UNION FENOSA WIND AUSTRALIA

Crookwell 3 Wind Farm

Chapter 11

HEALTH IMPACTS

11 Health

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 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 proposed Crookwell 3 Wind Farm, 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.

CDPL 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

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
- 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).

The NSW Legislative Council (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).

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;
- 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, *"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). 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).

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 study

The National Health and Medical Research Council (NHMRC) recently 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 World Health Organisation (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

A Community Affairs References Committee (the Committee) was established for 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 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 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).

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).

It should also 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).

The Community Affairs References Committee for the Australian Senate recommends in their recent 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) recently released a position statement, *Human Health Effects of Wind Turbines*, 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.*

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.).

A recent 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. It was confirmed through testing 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

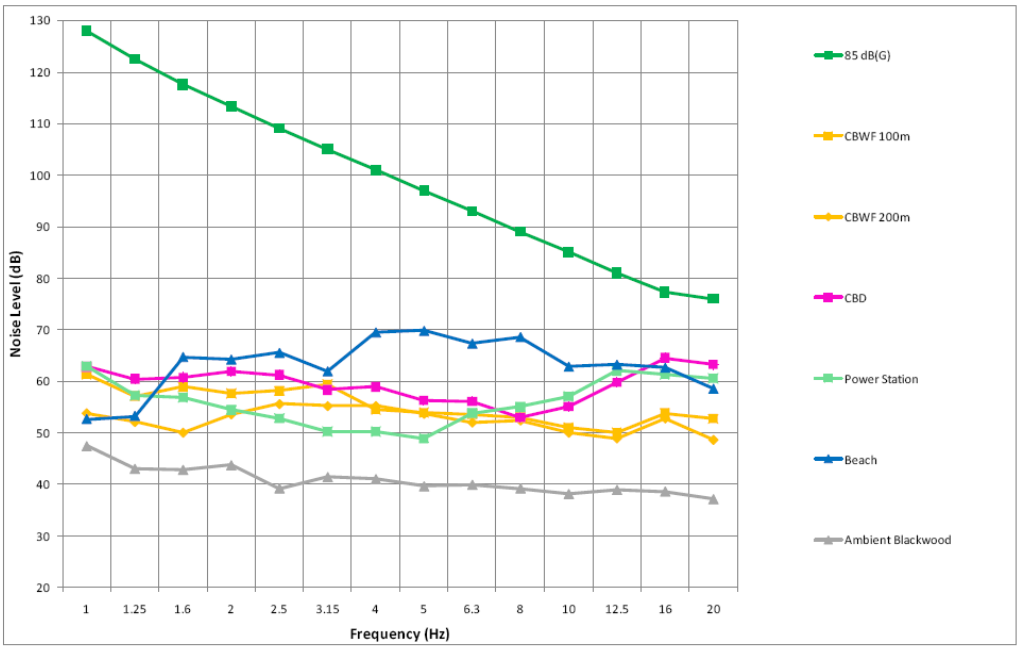
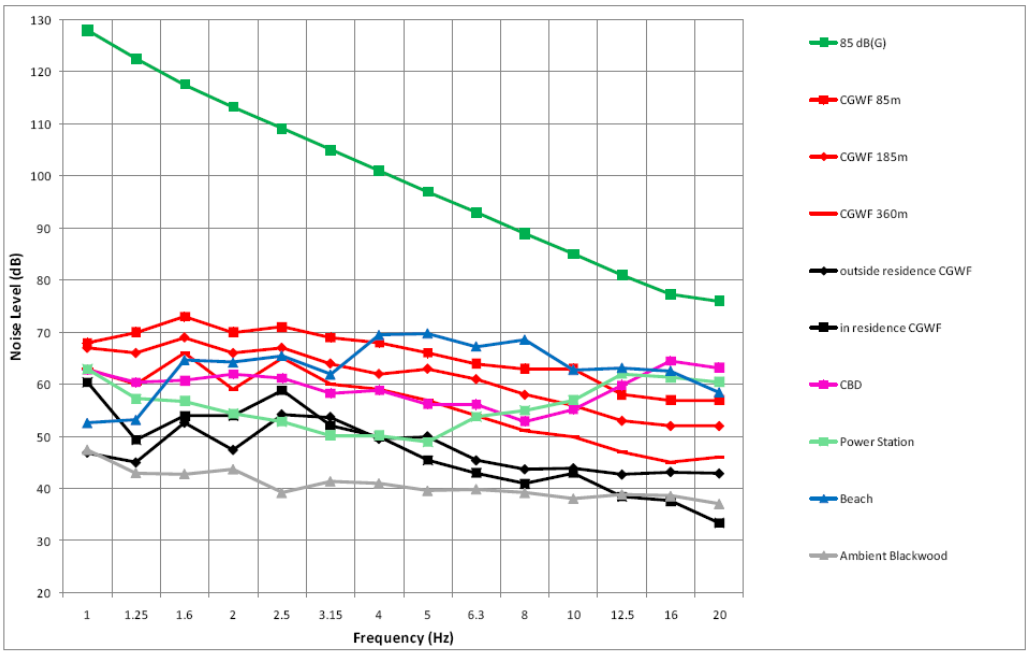


Figure 44 – Summary of Measurements Clements Gap Wind Farm



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.

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

11.3.4 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.

11.3.5 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).

11.3.6 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 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 13 – Shadow Flicker** for more information on the potential shadow flicker impacts arising out of the Crookwell 3 Wind Farm.

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).

11.3.7 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 (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.

11.4 Conclusions

Following a review of the current literature and scientific data, the National Health and Medical Research Council, 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 proposed Crookwell 3 Wind Farm is not considered to have any likely adverse health impacts on the local community and neighbouring residents. Moreover, CDPL 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 proposed development.

11.5 Mitigation

The following measures are recommended to mitigate and negate any health related impacts of the proposed Crookwell 3 Wind Farm:

- 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 not 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.

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Chapter 12

BLADE THROW IMPACTS

12 Blade Throw

12.1 Introduction

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

These issues are considered below.

12.2 Key Concerns

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 falling 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. The proponent seeks to enhance the amenity and 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).

12.3 Mitigation

The preferred turbine suppliers have tens of thousands of turbines installed across many countries across six continents, and have several decades of experience in the wind industry. These suppliers are the leaders in design, manufacturing and provision of service for wind turbines, and are committed to providing customers with a safe and high quality product.

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.

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Chapter 13

SHADOW FLICKER IMPACTS

13 Shadow Flicker

13.1 Introduction

A shadow flicker assessment has been prepared by Garrad Hassan Pacific Pty Ltd on behalf of CDPL to determine and assess the potential impact of shadow flicker arising from the proposed Crookwell 3 Wind Farm on surrounding view locations. The results of the shadow flicker assessment are summarised in the Landscape Visual Impact Assessment (LVIA) report by Green Bean Design Pty Ltd, and a copy of the detailed Shadow Flicker report for the Crookwell 3 Wind Farm is included in full in the LVIA at **Appendix 6**.

The assessment describes the shadow flicker effect as follows:

"Due to their height, wind turbines can cast shadows on surrounding areas at a significant distance from the base of the wind turbine tower. Coupled with this, the moving blades create moving shadows. When viewed from a stationary position, the moving shadows appear as a flicker giving rise to the phenomenon of 'shadow flicker'. When the sun is low in the sky the length of the shadows increases, increasing the shadow flicker affected area around the wind turbine".

Figure 45 illustrates a typical situation where shadow flicker may be experienced whilst driving along a road where trees cast shadows.

Figure 45 – Potential shadow flicker created by trees filtering sunlight across road

The report notes that the likelihood and duration of the shadow flicker effect depends upon a number of variable factors as follows:

- *direction of the property relative to the turbine;*
- *distance from turbine (the further the observer is from the turbine, the less pronounced the effect would be);*
- *wind direction (the shape of the shadow would be determined by the position of the sun relative to the blades, which would be oriented to face the wind);*
- *turbine height and rotor diameter;*
- *time of year and day (the height of the sun in the sky); and*
- *weather conditions (cloud cover reduces the occurrence of shadow flicker).*

It is important to note that the shadow flicker assessment may overestimate the actual number of annual hours of shadow flicker at a particular location due to a number of reasons including:

- *the probability that the wind turbines would not face into or away from the sun all of the time;*
- *the occurrence of cloud cover;*
- *the amount of particulate matter in the atmosphere (moisture, dust, smoke etc) which may diffuse sunlight;*
- *the presence of vegetation; and*
- *periods where the wind turbine may not be in operation due to low winds, or high winds or for operational or maintenance reasons.*

13.2 Methodology

Garrad Hassan utilised the following methodology in assessing the impact of the proposed Crookwell 3 Wind Farm:

"The number of hours of shadow flicker experienced annually at a given location can be calculated using a geometrical model which incorporates the sun path, topographic variation over the wind farm site and wind turbine details such as rotor diameter and hub height".

The report further suggests that this modelling makes the following assumptions:

- *that there are clear skies every day of the year;*
- *that the turbines are always rotating;*
- *that the sun can be represented as a single point;*
- *that the blades of the turbines are always perpendicular to the direction of the line of sight from the specified location to the sun; and*
- *that the sun is modelled as a point source.*

These assumptions, particularly that likelihood of a reduction of shadow flicker due to cloud cover has not been applied to the shadow flicker duration results, mean that the results contained in the report should be regarded as conservative.

As there are no guidelines by which to assess the impact of shadow flicker in New South Wales, the shadow flicker assessment prepared by Garrad Hassan adopted the Victorian Planning Guidelines which state:

"The shadow flicker experienced at any dwelling in the surrounding area must not exceed 30 hours per year as a result of the operation of the wind energy facility".

Shadow flicker was calculated at dwellings at heights of 2 m, to represent ground floor windows, and 6m, to represent second floor windows. An assessment of the possible reduction in shadow flicker duration due to turbine orientation has also been conducted.

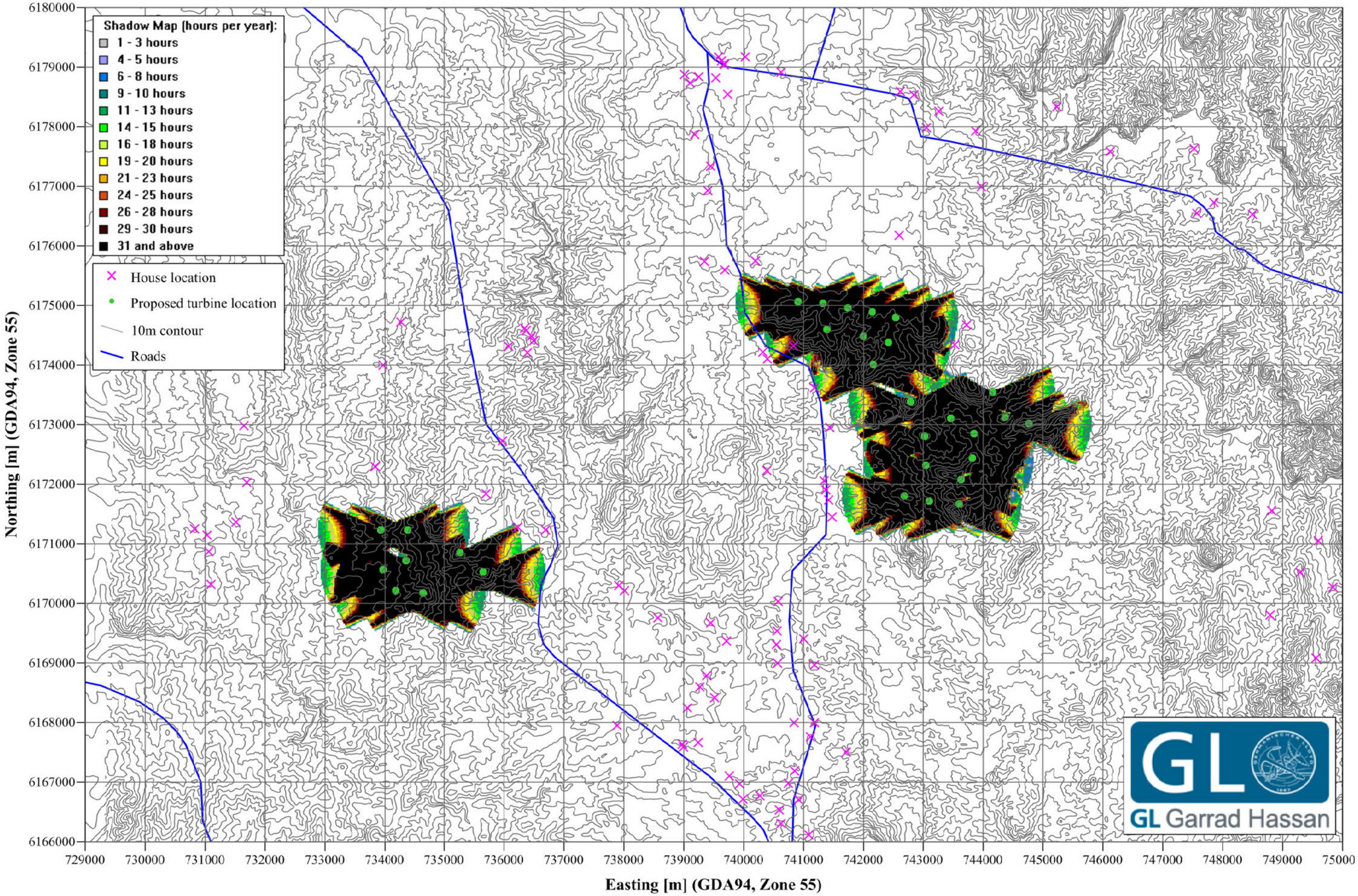
13.3 Results

Shadow Flicker

Garrad Hassan has assessed the impacts of shadow flicker arising from the proposed Crookwell 3 Wind Farm on surrounding view locations (refer to **Figure 46 – Theoretical annual shadow flicker duration at 6 metres**).

The results of the of the shadow flicker assessment for the Crookwell 3 Wind Farm determined that the following four residential view locations may be subject to some levels of shadow flicker:

- House ID 18, Wollondilly (associated residence);
- House ID 79, Leeston (associated residence);
- House ID 66, Little Vale (non-associated residence); and



Map of Crookwell III Wind Farm showing turbine, house locations and theoretical annual shadow flicker duration at 6 m.

FIGURE 46 Theoretical Annual Shadow Flicker Duration at 6 Metres

Source: SLR

– House ID 63, Rocky Corner (non-associated residence).

The Leeston residence that adjoins the Crookwell 3 East site has been determined as the only residence that may be subject to levels of shadow flicker in excess of 30 hours. It is important to note that this residence is an associated landowner.

None of the surrounding residential view locations were determined to have the potential to exceed the maximum theoretical duration of shadow flicker of greater than 30 hours per year for the Crookwell 3 South site (refer to **Table 20**).

Table 20 – Flicker Assessment Summary for the Crookwell 3 Wind Farm layout

House ID	Easting[1] [m]	Northing[1] [m]	Theoretical				Predicted Actual[3]	
			At Dwelling [hr/yr]		Max Within 50m of Dwelling[2] [hr/yr]		Max Within 50m of Dwelling[2] [hr/yr]	
			At 2 m	At 6 m	At 2 m	At 6 m	At 2 m	At 6 m
Limit			30	30	30	30	10	10
18	736232	6171276	0	0	28	28	10	10
63	741181	6173622	0	0	13	13	4	4
66	743524	6174343	0	0	9	12	3	4
79	740830	6174323	28	32	36	38	11	12

[1] MGA Zone 54 (GDA94 datum)

[2] Dwellings with zero hours shadow flicker have been omitted from this table

[3] Considering likely reductions in shadow flicker duration due to cloud cover and turbine orientation

The report found that in relation to the Leeston residence (dwelling 79);

– *It is located amongst mature tree plantings which screen the majority of views from the residence toward the Crookwell 3 East wind turbines.*

– *As there are likely to be limited views toward wind turbines from the residence, it is anticipated that Leeston would not experience the level of shadow flicker predicted in the assessment.*

Photosensitive Epilepsy

The report also considers the potential issue of 'photosensitive epilepsy', which is defined by the Canadian Epilepsy Alliance as *"a sensitivity to flashing or flickering lights, usually of high intensity, which are pulsating in a regular pattern – and people with photosensitive epilepsy can be triggered into seizures by them"*. The report notes that both the Canadian Epilepsy Alliance and Epilepsy Action Australia estimate that less than 5% of people with epilepsy are photosensitive.

An assessment of these sources found that;

"Given the low flicker frequency associated with the Crookwell 3 wind turbines, which falls below the range suggested by Epilepsy Action Australia as a potential trigger for photosensitive epileptic seizures, it is unlikely that the Crookwell 3 wind turbines would present a risk to people with photosensitive epilepsy".

Traffic

Motorists can experience shadow flicker sensations whilst driving as a result of shadows cast on the road from roadside or overhead objects such as trees, poles or buildings. Under certain conditions the sensation of shadow flicker may cause annoyance and may impact on a driver's ability to operate a motor vehicle safely. The

report considered the potential of shadow flicker associated with wind turbines to road uses and concluded;

"As the potential flicker frequency for the Crookwell 3 wind turbines is likely to be around 1Hz, it is unlikely that the flicker effect would cause annoyance or impact on a driver's ability to operate a motor vehicle safely whilst travelling along local roads surrounding the wind farm".

Blade Glint

The assessment also addresses 'blade glint', which is described as a *"phenomenon that results from the direct reflection of sunlight (also known as specular reflection) from a reflective surface that would be visible when the sun reflects off the surface of the wind turbine at the same angle that a person is viewing the wind turbine surface"*.

The report highlights that glint may be noticeable for some distance, but usually results in a low impact.

The report notes that the potential for blade glint from wind farms is reduced by the turbines' surfaces, including the towers and blades, *"as they are largely convex, which would tend to result in the divergence of light reflected from the surfaces, rather than convergence toward a particular point"*. Blade glint can also be further mitigated through the use of matt coatings.

13.4 Mitigation

The report concluded that several options are available for mitigation of shadow flicker and blade glint on the view locations such as the noted dwellings, based on the owner's approval. These options are as follows:

- *installation of screening structures or planting of trees to block shadows cast by the turbines;*
- *the use of turbine control strategies which shut down turbines when shadow flicker is likely to occur;*
- *matt coatings on wind turbines; and*
- *drawing the curtains at the times that flicker occurs.*