: noise or physical sensations of pulsation or pressure make it hard to go to sleep and cause frequent awakening;*
- *Headaches which are increased in frequency or severity;*
- *Dizziness, unsteadiness, and nausea;*
- *Exhaustion, anxiety, anger, irritability, and depression;*
- *Problems with concentration and learning; and*
- *Tinnitus (ringing in the ears)" (Layton 2009 cited in Pierpont 2006).*

Pierpont (2006) found that chronic sleep disturbance is the most common symptom of the 'Wind Turbine Syndrome', and that exhaustion, mood problems, and problems with concentration and learning are natural outcomes of poor sleep. She emphasizes that *"sensitivity to low frequency noise is a potential risk factor"* from wind farms. Pierpont found that *"some people sense low-frequency noise as pressure in the ears rather than heard as sound, or experience a feeling or vibration in the chest or throat"* (Moller & Pedersen 2004 cited in Pierpont 2006).

### 11.2.2 Annoyance and sleep disturbance

The NSW Legislative Council Report (No.5, 2009) notes that research has shown that 'noise annoyance' is an *"adverse health effect that can result from wind farms, as it can result in effects such as negative emotions and sleep disturbance"* (NSW Legislative Council 2009).

Van den Berg (2003), a prominent researcher of health impacts associated with wind farms and a critic of wind farm developments in close proximity to dwellings, contends that wind farm noise is a serious issue requiring further understanding. He argues that *"the wind speed at hub height [towards the top of a wind turbine] at night is up to 2.6 times higher than expected"*, causing *"up to 15 dB higher sound levels"* (NSW Legislative Council 2009, Van den Berg 2003).

### 11.2.3 Diseases

Pierpont also raises the concern of humans developing diseases due to close proximity to wind farms. Pierpont makes reference to vibroacoustic disease (VAD), arguing that the disease is caused by long-term exposure to low-frequency noise, most of which cannot be heard.

Aside from noise impacts, other perceived health concerns associated with wind farms include:

- shadow flicker;
- blade glint;
- blade throw;
- exacerbation of pre-existing health conditions and mental illnesses; and
- diminished wellbeing, such as depression and anxiety, due to the above impacts, as well as community division and other social impacts.

Pierpont raises the concern of exacerbated illnesses due to shadow flickering. Shadow flicker refers to the strobing effect caused by wind turbine blades blocking the sun as the blades rotate. Pierpont believes this to cause some people to become dizzy, lose their balance, or become nauseated. Furthermore, Pierpont states that *"people with a personal or family history of migraine, or migraine-associated phenomena such as car sickness or vertigo, are more susceptible to these effects... and has the potential, like other flashing lights, to trigger seizures in people with epilepsy"* (Pierpont 2006). Refer to **Chapter 17** for further details and mitigation measures relating to shadow flicker.

Concern is also given to the indirect health and safety impacts caused by wind farms, such as 'dizziness and spatial disorientation' from shadow flicker and blade glint that are 'hazardous while driving' (Pierpont 2006).

Blade throw is a potential public safety hazard involving a rotor blade dropping or being thrown from the nacelle of the wind turbine.

11.2.4 Stress-related issues

Issues surrounding local communities' sense of helplessness, powerlessness and stress from the development process of the wind farm project and/or the presence of wind farms in rural communities have also been noted in the literature and raised in wind farm planning hearings. These concerns are linked with depression and disruption to place-related identity (NSW Legislative Council 2009, Pierpont 2006).

The Public Health Association of Australia (PHAA) recommends *"effective early community consultation and engagement as the key to preventing misinformation and community division in deployment of renewable energy developments..."*

## 11.3 Review of the evidence

11.3.1 National Health and Medical Research Council Report 2010

The National Health and Medical Research Council (NHMRC) published a landmark study, *Wind Turbines and Health* (2010) (the NHMRC Report), which tested the hypothesis that *"there are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines"* (NHMRC 2010). The NHMRC is Australia's peak body for supporting health and medical research; for developing health advice for the Australian community, health professionals and governments; and for providing advice on ethical behaviour in health care and in the conduct of health and medical research. The Federal Health Council (the precursor to the National Health and Medical Research Council) was established in 1926 following a Royal Commission's recommendations.

The NHMRC conducted a comprehensive investigation of the current literature and scientific data on wind farm-related effects on human health, and found that the hypothesis was tested positive. A key finding of the NHMRC Report was that:

*"While a range of effects such as annoyance, anxiety, hearing loss, and interference with sleep, speech and learning have been reported anecdotally, there is no published scientific evidence to support adverse effects of wind turbines on health"* (NHMRC 2010).

This contention is supported by the WHO, which states that *"Wind energy is associated with fewer health effects than other forms of traditional energy generation and in fact would have positive health benefits"* (WHO 2004). Furthermore, WHO, in its Energy, Sustainable Development and Health study, also found that: *"In relation to all sources of energy, the health effects associated with wind energy are negligible"* (WHO 2004).

The ExternE Project referenced in this study considers wind energy *"to have the lowest level of impacts (health and environmental), of all the fuel cycles considered"* (CIEMAT 1998 cited in WHO 2004).

11.3.2 The Social and Economic Impacts of Rural Wind Farms Senate Inquiry 2011

A Community Affairs References Committee (the Committee) was established by the Australian Senate to investigate any adverse health effects for people living in close proximity to wind farms and the economic impact of rural wind farms. The Committee received more than 1,000 submissions, many letters and other documents, and had reviewed published information on the topic. Public hearings were held in 2011 in Canberra on 25 March and 17 May, Ballarat on 28 March 2011, Melbourne on 29 March and Perth on 31 March. The Committee conducted site visits to the Waubra and Hepburn wind farms in Victoria on 28 March 2011. The report, *The Social and Economic Impacts of Rural Wind Farms* was released in June 2011 (the report).

The Committee was unable to establish a direct link between the noise generated by wind farms and negative impacts on human health. However, the report recommends that the NHMRC should continue to review the research into wind farm health effects.

The Committee did not support a mandatory setback distance around wind farms, instead labelling it 'arbitrary' and preferred to apply setback distances using scientific measurements of sound effects.

11.3.3 Renewable Energy (Electricity) Amendment (Excessive Noise from Wind Farms) Bill Inquiry 2012

The Commonwealth Senate was introduced to the *Renewable Energy (Electricity) Amendment (Excessive Noise from Wind Farms) Bill 2012* (the bill) in June 2012. The Senate referred the provisions of the bill to the Environment and Communications Legislation Committee (the Committee) for inquiry and report in October 2012.

The bill seeks to amend the Renewable Energy (Electricity) Act 2000 (Act) to give powers to the Clean Energy Regulator that *"ensure that accredited power stations that are wind farms, either in whole or in part, do not create excessive noise"*(Environment and Communications Legislation Committee, 2012).

Although the Committee recommended that the bill not be passed, it made a number of conclusions and recommendations in relation to the information presented on wind farms and health impacts, discussed in the following chapters.

The Committee acknowledged the concerns of residents, who need to understand whether there may be health impacts of existing wind farms in their area, or of a proposed wind energy facility in their district.

Individual witnesses, and some organisations, reported to the committee a range of symptoms they said were being experienced by people living up to ten km away from wind farms. The most common reported complaint was sleep disturbance.

A key finding was that there is no scientific evidence to suggest that noise created by wind turbines affects human health. The Committee concluded however that it is premature to introduce regulatory changes such as those in this bill prior to the release of the NHMRC's further assessment in 2013 on wind farms and health impacts.

## 11.4 Findings

11.4.1 Noise impacts on health

A key issue amongst the health concerns associated with wind farm developments is impacts relating to noise. Wind turbines produce mechanical noise from the motor or gearbox, as well as aerodynamic noise, produced by wind passing over the blade of the wind turbine. As well as the general range of sound emissions, older wind turbines also generate infrasound (NHMRC 2010).

The NHMRC Report noted that, "*there is no reliable evidence that sounds below the hearing threshold produce physiological or psychological effects"* (Berglund 1995 cited in NHMRC 2010). The Minnesota Department of Health (2009) found that *"if functioning correctly, mechanical noise from modern wind turbines should not be an issue"* (MDH 2009 cited in NHMRC 2010). Dr Mark Diesendorf, the Deputy Director of the Institute of Environmental Studies at the University of NSW, states that *"infrasound was a problem with older wind turbine technology"* (NSW Legislative Council 2009), and that infrasound is *"virtually undetectable at a range of 400 metres"* (NSW Legislative Council 2009).

Recently, the NSW Health Department was consulted regarding the proposed Bodangora and Collector Wind Farm projects. Both of these projects are now approved. The Department's comments were noted in the NSW Government Planning Assessment Commission's Determination Reports for Bodangora and Collector Wind Farms on 30 August 2013 and 2 December 2013 respectively.

In relation to the Bodangora Wind Farm (33 turbines) and the Collector Wind Farm (55 turbines), the NSW Health Department stated that:

- *"there is no published scientific evidence to link wind turbines with adverse health effects"*
- *"noise from turbines may cause some disturbance to people living in close proximity (less than 700 metres from the turbines)… but that the 2km buffer distance provided in [each] instance was considered to be very conservative and precautionary from a health perspective"*
- *"there is no reliable evidence that sound below the hearing threshold produces physiological or psychological effects"*, which is consistent with the advice of the World Health Organisation, refer to **Chapters 11.4.2** – **11.4.4** below (NSW Health Department cited in NSW Planning Assessment Commission 2013a and NSW Planning Assessment Commission 2013b)

The Senate's Communications Legislation Committee (2012) *"did not find a causal link between the relatively low levels of noise that are produced by wind farm noise and the symptoms reported by those living near wind turbines"*.

The Community Affairs References Committee recommended in their report (June 2011) that the noise standards adopted by the states and territories for the planning and operation of rural wind farms should include appropriate measures to calculate the impact of low frequency noise and vibrations indoors at impacted dwellings.

The Public Health Association of Australia (PHAA) released a position statement, *Human Health Effects of Wind Turbines* (2011), in response to acoustic health effects of wind turbines that have been raised as an issue in the media. The key statements made by the PHAA are:

- *Renewable forms of energy, such as solar and wind, appear to be associated with relatively low adverse health effects.*
- *Reviews of the literature to date have failed to identify any adverse physiological effects attributed to exposure to wind turbines, with the exception of those mediated by noise in a small proportion of exposed people, in whom symptoms may be related to perception, annoyance and pyscho-sociological factors.*
- *There is no evidence to date to suggest that infrasound has significant effects on human health via physiological mechanisms at the low pressure levels generated by wind turbines.*

Importantly, it is noted in the Communications Legislation Committee's report (2012) that health effects from wind farm noise result from the same mechanisms as from other sound sources such as aviation noise, road traffic noise or nightclub or neighbourhood noise.

11.4.2 Infrasound impacts on health

A survey (Jakobsen 2005) of all known published results of infrasound from wind turbines found that *"wind turbines of contemporary design, where rotor blades are in front of the tower, produce very low levels of infrasound"* (Jakobsen 2005 cited in NHMRC 2010).

The Communications Legislation Committee (2012) concluded that, while it is possible that the human body may detect infrasound in several ways, there is no evidence to suggest that inaudible infrasound is creating health problems.

It should be noted that infrasound is constantly present in the environment, caused by various sources such as ambient air turbulence, ventilation units, ocean waves, distant explosions, volcanic eruptions, traffic, aircraft and other machinery (Rogers, Manwell & Wright, 2006 cited in NHMRC 2010).

Indeed, Van den Berg (2003) acknowledges that the level of infrasound generated by wind turbines does not cause serious problems for human health. He found that *"even though wind turbines did produce an appreciable amount of infrasound, the level was so far below the average human hearing threshold that it could not be a large scale problem"* (Van den Berg 2003, p.4).

Similarly, an Independent Expert Panel recently established by the Massachusetts Department of Environmental Protection (MDEP) and the Massachusetts Department of Public Health (MDPH) found that *"There is insufficient evidence that the noise from wind turbines is directly (i.e. independent from an effect on annoyance or sleep) causing health problems or disease)"* (MDEP & MDPH 2012). The report findings showed that the levels of infrasound produced by modern wind turbines at distances as close as 68 metres are well below the levels required for non-auditory perception (feeling of vibration in parts of the body, pressure in the chest, etc.).

11.4.3 Infrasound Measurements from Wind Farms and Other Sources study

An Australian study, *Infrasound Measurements from Wind Farms and Other Sources* (November 2010), was commissioned by Pacific Hydro to measure and compare infrasound levels from wind farms and common environment infrasound sources, both natural and man-made. The noise measurements were recorded for Pacific Hydro by an independent acoustic consulting firm, Sonus Pty Ltd.

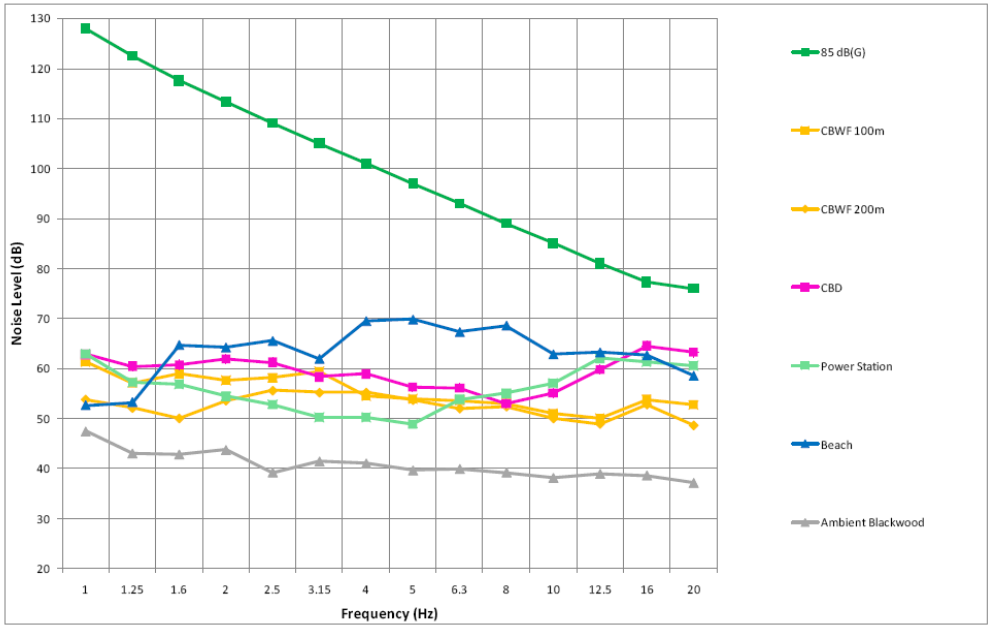
Infrasound was measured at two of Pacific Hydro's Australian wind farms, Clements Gap in South Australia and Cape Bridgewater in Victoria (both while operating and while the turbines were switched off). Infrasound was also measured at a beach, a cliff top along the coastline, in the Adelaide CBD close to two busy roads, and in an Adelaide suburb in close proximity to a gas-fired power station.

The methodology involved measurements being conducted below the ground surface in a test chamber. Testing confirmed that the levels of infrasound above the ground and within the chamber were the same in the absence of surface winds as when measuring a known source of infrasound.

The results determined that infrasound is not unique to wind farms. Furthermore, the levels of infrasound produced by wind turbines is well below perception thresholds and is also below levels produced by other natural and man-made sources (Pacific Hydro 2010). One of the highest levels of infrasound that was recorded was at a beach.

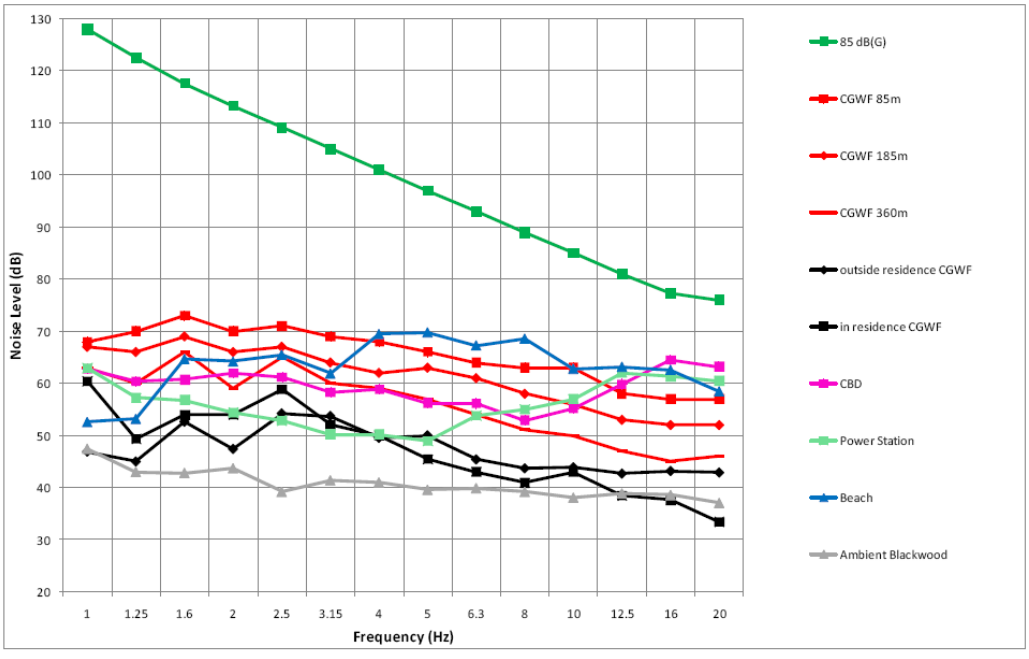
A summary of the results of the infrasound measurement results at the wind farms and at different sources are shown below against the perception threshold for infrasound established in international research as 85 dB(G) (refer to **Figures 43** and **44**)

**Figure 43** Summary of Measurements Cape Bridgewater Wind Farm




*Source: Infrasound Measurements from wind farms and other sources, Pacific Hydro 2010*

**Figure 44** Summary of Measurements Clements Gap Wind Farm




*Source: Infrasound Measurements from wind farms and other sources, Pacific Hydro 2010*

The study found that infrasound was recorded at higher levels on the beach and in the Adelaide CBD than near a wind turbine. The results at all of the sites came under the internationally recognised levels a human can perceive infrasound, which is 85 decibels - on a "G-weighted" scale standardised for the infrasound frequency range.

Pacific Hydro's study reinforces several international studies that infrasound emissions from wind farms are well below the hearing threshold and are therefore not detectable to humans. Further they are less than other areas where people spend extended periods of time, such as the beach or CBD.

11.4.4 Other recent infrasound research

Another recent study, *Wind turbines: does infrasound affect health?* published by the Bavarian Environment Agency in Germany in 2012, has found that wind turbines do not generate infrasound at a level that would damage human health (EWEA 2012). The study concludes that *"Wind energy structures generate infrasound which is far below normal human hearing and perception, which is why it cannot cause any damage to people"* (EWEA 2012).

Noise produced by wind turbines has significantly decreased over the last decade as turbine technology has advanced (NWCC 2002 cited in ODH 2008). The NHMRC study identifies that noise levels from a modern 10-turbine wind farm falls in the 35-45 dB range at a close distance of 350 metres both day and night. This represents sound levels similar to a quiet bedroom (35 dB), and only slightly higher than night time background noise levels in the countryside (20-40 dB) (SDC 2005 cited in NHMRC 2010). Infrasound is problematic to humans only if dB levels are high (greater than 115 dB) (ODH 2008).

In another study, the University of Auckland examined whether infrasound generated by wind turbines causes adverse health effects. They described their method as follows:

*"A sham-controlled double-blind provocation study, in which participants were exposed to 10 minutes of infrasound and 10 minutes of sham infrasound, was conducted. Fifty-four participants were randomised to high- or low-expectancy groups and presented audiovisual information, integrating material from the Internet, designed to invoke either high or low expectations that exposure to infrasound causes specified symptoms"* (Crichton, 2013).

They concluded that:

*"Healthy volunteers, when given information about the expected physiological effect of infrasound, reported symptoms that aligned with that information, during exposure to both infrasound and sham infrasound. Symptom expectations were created by viewing information readily available on the Internet, indicating the potential for symptom expectations to be created outside of the laboratory, in real world settings. Results suggest psychological expectations could explain the link between wind turbine exposure and health complaints"* (Crichton, 2013).

Please refer to **Chapter 10 – Noise Impacts** for a more detailed discussion on noise.

11.4.5 Vibroacoustic impacts on health

Scientific evidence details Vibroacoustic Disease as *"the clinical manifestation of a systemic disease that develops after long-term exposure to noise (≥1 0 yr) which is characterized by large pressure amplitude (≥90 dB SPL) within the lower frequency bands (≤500 Hz)"* (Branco & Rodriguez 1999).

In relation to concerns regarding Vibroacoustic Disease, the NSW Legislative Committee (2009) found that *"there does not appear to be any evidence to support the proposition that vibrations from wind turbines can cause this disease"* (NSW Legislative Committee 2009). As discussed above, noise produced by wind turbines is less than 90 dB.

### 11.4.6 Wind turbine syndrome

The existence of 'Wind Turbine Syndrome' is debatable and insufficient evidence has been presented to justify its existence as a health issue (NSW Legislative Committee 2009). While Nina Pierpont's research has been heavily drawn upon, the credibility of her work is questioned by scientists, particularly by acoustic specialists (NHMRC 2010).

Pierpont's reports were not published in peer-reviewed journals, the sample sizes used in the research are particularly small, and the conclusions are largely drawn from anecdotal evidence. The latter is known to be particularly unreliable and holds very little weight in medical circles. In addition, it is noted that *"many of the participants in Dr Pierpont's study had pre-existing medical conditions that may distort her findings"* (NSW Legislative Council 2009).

The Independent Expert Panel for MDEP and MDPH recently reviewed the literature surrounding this Syndrome and found that "*there is no evidence for a set of health effects, from exposure to wind turbines that could be characterized as a 'Wind Turbine Syndrome'"* (MDEP&MDPH 2012).

The Communications Legislation Committee (2012) concurred that recurring claims of a wind turbine syndrome, for which there is no peer-reviewed evidence, are "*obscuring the focus on assisting properly the small number of people whose cases do need attention"* (Communications Legislation Committee, 2012).

### 11.4.7 Shadow flicker and electromagnetic impacts on health

The NSW Legislative Committee (2009) also states that no experience of unreasonable or dangerous shadow flicker occurring in NSW as a result of wind farms has been presented. Shadow flicker occurs only in some places for a few days of the year, and occurs usually at sunrise or sunset for a few days of the year when the sun is in that position (NSW Legislative Council 2009). The report recommends that "*because shadow flicker can be predicted… wind turbines could simply be switched off for the period it was expected to occur"* (NSW Legislative Council 2009).

Please refer to **Chapter 17 – Shadow Flicker Impacts** for more information on the potential shadow flicker impacts arising out of the project.

The EPHC *Draft National Wind Farm Development Guidelines* maintain that risks such as epileptic seizures and the distraction of drivers as a result of shadow flicker are 'negligible' (EPHC 2009 cited in NSW Legislative Council 2009), for the following reasons:

- *Less than 0.5% of the population are subject to epilepsy at any one time, and of these, approximately 5% are susceptible to strobing light;*
- *Most commonly (96% of the time), those that are susceptible to strobe lighting are affected by frequencies in excess of 8 Hz and the remainder are affected by frequencies in excess of 2.5 Hz. Conventional horizontal axis wind turbines cause shadow flicker at frequencies of around 1 Hz or less;*
- *Alignment of three or more conventional horizontal axis wind turbines could cause shadow flicker frequencies in excess of 2.5 Hz; however, this would require a particularly unlikely turbine configuration (EPHC 2009 cited in NHMRC 2010).*

The electromagnetic fields produced by the wind farm also do not pose a threat to public health, as *"the closeness of the electrical cables between wind turbine generators to each other, and shielding with metal armour effectively eliminate any EMF"* (AusWEA cited in NHRMC 2010).

11.4.8 Impacts on psychological wellbeing

The Panel hearing for the Oaklands Hill Wind Farm (Victoria) proposal addressed the effects that *"unwanted proposals and the approval processes can have on stress levels and psychological wellbeing"* (DPCD 2008). The Panel concluded that they were not presented with any substantive evidence of a public health risk.

The Victorian Bald Hills Wind Farm Panel acknowledged that, *"it is almost impossible to propose a project of the scale of a wind farm, and not cause some polarisation of views and disruption in the affected community*" (DPCD, 2004).

Both Panels consider that the social harm generated would not be of a significantly adverse or lasting nature such that it was required to be considered in an assessment of environmental effects or a planning decision.

The impact of wind farms on the well-being of communities in NSW *"may be compounded by other issues raised, such as concerns associated with the planning process and the perception that community consultation is a tokenistic exercise that does not genuinely incorporate community concern"* (NSW Legislative Council 2009). The NSW Legislative Council (2009) acknowledges that there is an *"increased chance of being annoyed by wind farms in rural areas and if there is a pre-existing negative attitude to wind farm noise or the visual aspects of wind farms"*.

People who are opposed to wind farm projects in their local area may become anxious, causing stress related illnesses, which are genuine health effects arising from their worry (NHMRC 2010). However, these are not direct impacts of the wind turbine itself (NHMRC 2010). The NHMRC found that people who benefit economically from wind turbines were *"less likely to report annoyance, despite exposure to similar sound levels as people who were not economically benefiting"* (NHMRC 2010).

The NHMRC (2010) and NSW Legislative Council Report (No.5, 2009) indicate that a thorough and high-quality public consultation process may help to address the concerns of the relevant communities, as well as help to gain confidence and support for wind farm projects and avoid stress and anxiety in the process.

The Independent Expert Panel for MDEP and MDPH (2012) found that *"Most epidemiologic literature on human response to wind turbines relates to self-reported "annoyance," and this response appears to be a function of some combination of the sound itself, the sight of the turbine, and attitude towards the wind turbine project"*. The Panel recommends that measures taken to directly involve residents who live in close proximity to a wind turbine project serve to reduce the level of annoyance.

A recent scientific study has further examined the link between wind farms and health impacts.

The University of Sydney in March 2013 released a public health study that examined the historic (1993 – 2012) incidences of health complaints associated with all 49 Australian wind farms. They noted that "*florid allegations about health problems arising from wind turbine exposure (were) now widespread in parts of rural Australia and on the internet"* (Chapman, 2013). They found that 63% of Australian wind farms including 50% of those with a turbine size of greater than 1MW have never been subject to noise or health complaints and that Western Australia has no reported complaints Chapman, 2013).

The study further found that:

*"Only 120 individuals across Australia representing approximately 1 in 272 residents living within 5km of wind farms appear to have complained, with 81 (68%) of these being residents near 5 wind farms which have been heavily targeted by anti-wind farm groups. About 1 in 107 of those living near turbines >1MW have ever complained. The large majority (82%) of health and noise complaints commenced after 2009 when anti-wind farm groups began to add health concerns to their wider opposition. In the preceding years, health or noise complaints were rare despite large and small turbined wind farms having operated for many years"*.

They study concluded that *"In view of scientific consensus that the evidence for wind turbine noise and infrasound causing health problems is poor, the reported spatio-temporal variations in complaints are consistent with psychogenic hypotheses that health problems arising are 'communicated diseases' with nocebo effects likely to play an important role in the aetiology of complaints"*.

The study therefore suggests that wind farms may be harmless, and it is the expectation of harm from those living in proximity of the project that causes actual harm.

This study adds weight to an evolving view that the health impacts historically associated with wind farms have more to do with an opponent's worry and negative thoughts associated with the project and planning process, rather than any direct impact from the wind farm itself.

This phenomenon was evident in a famous planning dispute in Paris where residents blamed three installed mobile phone antennas in their area for causing headaches, nosebleeds, a metallic taste in their mouths, and a variety of other ills (Hamilton, 2009). The complaints continued until it was pointed out that the antennas were never activated (Hamilton, 2009).

### 11.4.9 Blade throw

DoPI refers to blade throw in the *Draft NSW Wind Farm Planning Guidelines*, and requested wind farm proponents to have regard to this potential safety hazard.

In relation to blade throw, the draft Guidelines state:

*The risk of 'blade throw' – involving a wind turbine's blades breaking or being ejected during operation – should be considered. Relevant considerations may include (but are not limited to):*

- *whether the proposed turbines are certified against relevant standards such as IEC 61400-23 Wind turbine generator systems – Part 23: Full-scale structural testing of rotor blades or other equivalent standards - evidence of any such certification should be provided,*
- *overspeed protection mechanisms including 'fail safe' mechanisms (e.g. back up (battery) power in the event of a power failure),*
- *operational management and maintenance procedures including any regular maintenance inspections,*
- *provisions for blade replacement in the event a blade fault is identified (e.g. during a periodic inspection),*
- *the separation distance between turbines, neighbouring dwellings and property boundaries, and*
- *the probability of blade throw occurring.*

Perceived safety issues surrounding blade throw relate specifically to the quality of the infrastructure. In extremely rare incidents, where improper design, manufacturing or installation has combined with strong wind gusts exceeding the design load of the turbine structure, turbine blades have collapsed and fell from the turbine.

The occurrence of blade throw can be defined as two types of infrastructure failure:

- The whole blade detaching from the rotor and falling away from the turbine; or
- Part of the blade breaking off and falling away from the turbine;

Occurrences of these two scenarios could be caused by the factors below:

- Design or manufacturing defect;
- Poor maintenance regime;
- Excessive winds during a storm;
- Exceeding maximum design loads;
- Rotor over-speed; or
- Lightning or fire.

Technological improvements and mandatory safety standards in turbine design, manufacturing, and installation as well as more frequent maintenance have made the occurrence of blade throw 'extremely rare' (NYSERDA 2005). Modern wind turbines are designed to international engineering standards which include ratings for weather events and hurricane-strength winds (AWEA 2012).

The risk of human injury or fatality by a wind turbine blade or debris at any range from a wind turbine is extremely low compared to other commonly accepted risks in the society. Even if a blade was to detach from the turbine, the chance of a person being underneath the turbines in what is a rural area, at that exact point in time, is extremely low.

The proponent seeks to protect the safety of the local area by utilising turbines models that meet the aforementioned standards in order to ensure that the wind farm operates safely in proximity to people and buildings.

The data from the preferred turbine manufacturer for this project shows that the probability of an individual being impacted by debris from a wind turbine in any given year at a distance of 1.1 x tip height, assuming 24 hour occupancy (i.e. a residence), is 1 in over 1 million (Vestas Wind Systems 2012). The probability of this occurrence decreases exponentially as the distance from the turbine increases (Vestas Wind Systems 2012).

Turbine setback distances of 1.1 x tip height is well within the setback distances required to achieve compliance for the quantitative predictions such as noise and shadow flicker. Therefore CDPL has ensured that through the design of the proposed turbine layout there are no dwellings within 1.1 x tip height of any wind turbine.

The probability of blade throw occurring to modern turbines by reputable turbine manufacturers are extremely low as manufacturers have improved their designs to incorporate over speed protection and built-in redundancies, fire detection, more effective maintenance regime, protection against lightning, and more consistent manufacturing processes. Turbines automatically shut down at certain wind speeds and terminate operation if significant vibrations or rotor blade stress is sensed by the monitoring system. In the rare occurrences where blades have failed, the failure typically results in components falling straight to the ground.

The Victorian Oaklands Hill Wind Farm Panel found that while there have been instances of structural failure in turbine blades and structures, a tower or blade collapse is extremely rare, given technological advances and *"the small amount of time that any person would spend at an unlucky spot within the range of potential debris from a rare structural failure, the risk of human impact would be miniscule"* (DPCD 2008).

Refer to **Chapter 11.6** below for the proposed measures to mitigate potential health risks caused by blade throw.

## 11.5 Conclusions

Following a review of the current literature and scientific data, the NHMRC, Australia's preeminent medical research body, found as recently as 2010 that *"there is currently no published scientific evidence to positively link wind turbines with adverse health effects"* (NHMRC 2010). Based on current evidence, modern wind farms do not pose a threat to human health and safety as long as current planning guidelines are followed (NHMRC 2010).

The scientific findings from measured levels of sound and infrasound demonstrate that impacts upon residences within close proximity of a wind turbine are negligible and that a buffer of 2km between sensitive receptors and a wind turbine is not justified in terms of potential health impacts.

As a result of this evidence, the project is not considered to have any likely adverse health impacts on the local community and neighbouring residents. Moreover, UFWA is committed to undertaking an appropriate level of community consultation at all stages of the project, in order to appropriately inform and involve the public in the development of the project, and respond to any gaps in knowledge or misinformation regarding wind farms and the project.

## 11.6 Mitigation

The following measures are recommended to mitigate and negate any health related impacts of the project:

- Provide accessible information on wind farm impacts including the benefits, and project details, process and updates.
- Install warning signs to alert the public against unauthorised site entry.
- Restrict access to the wind turbines and associated infrastructure to reduce personal injury and public hazards, including locked access to towers and electrical equipment, warning signs with postings of 24-hour emergency numbers, and fenced storage yards for equipment and spare parts.
- The wind generator blades, tower and nacelle are to be treated/painted with a non-reflective white or off white colour to reduce glare and minimise blade glint.
- Noise levels should comply with the applicable noise guidelines, unless an agreement is in place with the effected landowner(s), and in any case should not be more than the 45dB(A) noise limit (for indoors) recommended by the World Health Organisation (WHO) publication *Guidelines for Community Noise*.
- Shadow flicker at any dwelling should not exceed 30 hours per year unless an agreement is in place with the effected landowner(s).
- Wind turbines to be equipped with sensors that can react to any imbalance in the rotor blades and shut down the turbine if necessary.
- Regularly maintain and service all wind turbines.

In relation to blade throw, a number of measures are proposed for the project. Each turbine model considered for this project would be certified against the relevant standards including:

- IEC 61400-23 [Wind turbine generator systems, Full-scale structural testing of rotor blades]; and
- IEC 62305-1 / 3 / 4 [Protection Against Lightning].

Lighting protection systems are incorporated into the blade designed to reduce the risk of damage from lightning strikes to the blades. The safety systems are designed to initiate a shutdown of the turbine upon detection of failure.

The operational and maintenance contracts of the turbines provide incentives to maximise the output of the wind farm. The maximum output is achieved through rigorous maintenance regime to ensure the turbines are operating at full efficiency, and this includes mitigating and repairing any degradation to the blades to keep generation at optimum levels.

Additionally, the use of fencing and signage will discourage unauthorised access to the wind turbines, which would further reduce the risk of blade throw incidences.