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Wind Turbines and Health

A Rapid Review of the Evidence

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Wind Turbines and Health – A Rapid Review of the Evidence

The purpose of this paper is to present findings from a rapid review of the evidence from current literature on the issue of wind turbines and potential impacts on human health. In particular the paper seeks to ascertain if the following statement can be supported by the evidence: *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.* This statement is supported by the 2009 expert review commissioned by the American and Canadian Wind Energy Associations (Colby et al. 2009).

Context

In Australia, since the legislation of the *Renewable Energy (Electricity) Act* in 2000, wind power has been gaining prominence as a viable sustainable alternative to more traditional forms of energy production. Studies have found that there is increasing population demand for 'green' energy and that people are willing to pay a premium for renewable energy (Chatham-Kent Public Health Unit, 2008; Pedersen & Persson Waye, 2007). However as with any shift in technology, the emergence of wind farms is not without controversy.

There are two opposing viewpoints regarding wind turbines and their potential effect on human health. It is important to note that these views are frequently presented by groups or people with vested interests. For example, wind energy associations purport that there is no evidence linking wind turbines to human health concerns. Conversely, individuals or groups who oppose the development of wind farms contend that wind turbines can adversely impact the health of individuals living in proximity to wind farms.

Concerns regarding the adverse health impacts of wind turbines focus on the effects of infrasound, noise, electromagnetic interference, shadow flicker and blade glint produced by wind turbines. Does the evidence support these concerns?

Sound and Noise from Wind Turbines

Sound is composed of frequency expressed as hertz (Hz) and pressure expressed as decibels (dB). In terms of frequency sound can be categorised as audible and inaudible. Infrasound is commonly defined as sound which is inaudible to the human ear (below 16 Hz). Despite this commonly used definition, infrasound can be audible (EPHC, 2009). There is often confusion regarding the boundary between infrasound and low frequency noise (Leventhall, 2006). Human sensitivity to sound, especially to low frequency sound, is variable and people will exhibit variable levels of tolerance to different frequencies (Minnesota Department of Health, 2009).

Noise can be defined as any undesirable or unwanted sound. The perception of the noise is also influenced by the attitude of the hearer towards the sound source. This is sometimes called the nocebo effect, which is the opposite of the better known placebo effect. If people have been preconditioned to hold negative opinions about a noise source, they are more likely to be affected by it (AusWEA, 2004).

Wind turbines produce noise that can be classified into the following categories:

1. Mechanical noise which is produced from the motor or gearbox; if functioning correctly, mechanical noise from modern wind turbines should not be an issue.
2. Aerodynamic noise which is produced by wind passing over the blade of the wind turbine (Minnesota Department of Health, 2009).

As well as the general audible range of sound emissions, wind turbines also produce noise that includes a range of Special Audible Characteristics (SACs) such as amplitude modulation, impulsivity, low frequency noise and tonality (EPHC, 2009).

Table 1 compares the noise produced by a ten turbine wind farm compared to noise levels from some selected activities.

Activity	**Sound pressure level (dBA)[1]**
Jet aircraft at 250m	105
Noise in a busy office	60
Car travelling at 64kph at 100m	55
Wind farm (10 turbines) at 350m	**35-45**
Quiet bedroom	35
Background noise in rural area at night	20-40

Table 1: Noise levels compared to ten turbine wind farm (SDC, 2005).

Macintosh and Downie (2006) conclude that based on these figures "noise pollution generated by wind turbines is negligible".

One of the most common assertions regarding potential adverse noise impacts of wind turbines is concerned with low frequency noise and infrasound. It should be noted that infrasound is constantly present in the environment and is 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). In relation to wind turbines, Leventhall (2006) concludes that there is insignificant infrasound generated by wind turbines and that there is normally little low frequency noise. A survey 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). Another recent report concludes that wind farm noise does not have significant low-frequency or infrasound components (Ministry of the Environment, 2007). As discussed in further detail below the principal human response to audible infrasound is annoyance (Rogers, 2006).

Effects of Noise from Wind Turbines on Human Health

The health and well-being effects of noise on people can be classified into three broad categories:

[1] The "A" represents a weighting of measured sound to mimic that discernable by the human ear, which does not perceive sound at low and high frequencies to be as loud as mid range frequencies (AusWEA, nd. a).

1. subjective effects including annoyance, nuisance and dissatisfaction;
2. interference with activities such as speech, sleep and learning; and
3. physiological effects such as anxiety, tinnitus or hearing loss (Rogers, Manwell & Wright, 2006).

Several commentators argue that noise from wind turbines only produces effects in the first two categories (Rogers, 2006; Pedersen & Persson Waye, 2007).

Various studies of wind turbine effects on health have concentrated on the self-reported perception of annoyance. There are difficulties with measuring and quantifying subjective effects of noise such as annoyance. According to the World Health Organization (WHO) (1999) annoyance is an adverse health effect, though this is not universally accepted. Kalveram proposes that annoyance is not a direct health effect but an indication that a person's capacity to cope is under threat. The person has to resolve the threat or their coping capacity is undermined, leading to stress related health effects (Kalveram 2000). Some people are very annoyed at quite low levels of noise, whilst other are not annoyed by high levels.

It has been suggested that if people are worried about their health they may become anxious, causing stress related illnesses. These are genuine health effects arising from their worry, which arises from the wind turbine, even though the turbine may not objectively be a risk to health (Chapman 2010). The measurement of health effects attributable to wind turbines is therefore very complex.

One study of wind turbine noise and annoyance found that no adverse health effects other than annoyance could be directly correlated with noise from wind turbines. The authors concluded that reported sleep difficulties, as well as feelings of uneasiness, associated with noise annoyance could be an effect of the exposure to noise, although it could just as well be that respondents with sleeping difficulties more easily appraised the noise as annoying (Pedersen & Persson Waye, 2007).

Many factors can influence the way noise from wind turbines is perceived. The aforementioned study also found that being able to see wind turbines from one's residence increased not just the odds of perceiving the sound, but also the odds of being annoyed, suggesting a multimodal effect of the audible and visual exposure from the same source leading to an enhancement of the negative appraisal of the noise by the visual stimuli (Pedersen & Persson Waye, 2007). Another study of residents living in the vicinity of wind farms in the Netherlands found that annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study also concluded that people who benefit economically from wind turbines were less likely to report noise annoyance, despite exposure to similar sound levels as those people who were not economically benefiting (Pedersen et al, 2009).

In addition to audible noise, concerns have been raised about infrasound from wind farms and health effects. It has been noted that the effects of low frequency infrasound (less than 20Hz) on humans are not well understood (NRC, 2007). However, as discussed above, several authors have suggested that low level frequency noise or infrasound emitted by wind turbines is minimal and of no consequence (Leventhall, 2006; Jakobsen, 2005). Further, numerous reports have concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines (DTI, 2006; CanWEA, 2009; Chatham-Kent Public Health Unit, 2008; WHO, 2004; EPHC, 2009; HGC Engineering, 2007). In summary:

- ‘There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects’ (Berglund & Lindvall 1995).

- Infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour (DTI, 2006).

- Findings clearly show that there is no peer-reviewed scientific evidence indicating that wind turbines have an adverse impact on human health (CanWEA, 2009).

- Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effects in humans. Subaudible, low frequency sounds and infrasound from wind turbines do not present a risk to human health (Colby, et al 2009).

- The Chatham-Kent Public Health Unit (Ontario, Canada) reviewed the current literature regarding the known health impacts of wind turbines in order to make an evidence-based decision. Their report concluded that current evidence failed to demonstrate a health concern associated with wind turbines. ‘In summary, as long as the Ministry of Environment Guidelines for location criteria of wind farms are followed … there will be negligible adverse health impacts on Chatham-Kent citizens. Although opposition to wind farms on aesthetic grounds is a legitimate point of view, opposition to wind farms on the basis of potential adverse health consequences is not justified by the evidence’ (Chatham-Kent Public Health Unit, 2008).

- Wind energy is associated with fewer health effects than other forms of traditional energy generation and in fact will have positive health benefits (WHO, 2004).

- ‘There are, at present, very few published and scientifically-validated cases of an SACs of wind farm noise emission being problematic … the extent of reliable published material does not, at this stage, warrant inclusion of SACs … into the noise impact assessment planning stage (EPHC, 2009).

- While a great deal of discussion about infrasound in connection with wind turbine generators exists in the media there is no verifiable evidence for infrasound and production by modern turbines (HGC Engineering, 2007).

The opposing view is that noise from wind turbines produces a cluster of symptoms which has been termed Wind Turbine Syndrome (WTS). The main proponent of WTS is a US based paediatrician, Dr Pierpont, who has released a book ‘Wind Turbine Syndrome: A report on a Natural Experiment, presents case studies explaining WTS symptoms in relation to infrasound and low frequency noise. Dr Pierpont’s assertions are yet to be published in a peer-reviewed journal, and have been heavily criticised by acoustic specialists. Based on current evidence, it can be concluded that wind turbines do not pose a threat to health if planning guidelines are followed.

Shadow Flicker and Blade Glint

Shadow flicker occurs when the sun is located behind a wind turbine casting a shadow that appears to flick on and off as the wind turbine blades rotate (Chatham-Kent Public health Unit, 2008). It is possible to use modelling software to model shadow flicker before the finalisation of a wind farm layout and siting.

Blade glint occurs when the surface of wind turbine blades reflect the sun's light and has the potential to annoy people (EPHC, 2009).

Effects of Shadow Flicker and Blade Glint on Human Health

Shadow flicker from wind turbines that interrupts sunlight at flash frequencies greater than 3Hz has the potential to provoke photosensitive seizures (Harding, Harding & Wilkins, 2008). As such it is recommended that to circumvent potential health effects of shadow flicker wind turbines should only be installed if flicker frequency remains below 2.5 Hz under all conditions (Harding, Harding & Wilkins, 2008).

According to the EPHC (2009) there is negligible risk of seizures being caused by modern wind turbines 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.

In summary, the evidence on shadow flicker does not support a health concern (Chatham-Kent Public Health Unit, 2008) as the chance of conventional horizontal axis wind turbines causing an epileptic seizure for an individual experiencing shadow flicker is less than 1 in 10 million (EPHC, 2009). As with noise, the main impact associated with shadow flicker from wind turbines is annoyance.

In regards to blade glint, manufacturers of all major wind turbine blades coat their blades with a low reflectivity treatment which prevents reflective glint from the surface of the blade. According to the Environment Protection and Heritage Council (EPHC) the risk of blade glint from modern wind turbines is considered to be very low (EPHC, 2009).

Electromagnetic Radiation and Interference

Electromagnetic radiation (EMR) is a wavelike pattern of electric and magnetic energy moving together. Types of EMR include X-rays, ultraviolet, visible light, infrared and radio waves (AusWEA, nd. b).

Electromagnetic interference (EMI) from wind turbines may affect electromagnetic or radiocommunication signals including broadcast radio and television, mobile phones and radar (EPHC, 2009).

As high and exposed sites are best from a wind resource perspective, it is not unusual for any of a range of telecommunications installations, radio and television masts, mobile phone base stations or emergency service radio masts to be located nearby. Care must be taken to ensure that wind turbines do not passively interfere with these facilities by directly obstructing, reflecting or refracting their radio frequency EMR signals.

Effects of Electromagnetic Radiation and Interference from Wind Turbines on Human Health

Electromagnetic Fields (EMF) emanate from any wire carrying electricity and Australians are routinely exposed to these fields in their everyday lives. The electromagnetic fields produced by the generation and export of electricity from a wind farm do not pose a threat to public health (Windrush Energy 2004). The closeness of the electrical cables between wind turbine generators to each other, and shielding with metal armour effectively eliminate any EMF (AusWEA, nd. b).

Measures to Mitigate Potential Impacts of Wind Turbines

As with the introduction of any new technology, some communities are against wind farms being located in their area. Some factors which may increase community concern include coerced or unequal exposure, industrial, exotic and/or memorable nature of the turbine, dreaded, unknown or catastrophic consequences, substantial media attention, potential for collective action and a process which is unresponsive to the community. Voluntary exposure, for example choosing to house the turbine on community land, reduces concern (Adapted by Professor Chapman from Covello et al. methodology 1986).

One review of wind turbines and noise recommends that best practice guidelines such as those identifying potential receptors of turbine noise, following established setbacks and dispelling rumours regarding infrasound which have not been supported by research, are followed in order to mitigate any potential noise issues associated with wind turbines (Howe, 2007).

Sustainable Energy Authority Victoria (2003) also recommend that complying with standards relating to turbine design and manufacturing, site evaluation and final siting of wind turbines will minimise any potential impacts on the surrounding area.

The recently released Draft National Wind Farm Development Guidelines (EPHC, 2009) include detailed methodologies at different stages of the planning and development process to assess such issues as noise and shadow flicker to mitigate any potential impact. Such processes include a range of measures such as high-level risk assessment, data collection, impact assessment, detailed technical studies and public consultation.

Therefore if planning guidelines are followed and communities are consulted with in a meaningful way, resistance to wind farms is likely to be reduced and annoyance and related health effects avoided.

Conclusion

The health effects of many forms of renewable energy generation, such as wind farms, have not been assessed to the same extent as those from traditional sources. However, renewable energy generation is associated with few adverse health effects compared with the well documented health burdens of polluting forms of electricity generation (Markandya & Wilkinson, 2007).

This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement 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.*

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WIND FARMS TECHNICAL PAPER

Environmental Noise

Prepared for

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INTRODUCTION

Australian wind farms currently provide 1841MW of power or enough energy to power 772,286 homes (Clean Energy Council Renewable Energy Database, April 2010). With this level of generation comes a need to ensure their advantages are balanced against the amenity of the communities that live in their vicinity.

This Technical Paper has been prepared to provide the latest information to communities, developers, planning and enforcement authorities and other stakeholders on environmental noise from wind farms and includes:

- An explanation of the sources of noise from a wind farm and its characteristics;

- A summary of the various Australian wind farm noise standards and guidelines and a comparison of the local and International approaches;

- A description of the methodology associated with a detailed environmental noise assessment prepared for a wind farm in accordance with the relevant standards and guidelines;

- A description of the various terms used in those assessments including the ambient noise environment, background noise levels and characteristics such as modulation, tonality, infrasound and low frequency;

- A summary of the research conducted into a range of issues including:
  - Health impacts and annoyance;
  - Infrasound and low frequency;
  - Amplitude modulation; and
  - Sleep disturbance

EXECUTIVE SUMMARY

Virtually all processes generate noise, including wind farms. The response to noise by individuals can be wide and varied. Noise is often the most important factor in determining the separation distance between wind turbines and sensitive receivers. The assessment of noise therefore plays a significant role in determining the viability of and the size of wind farms.

Australian jurisdictions presently assess the noise from wind farms under a range of Standards and Guidelines applicable to each individual State or Territory.

The Standards and Guidelines used in Australia and New Zealand are stringent in comparison to other International approaches. They are also the most contemporary in the World, with recent updates and releases of the main assessment approaches occurring in both late 2009 and early 2010.

Notwithstanding the above, there are community concerns relating to both annoyance and health impacts associated with environmental noise from both planned and operating wind farms. As such, the Clean Energy Council has engaged Sonus to make an independent review of the available information relating to noise from wind farms.

The information in this Technical Paper results in the following key conclusions:

- The standards and guidelines used for the assessment of environmental noise from wind farms in Australia and New Zealand are amongst the most stringent and contemporary in the World;

- There are inherent discrepancies associated with a number of different approaches from jurisdiction to jurisdiction;

- The rate of complaints relating to environmental noise emissions from residents living in the vicinity of operating wind farms is very low;

- There are complaints relating to environmental noise emissions from residents living in the vicinity of operating wind farms. These complaints generally relate to concerns regarding low frequency noise and health related impacts; and

- There is detailed and extensive research and evidence that indicates that the noise from wind farms developed and operated in accordance with the current Standards and Guidelines will not have any direct adverse health effects.

THE NOISE FROM A WIND FARM

The acoustic energy generated by a wind turbine is of a similar order to that produced by a truck engine, a tractor, a large forklift or a range of typical earthmoving equipment. However, a wind turbine is a stationary source that operates in conjunction with other turbines in a generally windy environment, is located high above the ground and has different noise characteristics compared to these other noise sources.

This section provides information relating to the level and characteristics of noise from a wind farm.

Noise is inherently produced by moving elements. There are two main moving elements that generate the environmental noise from a wind turbine, being the external rotating blades and the internal mechanical components such as the gearbox and generator.

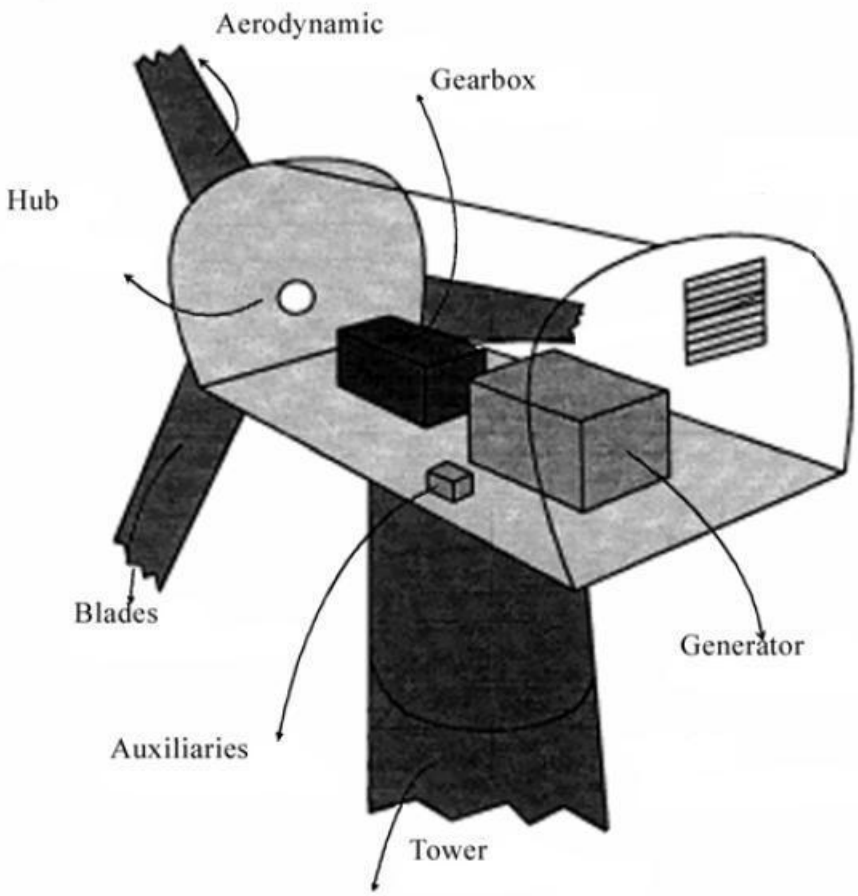


Figure 1 - (Modified from Wagner 1996)

The noise from the blades and the internal machinery are commonly categorised as aerodynamic and mechanical noise respectively.

Mechanical Noise

Mechanical noise sources are primarily associated with the electrical generation components of the turbine, typically emanating from the gear box and the generator. Mechanical noise was audible from early turbine designs. On modern designs, mechanical noise has been significantly reduced (Moorhouse et al., 2007), such that aerodynamic noise from the blades is generally the dominant noise emission from a wind turbine.

Aerodynamic Noise

Aerodynamic noise typically dominates the noise emission of a wind turbine and is produced by the rotation of the turbine blades through the air.

Turbine blades employ an airfoil shape to generate a turning force. The shape of an airfoil causes air to travel more rapidly over the top of the airfoil than below it, producing a lift force as air passes over it. The nature of this air interaction produces noise through a variety of mechanisms (Brooks et al., 1989).

In general terms, the noise we hear in any environment is a combination of energy at different frequencies. There are noise sources that have their dominant content of energy present in the higher frequencies, such as a whistle, and noise sources that have their dominant content in the low frequencies, such as a diesel locomotive engine. Most noise sources are "broadband" in nature; that is they possess energy in all frequencies. A typical broadband noise is music, where the bass content is in the low frequency region, and the voices and general melody are in the middle and higher frequencies.

Aerodynamic noise is broadband in nature and present at all frequencies. Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. Therefore, the A-weighted network (dB(A)) is the network used in wind farm standards and guidelines.

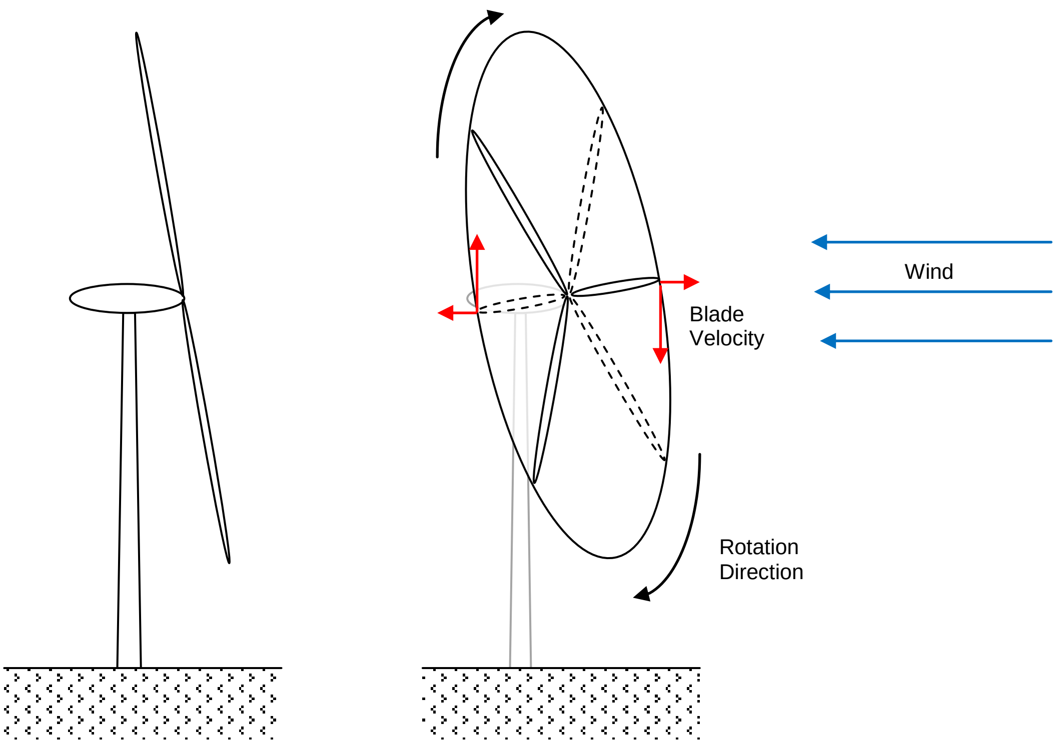
Aerodynamic noise can be further separated into the following categories, generally termed "characteristics":

Amplitude Modulation

Amplitude modulation is most commonly described as a “swish” (Pedersen, 2005). “Swish” is a result of a rise and fall in the noise level from the moving blades. The noise level from a turbine rises during the downward motion of the blade. The effect of this is a rise in level of approximately once per second for a typical three-bladed turbine as each blade passes through its downward stroke.

It was previously thought that “swish” occurred as the blade passed the tower, travelling through disturbed airflow, however, a recent detailed study indicates it is related to the difference in wind speed over the swept area of a blade (Oerlemans and Schepers, 2009).

Other explanations for the rise in noise level that occurs on the downward stroke relate to the slight tilt of the rotor-plane on most modern wind turbines to ensure that the blades do not hit the tower. An effect of the tilt is that when the blades are moving downwards they are moving against the wind. Conversely, when moving upwards they are moving in the same direction as the wind. Therefore, with the effective wind speed being higher on the downward stroke, it is suggested that a higher noise level is produced (Sloth, 2010).



Section displaying blade tilt

3D Elevation displaying blade velocity

Figure 2 - Blade Velocity due to Tilt

Low Frequency Noise

Noise sources that produce low frequency content, such as a freight train locomotive or diesel engine; have dominant noise content in the frequency range between 20 and 200 Hz (O'Neal et al, 2009). Low frequency noise is often described as a "rumble".

Aerodynamic noise from a wind turbine is not dominant in the low frequency range. The main content of aerodynamic noise generated by a wind turbine is often in the area known generically as the mid-frequencies, being between 200 and 1000Hz.

Noise reduces over distance due to a range of factors including atmospheric absorption. The mid and high frequencies are subject to a greater rate of atmospheric absorption compared to the low frequencies and therefore over large distances, whilst the absolute level of noise in all frequencies reduces, the relative level of low frequency noise compared to the mid and high frequency content increases. For example, when standing alongside a road corridor, the mid and high frequency noise from the tyre and road interaction is dominant, particularly if the road surface is wet. However, at large distances from a road corridor in a rural environment, the remaining audible content is the low frequency noise of the engine and exhaust.

This effect is exacerbated in an environment that includes masking noise in the mid and high frequencies, such as that produced by wind in nearby trees.

A typical separation distance between wind farms and dwellings is of the order of 1000m. At similar distances, in an ambient environment where wind in the trees is present, it is possible that only low frequencies remain audible and detectable from a noise source that produces content across the full frequency range. This effect will be more prevalent for larger wind farms because the separation distances need to be greater in order to achieve the relevant noise standards. A greater separation distance changes the dominant frequency range from the mid frequencies at locations close to the wind farm to the low frequencies further away, due to the effects described above.

The low frequency content of noise from a wind farm is easily measured and can also be heard and compared against other noise sources in the environment. Low frequency sound produced by wind farms is not unique in overall level or content and it can be easily measured and heard at a range of locations well in excess of that in the vicinity of a wind farm. The C-weighting network (dB(C)) has been developed to determine the human perception and annoyance due to noise that lies within the low frequency range.

Infrasound

Infrasound is generally defined as noise at frequencies less than 20 Hz (O'Neal et al., 2009). The generation of infrasound was detected on early turbine designs, which incorporated the blades 'downwind' of the tower structure (Hubbard and Shepherd 2009). The mechanism for the generation was that the blade passed through the wake caused by the presence of the tower.

Audible levels of infrasound have been measured from downwind blade wind turbines (Jakobsen, J., 2005). Modern turbines locate the blades upwind of the tower and it is found that turbines of contemporary design produce much lower levels of infrasound (Jakobsen, J., 2005), (Hubbard and Shepherd 2009).

Infrasound is often described as inaudible, however, sound below 20 Hz remains audible provided that the sound level is sufficiently high (O'Neal et al, 2009). The thresholds of hearing for infrasound have been determined in a range of studies (Levanthall, 2003).

Non-audible perception of infrasound through felt vibrations in various parts of the body is not possible for levels of infrasound that are below the established threshold of hearing and only occurs at levels well above the threshold (Moeller and Pedersen, 2004).

Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. The G-weighting has been standardised to determine the human perception and annoyance due to noise that lies within the infrasound frequency range (ISO 7196, 1995).

A common audibility threshold from the range of studies is an infrasound noise level of 85 dB(G) or greater. This is used by the Queensland Department of Environment and Resource Management's (DERM's) draft Guideline for the assessment of low frequency noise as the acceptable level of infrasound in the environment from a noise source to protect against the potential onset of annoyance and is consistent with other approaches, including the UK Department for Environment, Food and Rural Affairs (DEFRA., Leventhall, 2003).

Whilst the aerodynamic noise from a rotating turbine blade produces energy in the infrasound range, measurements of infrasound noise emissions from modern upwind turbines indicates that at distances of 200 metres, infrasound is in the order of 25 dB below the recognised perception threshold of 85 dB(G) and other similar recognised perception thresholds (Hayes Mckenzie Partnership Ltd, 2006). A 25 dB difference is significant and represents at least a 100 fold difference in energy content. Infrasound also reduces in level when moving away from the source, and separation distances between wind farms and dwellings are generally well in excess of 200m.

Notwithstanding the above, there are natural sources of infrasound including wind and breaking waves, and a wide range of man-made sources such as industrial processes, vehicles and air conditioning and ventilation systems that make infrasound prevalent in the natural and urban environment (Howe, 2006).

Future Designs

A wind turbine converts wind energy into rotational energy (which in turn becomes electricity) and acoustic energy. An efficient wind turbine converts more of the wind energy into rotational energy with all other factors, such as blade angles, being equal. Therefore, it is in the best interests of wind turbine manufacturers to research and make available quieter turbines, as this indicates an increase in the available electricity generating capacity as well as the benefits of lower noise levels:

> *The sound produced by wind turbines has diminished as the technology has improved. As blade airfoils have become more efficient, more of the wind energy is converted into rotational energy, and less into acoustic energy. Vibration damping and improved mechanical design have also significantly reduced noise from mechanical sources.*
> *(Rogers et al, 2006)*

STANDARDS AND GUIDELINES

Australia presently assesses the noise from wind farms under a range of Standards and Guidelines applicable to each individual State or Territory, shown below in Table 1

Table 1 – Summary of Australian State Standards and Guidelines for Wind Farms

State or Territory	Assessment Procedure	Comments
South Australia	SA EPA Wind Farms Environmental Noise Guidelines July 2009	The 2009 Guidelines is an updated version of the original 2003 Guidelines. The release follows a review process initiated in 2006
New South Wales	SA EPA Wind Farms Environmental Noise Guidelines February 2003	New South Wales has not automatically endorsed the 2009 version of the Guidelines, and at this stage retains the 2003 version as the primary assessment procedure.
Western Australia	SA EPA Wind Farms Environmental Noise Guidelines February 2003	The document EPA Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise Draft May 2007 refers to the 2003 version as the primary assessment procedure. The WA Government has not endorsed the 2009 version of the Guidelines at this stage.
Queensland	No formal assessment procedure	The New Zealand Standard and the South Australian 2003 Guidelines have been referenced by the Queensland Government in the past.
Victoria	New Zealand Standard NZS 6808:1998 *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*	The document Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria refers to the 1998 version of the New Zealand Standard as the primary assessment procedure. The 2010 version of the Standard has not been endorsed in the Guidelines at this stage.
Tasmania	Department of Primary Industries, Water and Environment (Tasmania) *Noise Measurement Procedures Manual 2004*	The document does not provide objective criteria and therefore the use of one of the assessment procedures noted for the States above will be required in conjunction with the 2004 Manual.
ACT and Northern Territory	No formal assessment procedure	To be assessed on a case by case basis.

In addition to the above, Australian Standard AS4959 – 2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* has been released recently. The Standard does not provide any objective criteria, but rather it aims to provide a suitable framework to develop a method for the measurement, prediction and assessment of noise from wind farms.

Based on the above, a wind farm proposal could be subject to a range of assessment procedures depending on the jurisdiction. Whilst there are consistent elements in the different procedures, there are inherent and important discrepancies.

Objective Standards

In general terms, the noise from a wind farm increases with wind speed up until the rated power (electrical output capacity) of the particular turbine, when the noise then remains constant or even reduces at higher wind speeds. The increase in wind turbine noise as the wind speed increases normally plateaus, or even potentially diminishes, occurs in an environment where the background noise level continues to increase, the effect of which is to assist in masking the wind farm noise.

Therefore, wind farm standards and guidelines in Australia and New Zealand set a base noise limit that generally applies at lower wind speeds when the background noise is relatively low, and a background noise related limit that allows the wind farm to generate higher noise levels as the wind speed increases.

In circumstances where the background noise levels are sufficiently low, the base noise limit applies. This generally occurs at lower wind speeds and/or at dwellings that are not subject to a sufficiently high background noise environment, such as might occur at a dwelling deep in a valley with little to no surrounding vegetation.

In circumstances where the background noise levels increase sufficiently, the background noise related limit applies. This generally occurs at higher wind speeds and/or at dwellings that are subject to a high background noise environment, such as might occur at a dwelling on a ridge top surrounded by trees.

Where the wind farm is able to achieve the base line noise limit at higher wind speeds, the masking effect of the background noise environment does not need to be taken into account. This is because the base line noise limit is generally established to ensure there are no adverse noise impacts, even in a low background noise environment when the masking effects are limited.

The objective standards provided by the various assessment procedures is summarised in the table below:

Table 2 - Objective Standards

Assessment Procedure	**Objective Standard**	**Comments**
Government of South Australia Wind Farms Environmental Noise Guidelines February 2003	Base noise limit: 35 dB(A) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The limits are an equivalent (or effectively an average) noise level.
Government of South Australia Wind Farms Environmental Noise Guidelines July 2009	Base noise limit: 35 dB(A) (Rural living locality) Base noise limit: 40 dB(A) (in other localities including general farming and rural areas) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The base noise level limit has been increased to 40 dB(A) to ensure consistency with the assessment limits applied by the *South Australian Environment Protection (Noise) Policy 2007* to other noise sources in a general farming or rural locality.
New Zealand Standard NZS 6808:1998 *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*	Base noise limit: 40 dB(A) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	Whilst there is conflicting information in the Standard, the limits are taken to be an equivalent noise level.

Assessment Procedure	**Objective Standard**	**Comments**
New Zealand Standard NZS 6808:2010 *Acoustics – Wind Farm Noise*	Base noise limit: 35 dB(A) (High amenity area) Base noise limit: 40 dB(A) (Other areas) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The limits are expressed explicitly in the Standard to be a 90th percentile level (L_{A90}). The L_{A90} is inherently less than the equivalent noise level and therefore the limits are higher (less stringent) than those in the South Australian Guidelines. A high amenity area is related to a review of the planning system and the specific requirement in the relevant plan to maintain a high degree of protection to the "sound environment". If the area is deemed to be of high amenity, then the L_{A90} 35 dB(A) base noise level limit applies only during the night period, and for wind speeds less than 6 m/s or other defined threshold for that specific proposal.
Australian Standard AS4959 – 2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators*	Deferred to the relevant jurisdiction.	Notes that the jurisdiction should have a base noise level limit and a background noise level limit.
Environment Protection Heritage Council (EPHC) prepared Draft National Guidelines October 2009 and July 2010	Deferred to the relevant jurisdiction.	Notes that the jurisdiction should have a base noise level limit and a background noise level limit.

Comparison of the objective standards with International approaches

The objective standards provided by a range of International assessment procedures is summarised in the table below (Reference 1 unless noted otherwise):

Table 3 – Summary of International Standards

Assessment Procedure Country of Origin	**Objective Standard**	**Comments**
Sweden	Base noise limit: 40 dB(A) Low background areas: 35 dB(A)	The approach does not provide a definition for a low background area.
Denmark	Noise limit: 44 dB(A) @ 8m/s 42 dB(A) @ 6m/s For sensitive areas such as institutions, allotment gardens and recreation: Noise limit: 39 dB(A) @ 8m/s 37 dB(A) @ 6m/s	No background noise limit is applied. The noise limits are determined for wind speeds taken at 10m above the ground.
France	Background noise limit margin: 5 dB(A) – day time Background noise limit margin: 3 dB(A) – night time	Based on a background noise measurement made at a wind speed of 8m/s
The Netherlands	Noise limit: 40 dB(A) at night increasing incrementally up to 50 dB(A) at 12m/s	

Assessment Procedure Country of Origin	**Objective Standard**	**Comments**
United Kingdom	Base noise limit: 40 dB(A) (day time) Base noise limit: 43 dB(A) (night time) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The limits are a 90th percentile level (L_{A90}). The L_{A90} is inherently less than the equivalent noise level. The UK assessment procedure indicates the L_{Aeq} from a wind farm is typically of the order of 2 dB(A) greater than the L_{A90} The procedure notes that the recommended noise levels take into account “swish”.
USA (Illinois) (Reference TD178-01F06)	Base noise limit: 55 dB(A) (day time) Base noise limit: 51 dB(A) (night time)	The noise limits are determined for an 8 m/s wind speed taken at 10m above the ground. There are no uniform noise standards in the USA, with local counties establishing their own approaches which vary considerably.

In broad terms, the Standards and Guidelines used in Australian jurisdictions include the following common elements:

- Objective standards that provide a base noise limit and a background noise related limit, with the exception of the EPHC draft Guidelines and the Australian Standard;
- A background noise and wind speed measurement procedure to determine the applicable background noise related limits at each dwelling;
- A noise level prediction methodology to enable a comparison of the predicted noise level from the wind farm against the noise limits at each dwelling;
- The required adjustments to the predicted noise levels to account for any special audible characteristics of the wind farm noise;
- A compliance checking procedure to confirm the operational wind farm achieves the predicted noise levels at each dwelling.

In addition, Australian jurisdictions are amongst the most stringent and the most contemporary in the World.

Noise Levels

A common issue for people considering the environmental noise from wind farms is the ability to place the wind farm's noise levels and characteristics in context compared to the ambient environment.

A site visit to an operating wind farm at different times and at typical separation distances between a wind farm and a dwelling, starting from the order of 700m from the nearest turbine, greatly assists in providing this context.

To assist in providing context for typical noise levels from a wind farm, Chart 1 (below) provides the order of noise level in the vicinity of a modern wind turbine. It should be noted that the noise levels presented in the chart will vary according to a range of variables discussed in further detail in the noise propagation section of this Paper.

The base noise level requirement of 35 or 40 dB(A) provided in the main assessment tool in Australia, the South Australian EPA Wind Farm Guidelines, represents a low (stringent) noise level in an environmental noise context. It is significantly more stringent than the World Health Organisation's recommended guideline value of 45 dB(A) for sleep disturbance effects and than the recommended noise levels for road or rail infrastructure development that might occur in a rural environment, where levels of the order of 55 and 60 dB(A) respectively are typically recommended.

The base noise level requirements also need to be considered in the context of the ambient environment. Wind farms are generally located in a rural environment, where the associated planning system often envisages and promotes activity associated with primary industry.

A wind farm is also inherently located in areas where wind is present and therefore background noise levels from wind in the trees and around structures such as houses and sheds can be elevated. The effect of elevated background noise levels is to provide masking of other noise sources in the environment.

Regardless of the stringency of the base noise level or the available masking effect of the ambient environment, wind farm standards and guidelines are not established to ensure inaudibility. The ability to hear a wind farm designed and operated in accordance with the standards and guidelines in Australia will vary according to a range of variables such as the influence of the ambient environment, the local topography, the distances involved and the weather conditions at the time.

All noise, from any noise source including wind farms, which is audible, will result in complaints from some people. In addition, recent research indicates the potential for complaints, annoyance and its associated stress and health impacts may be exacerbated by rhetoric, fears and negative publicity (Colby et al, 2009). There is a significant amount of mis-information and negative publicity about the impacts of wind farms available in the broader community.

Only a few field studies on noise annoyance among people living close to wind turbines have been conducted and further investigations have been recommended by these studies. The European studies (Pedersen, 2005) indicate correlation between the noise level and annoyance, but stronger correlation with factors such as overall sensitivity to noise, attitude towards the noise source, attitude towards the area as a pristine place or a place for economic development, influence over the proposal, daily hassles, visual intrusion and the age of the turbine site.

Tickle (2006) compared the incidence of complaints in Australia and New Zealand, about noise from wind farms and complaints about noise in general and found that once wind farms are built the rates of complaints are very low in Australia and New Zealand.

Notwithstanding the above reasons or information, if a noise source can be heard, then annoyance can result for some people, regardless of the noise level or the standard or guideline that applies.

Figure 3 below provides some relative noise level information and compares wind turbines against common community noise levels:

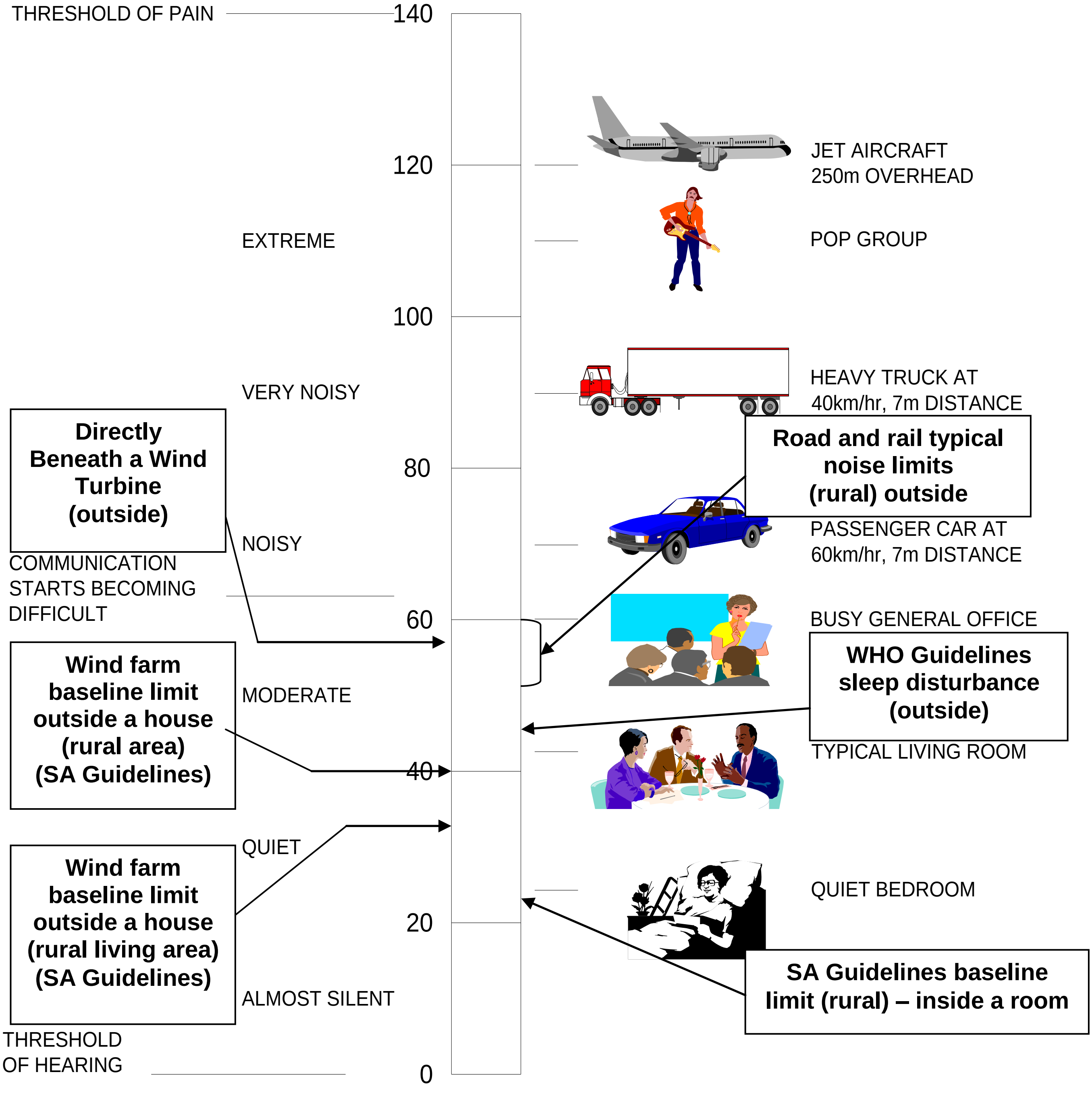


Figure 3 – Subjective Comparison of Noise Levels

ASSESSMENT METHODOLOGY

Whilst each Australian jurisdiction is subject to its own Standards and Guidelines and associated detailed requirements, the broad methodology for an environmental noise assessment of a wind farm proposal is similar amongst jurisdictions.

This section of the Technical Paper provides the background to the assessment process to assist in interpretation and understanding of the technical information that will generally be provided as part of a wind farm proposal and assessment.

Environmental Noise Assessment

Noise is often the most important factor in determining the separation distance between wind turbines and sensitive receivers. The assessment of noise therefore plays a significant role in determining the viability of and the size of wind farms.

The developer of a wind farm makes an assessment of the environmental noise from the proposed layout and to determine any necessary modifications to ensure compliance with the relevant Standard and Guidelines. The modifications during the planning and design phase of the project might comprise the removal or relocation of some turbines or the operation of certain turbines at reduced speeds or “modes” that correspond to lower noise levels. The assessment is generally made by an independent acoustic engineer specialising in the prediction and assessment of noise and vibration impacts across a broad range of sectors, including wind farms.

Methodology

The broad methodology associated with an environmental noise assessment of a wind farm proposal is as follows:

1. Review the proposed layout to identify dwellings where the relevant criteria might be exceeded;

   The purpose of the identification is to determine the locations at which background noise monitoring will be conducted.

   The background noise monitoring is a measurement method used to establish the existing ambient noise environment at a dwelling. The technical definition of the background noise is the noise level that is exceeded for 90% or 95% of the measurement period. In subjective terms, it represents the "lulls" that occur in the environment, in between intermittent events such as the overhead passage of an aircraft, a dog barking, wind gusts in trees, or the occasional passing of a vehicle on a nearby road. This is because the background noise excludes all noise level data that is not present for at least 90% (or 95% depending on the Standard or Guideline used) of the time. A common term used in the assessment is the "ambient" noise. The ambient noise is generally taken to include all the intermittent events, whilst the background noise effectively removes these events and represents the noise environment in their absence.

   The background noise at a dwelling is important because it can mask the noise of a wind farm, and the level of that masking can be an important factor in the assessment. The most general source of background noise level masking, particularly at higher wind speeds, is wind in nearby trees.

   The land owners who have a turbine on their land are also identified during this process, as the assessment criteria applied to them are relaxed by most Standards and Guidelines in comparison to dwellings without an association with the proposed wind farm.

Land holdings where a development approval exists to construct a dwelling are also generally identified as most Standards and Guidelines define these as locations where the relevant criteria need to be met.

Once those dwellings and land holdings are identified, the locations that best represent the range of dwellings in the locality are selected. These are generally defined as dwellings that are closest to the wind farm. The Standards and Guidelines generally allow a single dwelling to represent a range of dwellings that are either in the near vicinity or expected to be subject to a similar background noise environment.

A term that is commonly used in the Standards and Guidelines is "relevant receiver location". These locations are generally:

- Where someone resides or has development approval to build a dwelling; and
- Where the predicted noise level exceeds the base noise level for wind speeds up to the rated power of the wind turbine; and
- Representative of the worst case location when considering the range of dwellings, such as a dwelling that is located amongst a similar group in the near vicinity and is the closest to the wind farm.

2. <u>Conduct a background noise monitoring regime at the relevant receiver locations;</u>

The measurement of background noise levels is a critical aspect of the environmental noise assessment as it is the method by which criteria are determined.

The exception to the need to conduct a background noise monitoring regime is in circumstances where the wind farm is able to achieve the base noise level limit (or a prescribed noise level that is less than the base noise level) at wind speeds where the noise output of the particular turbine is at its maximum. This is because the base noise level limit is generally established to ensure there are no adverse impacts even in a low background noise environment where the masking effect is limited or negligible.

Notwithstanding compliance with the base noise level limit, a background noise monitoring regime may still be conducted as it the means by which compliance checking procedures are generally based upon. The compliance checking procedure is discussed in further detail in a dedicated section below.

Where conducted, the background noise monitoring can be over a range of the order of 10 days to 4 weeks, depending on the particular requirements of the relevant Standard or Guideline. The period of monitoring can also be extended where excessive wind or rain adversely affect the data. The apparatus used to continually measure and record the background noise levels over this period is known as a “logger”.

The location of the logger is typically at least 5m from the building facade to remove the effects of large reflecting surfaces. The location is also required to be representative of background noise levels and this is generally achieved by placing the logger at an equivalent distance to tall trees as the facade of the house. The logger is also generally placed on the windfarm side of the dwelling to enable any future compliance checking measurements at dwellings to be taken at the same point.

Photographs and a GPS grid reference are typically used to identify each noise logging location. A typical installation is shown in Figure 4 below. The noise logger, comprising a sound level meter and batteries within a weatherproof container connected to a pole mounted microphone, is located in the centre of the photograph.

Figure 4 – Typical Noise Monitoring Installation

Some Standards and Guidelines explicitly require the removal of adverse data and data outside of the wind speed operating range of the turbines and it is considered good practice to do so. The 2003 and 2009 SA Guidelines require data points where rain has occurred and when wind on the microphone has had an impact on the measured noise levels to be removed. A way of measuring the occurrence of these factors is to place a weather logger adjacent to one of the background noise loggers to record rainfall, wind speed and wind direction. If in close proximity, a local Bureau of Meteorology weather station can also be used to identify adverse weather periods.

An acoustic engineer would take of the order of one hour to set up the noise logging equipment at each location. Access is normally organised directly with the land holder or dwelling occupier in accordance with established project protocols. Clearly, a land holder or occupier does not need to grant access to their property, however, an advantage of doing so is the ability to confirm compliance, or otherwise, of the operational wind farm against the relevant Standards or Guidelines at a point in the future.

3. Analyse the background noise monitoring data to determine the noise level criteria;

Following the removal of data adversely affected by local weather conditions, the remaining data points are correlated against the wind speed collected at the same time and for the same period as the background noise levels. The background noise level is determined for every ten minute period throughout the 2 to 4 week monitoring regime.

The wind speed is measured by the developer or another independent expert at a representative location within the wind farm by erecting a wind mast with anemometers, sometimes at a number of different heights. There may be more than one wind mast depending on the size of a wind farm.

Earlier Standards and Guidelines required the wind speed to be measured at 10m above the ground, however, recent requirements relate to measurements at or near the proposed hub height of the wind turbine, which may be of the order of 80m above the ground. The reason for the 10m measurement height was to provide correlation with the way the sound power level of a wind turbine is measured in accordance with IEC 61400 – 11 (IEC, 2002)[1], whereas the increase to at or near hub height has been introduced to better represent actual operating scenarios.

The purpose of the correlation of the two sets of data, being the wind speed measured at the wind farm site (data set one) and the background noise levels measured at a relevant receiver (data set two), is to establish the relationship between the operating wind farm and the average background noise level at dwellings in the vicinity, and in turn, to determine the applicable criteria at those dwellings. That is, the correlated data will determine whether the wind farm will be operational during periods when the background noise levels are on average low, providing limited masking, or when the background noise levels are on average high, providing a greater level of masking.

A best fit regression analysis is conducted on the two sets of data. An example plot produced from background noise measurements is given in Figure 5 below.

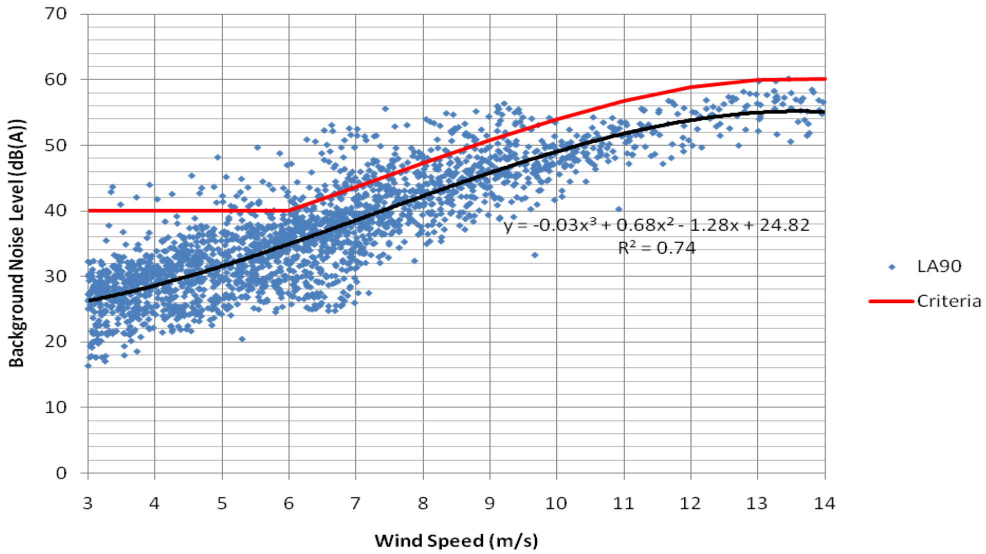


Figure 5 – Example Regression Analysis Plot

[1] An expected revision of the IEC standard will include reference to a hub height measurement position

Whilst most regression analyses will show the trend of the background noise level increasing with an increasing wind speed at the wind farm, the analyses will vary for each individual dwelling. Figure 5 shows a strong relationship between the background noise level and the wind speed at the wind farm, but this will not be the case in all circumstances. Some dwellings may be located such that they are shielded from the effects of the wind at the wind farm site.

The red line in the figure shows how the correlated data is used to determine the applicable noise level criteria at a dwelling. In this example, the base noise level limit is 40 dB(A), and this is not increased until the average background noise level increases sufficiently to provide a suitable level of masking. In this example, the background noise level becomes suitably high at wind speeds at the wind farm site that are at and above 6 m/s.

An important feature of the regression analysis is that it represents a line of best fit or effectively an "averaging" of the data. Therefore, there will be times when the environment provides more masking than indicated by the line of best fit, and other times when the environment provides less masking.

4. Predict the noise level from the proposed wind farm;

The prediction of noise from a wind farm can be made at any location from a range of available models, and the various Standards and Guidelines provide flexibility with respect to the selection of that model and the assumptions that are made.

In broad terms, the most basic noise models determine the noise level at a location based on the acoustic energy of the noise source, in this case the wind turbine, and the attenuation of noise over distance. These types of noise models do not account for other attenuation factors such as ground absorption, meteorological effects and screening due to ground contours and as such are considered to be inherently conservative (predicting higher noise levels than expected in situ). Basic models are often used by developers to establish a preliminary layout of a wind farm. The more complex and refined models include attenuation due to the factors noted above.

Wind Turbine Sound Power Levels for input to the noise model

The acoustic energy of the noise source is commonly termed the "sound power level", and for wind turbines it is determined in accordance with the International Standard IEC 61400-11 "Wind turbine generator systems – Part 11: Acoustic noise measurement techniques". The sound power level is generally provided for each integer wind speed ranging from the speed that the turbine "cuts in" for operation through to the speed at which it approaches its rated power. The sound power level increases with wind speed and then remains constant or even reduces in higher wind speeds. The sound power level is a constant that does not alter with location for a given wind speed.

The final selection of the wind turbine to be used at a site is typically subject to a competitive tendering process. The tendering process generally occurs in the design and development phase of the project after project approval is granted. This is consistent with a range of other industries and sectors, where plant and equipment contracts are not finalised until after project approval is granted, when all conditions of that approval are known and commitments to outlay significant capital cost can be made.

In addition, lead times between the project approval and procurement stage of a major project can be over a period of years, in which time there may be changes in the turbine models, their available technology and their noise levels. Therefore, it is common practice that noise assessments conducted for the purposes of project approval are made based on representative turbines, rather than a final selection.

The selection of the representative turbines is often made by the proponent or by the proponent in conjunction with an acoustic engineer, to ensure the turbines used are representative of the final turbine selection.

It is in the best interest of a proponent in any major wind farm project to select representative turbines for noise assessment purposes during the project approval stage, as any approval granted is likely to result in conditions and site constraints based on that selection and subsequent assessment. These constraints need to provide sufficient flexibility to invite a range of suppliers to tender for the project as part of a competitive process during the design development and documentation stage of a project.

It is a common arrangement for the wind turbine manufacturer to guarantee a sound power level of a particular make and model of a turbine to a wind farm developer. This guarantee is then confirmed in situ repeating the methodology provided by the International Standard (IEC, 2002).

Attenuation factors for input to the noise model

The attenuation factors are generally chosen to represent the “worst case” situation, such as assuming that the wind is blowing from the turbine to the dwellings or “downwind”, however, there is flexibility in the Standards and Guidelines with respect to the factors used for inputs to the models, provided the rationale for these inputs is included in the assessment. Ultimately, the selection of the model and its input factors must be conservative enough to ensure compliance of the operational wind farm. A requirement to conduct a “compliance checking” procedure is included in the Standards and Guidelines used in Australia.

A typical approach to the modeling process is to conduct initial predictions with a simple model that provides a preliminary estimate of the noise. This assists in confirming the proposed background noise logger locations and the preliminary wind farm layouts. These initial predictions are then refined after the background noise monitoring has been completed with a more complex model. In Australia, this is typically either the CONCAWE or ISO-9613 noise propagation model using conservative assumptions.

Joule (*Reference*) has conducted a study of the accuracy of the ISO-9613 model as it relates to wind farms and found that:

> *The accuracy of output from the ISO model is impressive. Agreement with sound pressure levels measured under conditions of an 8 m/s positive vector wind speed has been measured to within 1.5dB(A) on flat, rolling and complex terrain sites.*

As with any model, the accuracy is subject to its inputs which are summarised in the Joule Paper (Bass et al, 1998*)* and in other summary works (Bowdler et al, 2009). These include the temperature and humidity to be used, how hard or soft the ground should be taken to be, the relative height of the receiver and the amount of "barrier" attenuation that should be applied to the ground contours.

Provided these inputs are applied to the ISO 9613 model, the Joule study found that the calculated sound pressure levels are validated to agree to within 2dB(A) of noise levels measured under practical 'worst case' conditions at distances of up to 1000m from a noise source, and that due to the

> *observed scatter of measured sound pressure levels under these same conditions*, ….. *an 85% level of confidence can be placed on the noise levels measured in practice not exceeding the calculated level by more than 1dB(A).*

A 1 dB(A) difference is negligible in terms of perception.

The ISO 9613 model assumes that a receiver is downwind from all wind turbines. In some circumstances such as where the turbines are on opposite sides of a dwelling but at similar distances this will provide a conservative outcome (a predicted noise level higher than that expected in situ). The Standards and Guidelines used in Australia therefore provide the flexibility to use other models that account for an upwind scenario.

5. Compare the predicted noise levels with the criteria;

A comparison is made between the predicted noise levels and the noise level criteria established by the background noise monitoring regime. This comparison is made for each integer wind speed, generally within the operating range of the wind turbine.

Where the predicted noise levels achieve the criteria, then the process and results are summarised in a report suitable for submission to the relevant authority. The extent of information provided in the reports is summarised in Step 6 below.

Where the predicted noise levels do not achieve the criteria, then mitigation options are considered. The options considered will depend on the number of locations the criteria are exceeded at, the difference between the predicted noise level and the criteria, and the number of integer wind speeds at which the predicted noise level exceeds the criteria. The mitigation options include:

- The operation of wind turbines under reduced noise level modes for particular conditions;
- The consideration of alternative turbines with lower sound power levels;
- The adjustment of the wind turbine layout;
- The consideration of removing turbines from the layout.

An example is provided for a dwelling in a low background noise environment:

- *Due to the background noise levels being low on average at the closest dwelling to the proposed wind farm over the required monitoring period, the baseline noise limit applies at all operating wind speeds. In this example, the dwelling is located in a general farming area and the baseline limit is 40 dB(A);*
- *The highest sound power level from the representative turbine selection occurs at a hub height wind speed of 10m/s;*
- *The predicted noise level at wind speeds of 10m/s or greater is 43 dB(A) at the closest dwelling and therefore exceeds the noise level criterion of 40 dB(A);*
- *The options available to reduce the predicted noise level by 3 dB(A) include:*
  1. *Adjusting the layout of the closest turbines to the dwelling;*
  2. *Operating the closest 4 turbines to the dwelling in a low noise mode at wind speeds of 10m/s or greater. This is only required to occur under downwind conditions (wind from the turbines to the dwelling), as the model shows that under upwind conditions (wind from the dwelling to the turbines) the wind farm complies with the baseline limit, even at full mode operation;*
  3. *Selecting an alternative wind turbine with a lower sound power level.*
  4. *Removing the closest turbine to the dwelling.*
- *Of the above, Option 2 is selected, due to the flexibility it provides in the future competitive tendering process for the final wind turbine selection, and the ability of contemporary turbine control systems to implement an operating strategy where certain turbines can be operated in certain "modes" under specific operating conditions like wind speed and/or wind direction.*

Once the predicted noise levels achieve the environmental noise criteria at each relevant receiver and for each operational wind speed, a summary report is prepared that is suitable for submission to the relevant regulatory authority.

6. <u>Prepare a report suitable for submission to the relevant regulatory authority;</u>

A report is prepared by the developer that summarises the above five steps. In general terms, the report would typically provide the following information, subject to the particular requirements of the regulatory authority assessing the development proposal:

- Background noise measurement locations;
- Time and duration of the background noise monitoring regime;
- Wind speed monitoring locations and heights above ground;
- Graphical correlation plot of the wind speed versus background noise level data;
- A summary of the environmental noise criteria for the project at each integer wind speed based on the correlation;
- The make and model of the representative wind turbine/s;
- The positions of the wind turbines;
- The model used to predict the wind farm noise levels;
- The input assumptions and factors used in the model;
- The predicted noise levels at the closest dwellings to the wind farm at each integer wind speed;
- A comparison of the predicted noise levels against the criterion at each integer wind speed for the closest dwellings to the wind farm;
- The modifications or operating strategy required to ensure compliance with all noise criteria for all wind speeds and at all locations;
- A comparison of the predicted noise levels against the criteria at each integer wind speed for the closest dwellings to the wind farm, showing compliance with the proposed modification or operating strategy in place.

The above six steps provide an overview of the typical assessment methodology. The following information provides frequently asked questions during the preparation and finalisation of such an assessment.

Separation Distances

A common request from the surrounding community is to provide a set separation distance between the wind farm and the nearest dwelling.

Where an objective assessment method is used as outlined above, there is no set distance that could be applied with equity to every wind farm. This is because of the range of factors that affect the predicted and the resultant operational wind farm noise level. These factors include the number of turbines, their locations relative to the dwelling, the sound power level of the turbine, the topography between the turbines and the dwelling, the existing background noise environment at the dwelling and the resultant criteria applied by the relevant Standards and Guidelines.

Separation distances between wind farms and dwellings can be of the order of 800 to 1200m. These separation distances will change according the above factors. The separation distances are related to the stringency of the assessment criteria within the relevant Standards and Guidelines.

Assessment Process

An environmental noise assessment for a wind farm needs to contain significant detail to show compliance with Australian jurisdiction's Standards and Guidelines.

As with all assessments, there might be areas that are contended to be at variance with the requirements of those Standards and Guidelines.

Each State Jurisdiction will have its own specific rules with respect to the ability to appeal in situations where the parties do not agree that the assessment provides the necessary information or where a decision of the relevant regulatory authority is in dispute.

A number of wind farms have been considered in the environmental courts in their relevant jurisdictions, including:

- Taralga Landscape Guardians Inc vs Minister for Planning and RES Southern Cross Pty Ltd, NSW Land and Environment Court Proceedings No. 10196 of 2006;
- RES Southern Cross Pty Ltd v Minister for Planning (DOP) and Taralga Landscape Guardians Incorporated (TLG) NSW Land and Environment Court Proceedings No. 11216 of 2007;
- Epuron Pty Ltd & Gullen Range Wind Farm Pty Ltd & Ors vs Parkesbourne / Mummel Landscape Guardians Incorporated (PMLG), NSW Land & Environment Court Proceedings No. 41288 of 2008.

Judgments made in matters such as these provide important clarification in interpretation of the Standards and Guidelines or their general application and scope. Relevant outcomes from the above judgments include:

- An additional 5 dB(A) penalty for excessive amplitude modulation is not necessary when using the SA 2003 Guidelines. However, the application of acoustic treatment to the facades of dwellings in the vicinity might be a precautionary approach for the established presence of such excessive modulation;

- The heightened sensitivity of an individual to noise should not be taken into account in the assessment of a wind farm, but rather the objective and empirical methods of the relevant Standards and Guidelines adopted by consent authorities and regulators should be relied upon.

The judgment relating to the heightened sensitivity of an individual is important and can be found at Paragraph 154 of the Gullen Range judgment as follows:

> *Inserting subjectivity consent requirements based on an individual's or a group of individuals' reaction to the noise from the wind farm, based on their opposition to the development, is entirely alien to the planning system. Whilst, in some areas such as streetscape impact, individual aesthetic considerations may arise and judgments made upon them, we are unaware of any authority to support the proposition that, where there is a rationally scientifically measurable empirical standard against which any impact can be measured and determined to be acceptable at a particular empirically determined level, that there should be some allowance made for a subjective response to the particular impact.*

Compliance Checking

The assessment process occurs well before a wind farm is operational. Therefore, to confirm compliance with the assessment criteria, a measurement procedure is conducted once the wind farm is operational.

The Standards and Guidelines in Australian jurisdictions all provide a methodology for noise level measurements of an operational wind farm.

The term commonly applied to these measurements is “compliance checking”.

It is common for a planning or relevant regulatory authority to impose a condition of approval for a wind farm development that requires “compliance checking” and reporting thereon within a certain timeframe of commissioning the wind farm.

In general terms, compliance checking can effectively be a repeat of the background noise monitoring regime. The variations that are applied to the compliance checking procedure might include collecting a minimum number of noise level data points under downwind conditions. A comparison is then made of the noise environment before the wind farm and after the establishment and operation of the wind farm.

As wind farm assessments account for the masking effect of the ambient environment, there will be inherent difficulties in identifying the wind farm noise amongst other noise, in particular and most commonly, the background noise generated by wind in the trees. Therefore, compliance checking procedures generally provide a level of flexibility in the methodology, which might include turning the turbines on and off to determine their influence amongst other noise in the environment, or measuring at a location much closer to the wind farm, where the noise from the wind farm is more dominant in comparison to other noise in the environment.

TOPICS OF INTEREST

A range of topics of interest exist for wind farms that are raised by the community, by acoustic engineers, by health professionals, by the industry and by regulatory authorities.

The key topics to be addressed are those that relate to the health of the surrounding community.

There has been extensive research conducted into the relationship between noise levels and characteristics of wind farms and the potential for adverse health impacts, and the research overwhelmingly concludes that wind farm noise does not adversely impact on a person's health.

Health Effects

In 2009 the American and Canadian Wind Energy Associations established a scientific advisory panel comprising medical doctors, audiologists and acoustic professionals from the United States, Canada, Denmark and the United Kingdom to produce "an authoritative reference document for legislators, regulators, and anyone who wants to make sense of the conflicting information about wind turbine sound". (Colby et al, 2009)

The Panel concluded:

> *there is no reason to believe, based on the levels and frequencies of the sounds and the panel's experiences with sound exposures in occupational settings, that the sound from wind turbines could plausibly have direct adverse health consequences.*

The Victorian Department of Health (DH) (WorkSafe, 2010) has examined both the peer-reviewed and validated scientific research and concluded that

> *the weight of evidence indicated that there are no direct health effects from noise (audible and inaudible) at the levels generated by modern wind turbines.*

The Australian Government's National Health and Medical Research Council (NHMRC, 2010) has examined the "evidence from current literature on the issue of wind turbines and potential impacts on human health" and concludes:

> *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).*

Notwithstanding the above, Dr Nina Pierpont (Pierpont, 2009) contends that adverse health outcomes are caused by wind farm noise and in particular, its low frequency content. Pierpont uses the term "wind farm syndrome" to describe the effects, which include headaches, sleeplessness and anxiety. The Pierpont report is not peer reviewed and the hypothesis is based on the assumption that infrasound levels near wind farms are higher than infrasound levels in the general environment.

The American and Canadian Wind Energy Association's panel reviewed the Pierpont report and the "wind farm syndrome" and concluded:

> *"Wind turbine syndrome," not a recognised medical diagnosis, is essentially reflective of symptoms associated with noise annoyance and is an unnecessary and confusing addition to the vocabulary on noise. This syndrome is not a recognised diagnosis in the medical community. There are no unique symptoms or combinations of symptoms that would lead to a specific pattern of this hypothesized disorder. The collective symptoms in some people are more likely associated with annoyance to low sound levels (Colby et al, 2009).*

To this end, the panel's report provides information on "the complex factors culminating in annoyance", which includes the nocebo effect (Spiegel, 1997).

The nocebo effect is "an adverse outcome, a worsening of mental or physical health, based on fear or belief in adverse effects. This is the opposite of the well known placebo effect, where belief in positive effects on an intervention may produce positive results" (Colby et al, 2009).

With respect to the nocebo effect, the panel concludes:

> *..the large volume of media coverage devoted to alleged adverse health effects of wind turbines understandably creates an anticipatory fear in some that they will experience adverse effects from wind turbines. ….The resulting stress, fear, and hyper vigilance may exacerbate or even create problems which would not otherwise exist. In this way, anti-wind farm activists may be creating with their publicity some of the problems they describe (Colby et al, 2009).*

There is a large amount of publicly available material that deals with alleged adverse health effects of wind turbines regardless of the overwhelming research to the contrary. A recent and relevant example includes an article as part of a series in the Sydney Morning Herald (SMH, 2010) on wind farms which included a quote that linked Hitler's torture methods to noise from a wind farm without any further information regarding the conclusions of recent health related research in the article.

The NHMRC review provides consistent conclusions to the panel with respect to health:

> *It has been suggested that if people are worried about their health they may become anxious, causing stress related illnesses. These are genuine health effects arising from their worry, which arises from the wind turbine, even though the turbine may not objectively be a risk to health (Chapman, 2009)*

Based on the above, it is essential that all stakeholders have access to a source of consolidated information that summarises the topics of interest that are commonly raised and the research that is available on these topics. A broad summary of health effects has been provided above, and the specific topics of interest commonly linked to adverse health effects are addressed in detail below, which include infrasound and low frequency content of a wind farm, amplitude modulation and sleep disturbance effects.

Infrasound and low frequency noise

The hypotheses regarding a link between infrasound from wind farms and the presence of adverse health effects including dizziness, headaches and nausea made by Pierpont (Pierpont, 2009) are not based on measured levels of infrasound from operational wind farms.

Specific International studies that have measured the levels of infrasound in the vicinity of operational wind farms indicate the following:

- The levels of infrasound are significantly below recognised perception thresholds and are therefore not detectable to humans (Hayes McKenzie Partnership Ltd, 2006); and
- The levels of infrasound are of the same order as those measured in residential areas due to general urban activity (Howe, 2006).

Similar studies are currently being conducted in Australia in order to provide an objective assessment and confirmation of the European research.

Notwithstanding the results of the objective assessments, Colby et al, 2009, have critiqued the Pierpont hypotheses and conclude:

> *No foundation has been demonstrated for the new hypothesis that exposure to sub-threshold, low levels of infrasound will lead to vibroacoustic disease. Indeed, human evolution has occurred in the presence of natural infrasound.*

Infrasound is a specific component of low frequency noise that requires a specific measurement methodology to identify it as it is readily affected by wind on the microphone. Wind is a source of natural infrasound.

Whilst the hypotheses regarding adverse health effects often refer to “low frequency noise”, this is often a generic description which is taken to include infrasound.

The low frequency content of noise from a wind farm is easily measured and can also be heard and compared against other noise sources in the environment. Low frequency sound produced by wind farms is not unique in overall level or content and it can be easily measured and heard at a range of locations well in excess of that in the vicinity of a wind farm.

Colby et al (2009) notes with respect to low frequency noise:

> *The low frequency sound emitted by spinning wind turbines could possibly be annoying to some when winds are unusually turbulent, but there is no evidence that this level of sound could be harmful to health. If so, city dwelling would be impossible due to the similar levels of ambient sound levels normally present in urban environments.*

Amplitude Modulation

Amplitude modulation is an inherent noise character associated with wind farms. It should be noted that the ambient environment modulates in noise level by a significantly greater margin and over a significantly greater time period than that which would be audible from a wind farm at a typical separation distance. Notwithstanding, the South Australian Guidelines (2003 & 2009) note that the objective standards include a 5 dB(A) penalty for this fundamental and inherent character of amplitude modulation.

A 5 dB(A) penalty is a significant acoustic impost. To reduce a noise source by 5 dB(A) requires either the distance between the source and the receiver to be approximately doubled, or the noise source to reduce its output by two thirds. In wind farm terms, this means the distance between the farm and the nearest dwellings might need to be doubled, or up to two thirds of the total turbine numbers would need to be removed, compared to a wind farm not subject to such a penalty.

The ability to hear the “swish” (amplitude modulation) depends on a range of factors. It will be most prevalent when there is a stable environment (temperature inversion) at the wind farm and the background noise level at the listening location is low. In addition, amplitude modulation is greater when located cross wind from a wind turbine (Olermans and Schepers, 2009). It is noted that whilst the amplitude modulation is greater at a cross wind location, the actual noise level from the wind farm will be lower than at a corresponding downwind location. These conditions are most likely to occur when wind speeds at the wind farm are low under a clear night sky.

The swish is at its greatest under the above conditions as the change in wind speed at increased heights above the ground is also at its greatest, and this results in an increased difference in wind speed as the blades move through the top of their arc and down past the tower. In addition, if there are several turbines subject to similar conditions, then it is possible this can have an amplifying effect on the modulation. The increase in swish under these specific conditions is termed the Van Den Berg Effect, and it is suggested higher levels of swish might result in higher levels of annoyance and potentially sleep disturbance.

The Van Den Berg effect was observed on a flat site in Europe under specific conditions and in the two matters before the NSW Land and Environment Court (Gullen Range wind farm NSW LEC 41288 of 2008 and Taralga wind farm NSW LEC 11216 of 2007), it has been determined by the relevant experts that the required meteorological conditions to trigger the effect were not a feature of the environment. In Gullen Range (NSW LEC 41288 of 2008), the meteorological analysis prepared by Dr Chris Purton concluded that suitable conditions for this effect are not a feature of the area because of the elevated ridgeline location of the wind farm (Purton, evidence NSW LEC 41288 of 2008).

If suitable conditions did exist to regularly generate high levels of swish, then there is no scientific research to indicate that the existing Standards and Guidelines do not adequately account for it. Indeed, given the conditions are more likely to occur at night, then sleep disturbance would be the main issue to address, and the noise standards applied to wind farms are significantly more stringent than limits established for the potential onset of sleep disturbance. This is discussed in further detail in the following section.

In the first draft of the National Wind Farm Development Guidelines (EPHC, 2009), excessive swish is referred to as one of the potential Special Audible Characteristics (or SACs) along with low frequency, infrasound and tonality. It recommends that:

> *With the exception of tonality, the assessment of SACs will not be carried out during the noise impact assessment phase, that is, pre-construction. This arrangement reflects two key issues:*
>
> *i. There are, at present, very few published and scientifically-validated cases of any SACs of wind farm noise emission being problematic at receivers. The extent of reliable published material does not, at this stage, warrant inclusion of SACs other than tonality into the noise impact assessment planning stage.*
>
> *ii. In the case that reliable evidence did demonstrate merit in assessing such factors during the pre-construction phase, there is a gap in currently available techniques for assessing SACs as part of the noise impact assessment. In part this is due to the causes of most SACs in wind turbine noise emission not yet being clearly understood.*

In summary:

- Swish is an inherent noise characteristic of a wind farm;
- Modulation in noise level is a feature of the ambient noise environment surrounding a wind farm;
- The level and depth of swish can vary with meteorological conditions, and under certain conditions, will be more prevalent;
- The conditions to consistently generate high levels of audible swish have not been established to be a typical feature of Australian wind farms;
- The level, depth, time and testing regime for excessive swish that would justify introducing a more stringent standard have not been established;
- Sleep disturbance is the key issue associated with excessive swish, if it is to occur.

Sleep Disturbance

The World Health Organisation (WHO) establish a recommendation of 30 dB(A) inside a bedroom to prevent the potential onset of sleep disturbance effects (WHO, 1995).

The WHO guidelines indicate a noise level of 30 dB(A) inside a typical bedroom correlates to an external noise level with the windows open of the order of 45 dB(A). The typical baseline limit criterion of 35 dB(A) to 40 dB(A) found in Australian wind farm Standards and Guidelines is therefore significantly more stringent than the WHO guidelines recommendation of 45 dB(A), by a margin of at least 5 dB(A) and up to 10 dB(A).

For comparison purposes, a wind farm that complies with a 40 dB(A) baseline limit could introduce twice as many turbines again onto the site, or move of the order of half as close to the nearest dwelling, and still achieve the WHO recommendations to prevent the potential onset of sleep disturbance.

It should also be noted that the WHO recommendations are considered conservative in that they consider all available research and then use the most stringent approach to indicate the "potential onset" of sleep disturbance effects, which is not defined as full awakening, but rather as a change in the stage of sleep.

The UK Department of Trade and Industry (ETSU, 1997) recognise the above effect and recommend increasing the allowable noise level for wind farms during the night period, based on sleep disturbance effects. The baseline limit for wind farms during the night time in the UK is therefore 45 dB(A).

Based on the above, the baseline limits of Standards and Guidelines in Australia are sufficiently stringent to ensure the potential onset of sleep disturbance effects from the operation of a compliant wind farm does not occur.

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INFRASOUND MEASUREMENTS FROM WIND FARMS AND OTHER SOURCES

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CONTENTS

EXECUTIVE SUMMARY

Infrasound is generated by a range of natural sources, including waves on a beach and against the coastline, waterfalls and wind. It is also generated by a wide range of man-made sources such as industrial processes, vehicles, air conditioning and ventilation systems and wind farms.

Specific International studies, which have measured the levels of infrasound in the vicinity of operational wind farms, indicate the levels are significantly below recognised perception thresholds and are therefore not detectable to humans.

The measurement of infrasound at low levels requires a specific methodology, as it is readily affected by wind on the microphone. Such a methodology has been developed for this study to measure infrasound from two Australian wind farms for the purposes of comparison against recognised perception thresholds. This study also measures the levels of infrasound from a range of natural and man made sources using the same methodology for the purposes of comparison against the wind farm results.

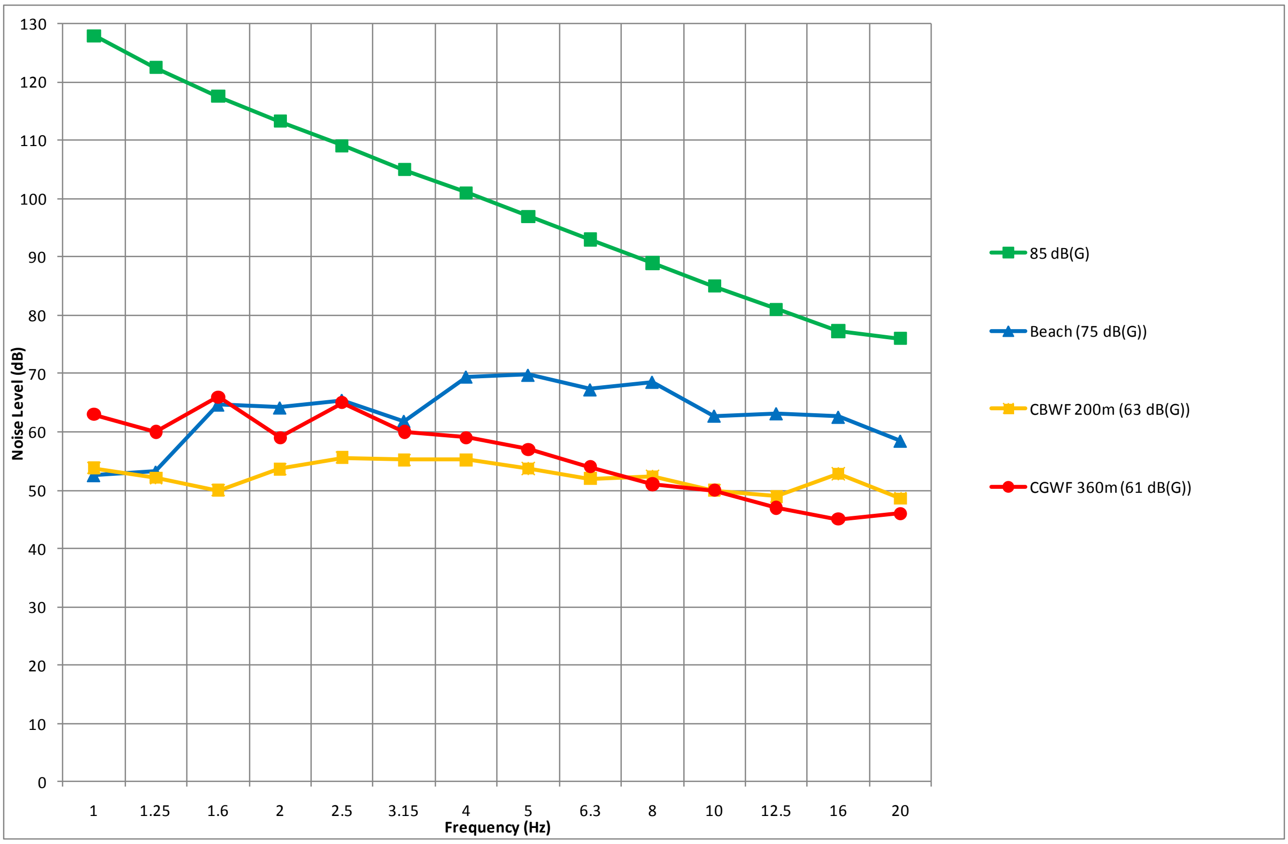
The specific methodology is based on measurements being conducted below the ground surface in a test chamber that is approximately 500mm square and 500mm deep to reduce the influence that even light surface breezes can have on the infrasound results.

The below ground methodology has been tested as part of this study and it has been confirmed that levels of infrasound above the ground and within the chamber are the same in the absence of surface winds when measuring a known and constant source of infrasound.

The methodology has also been tested on site, and it has been confirmed that the expected theoretical reduction in infrasound of 6 dB per doubling of distance can be measured from a wind turbine. This reduction cannot be measured above the ground surface due to wind on the microphone influencing the results. This result confirms that the below ground methodology is able to reduce the influence of wind on the microphone to identify the level of infrasound from a noise source.

Infrasound was measured at two Australian wind farms, Clements Gap in the mid-North of South Australia (CGWF) and Cape Bridgewater in the coastal region of south-western Victoria (CBWF), using the below ground methodology. Infrasound was also measured in the vicinity of a beach, the coastline, a central business area and a power station using the below ground methodology.

A summary graph of the results of the infrasound measurement results at the wind farms and at a beach are shown below against the perception threshold for infrasound established in international research as 85 dB(G).



Summary Graph – Infrasound measurement results from two Australian wind farms (Clements Gap at 61 dB(G) and Cape Bridgewater at 63 dB(G)) compared against measurement results at a beach (measured at 75 dB(G)) and the internationally recognised Audibility Threshold (85 dB(G))

The measurement results indicate that the levels of infrasound in the vicinity of the two Australian wind farms are:

- well below the perception threshold established in International research as 85 dB(G); and
- of the same order as other International infrasound measurement results (a table summarising the results of other measurements is provided in this study); and
- of the same order as that measured from a range of sources including the beach, the Adelaide Central Business District and a power station.

This Australian study therefore reinforces several international studies by government organisations that infrasound emissions from wind farms are well below the hearing threshold and are therefore not detectable to humans.

This study goes beyond the international studies by providing comparative measurements of natural and other human made sources. These sources, including waves on a beach and motor vehicles, have been found to generate infrasound of a similar order to that measured in close proximity to wind farms.

In addition, measurements of the transfer of infrasound from outside to inside a dwelling have been made in this study, to confirm that the levels of infrasound inside a dwelling will be lower than the levels of infrasound outside a dwelling for an external noise source. This information is important because there is limited research available on this transfer.

INTRODUCTION

Noise is often the most important factor in determining the separation distance between wind turbines and sensitive receivers. The assessment of noise therefore plays a significant role in determining the viability of and the size of wind farms.

Australian States presently assess the noise from wind farms under a range of Standards and Guidelines. These Standards and Guidelines do not provide prescriptive requirements for infrasound from wind farms due to the absence of evidence that infrasound should be assessed.

Notwithstanding, there have been concerns raised by the community regarding infrasound levels from wind farms.

Pacific Hydro has therefore engaged Sonus to make an independent assessment of the infrasound produced by wind farms.

To further investigate infrasound in the vicinity of Australian wind farms, this study:

- Develops a methodology to measure infrasound that minimises the influence of wind on the microphone;
- Measures the levels of infrasound at a range of distances from two wind farms;
- Compares the results against recognised audibility thresholds;
- Compares the results with previous wind farm infrasound measurements made in a range of other studies; and
- Compares the results with infrasound measurements made of natural sources, such as beaches, and man-made sources, such as a power station and general activity within the Central Business District of Adelaide.

INTERNATIONAL DESKTOP RESEARCH

Noise is inherently produced by movement. There are two main moving parts that generate the environmental noise from a wind turbine, being the external rotating blades and the internal mechanical components such as the gearbox and generator.

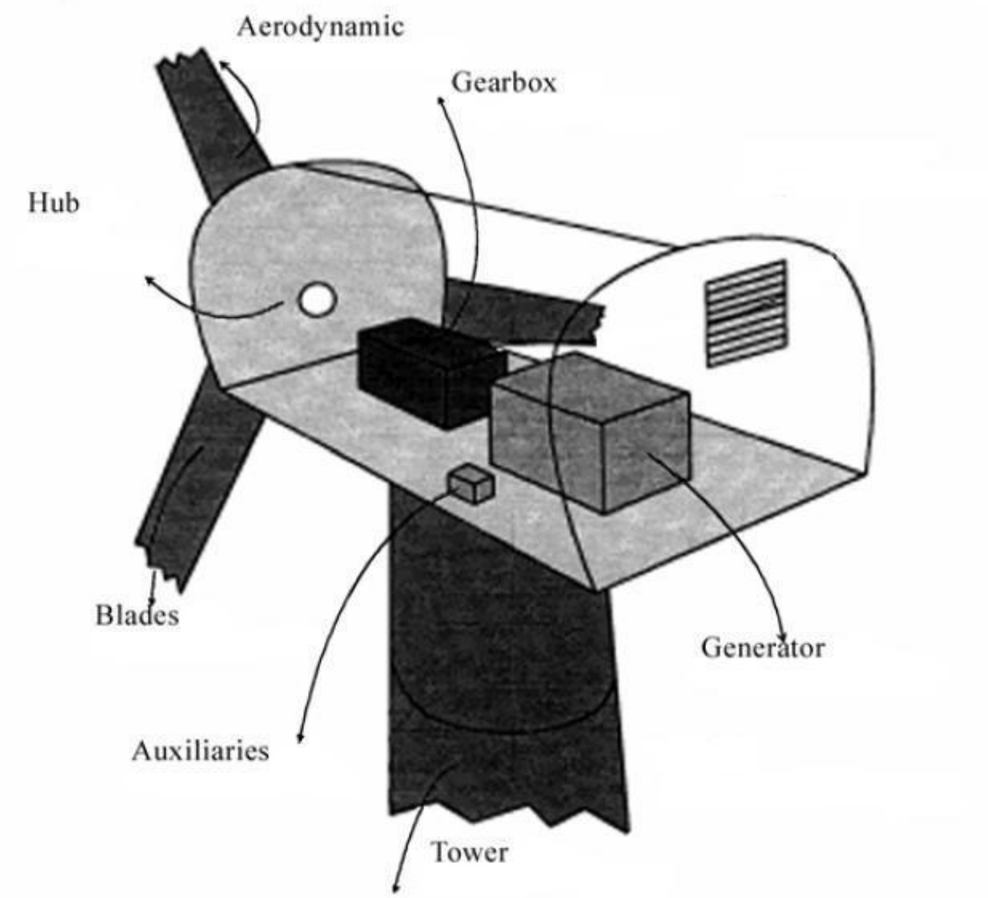


Figure 1 - (Modified from Wagner 1996)

The noise from the blades and the internal machinery are commonly categorised as mechanical and aerodynamic noise respectively.

Mechanical Noise

Mechanical noise sources are primarily associated with the electrical generation components of the turbine, typically emanating from the gear box and the generator. Mechanical noise was audible from early turbine designs, however, on modern designs, mechanical noise has been significantly reduced (Moorhouse et al., 2007).

Aerodynamic Noise

Aerodynamic noise typically dominates the noise emission of a wind turbine and is produced by the rotation of the turbine blades through the air.

Turbine blades employ an airfoil shape to generate a turning force. The shape of an airfoil causes air to travel more rapidly over the top of the airfoil than below it, producing a lift force as air passes over it. The nature of this air interaction produces noise through a variety of mechanisms (Brooks et al., 1989).

Aerodynamic noise is broadband in nature and includes acoustic energy in the infrasound, low, mid and high frequency ranges.

Whilst the aerodynamic noise from a rotating turbine blade produces energy in the infrasound range, there are natural sources of infrasound including wind and breaking waves, and a wide range of man-made sources such as industrial processes, vehicles and air conditioning and ventilation systems that make infrasound prevalent in the natural and urban environment (Howe, 2006).

Aerodynamic noise can be further separated into the following categories which are relevant to the infrasound study:

Amplitude Modulation

Amplitude modulation is most commonly described as a "swish" (Pedersen, 2005). "Swish" is a result of a rise and fall in the noise level from the moving blades. The noise level from a turbine rises during the downward motion of the blade. The effect of this is a rise in level of approximately once per second for a typical three-bladed turbine as each blade passes through its downward stroke.

It was previously thought that "swish" occurred as the blade passed the tower, travelling through disturbed airflow, however, a recent study indicates it is related to the difference in wind speed over the swept area of a blade (Oerlemans and Schepers, 2009).

Other explanations for the rise in noise level that occurs on the downward stroke relate to the slight tilt of the rotor-plane on most modern wind turbines to ensure that the blades do not hit the tower. An effect of the tilt is that when the blades are moving downwards they are moving against the wind. Conversely, when moving upwards they are moving in the same direction as the wind. Therefore, with the effective wind speed being higher on the downward stroke, it is suggested that a higher noise level is produced.

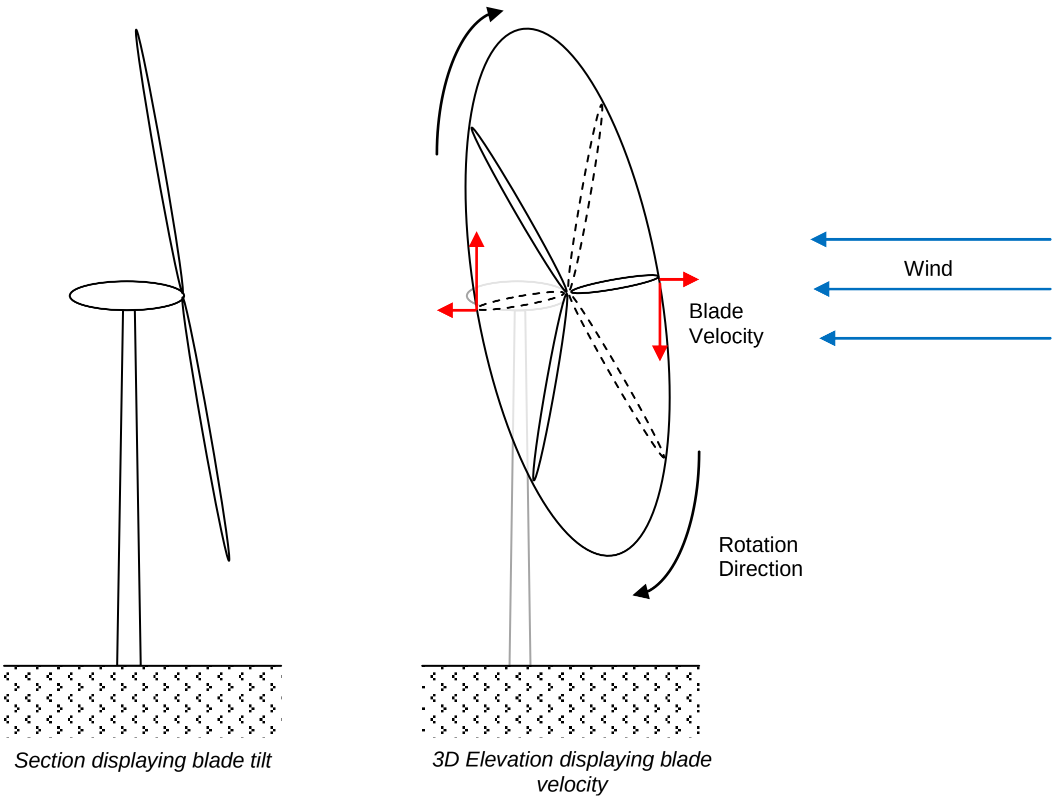


Figure 2 - Blade Velocity due to Tilt

Low Frequency Noise

Noise sources that produce low frequency content, such as a freight train locomotive or diesel engine have dominant noise content in the frequency range between 20 and 200 Hz (O'Neal et al, 2009). Low frequency noise is often described as a "rumble".

Aerodynamic noise from a wind turbine is not dominant in the low frequency range. The main content of aerodynamic noise generated by a wind turbine is often in the area known generically as the mid-frequencies, being between 200 and 1000Hz.

Noise reduces over distance due to a range of factors including atmospheric absorption. The mid and high frequencies are subject to a greater rate of atmospheric absorption compared to the low frequencies and therefore over large distances, whilst the absolute level of noise in all frequencies reduces, the relative level of low frequency noise compared to the mid and high frequency content increases. For example, when standing alongside a road corridor, the mid and high frequency noise from the tyre and road interaction is dominant, particularly if the road surface is wet. However, at large distances from a road corridor in a rural environment, the remaining audible content is the low frequency noise of the engine and exhaust.

This effect will be more prevalent in an environment that includes masking noise in the mid and high frequencies, such as that produced by wind in the trees.

Separation distances between wind farms and dwellings can be of the order of 800 to 1200m. At these distances, in an ambient environment where wind in the trees is present, it is possible that only low frequencies remain audible and detectable from a noise source that produces content across the full frequency range. This effect will become more prevalent for larger wind farms because the separation distances need to be greater in order to achieve the relevant noise standards. A greater separation distance changes the dominant frequency range from the mid frequencies at locations close to the wind farm to the low frequencies further away, due to the effects described above.

Low frequency sound produced by wind farms is not unique in overall level or content. Low frequency noise from other sources that is well in excess of that in the vicinity of a wind farm can be measured and heard at a range of suburban and rural locations.

The low frequency content of noise from a wind farm is inherently considered as part of its environmental noise assessment against relevant standards and guidelines.

Infrasound

Infrasound is generally considered to be noise at frequencies less than 20 Hz (O'Neal et al., 2009). The generation of infrasound was detected on early turbine designs, which incorporated the blades 'downwind' of the tower structure (Hubbard and Shepherd, 1990). The mechanism for the generation was that the blade passed through the wake caused by the presence of the tower.

Audible levels of infrasound have been measured from downwind blade wind turbines (Jakobsen, J., 2005). Modern turbines locate the blades upwind of the tower and it is found that turbines of contemporary design now produce much lower levels of infrasound (Jakobsen, J., 2005), (Hubbard and Shepherd 1990).

Infrasound is often described as inaudible, however, sound below 20 Hz remains audible provided that the sound level is sufficiently high (O'Neal et al., 2009). The thresholds of hearing for infrasound have been determined in a range of studies (Leventhall, 2003). These thresholds are depicted in graphical form below for frequencies less than 20 Hz (Figure 3).

Non-audible perception of infrasound through felt vibrations in various parts of the body is also possible, however, this is found to only occur at levels well above the audible threshold (Moeller and Pedersen, 2004).

Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. The G-weighting has been standardised to determine the human perception and annoyance due to noise that lies within the infrasound frequency range (ISO 7196, 1995).

A common audibility threshold from the range of studies is an infrasound noise level of 85 dB(G) or greater. This is used by the Queensland Department of Environment and Resource Management's (DERM's) draft Guideline for the assessment of low frequency noise as the acceptable level of infrasound in the environment from a noise source to protect against the potential onset of annoyance.

The audibility threshold limit of 85 dB(G) is consistent with other European standards and studies, including the UK Department for Environment, Food and Rural Affairs threshold developed in 2003 (DEFRA., Leventhall, 2003), the UK Department of Trade and Industry study (DTI, Hayes McKenzie, 2006), the German Standard DIN 45680, the Denmark National Standard and independent research conducted by Watanabe and Moeller (Watanabe and Moeller, 1990).

The 85 dB(G) audibility threshold limit is shown in Figure 3 below. Other audibility thresholds have also been overlaid to provide a comparison.

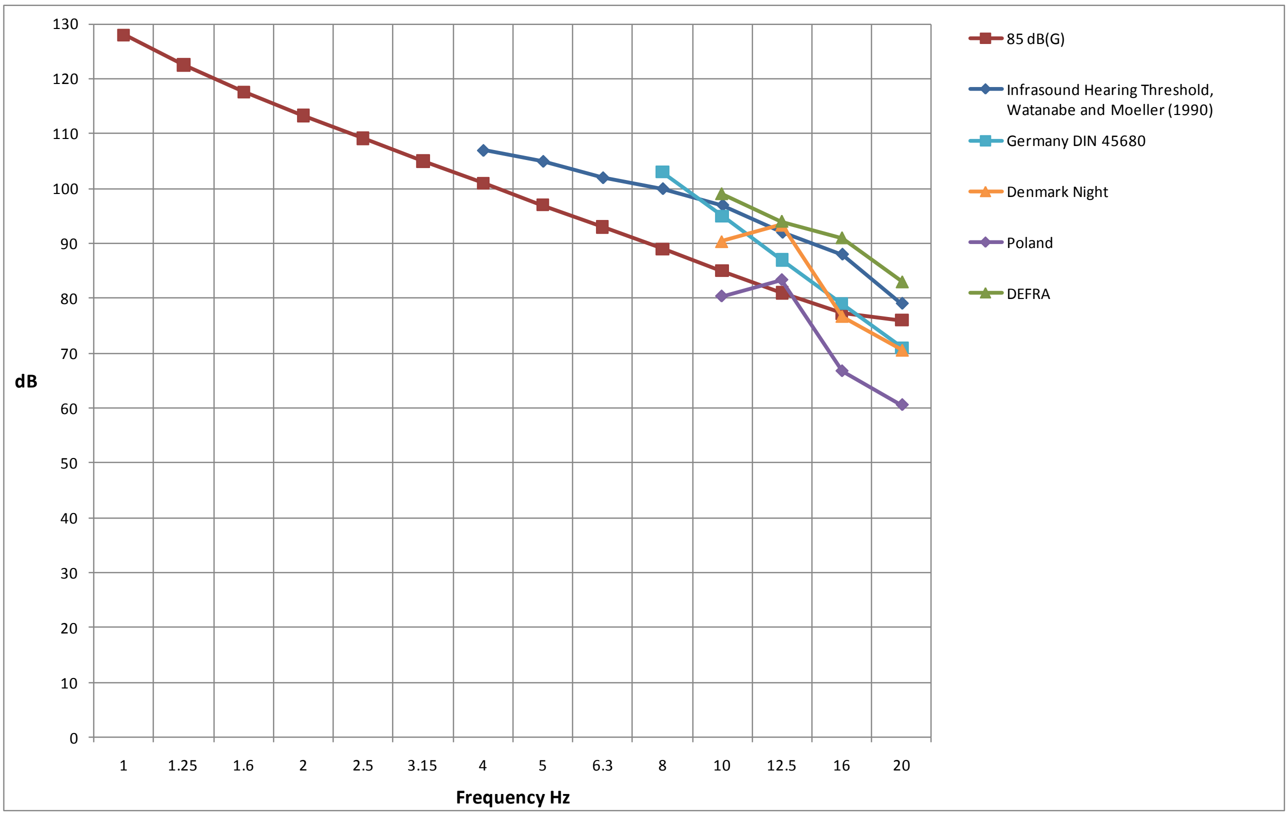


Figure 3 - Audibility Threshold Curves from the Listed Sources

DETERMINATION OF A MEASUREMENT METHODOLOGY

Microphone Mounting Method

A microphone mounting method is provided in IEC 61400-11 (IEC, 2002), as shown in Figure 4 below. The method was developed to minimise the influence of wind on the microphone for the measurement of noise in frequencies higher than those associated with infrasound. This is achieved by mounting the microphone at ground level on a reflecting surface and by protecting the microphone with two windshields constructed from open cell foam.

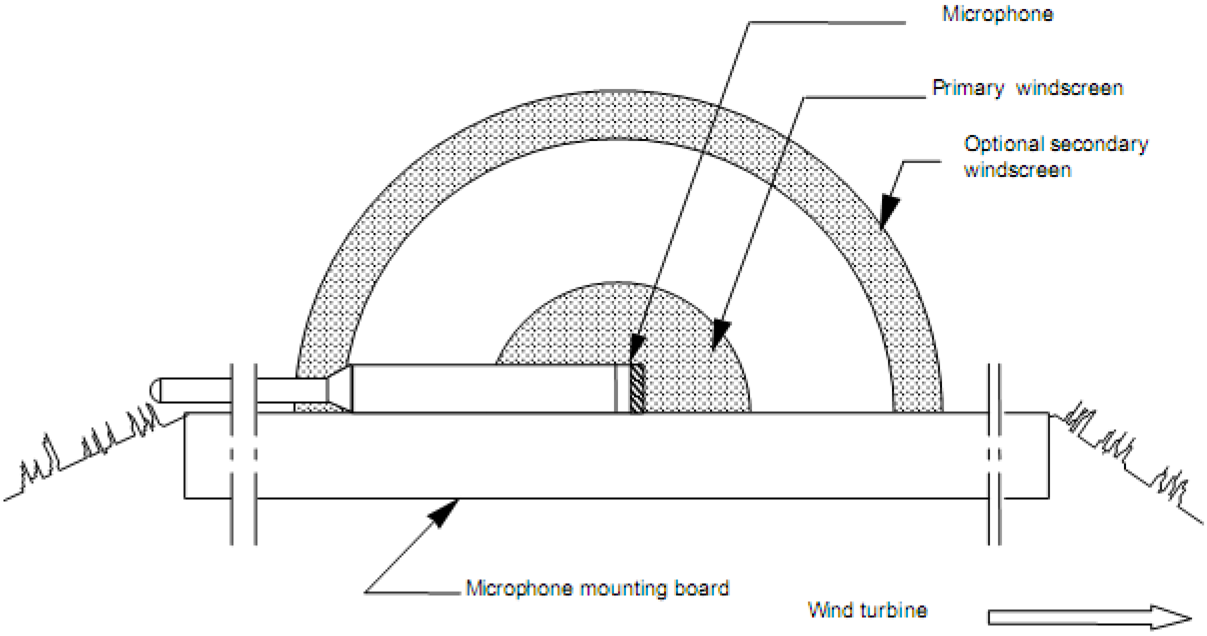


Figure 4 - Mounting of the microphone – vertical cross-section (Reproduced from Figure 1b, IEC 61400-11)

The above method was not developed specifically for the measurement of infrasound, and wind gusts can be clearly detected when measuring in the infrasound frequency range using the above method.

Therefore, this study has developed an alternative method to reduce the influence of wind on the microphone that would otherwise mask the infrasound from the turbine.

A below ground surface method was developed based on a similar methodology (Betke et al, 2002). This method has been adapted for this study, and includes a dual windshield arrangement, with a foam layer mounted over a test chamber, and a primary windshield used around the microphone.

The microphone mounting arrangement is depicted in the following schematic:

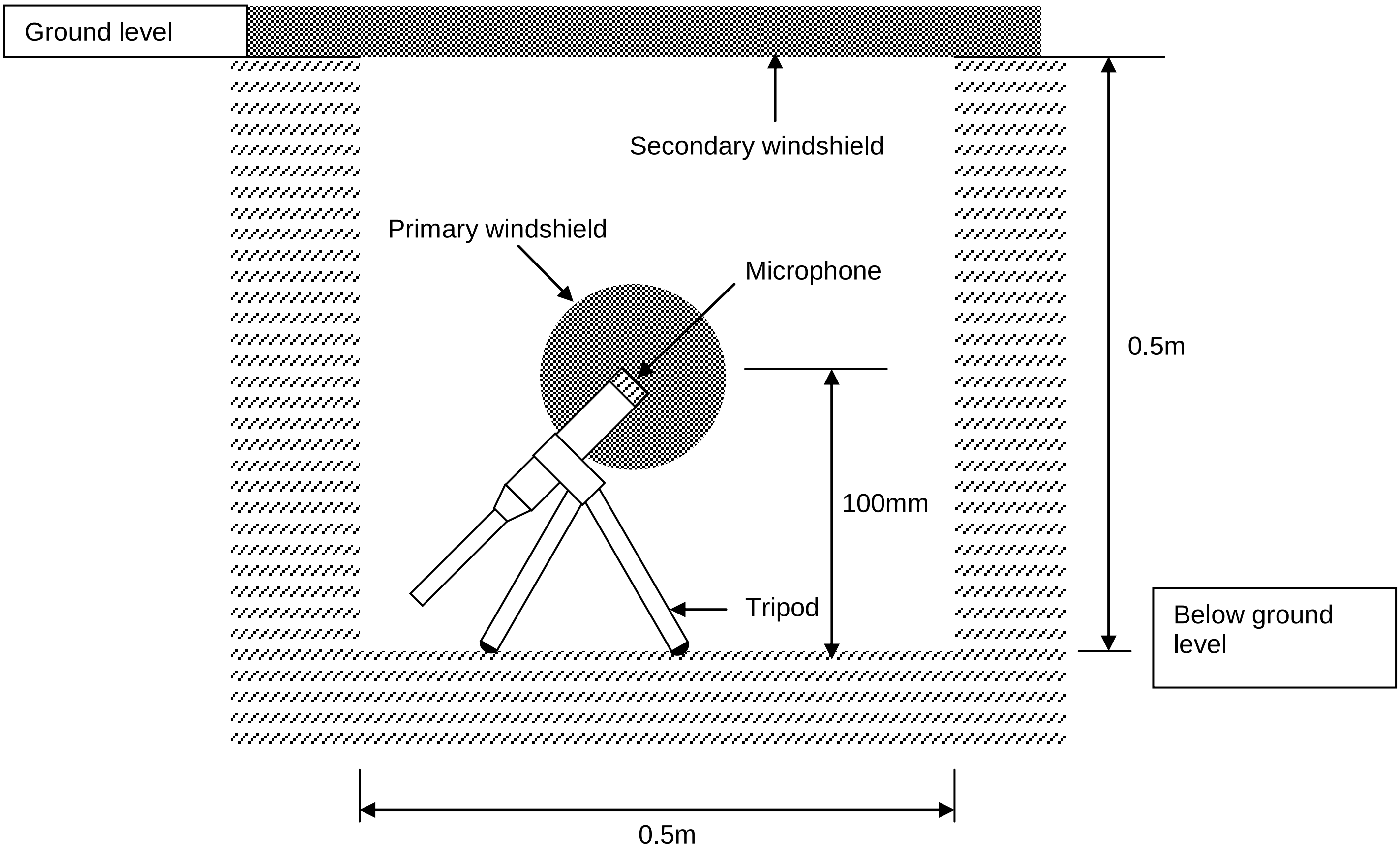


Figure 5 - Schematic of Microphone Position

Inputs

The measurement methodology was developed with the following inputs:

- Literature review related to wind turbine infrasound research;

- Measurements to determine the influence of wind on the microphone using different measurement techniques, including the IEC 61400-11 measurement procedure, placing the microphone in an enclosure above the ground, and placing the microphone in a 500mmx500mmx500mm deep (approximate) test chamber with an open cell foam (acoustically transparent) lid, based on the Betke et al method. The measurements were initially made at locations without any appreciable man made noise sources;

- Measurements to determine the level of transfer of infrasound at a range of different frequencies between 8Hz and 20Hz, from immediately outside a chamber to inside a chamber, under conditions of negligible wind and ambient noise influence. The infrasound noise source (bass speaker and tone signal generator) was placed 10m away from the chamber and 1m above the ground;

- Measurements to determine the level of transfer of infrasound at a range of different frequencies between 8Hz and 20Hz, from immediately outside a lightweight elevated dwelling with windows open, to inside a room within that dwelling, under conditions of negligible wind and ambient noise influence, comprising use of an infrasound noise source (bass speaker and tone signal generator) placed 10m from the dwelling and 1m above the ground;

- Discussions with Mr Andrew Roberts of REPower Australia Pty Ltd regarding the test measurement procedure and the preliminary results.

Based on the above, the important factors for an infrasound measurement methodology comprise:

- The ability to reduce the influence of wind on the microphone;
- Turning the noise source on and off to confirm infrasound from the source can be identified within the ambient environment;
- Measurement conditions that minimise the influence of the ambient environment whilst enabling the operation of a wind farm. This is expected to comprise a light breeze (similar to a Beaufort Scale 2 breeze of between 2 and 3 m/s at ground level) occurring on a night or early morning with a clear sky.

MEASUREMENTS

Equipment

All measurements were made with the SVANTEK 957 Type 1 NATA calibrated sound and vibration analyser. The SVANTEK 957 Type 1 meter has a measured frequency response to 0.5 Hz. A GRAS 40AZ ½" free field microphone with a frequency response of ±1dB to 1 Hz was also used. The meter and microphone arrangement is therefore suitable for measurement of noise levels in the infrasound range.

Controlled Verification

The below ground technique was analysed at a remote site away from a wind farm, transport corridor or other appreciable noise source and in very still conditions. The location was a suburban property in Blackwood, a suburb of the Adelaide Hills.

The aim of the analysis was to determine the level of transfer of infrasound from outside to inside the chamber. The following procedure was used:

- Generation of a constant level of infrasound using a tone signal generator and sub-woofer speaker, mounted 1m above the ground at a distance of 10m horizontally from the chamber. The infrasound was generated at a number of discrete frequencies between 8 and 20 Hz;
- Measurement of the infrasound using the IEC 61400-11 above ground technique;
- Measurement of the infrasound using the below ground technique;
- Measurement of the infrasound without the tone signal generator operating (ambient infrasound).

In addition, to provide additional information regarding the noise level reduction of infrasound from outside to inside a dwelling, a measurement of infrasound inside a lightweight dwelling with the windows open was also made at a number of discrete frequencies.

The testing was conducted between approximately 9pm and 11pm on two occasions in Blackwood under conditions of negligible breeze and no appreciable ambient noise sources.

The measurement results are summarised in the following tables and the ambient noise level is shown in Figure 6.

Table 1 - Measurement approximately 10m from controlled source with no wind

Frequency (Hz)		8.00	10.0	12.5	16.0	20.0
Noise Level (dB)	Inside chamber	47	50	54	60	63
	Outside chamber	47	50	54	60	63

Table 2 - Measurement of ambient conditions in test location (controlled source turned off)[1]

Frequency (Hz)	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	39	38	39	39	37	**51**

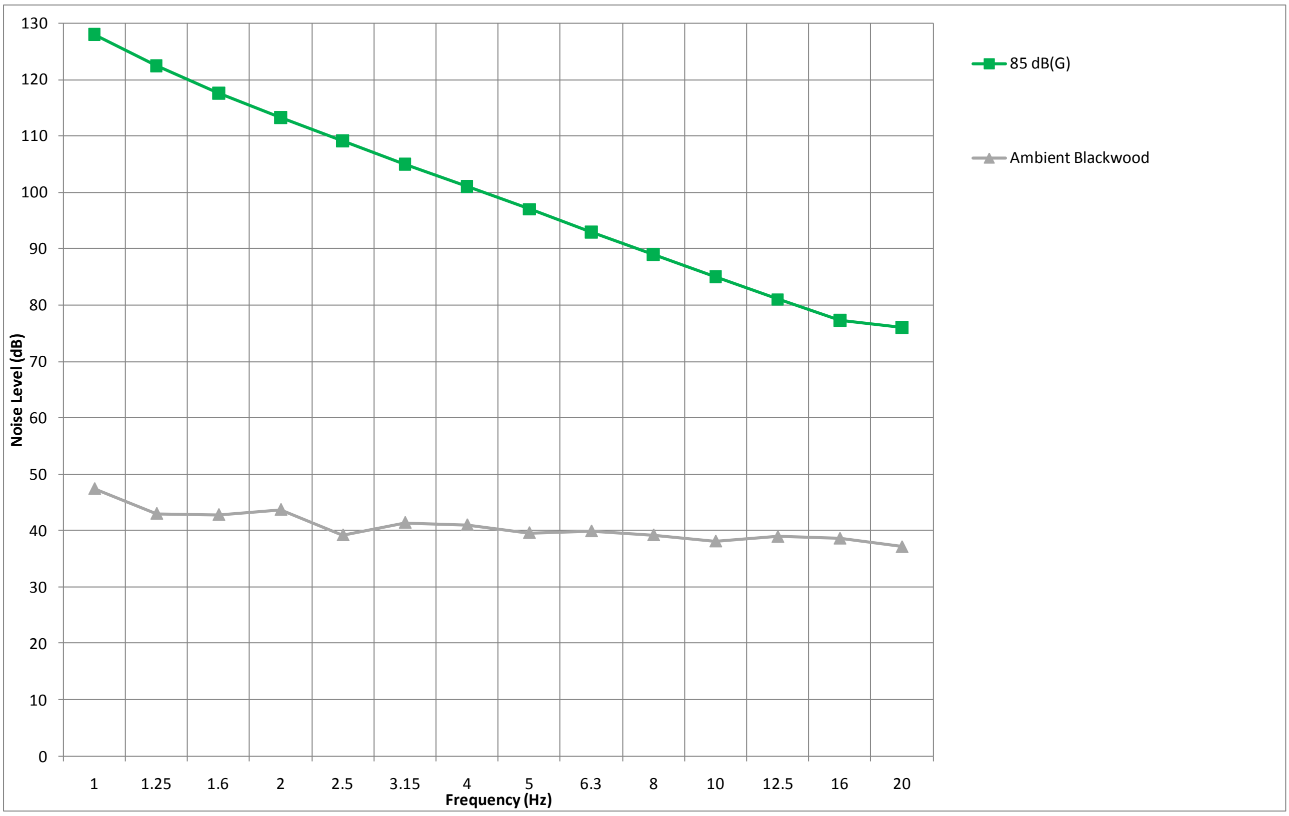


Figure 6 - Ambient infrasound noise level measured without any appreciable noise sources or wind

[1] Measurements of the ambient levels of infrasound were also made at frequencies lower than 8 Hz. These results are shown in Figure 8. The sub-woofer arrangement was not able to generate infrasound below 8 Hz. Table 7 shows the results from 8 Hz to 20 Hz for the purposes of comparison with Table 6.

The results of the testing of the effect of a lightweight facade (with the windows open) on the transfer of infrasound are presented in the following tables:

Table 3 - Measurement of facade transfer with controlled source

Frequency (Hz)		10.0	16.0	20.0
Noise Level (dB)	Inside house	47	61	54
	Outside house	54	63	56

Table 4 - Measurement of ambient conditions in house locations

Frequency (Hz)		10.0	16.0	20.0
Noise Level (dB)	Inside house	37	41	34
	Outside house	42	43	41

The above conclusions can be made from the above results and on site observations:

- The measurement of a constant source of infrasound in still conditions is the same above the ground as in the chamber using the technique described above. Therefore, the below ground technique can be used to measure the infrasound from a source;
- The results are consistent at a number of discrete frequencies between 8 Hz and 20 Hz;
- The levels of infrasound inside a dwelling will be lower than the levels of infrasound outside a dwelling for an external noise source. This information is important because there is limited research available on this transfer. These results are consistent with Jakobsen, J., 2005, who found that “the outdoor to indoor correction may be quite small in a part of the infrasound range, but it is unlikely to become negative, which would imply a higher level indoors than out of doors”.

RESULTS

Infrasound was measured at Clements Gap in the mid-North of South Australia (CGWF) and Cape Bridgewater in the coastal region of south-western Victoria (CBWF), using the verified below ground methodology. At Clements Gap, measurements were also made concurrently using the above ground technique provided by IEC 61400-11.

The following sections summarise the results of the measurements at the wind farms and in the vicinity of other sources of infrasound including a beach, the coastline, a central business area and a power station.

Testing at Clements Gap Wind Farm

Testing at the Clements Gap wind farm was conducted using the following procedure:

- Measurement of infrasound using the IEC 61400-11 above ground technique at distances of 85, 185 and 360m from the base of the turbine in a downwind direction; and
- Measurement of infrasound using the below ground technique at distances of 85, 185 and 360m from the base of the turbine in a downwind direction.

The testing was conducted between approximately 7pm and 11pm on Tuesday the 11th of May under a clear night sky with a light breeze. Operational data indicates the turbines were subject to hub height wind speeds of the order of 6 to 8m/s during the period of the testing.

The measurement results in close proximity to the wind turbine are summarised in the following tables and shown in the following figure. The tables provide the measured noise level at each 1/3 octave band between 1 and 20 Hz and also sum the results to provide an overall dB(G) noise level. The figure includes the 85 dB(G) audibility threshold.

Twenty (20) continuous 1 minute measurements were made at each location. The presented results are typical of those during the measurement period, excluding those at the start and end of the period, where movements adjacent the measurement equipment might influence the results. The number of continuous measurements is based on the on site observations regarding the repeatability of the results.

Table 5 - Measurement approximately 85m downwind from closest operational turbine (No. 25)

Frequency (Hz)		1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	Inside chamber	68	70	73	70	71	69	68	66	64	63	63	58	57	57	**72**
	Outside chamber	70	71	72	70	69	69	68	67	66	63	60	57	57	56	**71**

Table 6 - Measurement approximately 185m downwind from closest operational turbine (No. 25)

Frequency (Hz)		1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	Inside chamber	67	66	69	66	67	64	62	63	61	58	56	53	52	52	**67**
	Outside chamber	80	79	79	77	77	77	75	75	73	72	71	69	66	64	**80**

Table 7 - Measurement approximately 360m downwind from closest operational turbine (No. 25)

Frequency (Hz)		1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	Inside chamber	63	60	66	59	65	60	59	57	54	51	50	47	45	46	**61**
	Outside chamber	71	69	72	72	72	68	69	65	64	61	59	55	53	50	**67**

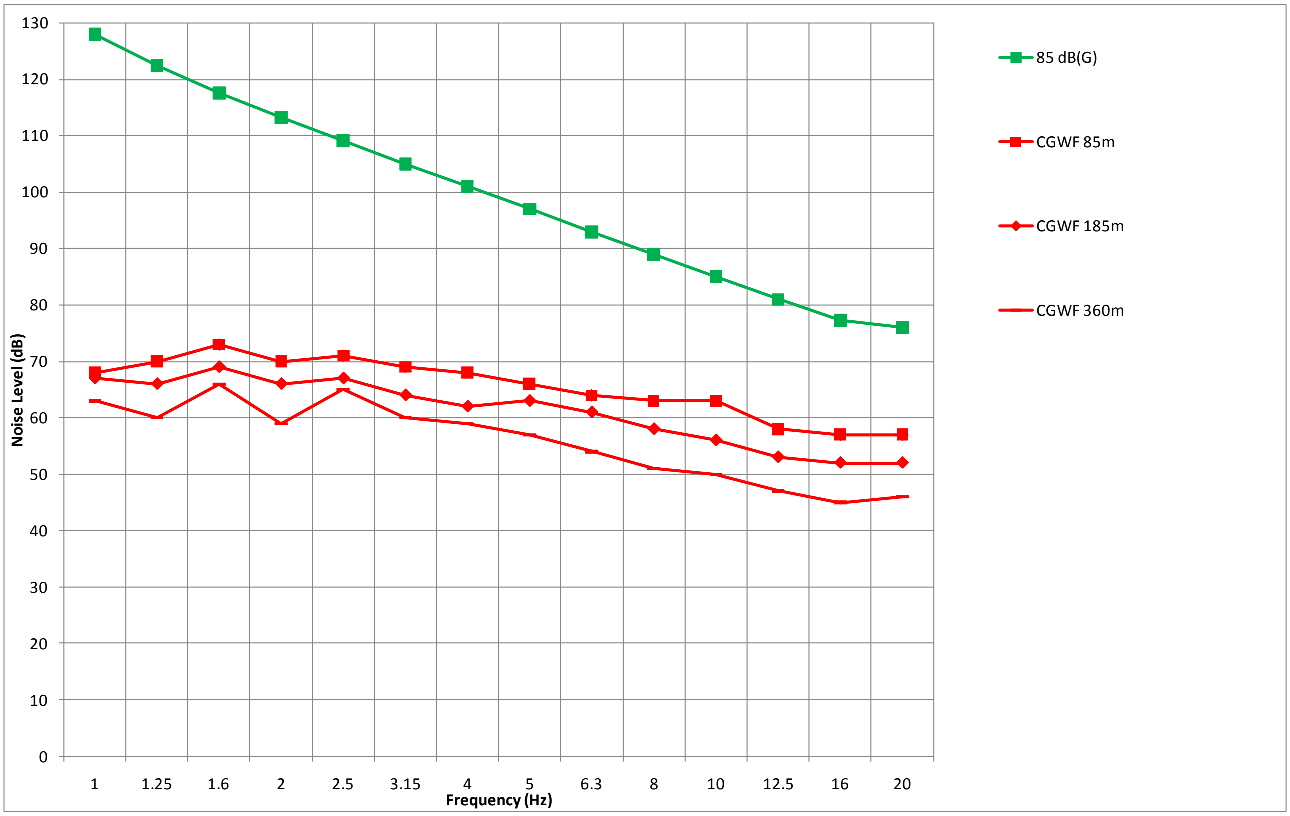


Figure 7 - Infrasound measurements below the ground at Clements Gap wind farm

The theoretical reduction in noise level from a noise source is 6dB for every doubling of the distance from that source due to the "hemispherical spreading" of the sound wave. This reduction theoretically applies to noise at all frequencies, including below 20 Hz. Tables 5, 6 and 7 indicate that a reduction in the order of 6 dB is achieved using the below ground technique, but not for the above ground technique. This is due to the above ground measurements being influenced by surface wind on the microphone.

The following conclusions can be made from the results and on site observations:

- The wind turbines generate infrasound;
- The level of infrasound is well below the audibility threshold of 85 dB(G);
- The distances at which the measurements of the operational wind farm were made are significantly less than separation distances expected between a wind farm and a dwelling, where the levels of infrasound will be correspondingly lower;
- A noise level reduction of approximately 6 dB was measured inside the chambers when doubling the distance from turbine 25. This indicates the level of infrasound measured below the ground was directly associated with turbine 25;
- The measurements above the ground surface did not reduce by 6 dB due to the presence of surface winds and their influence on the results. This indicates the IEC 61400-11 based test does not enable the infrasound from the turbines to be separated from infrasound due to the wind.

In addition to the above testing in close proximity to an individual turbine, the "Byarlea" residence was visited, which is approximately 1200m to the east of the nearest turbines in the Clements Gap wind farm.

An infrasound measurement was made within a room of the dwelling. The refrigerator was operating in the dwelling at the time of the measurement but a full survey of other operating equipment was not made. A level of the order of 51 dB(G) was measured.

Given the still conditions at the dwelling at the time of inspection, a local above ground infrasound measurement outside the dwelling was able to be made. A level of the order of 58 dB(G) was measured. The results of the measurements are presented in Tables 8 and 9 and Figure 8 below:

Table 8 - Measurement inside a room of a dwelling

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	60	49	54	54	59	52	50	45	43	41	43	38	38	33	**51**

Table 9 - Measurement outside of dwelling

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	47	45	53	47	54	54	50	50	45	44	44	43	43	43	**58**

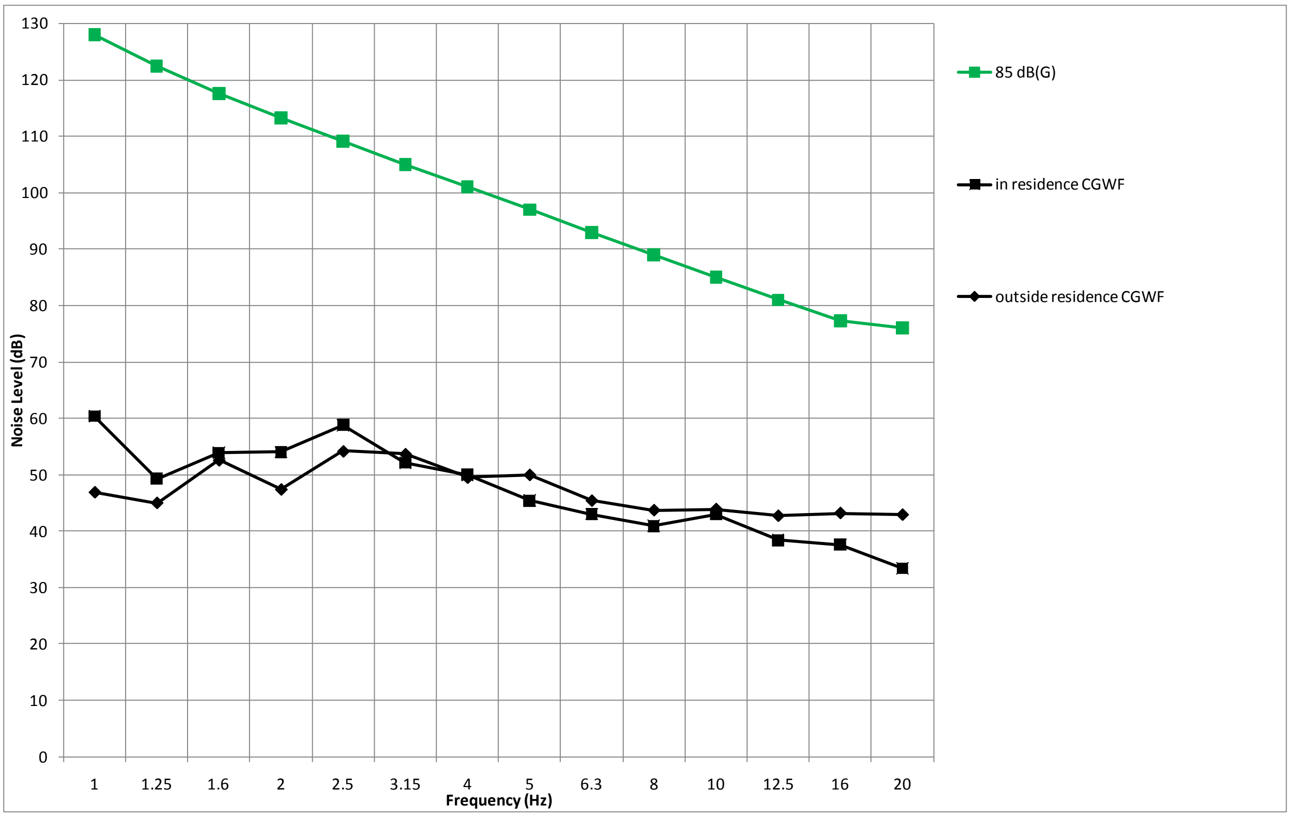


Figure 8 - Measurements of infrasound inside and outside a dwelling in the vicinity of the Clements Gap wind farm

The above conclusions can be made from the above results and on site observations:

- The levels of infrasound inside a dwelling in the vicinity of a number of turbines associated with the Clements Gap wind farm is well below the audibility threshold of 85 dB(G);
- The levels of infrasound outside a dwelling in the vicinity of a number of turbines associated with the Clements Gap wind farm is well below the audibility threshold of 85 dB(G).

Testing at Cape Bridgewater Wind Farm

The controlled verification testing and the Clements Gap Wind Farm test confirmed that the use of the below ground technique was able to reduce the influence of wind on the microphone and identify the level of infrasound associated with a wind turbine and/or a wind farm.

Therefore, testing at the Cape Bridgewater wind farm was conducted using the following trialled and analysed procedure based around the below ground technique:

- Measurement of infrasound using the below ground technique in close proximity to an operating wind turbine at distances of 100 and 200m from the base of the turbine in a downwind direction;
- Measurement of infrasound with the wind farm not operating;
- Measurement of infrasound at the beach to the east of Cape Bridgewater;
- Measurement of infrasound in the vicinity of the coastline to the west of Cape Bridgewater;
- Measurement of infrasound in a designated forest area approximately 8km inland from the coast, under conditions of negligible wind.

The testing at the wind farm site was conducted between approximately 4am and 6am on Wednesday the 2nd of June under a clear night sky with a light breeze. During the testing, the operational status of the turbines was constantly observed and confirmed. The results in Tables 10 and 11 were taken at distances of 100m and 200m respectively from the closest operational turbine. The results in Table 12 were taken with the wind farm stationary at the 100m measurement location.

The measurement results in close proximity to the wind turbine are summarised in the following tables and shown in the following figure. The tables provide the measured noise level at each 1/3 octave band between 1 and 20 Hz and also sum the results to provide an overall dB(G) noise level. The figure includes the 85 dB(G) audibility threshold and the ambient noise result from the Adelaide Hills.

Twenty (20) continuous 1 minute measurements were made at each location. The presented results are typical of those during the measurement period, excluding those at the start and end of the period, where movements adjacent the measurement equipment might influence the results.

Table 10 - Measurement approximately 100m downwind from closest operational turbine

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	61	57	59	58	58	59	55	54	54	53	51	50	54	53	**66**

Table 11 - Measurement approximately 200m downwind from closest operational turbine

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	54	52	50	54	56	55	55	54	52	52	50	49	53	49	**63**

Table 12 - Ambient infrasound measurement (with the wind farm not operating)

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	54	52	51	52	55	56	56	56	55	54	52	51	50	47	**62**

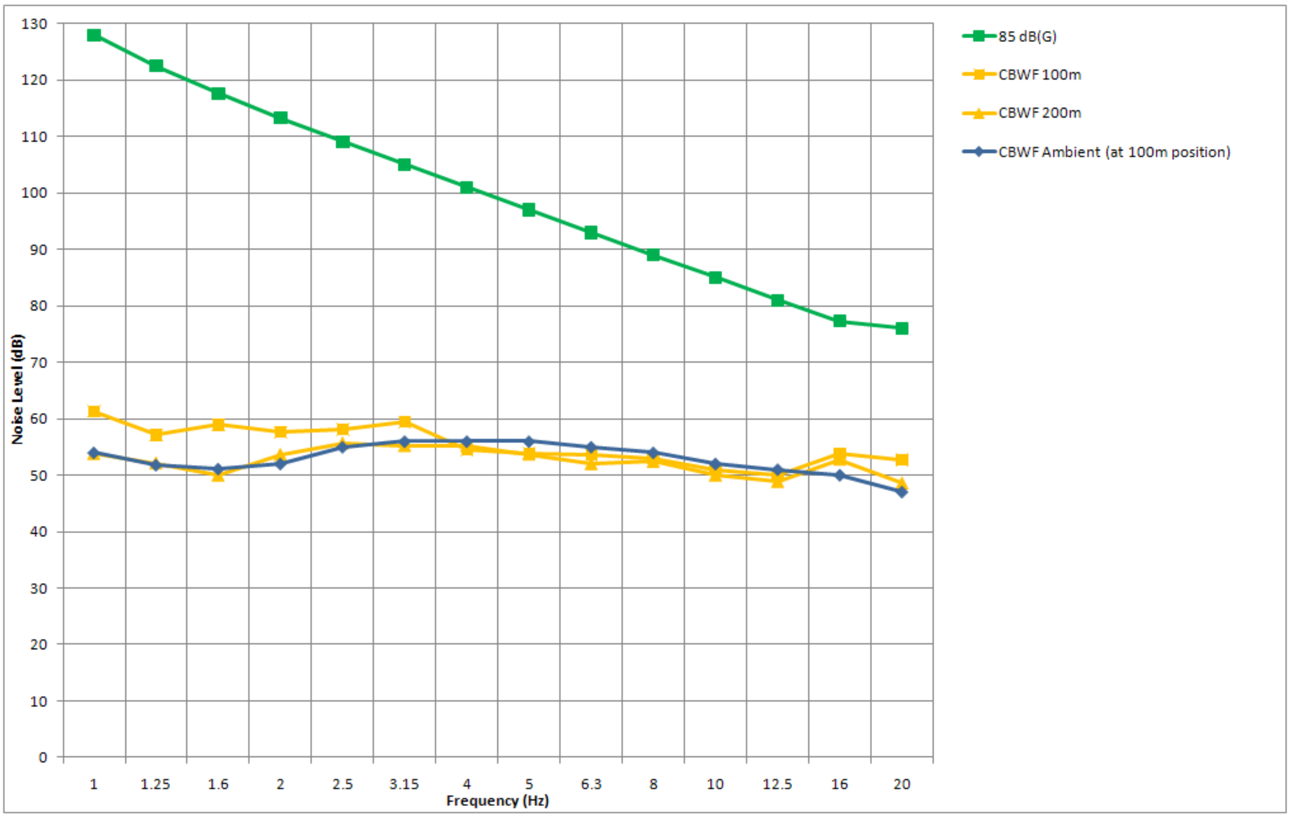


Figure 9 - Infrasound measurements below the ground at Cape Bridgewater wind farm

The above conclusions can be made from the above results and on site observations:

- The wind turbines generate infrasound;
- The level of infrasound is well below the audibility threshold of 85 dB(G);
- The distances at which the measurements of the operational wind farm were made are significantly less than separation distances between a wind farm and a dwelling, where the levels of infrasound will be correspondingly lower;
- A high level of ambient infrasound exists (infrasound in the absence of noise from the wind farm) which influences the results for the wind turbines.

Measurements were made in the vicinity of the adjacent beach and the coastline to confirm the source of the high ambient infrasound levels. In addition, a measurement was made inland to determine the extent of influence of the high ambient infrasound levels.

The results of the measurements are presented in Figure 10 below:

Table 13 – Beach at approximately 25m from the high water mark

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	53	53	65	64	66	62	70	70	67	69	63	63	63	59	**75**

Table 14 –On the cliff face at approximately 250m from the coastline

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	59	59	61	64	65	67	65	62	60	60	58	56	56	54	**69**

Table 15 – Inland at approximately 8km from the coast

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	50	46	62	61	55	50	52	52	51	47	44	44	44	43	**57**

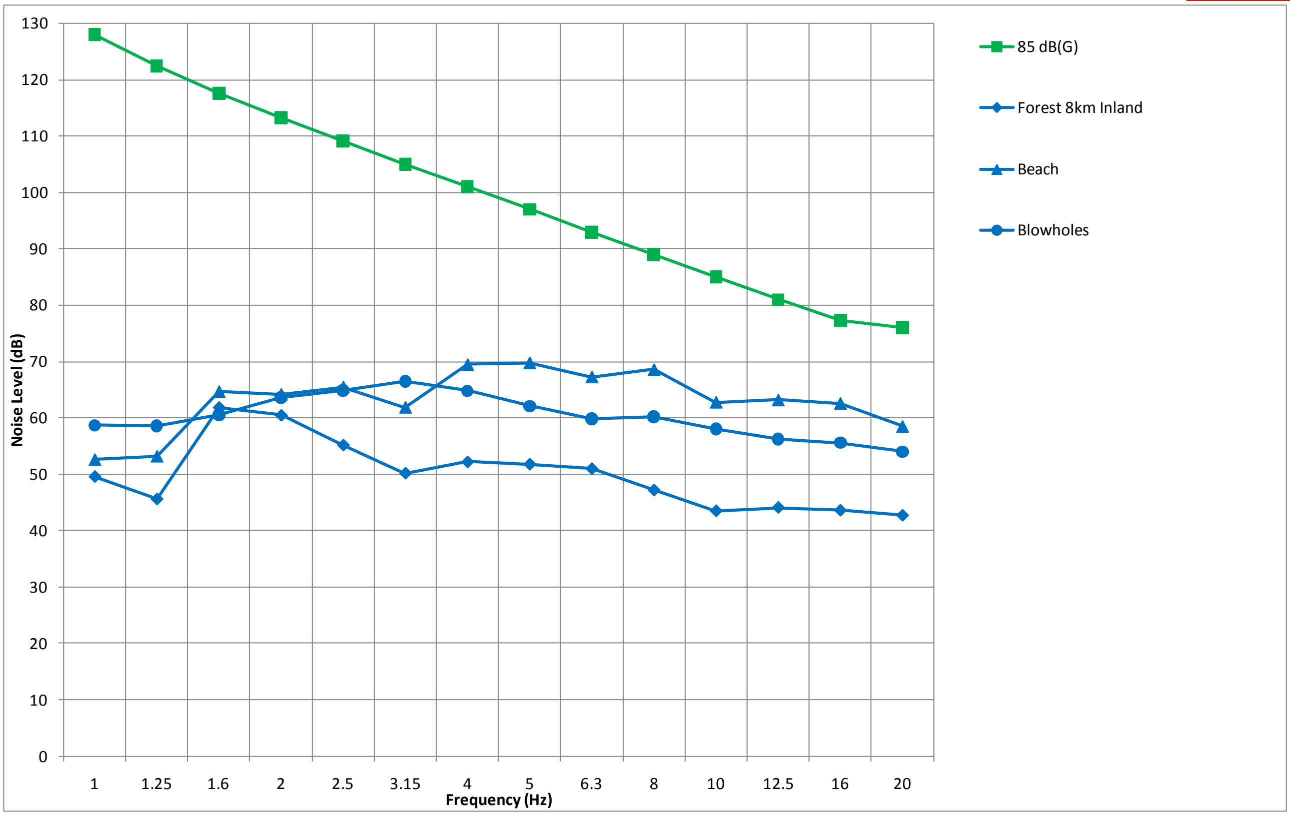


Figure 10 - Ambient noise measurements in the vicinity of Cape Bridgewater

The following conclusions can be made from the above results and on site observations:

- Natural sources generate infrasound;
- The levels of infrasound from natural sources are of the same order as those measured within 100m of a wind turbine;
- Measurable levels of infrasound that are of a similar order to that measured in close proximity to a wind farm are prevalent in the natural environment over a large area due to sources other than wind farms.

The following map depicts measurement locations relative to the turbine:

Map 1: Cape Bridgewater Wind Farm Measurement Locations

Testing of other man-made noise sources

Testing has been conducted using the below ground technique in the vicinity of other man-made noise sources using the following procedure:

- Measurement of infrasound using the below ground technique at a distance of approximately 350m from a gas fired power station;
- Measurement of infrasound using the below ground technique within the Adelaide Central Business District at approximately 70m and 200m from two major road corridors;

The measurement results are summarised in the following tables and shown in the following figure. The tables provide the measured noise level at each 1/3 octave band between 1 and 20 Hz and also sum the results to provide an overall dB(G) noise level. The figure includes the 85 dB(G) audibility threshold and the ambient noise result from the Adelaide Hills.

The results presented are typical of those during the measurement period, excluding those at the start and end of the period, where movements adjacent the measurement equipment might influence the results.

Table 16 – Power Station

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	63	57	57	54	53	50	50	49	54	55	57	62	61	61	**74**

Table 17 - CBD

Frequency (Hz)	1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	Total (dB(G))
Noise Level (dB)	63	60	61	62	61	58	59	56	56	53	55	60	65	63	**76**

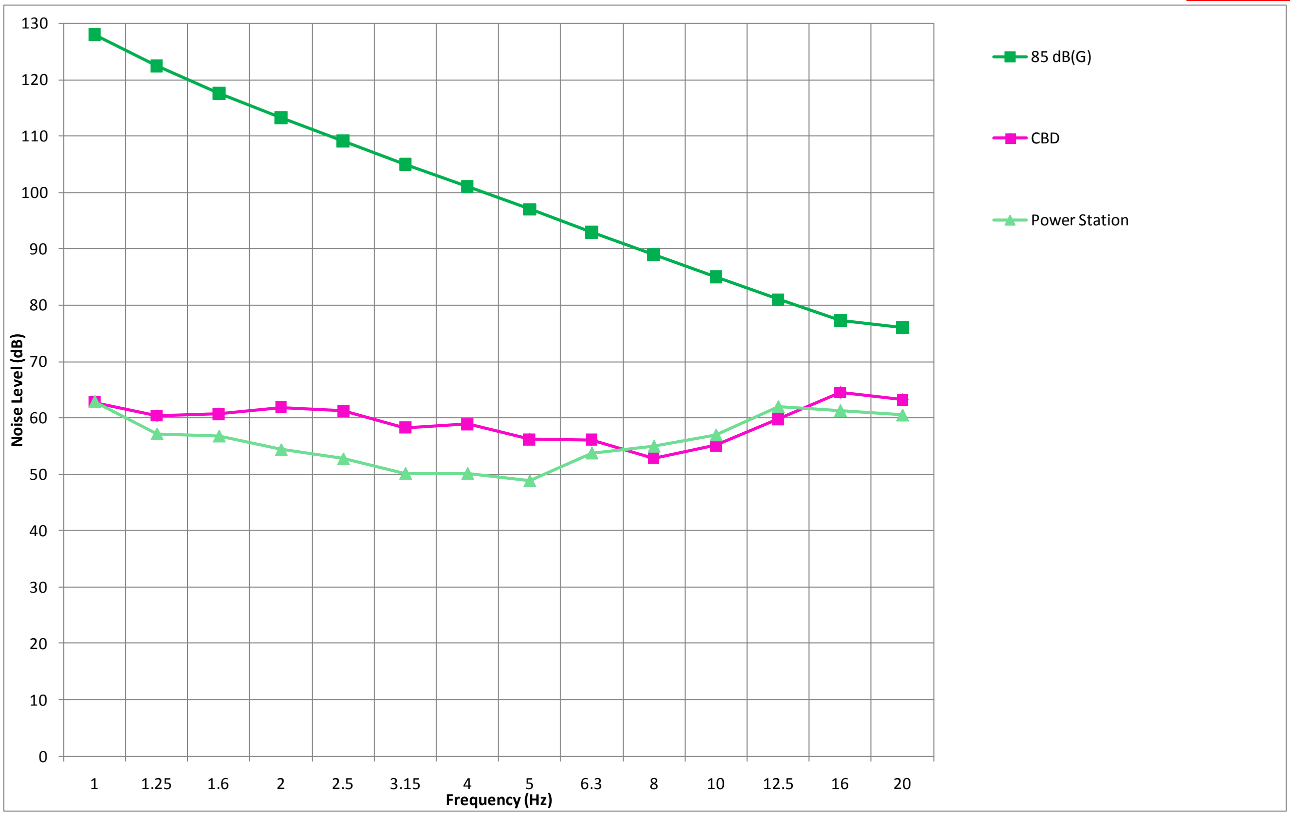


Figure 11 - Infrasound from man-made noise sources

The following conclusions can be made from the above results and on site observations:

- Man made sources generate infrasound;
- The levels of infrasound from man made sources are of the same order at those measured within close proximity of a wind turbine;
- Measurable levels of infrasound that are of a similar order to that measured in close proximity to a wind farm are prevalent in the urban environment over a large area due to sources other than wind farms.

Comparison against International results

The Canadian Wind Energy Association (Howe, 2006) and Jakobsen, J., 2005, provide a summary of results of infrasound testing at a range of sites. The data is presented as an overall dB(G) level. The methodology used to measure these data is not known and therefore the results might be influenced by wind or other sources. These data and the measured levels as part of this study are summarised in the following table:

Table 18 - Summary of Infrasound Levels

Noise source	Distance (m)	Infrasound level dB(G)	Comments
General Electric MOD-1	105	107	Downwind turbines, known to generate higher levels of infrasound compared to a modern upwind turbine
General Electric MOD-1	1000	75	Downwind turbine
Hamilton Standard WTS-4	150	92	Downwind turbine
Hamilton Standard WTS-4	250	85	Downwind turbine
Boeing MOD-5B	68	71	Upwind two bladed turbine at a limited separation distance – this shows the significant reduction between downwind and upwind turbines
US Wind Power USWP-50	500	67-79	14 downwind turbines influencing the results
WTS-3	750	68	Downwind turbine
WTS-3	2100	60	Downwind turbine
Enercon E-40	200	64	Modern upwind turbine
Vestas V66	100	70	Modern upwind turbine
Vestas V80	60	79	Influenced by wave action from the Atlantic Ocean (HGC Engineering, 2006)
GE 1.5MW	300	67	Modern upwind turbine
Nordex N-80	200	60 (7m/s)	Measurements were made downwind from 5m/s to 12m/s. The level increases by approximately 1 dB(G) for each 1m/s increase in wind speed from 5m/s
DTI Wind Farm	1000	65	Details of the turbine type were not provided in the DTI study. The wind farm included seven turbines (DTI, Hayes McKenzie, 2006)
Siemens SWT 2.3-93	300	73	Measured as part of the “Epsilon” study (O’Neal, 2009)
GE 1.5sle	300	70	Measured as part of the “Epsilon” study (O’Neal, 2009)
Clements Gap	85	72	Modern upwind turbine
Clements Gap	180	67	Modern upwind turbine
Clements Gap	360	61	Modern upwind turbine
Cape Bridgewater	100	66	Modern upwind turbine, influenced by the ambient noise environment
Cape Bridgewater	200	63	Modern upwind turbine, influenced by the ambient noise environment

The main source of uncertainty associated with the measurement of infrasound is the influence of wind on the microphone. The methodology used by the international studies is not explicitly nominated, and therefore the contribution of wind on the microphone in the above results is not known. However, the infrasound associated with the turbines will be at most the same and more likely less than the results in the above table.

This study employs a specific methodology that aims to reduce the influence of wind on the microphone and therefore the extent of the uncertainty in the infrasound attributable to the turbines. However, the influence of wind and the presence of infrasound in the ambient environment when measuring in the vicinity of the coast, as is the case at Cape Bridgewater, are still expected to influence the results. Therefore, as for the international studies, the uncertainty predominantly relates to the extent that the infrasound from the turbines is below the results presented in this report.

Jakobsen, J. 2005 notes the following with respect to review of the data available for the 2005 works:

> *….the level from an upwind turbine of contemporary design at 100m distance would be about 70 dB(G) or lower, while the level from a downwind machine can be 10 to 30 dB higher.*

The results of this study show infrasound noise levels of the order of 60 to 70 dB(G) in close proximity to wind turbines. Based on the above table, these levels show consistency with other International measurements of modern upwind turbines. In addition, the measured noise levels in this study are provided by a detailed methodology that reduces the influence of the wind and therefore the uncertainty for the results.

CONCLUSION

The following conclusions can be made from the results of the study:

- Wind turbines generate infrasound, however, measurements made both outside and inside and at a variety of distances significantly less than separation distances between wind farms and dwellings, indicate the infrasound produced by wind turbines is well below established guideline perception thresholds;
- The level of infrasound that has been measured in both a rural coastal and an urban environment is of the same order as that measured within 100m of a wind turbine.

The following figure overlays the compiled results of the study:

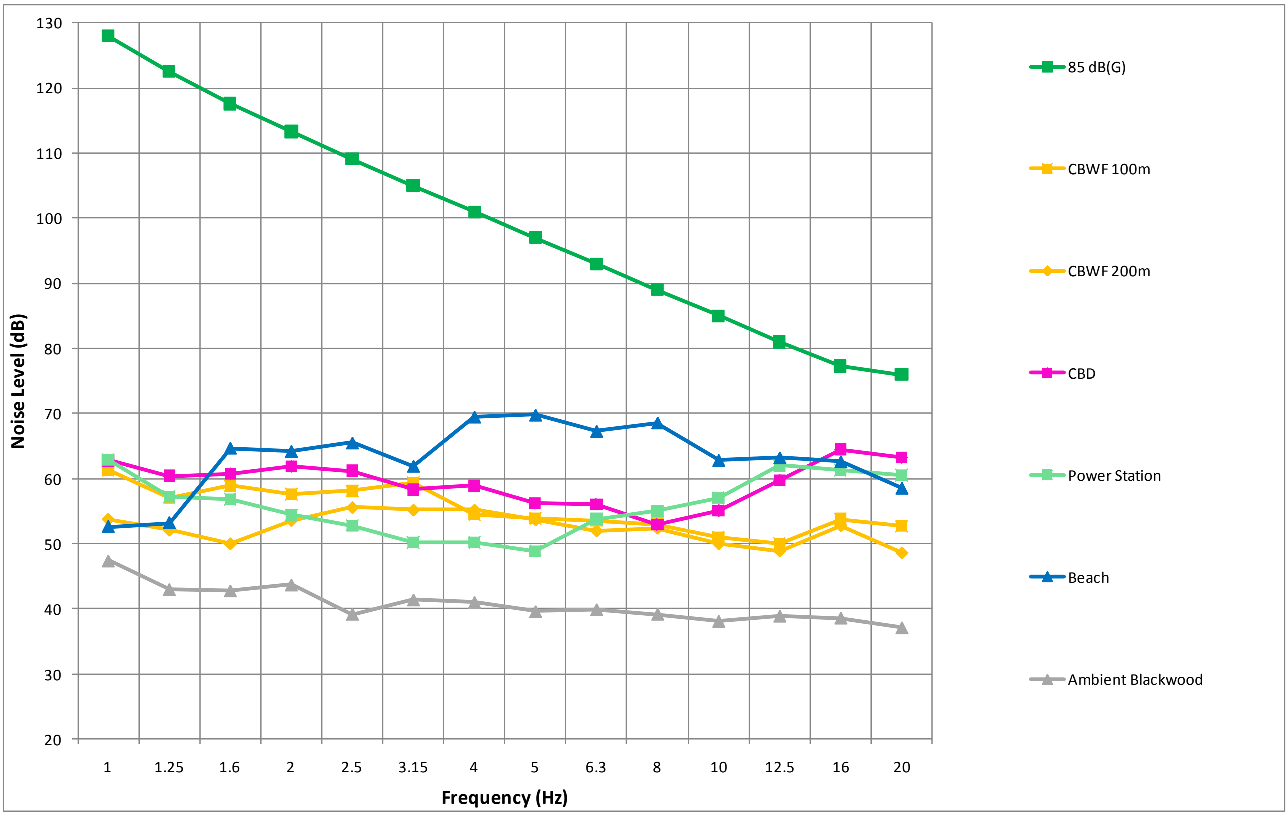


Figure 12 - Summary of Measurements Cape Bridgewater Wind Farm (CBWF)

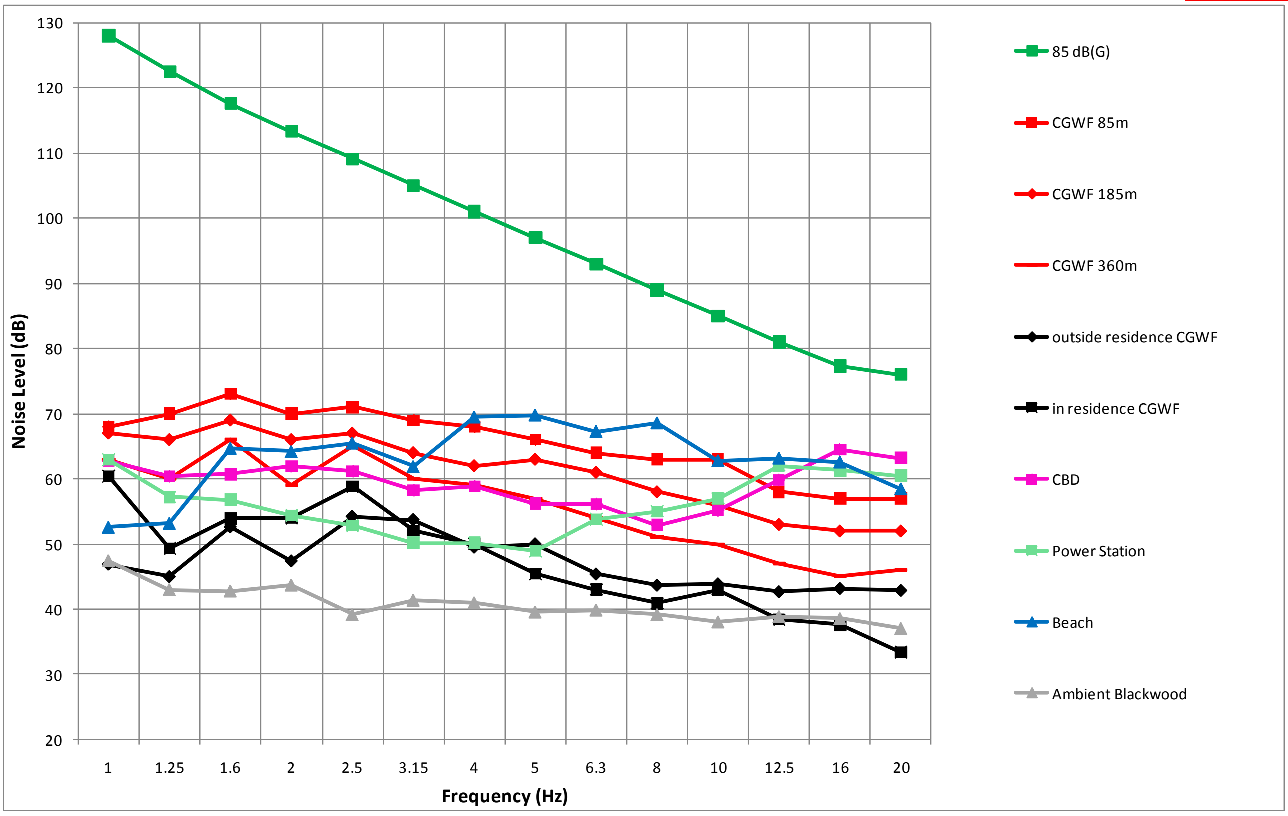


Figure 13 - Summary of Measurements Clements Gap Wind Farm (CGWF)

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Low Frequency Noise and Wind Turbines

Keele University Rejects Renewable Energy Foundation's Low Frequency Noise Research Claims

August 2005

Following a press release from the Renewable Energy Foundation (REF) and the associated article in the Scotsman at the beginning of August 2005, Professor Styles's team at Keele university have put together a rebuttal to what was a misinterpretation and confusion of various studies. Below is also included the original REF release and Scotsman article.

Wind farm noise
by (PROF) PETER STYLES, President, Geological Society of London,
SAM TOON, Keele University, Staffordshire

We are writing to clarify some misconceptions in your report (8 August) about wind farm noise. While it is technically correct that "*vibrations can be picked up as far away as 10km*", to give the impression that they can be felt at this distance is highly misleading.

The levels of vibration from wind turbines are so small that only the most sophisticated instrumentation and data processing can reveal their presence, and they are almost impossible to detect.

The Dunlaw study was designed to measure effects of extremely low level vibration on one of the quietest sites (Eskdalemuir) in the world, and one which houses one of the most sensitive seismic installations in the world.

Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise - they are not confined to wind turbines.

To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health.

It is, however, an issue for the Eskdalemuir seismic array, as it can detect this level of vibration. It is designed to detect explosions and earthquakes of a low magnitude from all over the world.

The infrasound generated by wind turbines can only be detected by the most sensitive equipment, and again this is at levels far below that at which humans will detect the low frequency sound. There is no scientific evidence to suggest that infrasound has an impact on human health.

Wind-farm noise rules 'dated'
by JAMES REYNOLDS - The Scotsman

Guidelines on noise from wind farms urgently need to be revised, research suggests.

One study on the modern, tall turbines now used, conducted at Dunlaw wind farm in the Borders, found that when the 60-metre turbines start to generate electricity, even at low wind speeds, vibrations can be picked up as far away as 10km.

Earlier studies concluded there was no significant risk to health from vibrations produced by wind farms.

But campaigners say this research was done on much smaller turbines than those used today.

The research on the Dunlaw wind farm is backed up by a study just published by acoustic experts at the University of Groningen in the Netherlands. It also claims that measurable, low-frequency noise is present and is relevant to the audible noise nuisance often reported.

Professor Peter Styles, who led the team from Keele University that studied Dunlaw wind farm, said: "*We have clearly shown that wind turbines generate low-frequency sound [infrasound] and acoustic signals which can be detected at considerable distances [many kilometres] from wind farms on infrasound detectors and on low-frequency microphones.*

"*When the wind farm starts to generate at low wind-speeds, considerable infrasound signals can be detected at all stations out to 10km.*"

Professor John Ffowcs Williams, professor of engineering at Cambridge University and a world expert on acoustics and noise reduction, said: "*The regulations are dated and in other ways inadequate. It is known that modern, very tall turbines do cause problems, and many think the current guidelines fail adequately to protect the public.*"

Jason Ormiston, wind energy officer for the industry body Scottish Renewables, said: "*Expert opinion recognises there is no direct effect on human health from noise at the level generated by wind turbines.*"

Dr Geoff Leventhall, consultant in noise, vibration and acoustics and the author of a government report on low-frequency noise and its effects, says: "*I can state quite categorically that there is no significant infrasound from current designs of wind turbines.*"

REF PRESS RELEASE
4th August 2005

Studies on Wind Turbine Noise Raise Further Concerns

Two studies recently analysed by the Renewable Energy Foundation have today raised further concerns over Wind Turbine noise.

REF supported further research by G. P. van den Berg, of the Faculty of Mathematics and Natural Sciences, University of Groningen into the presence of low frequency components in wind turbine noise. G. P. van den Berg's work establishes that measurable low frequency noise is present, and is relevant to the audible noise nuisance commonly reported. This reinforces doubts shared by many acousticians with regard to the continuing usefulness of current UK noise regulations relating to wind turbines, ETSU-R-97, which are now some ten years old, and refer to a previous generation of much smaller turbines.

Hitherto, it has been assumed that low-frequency sound from wind turbines has not been a major factor contributing to annoyance as the blade passing frequency is of the order of one hertz where the human auditory system is relatively insensitive. This argument, however, can now been seen to obscure a very relevant effect: the blade passing frequency modulates well audible, higher-frequency sounds and thus creates periodic sound. This means that residents near wind turbines have observed that, often late in the afternoon or in the evening the turbine sound acquires a distinct 'beating' character, the rhythm of which is in agreement with the blade passing frequency, and that this effect is stronger for modern (tall) wind turbines.

Professor Peter Styles and his team at Keele University have very recently also published a major study on vibrations from the 60m high wind turbines at Dunlaw. Interesting findings in this second report include that '*When the windfarm starts to generate (even) at low wind speeds, considerable infrasound signals can be detected at all stations out to c 10km*' (p. 66). *We have clearly shown that wind turbines generate low frequency sound (infrasound) and acoustic signals which can be detected at considerable distances (many kilometres) from windfarms on infrasound detectors and on low-frequency microphones.*'

Whilst earlier studies conclude there was no significant risk to human health from vibrations produced by wind-farms, these studies are dated, and refer to older, much smaller turbines. Concern is increased as most modern wind turbines are in excess of 100m (much bigger than those at Dunlaw), and developers are proposing to install these devices as close as 650m to human habitation (sometimes closer).

Professor Ffowcs-Williams, Emeritus Rank Professor of Engineering at the University of Cambridge, one of the UK's leading acoustical experts and an advisor to REF, said: "*Van den Berg's paper adds weight to the criticisms frequently offered of UK regulations covering wind turbine noise, ETSU-R-97. The regulations are dated and in other ways inadequate. It is known that modern, very tall turbines, do cause problems, and many think the current guidelines fail adequately to protect the public. This is a rapidly evolving field, and knowledge is growing fast. The Keele report, for example, is very important, and raises further questions with regard to the effect that modern wind turbines have on local residents. Sensitivity to lower frequency vibration varies considerably between individuals, and with Professor Styles providing clear evidence of detectable low frequency vibration at very large distances (10km), even from smaller turbines, it is entirely sensible to ask whether these cause problems for sensitive individuals living in much closer proximity. It really is time for the DTI to clear the air on this one, and institute a comprehensive and fully transparent study, obtaining data from the United States and Europe, as well as the United Kingdom.*"

For more information and an extensive Technical Annex on low frequency noise studies, see BWEA briefing on Low Frequency Noise and Wind Turbines.

PRELIMINARY ASSESSMENT OF THE IMPACT OF WIND FARMS ON SURROUNDING LAND VALUES IN AUSTRALIA

Prepared for:

NSW Valuer General

August 2009

CONTENTS

EXECUTIVE SUMMARY

- The aim of this study was to conduct a preliminary assessment on the impacts of wind farms on surrounding land values in Australia, mainly through the analysis of property sales transaction data. This included consideration of the contribution of various factors (including distance to a wind farm, view of a wind farm, and land use) to any price changes, positive or negative.

- A review of wind farms currently operating in Australia revealed that they have been developed in locations generally removed from densely populated areas. As a result the small samples of sales transactions available for analysis limited the extent to which conclusions could be drawn.

- This study investigated eight (8) wind farms across varying land uses (rural, rural residential, residential) using conventional property valuation analysis. Two (2) wind farms were selected in NSW and six (6) in Victoria.

- The main finding was that the wind farms do not appear to have negatively affected property values in most cases. Forty (40) of the 45 sales investigated did not show any reductions in value. Five (5) properties were found to have lower than expected sale prices (based on a statistical analysis). While these small number of price reductions correlate with the construction of a wind farm further work is needed to confirm the extent to which these were due to the wind farm or if other factors may have been involved.

- Results also suggest that a property's underlying land use may affect the property's sensitivity to price impacts. No reductions in sale price were evident for rural properties or residential properties located in nearby townships with views of the wind farm.

- The results for rural residential properties (commonly known as 'lifestyle prop's') were mixed and inconsistent; there were some possible reductions in sale prices identified in some locations alongside properties whose values appeared not to have been affected. Consequently, no firm conclusions can be drawn on lifestyle properties.

- Overall, the inconclusive nature of the results is consistent with other studies that have also considered the potential impact of wind farms on property values.

- Further analysis (with additional data and expansion of the study area to other states) may yield more comprehensive results. Notwithstanding this, further studies are also likely to be limited by the availability of sales transaction data.

1. INTRODUCTION

1.1 INSTRUCTION

PRESTON ROWE PATERSON NEWCASTLE AND CENTRAL COAST WAS FORMALLY INSTRUCTED BY:

Richard Sollorz for and on behalf of Department of Lands

INSTRUCTION DATE	26/06/2009
PURPOSE OF REPORT	TO CONDUCT A PRELIMINARY ASSESSMENT OF THE IMPACT OF WIND FARMS ON SURROUNDING LAND VALUES

The report conforms to the Professional Ethics and Practice Standards of the Australian Property Institute.

1.2 BACKGROUND

Renewable energy - and wind energy in particular - is growing strongly in NSW and Australia. This growth is expected to increase with the introduction of the Commonwealth's Renewable Energy Target to 20 per cent of Australia's electricity supply by 2020, which is expected to drive major new investment.

The impact of wind farms on surrounding land values is a common source of conflict between proponents and objectors to proposed wind farms. This is hampered by the fact that there is relatively limited objective information available on this issue, including in a NSW context.

1.3 PURPOSE

The main purpose of this study is to provide objective and credible information to allow the issue to be considered in a more constructive fashion.

Furthermore, information was sought on the contribution of various factors (including distance to a wind farm, view of a wind farm, and land use) to any price changes, positive or negative.

1.4 SCOPE OF DILIGENCE

This report has been written in response to a request from the NSW Valuer General for a preliminary study on the impact of wind farms on surrounding land values in Australia. The aim of this study was to undertake a preliminary investigation through the analysis of property sales transaction data.

The authors have attempted to review all of the literature on the topic to date, and have completed a study based on the most appropriate methodology given both the sample data characteristics and the reporting time frame.

2. CONTEXT

Wind farms in Australia are a relatively new industry. The first wind farm connected to the national energy grid was built in 1998 at Crookwell in NSW. Since then, 42 wind farms have been built in Australia with many more in planning or feasibility stages (Wikipedia, 2008). In addition to the production of renewable energy, the wind farms typically provide economic benefits for the host towns. Economic benefits include the creation of jobs during construction, ongoing maintenance jobs, rental income for properties with wind turbines on them and, in some cases, increased tourism.

However, there are often community concerns emanating from perceptions about the impact a wind farm could have on the value of the surrounding properties. These perceptions are understandable as visual impacts which alter the aesthetics (i.e. views) of a property and noise are known to be able to effect property values (Simons & Saginor, 2006 cited in Hoen & Wiser, 2008). Some examples of the potential influence of aesthetics and noise are listed below.

Aesthetics:

- Properties with water views generally sell for a higher price than those without water views.
- Views of high powered transmission lines can reduce the value of a property.
- Views of highways can reduce property values.

Noise:

- Properties on main roads often sell for a lower price than those located away from main roads where there is less traffic noise.
- Properties under aircraft flight paths frequently sell for a lower price than those nearby.

A wind farm has the potential to impact the area surrounding it both visually and audibly. A wind turbine is a large structure commonly around 100 meters in height with three (3) blades with diameters almost as large as the height of the base tower. The aesthetics of a view of a wind farm are affected by the distance the observer is located away from the wind farm, the positioning, and the number of turbines. Turbines positioned closer together generally have a greater potential to impact on the aesthetic appearance than those that are spaced further apart. As the density of turbine placement increases the potential for the wind farm to take on more industrial like appearances increases. However, whether the view of a wind farm is considered to be a negative one or not is largely subjective and studies looking at people's perceptions often find varying opinions (Bond, 2009; RICS, 2004).

Wind turbines also generate noise that can be heard at varying distances, depending on a range of factors such as topography and weather conditions. The type of noise produced by a wind turbine is low frequency and has been qualitatively described as a "swishing noise" that is repetitive in nature (Bond, 2009).

While wind farms can impact views and generate noise, studies completed to date analysing sales transaction data have not found consistent evidence of obvious discernible negative impacts on property values due to the presence of wind farms. A review of the current literature on the topic follows.

3. LITERATURE REVIEW

There has been little research in Australia and overseas on the impacts of wind farms on surrounding property values. The limited research that has been completed generally falls into two categories:

- Studies that have analysed property sales transaction data, and
- Studies that have investigated the opinions of residents and/or property industry professionals on the impact of wind farms.

3.1 PROPERTY SALES TRANSACTION DATA RESEARCH

A summary of previous studies which have analysed sales transaction data is presented below. The studies vary in size and methodology. While some studies have found slight negative impacts, the larger more comprehensive studies have generally found no statistical evidence of reductions in value associated with the development of a wind farm. A more detailed description is provided in the following subsections.

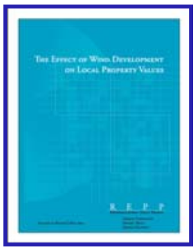
Author (Year)	Nation	Methodology	Finding
Jorgenson (1996)	Denmark	Sample: 102 locations Analysis: Hedonic price modelling	Slight reduction in value found.
Sterzinger et. al. (2003)	US	Sample: 25,000 Analysis: Hedonic price modelling	Increases in values found.
Henderson & Horning (2006)	Australia (Crookwell, NSW)	Sample: 78 Analysis: Conventional valuation analysis	No reduction in value found.
Sims & Dent (2007)	UK	Sample: 1,052 Analysis: Hedonic pricing modelling	No conclusive statistical relationship found.
Hoen & Wiser (2008)	US	Sample: 450. Analysis: Hedonic price modelling with physical inspections of each sale. Possibly most robust study to date.	No statistical relationship found. Some isolated cases of value reduction.
Hives (2008)	Australia (Waubra, Victoria)	Sample: 12 Analysis: Conventional valuation analysis	No reduction in value found for rural properties. Possible reduction found in lifestyle properties.
Jess (2008)	Australia (Victoria)	Sample: 7 Analysis: Conventional valuation analysis	Revealed developer had purchased surrounding properties. One property value estimated to have reduced by 30% but subjective.

3.1.1 *"Social Assessment of Wind Power: Visual; Effect and Noise from Windmills – Quantifying and Valuation" – Jørgensen (1996) - Denmark*

One of the earliest studies that investigated the impacts of wind farms on property prices was conducted by Jørgensen (1996) in Denmark. The impact of wind farms on property sale transaction prices in 102 locations were analysed using a 'hedonic' pricing method. Hedonic modelling investigates the relationship between variables and an item being investigated (such as property value) by deconstructing the item being researched into its constituent characteristics and obtaining estimates of the contributory value of each characteristic. This is usually achieved through a statistical method known as 'regression analysis' (Wikipedia, 2008).

Jørgensen (1996) found that, on average, properties located close to a wind turbine sold for 16,200 DKK (approximately $3,700 AUD) less than those located further afield. Furthermore, on average properties located close to 12 or more wind turbines sold for 94,000 DKK (approximately $21,600 AUD) less than those located further afield. However, as noted by Sims and Dent (2007) the impact overall was relatively small and some of the results were not statistically significant.

3.1.2 *"The Effect of Wind Development on Local Property Values" – Sterzinger, Beck & Kostiuk (2003) – United States*



One of the largest studies completed to date was undertaken in the USA by Sterzinger, Beck and Kostiuk (2003). The report was commissioned and published by the Renewable Energy Policy Project (REPP). The study compared the average monthly change in value of properties across three scenarios:

- First scenario - compared changes in value of (a) properties located in the view shed of a wind farm with (b) properties in a comparable region for a period of three (3) years before the wind farm started operating and three (3) years after it started operating.
- Second scenario - compared changes in value of properties located in the view shed of a wind farm (a) in the period <u>before</u> the wind farm started operating to (b) changes in the period <u>after</u> it started operating.
- Third scenario - compared changes in value of properties located in the view shed of a wind farm with properties in a comparable region but only for the period after the wind farm started operation.

The view shed of a wind farm was defined to include those properties located within a five (5) mile radius (approximately eight (8) kilometers) of a wind turbine. Comparable regions were selected based on the area not having a view of the turbines and having similar demographics to the view shed areas. This was performed across ten (10) wind farm locations and a total of 25,000 property sales were analysed. This resulted in 30 separate analyses (Sterzinger et al., 2003).

In all but four (4) of their analyses Sterzinger et al. (2003) found that the change in property values was positive and greater in areas affected by the wind farm than in the comparison area.

Sterzinger et al. (2003) concluded that property values generally increased faster after a wind farm started operating and faster within the view-shed of the wind farm than in comparable areas located further away from wind farms.

3.1.3 *"Property Stigma: Wind Farms Are Just the Latest Fashion" – Sims & Dent (2007) – United Kingdom*


Property stigma: wind farms are just the latest fashion

Sims and Dent (2007) investigated the impacts of wind farms on property values in the UK. The study was based on an analysis of 1,052 sales of houses over a period of five (5) years from areas surrounding two (2) wind farms in Cornwall in the UK. The two (2) wind farms were selected based on a sufficient number of residential properties being located within five (5) miles (approximately 8 kilometres) from the turbines. A third wind farm was also selected for analysis, however, the presence of an open cut mine next to the residences was considered to limit the extent to which conclusions could be drawn in this area.

Sales were adjusted to an inflation index to allow for the analysis of the present value of each property in the sample. The data was then analysed using multiple regression, correlation and frequency analysis with the main variable analysed being the distance between the properties and the wind turbines.

The results of Sims and Dent (2007) were varied for different models. Overall, there was no conclusive relationship found between distance to a wind farm turbine and property price with only terraced and semi detached properties located in a mid range (3.5 to 4 miles) from a wind farm found to be related to a reduction in property price.

Sims and Dent (2007) conclude by outlining that their results may be more reflective of the fact that wind farms are developed in suitable sites (e.g. rural areas) where potential impacts are likely to be minimised.

3.1.4 *"The Effects of Wind Facilities on Surrounding Properties - Preliminary Results" – Hoen & Wiser (2008) – United States*

Hoen and Wiser (2008) recently presented preliminary results of a two (2) year study into the impacts of wind farms on surrounding property values in the United States. The research appears to be one of the most comprehensive studies to be carried out to date. The study employed hedonic pricing models to test the effects of wind farm impacts on sales transaction prices while controlling for variables such as dwelling size, land size, dwelling condition and quality of views. The authors inspected each property and rated the properties quality of views and the extent to which wind turbines impacted on the views. This was carried out at 10 different wind farms across the country with more than 450 property sales at each wind farm investigated. This provided the sample for subsequent statistical analysis.

The study assessed whether sale prices were affected by virtue of being simply located near a wind farm (termed "area stigma"). This was tested by comparing price changes after the construction of a wind farm with price levels before the announcement of the wind farm while controlling for house price inflation. This was carried out annually for up to four (4) years after the completion to test for effects of time. Preliminary analysis indicated no evidence of price reduction in any period after the construction of a wind farm.

The extent to which views of wind turbines contribute to property price changes (termed "scenic vista stigma") was also assessed. This was tested by comparing (a) sales of homes with views (based on the qualitative rating of the view) with (b) sales of homes without views. Preliminary analysis indicated that there was no significant difference between sale prices of homes with views and those without views.

The final assessment considered possible "Nuisance Effects" of dwelling being located very close to wind turbines (within ¼ mile, ½ mile and one (1) mile). This was tested by comparing sales of closely located properties with those located further away. Preliminary analysis indicated that there was no statistical evidence that dwellings located close to a wind farm sell for less than those located further away.

Hoen and Wiser (2008) did note that although there may be isolated cases of reductions in value, the largest potential effect found was a 15% reduction in sale price when located within ¼ mile of a wind turbine, these effects are not widespread in their sample.

The study is currently ongoing. When completed, it will provide a comprehensive piece of research that will likely make a substantial contribution to the issue at hand.

3.1.5 *"Land Value Impact of Wind Farm Development: Crookwell NSW" – Henderson & Horning (2006) – Australia*

Henderson and Horning Property Consultants prepared a report on behalf of Taurus Energy Pty Ltd on the effect of the Crookwell Wind Farm in NSW Australia on local property values. Taurus is the proponent of the wind farm.

The report included an analysis of 78 property sales surrounding the Crookwell Wind Farm over a period of 15 years from 1990 to January 2006. Sales of properties in the view shed of the wind farm (using a 6 kilometre threshold) were compared with sales of those not in the view shed.

No reductions in property values for were found for properties in the view shed of the wind farm.

3.1.6 *"Wind Farms: The Local Experience" – Hives (2008) - Australia*

In August 2008, two presentations were given by property valuation consultants at the Australian Property Institute's (API) Country Conference on recent work they had completed on wind farms and surrounding property values. Hives (2008) presented an analysis of individual sales transactions from properties surrounding the Waubra wind farm near Ballarat in Victoria. The wind farm was being constructed at the time of the study, although many turbines had already been erected. Hives hypothesised that:

- Agricultural land with turbine leases would become more valuable
- Adjoining agricultural land values would not be affected
- Lifestyle properties and residential properties located in the town might be affected

Results of 12 individual sales analysis indicated that:

- Properties benefiting from turbine leases increased in value.
- Rural properties were unaffected.
- Some detrimental effects were evident on lifestyle properties.

Hives (2008) concluded that lifestyle values had the greatest potential to be affected as a large part of their value is typically derived from the aesthetic qualities of the surrounding environment.

3.1.7 *"Negative Affects to Property Values near Wind Farm Developments in South Gippsland" – Jess (2008) - Australia*


"NEGATIVE AFFECTS TO PROPERTY VALUES NEAR WIND FARM DEVOLPMENTS IN SOUTH GIPPSLAND"

Brief overview of Wind Farms and the affects to property values in the South Gippsland area, focussing on Wonthaggi, Bald Hills, Dollar, Toora and Devon North

In a separate presentation at the API Country Conference Jess (2008) presented a range of sales transactions that had occurred at the Toora wind farm in south east Victoria. The sales transactions indicated that the wind farm developer had been purchasing surrounding properties following planning approval and completion. Also, a sales transaction of a 'lifestyle' property which sold both before and after the construction of the wind farm was presented. The property was located close to the wind turbines with substantial views of the turbines. It was estimated that the sale after the construction of the wind farm was approximately 30% below the market value of the property had the wind farm not existed. However, this was a single transaction and such a decrease has not been evident in other sales nearby.

3.2 PERCEPTUAL STUDIES

In addition to research on property sales transaction data, there has also been some research conducted into local residents' and industry professionals' opinions of the effect of wind farms. Perceptual research generally indicates that a portion of the public both in Australia and internationally believe that wind farms negatively affect property values.

3.2.1 *"A Tale of Two Windy Cities: Public Attitudes towards Wind Farm Development" – Bond (2009) - Australia*

Bond (2009) researched public attitudes towards wind farms and property values among residents living in the towns Albany and Esperance, Western Australia (WA). Each town is located close to a wind farm in WA. The siting of the wind farms in these locations was deemed to be too far away (more than 10 kilometers) from residential areas to conduct hedonic modeling. Rather postal surveys were used in order to gain a qualitative understanding of resident's attitudes towards the wind farms. A total of 800 paper surveys were posted to Albany with a 38% response rate. Additionally 500 surveys were posted to Esperance with a 21% response rate.

Survey responses indicated that residents generally considered wind farm developments to be positive providing they were located a sufficient distance away from homes as to not disturb them. The distance reported to be acceptable was generally over five (5) kilometers away. Approximately two thirds of Albany residents and one third of Esperance residents felt more in favor of the wind farms after the farms were completed.

Over two thirds of survey respondents indicated that a wind farm would not influence the price they would be willing to pay for a property. On the other hand, nearly a quarter of survey respondents indicated that they would pay less, with 38% indicating they would pay 1-9% less, while 22% of respondents indicated they would pay 10-19% less.

3.2.2 *"Impact of Wind Farms on the Value of Residential Property and Agricultural Land" – RICS (2004) – United Kingdom*

A survey of members of the UK Royal Institute of Chartered Surveyors in 2004 found that 60% of the 405 respondents believed residential property values decreased if the property was in view of a wind farm. Further, 72% of respondents believed wind farm developments had either no effect or a positive effect on the agricultural value of the land. Visual impact, fear of blight and the proximity of a property to a wind farm were considered the main drivers to reductions in property values.

3.2.3 *Bald Hills Wind Farm Panel Inquiry (2004) - Australia*

As reported in the Bald Hills Wind Farm Panel Inquiry (2004), similar views on the impact of wind farms were expressed by Australian property industry professionals. In June 2004 the Victorian Minister for Planning appointed a panel to examine a proposal for a wind farm at Bald Hills, near Tarwin Lower in South Gippsland, Victoria. The Panel's inquiry included a report on the effects of the wind farm development on property values. The Panel considered a number of submissions from property valuers and real estate agents. The Panel's response to the submissions was:

"All that appears to emerge from the range of submissions and evidence on valuation issues is the view that the effect of wind energy facilities on surrounding property values is inconclusive, beyond the position that the agricultural land component of value would remain unchanged. On this there appeared to be general agreement. It therefore follows that it has not been demonstrated to the satisfaction of this Panel that significant value changes, transfers or inequities would result from the project proceeding."

In their final conclusion on property values, the Panel noted that valuation effects from the wind farm development may occur, specifically, devaluation of the amenity, lifestyle and non-agricultural development component of the surrounding land. However, the Panel also noted that these effects would not impact the planning permit as the wind farm is permissible within the rural land use zone and is consistent with relevant planning guidelines (Bald Hills Wind Farm Panel Inquiry, 2004).

3.2.4 *Judicial Interpretation on Compensation Issues - Australia*

The issue of compensation in regards to the reduction in values of surrounding properties of a wind farm development has been ruled upon in a case in the Land and Environment Court of NSW.

In February 2007, in *Taralga Landscape Guardians Inc v Minister for Planning and RES Southern Cross Pty Ltd,* the plaintiff (Taralga Landscape Guardians) argued that properties surrounding the wind farm development would suffer from blight in the form of loss of future property value or from loss of amenity and, consequently, there should be payment of compensation if the project where to proceed. The judgement ruled in favour of the defendant:

> *"If the concepts of blight and compensation, as pressed by the Guardians, were to be applied to this private project (a proposition which I reject) then any otherwise compliant private project which had some impact in lowering the amenity of another property (although not so great as to warrant refusal on general planning grounds when tested against the criteria in s 79C of the Act) would be exposed to such a claim.*
>
> *Creating such a right to compensation (for creating such a right it would be) would not merely strike at the basis of the conventional framework of landuse planning but would also be contrary to the relevant objective of the Act, in s 5(a)(ii), for "the promotion and co-ordination of the orderly and economic use and development of land"."*

While this case does not answer the question as to whether a property reduces in value due to the development of a wind farm, it sets a clear precedent as to how the courts may view compensation claims in relation to this.

From the literature review, it is apparent that the perceptions of the negative effect on land values are not borne out by the statistical analysis of sales data, except in very few cases.

4. METHODOLOGY

4.1 SAMPLE SELECTION

A total of eight wind farm sites were selected for analysis comprising six (6) wind farms from Victoria and two (2) from NSW. Victorian wind farms selected were Waubra, Challicum Hills, Toora, Wonthaggi, Cape Bridgewater and Codrington/Yambuk. NSW wind farms selected were Blayney and Capital. A review of wind farms completed in Australia to date and the eight (8) sites selected is shown in the table overleaf.

Wind farm sites were selected based on the availability of market data (i.e. property sale transactions) and the surrounding land use. The aim was to select sites from differing surrounding land uses including rural land, rural residential/lifestyle land and urban housing.

On investigation it was evident that wind farms completed in Australia are generally located in rural areas, either inland or on the coast, but visually removed from densely populated areas. This limited the availability of property sales transactions data for analysis.

Of the five wind farms completed to date in NSW, only Blayney and Capital were selected for analysis. Crookwell has been comprehensively covered by Henderson and Horning (2006), while Hampton and Kooragang were considered too small, with each having only around one (1) MW capacity (1-2 turbines).

In Australia, at the time of investigation it was rare for a project to be less than 30 MW and an average scale is closer to 100 MW. In NSW, it is understood that the trend is towards larger projects. The median generating capacity of planned projects in NSW is understood to be around 200 MW, while the average is closer to 300 MW. As there were limited sites in NSW with larger sites being located in other states the sample selection was expanded to include wind farms outside of NSW.

The largest concentrations of wind farms in Australia are in Victoria and South Australia. Aerial photography analysis indicated that South Australian wind farms were located in remote areas that have limited, if any, surrounding development. Similar conditions were evident at Victorian wind farms, although a number of Victorian wind farms appeared to be located closer to more densely populated areas. Victorian wind farms were selected for analysis on the basis that they provided the best opportunity to yield the most sales transaction data from sites across differing land uses.

Project Name	Capacity (MW)	Surrounding Land Use	Selected
NSW			
Capital Wind Farm	177	Rural	✓
Blayney Wind Farm	10	Rural/State Forest	✓
Crookwell Wind Farm	5	Rural	
Hampton Wind Park	1	Rural/Forest	
Kooragang , Newcastle	<1	Industrial	
SA			
Snowtown Wind Farm (Barunga Ranges)	170	Rural/Rural Township	
Lake Bonney Wind Farm - Stage 2	159	Coastal Rural/Small Coastal Town	
Hallett Wind Farm - Hallett 1 Brown Hill	95	Rural/Rural Township	
Wattle Point Wind Farm	91	Coastal Rural/Small Coastal Town	
Lake Bonney Wind Farm - Stage 1	81	Coastal Rural/Small Coastal Town	
Mount Millar Wind Farm	70	Rural/Forrest	
Cathedral Rocks Wind Farm	66	National Park	
Canunda Wind Farm	46	Coastal Rural/Small Coastal Town	
Starfish Hill Wind Farm	35	Coastal Rural/Small Coastal Town	
Coober Pedy	<1	Desert	
VIC			
Waubra Wind Farm	192	Rural/Rural Township	✓
Challicum Hills Wind Farm	53	Rural	✓
Cape Bridgewater	51	Rural/Coastal Lifestyle	✓
Yambuk	30	Coastal Rural	✓
Toora Wind Farm	21	Coastal Rural/Small Coastal Town	✓
Codrington Wind Farm	18	Coastal Rural	✓
Wonthaggi Wind Farm	12	Coastal Rural/Small Coastal Town	✓
QLD			
Thursday Island	<1	Coastal Township	
Windy Hill Wind Farm	12	Rural/Forest	
TAS			
Woolnorth Wind Farm	140	Coastal Rural	
Musselroe Wind Farm	138	Coastal Rural	
Huxley Hill Wind Farm	3	Coastal Rural/Small coastal Town	
WA			
Walkaway Wind Farm	90	Rural	
Emu Downs Wind Farm	80	Rural	
Albany Wind Farm	21	Coastal Bushland/National Park	
Nine Mile Beach	4	Coastal Bushland	
Ten Mile Lagoon	2	Coastal Bushland	

*Approximate. Values rounded. Please note Codrington and Yambuk wind farms are located next to each other and considered as one site in the analysis.
Source: Department of Lands, Wikipedia (2008).

4.2 ADPOTED METHOD OF ANALYSIS

Wind farm sites were investigated using the following analytical techniques:

- 'Before and after' sales analysis
- 'Matched pairs' sales analysis

The process involved in each of these is described below. These are conventional valuation techniques and have been widely used and accepted by the industry in property compensation matters. Additionally, a direct comparison of sales provides reasonably clear evidence as to whether or not there is a difference in price attributable to a property's proximity to a wind farm.

The 'before and after' method was mainly applied to Victorian sites due to limited sales data able to be investigated within the bounds of the preliminary scope of the exercise. Conversely, the 'matched pairs' method was mainly applied to one (1) NSW site as it provided sufficient data for this type of analysis.

For each of the wind farm sites all of the property sales transactions that occurred in a ten (10) kilometre radius from the wind farm in the period after construction had begun were investigated and analysed. The analysis was generally limited to sales that had occurred up to four (4) years after construction of the wind farm, but in some cases due to low number of sales the search was extended to include all sales available to date. Sample wind farms sites were physically/visually inspected, and properties were categorised according to whether a wind farm was visible from the property or not.

Limited discussions were also held with local property professionals to gauge anecdotally how the local market had perceived the wind farms.

4.2.1 *Rationale*

Due to limitations surrounding sales data availability and large differences in the physical characteristics of properties, the sample was not considered suitable for hedonic modelling techniques as used in previous research (Hoen & Wiser, 2008; Sims & Dent, 2007; Sterzinger, Beck & Kostiuk, 2003).

The availability of sale data for analysis was limited as much of the wind farm development that has occurred to date has been in remote and/or farmland areas with low population densities and a corresponding small number of property sales. This limited the scope for statistical analysis.

Additionally, there was significant variation in the characteristics of the properties surrounding the wind farms; this included characteristics which are commonly known to influence the value or sale price of a property. Examples include land size, dwelling size, dwelling condition, and improvements. These differences further limited the extent to which sales data could be compared using statistical analysis.

Also, the use of hedonic price indexes in conjunction with statistical analysis can have its problems. A complex array of factors affects property sales prices (especially residential properties). Some difficulty can usually be expected in deriving a meaningful coefficient for the detriment being studied (in this case, sale price reductions). Because of this, studies which concentrate on a conventional valuation analysis of individual sales can provide useful results depending upon the data being available.

4.2.2 *'Before and After' Method*

In the 'before and after' method:

1. The percentage change in sale price was calculated for properties that sold before the construction of a wind farm and after the construction of a wind farm.
2. The percentage change in sale price was then compared to the market movement in the local area (i.e. the wider local government area).
3. Those properties that showed a change in value that did not keep pace (i.e. was less than) the market movement were deemed to be possibly affected by the wind farm.
4. Properties that showed a change in sale price that was either higher or in line with the broader market movement were deemed to not have been negatively affected by the wind farm.
5. Where possible, factors in addition to the wind farm that could influence a change in a property's sale price were noted, for example, an improvement to the property in between the sale dates, although the capacity to do this was limited to some extent by the preliminary scope of the assessment.

The comparable market movement was calculated using the change in median value of the local government area (LGA) in which the wind farm was located. The LGA area was considered to be large enough that the LGA median sale price value would not be materially affected by any wind farm related impacts. It should be noted that the trend in LGA median sale price may differ to corresponding trends in individual suburbs. This difference may be even more pronounced when comparing different property types. Notwithstanding this, on balance the LGA median sale price value was considered the best representation of the broader market movement available.

In some areas, the LGA's median price movement was also compared to the median price movement of the suburb in which the wind farm was located. This was done to provide additional background to the primary analysis method. However, evidence is so thin that there is no actual statistical data for some discrete study areas.

4.2.3 *'Matched Pairs' Method*

In the 'matched pairs' method:

1. Properties that (a) had sold after the construction of the wind farm and were located in the view shed of the wind farm were compared to (b) comparable properties that had also sold after the construction of the wind farm but weren't located in the view shed.
2. If a property located in the view shed sold for less than the comparable property outside the view shed it was deemed to be affected by the wind farm.

5. RESULTS

A total of 45 property transactions were investigated within the eight (8) study areas applying the 'before and after' and/or 'matched pairs' evaluation method. Of these, only five (5) showed an indication of being adversely affected by the view of wind farms. A summary of the results is presented in the table below, while a detailed overview of the results for each wind farm site is presented in the subsections following.

Wind Farm Site	Age	Number of Turbines	Method	Useable Sample	Results	
					Unaffected Properties (No Value reduction found)	Affected Properties (Actual or possible value reduction found)
Blayney, NSW	2000	15	Matched pairs	12	12 *(8 rural properties; 4 lifestyle properties)*	0
Capital, NSW	2009	67	-	0	Inconclusive	-
Toora, VIC	2002	12	Before and after	14	10 *(3 rural properties; 4 township properties; 3 lifestyle properties)*	1 *(1 lifestyle property with possible 24% reduction)* *3 properties purchased by wind farm developer*
Waubra, VIC	2009	128	Both	6	5 *(4 township properties; 1 lifestyle property)*	1 *(1 lifestyle property with possible 27% reduction)*
Wonthaggi, VIC	2005	6	Both	7	6 (1 rural property; 5 township properties)	1 *(1 township property with actual 6% reduction)*
Codrington / Yambuk, VIC	2001 / 2005	34	Before and after	3	1 (1 lifestyle property)	2 *(2 lifestyle properties with possible 6% & 25% reductions)*
Cape Bridgewater, VIC	2008	29	-	0	Inconclusive	-
Challicum Hills, VIC	2002	35	-	3	Inconclusive	-
Total				45	34	5 (6 inconclusive)

Note: Sites with samples of 0 were found to have no sales transactions since the construction of the wind farm. 'Actual' means an absolute reduction in values, while 'Possible' means an observed slower rate of increase relative to comparators. 'Lifestyle properties' mean properties over 2,000 square meters in size but in use for primarily residential purposes only (e.g. hobby farms).

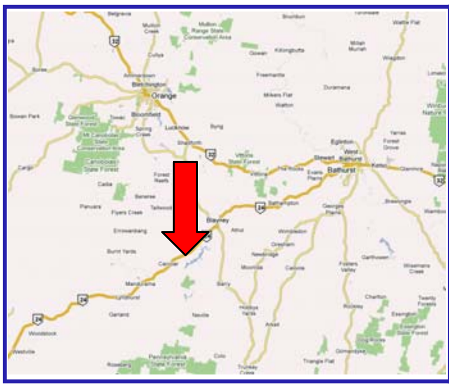
Overall, there were no observed impacts on the 12 rural properties, a small observed impact on 1 out of the 14 township properties (which may have been due to other factors e.g. a 'distressed sale'), and observed impacts on 4 out of the 13 lifestyle properties.

5.1 SITE 1: BLAYNEY WIND FARM – BLAYNEY, NSW

View looking south east to Blayney wind farm from Carcoar Dam Road

5.1.1 SITE DESCRIPTION

Number of Turbines:	Blayney wind farm consists of 15 turbines approximately 45 metres high with a blade diameter of 47 metres.
Age:	The wind farm commenced operations in October 2000.
Location:	Blayney wind farm is located in the Blayney Shire in NSW, 52 kilometres south west of Bathurst and approximately 255 kilometres west of Sydney.
Demographic context:	In the 2006 Census Blayney had a population of 3,091 persons with 1,285 dwellings and Carcoar had a population of 504 persons with 236 dwellings.
Site Description:	The wind farm is located in an elevated position in the hills to the south west of Lake Carcoar on two rural properties. The turbines are well spaced and do not appear overly visually prominent. The surrounding properties primarily consist of rural farmland with the Carcoar town centre located approximately 5 kilometres from the wind farm and Blayney town centre located approximately 10 kilometres away.



5.1.2 MARKET OVERVIEW

The change in the median price of house sales in the local government are of Blayney from 1998 to 2008 is presented in the table below (No comparison median analysis was available due to the wind farm being located in a rural area):

BLAYNEY LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
1998	$59,000	86	-
1999	$75,000	79	27%
2000	$80,000	81	7%
2001	$82,500	93	3%
2002	$102,000	145	24%
2003	$125,000	151	23%
2004	$150,000	94	20%
2005	$173,500	90	16%
2006	$179,000	70	3%
2007	$180,000	100	1%
2008	$185,000	75	3%

5.1.3 MARKET EVIDENCE:

Blayney was considered a good example for this study as a number of sales of surrounding properties both with and without views of the wind farm have occurred over an extended period of time following the wind farm's construction. In the nine (9) year period after the construction of the wind farm (between 2000 and 2009) a total of 21 sales were recorded within a 10 kilometre radius of the wind farm once transactions to related parties were removed (e.g. interfamily transfers). The similarity of the properties allowed for a 'matched pairs' sales analysis.

It was not possible to find a comparable sale to match each individual property in the study area surrounding Blayney Wind Farm. Instead the base market land values across rural and lifestyle properties were established based on the pool of available sales without views of the wind farm. The sales of properties with views of the wind farm were then compared to the base land values for the area.

Rural properties without views:

The following rural properties have no views of the wind farm and form the base market land values for comparison with properties that have views of the wind farm.

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Analysed Land Value per Ha</th></tr>
<tr><td>Property A
BLAYNEY</td><td>11/12/2000</td><td>$457,000</td><td>246.77 Ha</td><td>$1,850</td></tr>
<tr><td colspan="5">Vacant undulating to hilly grazing land with 25% slightly timbered. Possible distant views of wind farm from elevated ridge but large area would not have views. Located approximately 8 kilometres from wind farm.</td></tr>
<tr><td>Property B
CARCOAR</td><td>02/08/2002</td><td>$125,000</td><td>41.18 Ha</td><td>$3,035</td></tr>
<tr><td colspan="5">Vacant hilly mostly cleared grazing land with gully through middle. Long elongated lot with no attractive home site available. The property is located slightly out of town along a gravel road. No views of wind farm.</td></tr>
<tr><td>Property C
BLAYNEY</td><td>28/05/2003</td><td>$300,000</td><td>93 Ha</td><td>$3,226</td></tr>
<tr><td colspan="5">Vacant undulating grazing land slightly timbered in part. Possible distant views of wind farm from elevated portion but could find a home site without views of wind farm. Located approximately 8 kilometres from wind farm. Temporary dwelling appears to be installed since sale.</td></tr>
<tr><td>Property D
CARCOAR</td><td>15/11/2004</td><td>$471,800</td><td>90.36 Ha</td><td>$5,221</td></tr>
<tr><td colspan="5">Vacant undulating to hilly cleared grazing land. The property is located slightly out of town along a gravel road with the rear boundary bordered by a train line. No views of wind farm.</td></tr>
<tr><td>Property E
NEVILLE</td><td>04/12/2007</td><td>$285,000</td><td>38.75 Ha</td><td>$7,097</td></tr>
<tr><td colspan="5">Vacant valley floor cleared grazing land with some evidence of pasture improvement and an old sheering shed. Value of improvements estimated to be $10,000. No views of wind farm.</td></tr>
</table>

Rural properties with views:

The following rural properties have views of the wind farm and are compared to the base market land values to determine if the wind farm has impacted the value.

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Analysed Land Value per Ha</th><th>Finding</th></tr>
<tr><td>Property F
BLAYNEY</td><td>07/05/2000</td><td>$135,000</td><td>39.79 Ha</td><td>$3,393</td><td rowspan="2">No reduction in value found</td></tr>
<tr><td colspan="5">Vacant hilltop grazing land with poor access on a secluded ridge. Distant views of wind farm located approximately 7 kilometres away. House built since sale in full view of wind farm. Compared to property B ($3,035 per Ha) which is a slightly inferior property and sold two years later in a rising market. Thus land value considered to be in line with market rates.</td></tr>
<tr><td>Property G
NEVILLE</td><td>24/07/2004
24/12/2001</td><td>$680,000
$532,880</td><td>83.98 Ha</td><td>$8,097
$6,345</td><td rowspan="2">No reduction in value found</td></tr>
<tr><td colspan="5">Vacant hilly to steep cleared grazing land with steep river frontage and extensive views to the north. Boarders wind farm property with turbines located within 1 kilometre. Has extensive views of wind turbines. A superior property to property C ($3,226 per Ha) and property D ($5,221) but inferior to property E ($7,097 per Ha). Shows no reduction in value.</td></tr>
<tr><td>Property H
BLAYNEY</td><td>14/03/2003</td><td>$900,000</td><td>278.4 Ha</td><td>$3,017</td><td rowspan="2">No reduction in value found</td></tr>
<tr><td colspan="5">Vacant undulating to hilly cleared grazing land with Carcoar dam at rear. Older homestead with very small weatherboard and iron detached dwelling and old sheds. Estimated value of improvements $60,000. The property has views of the wind farm to the southerly aspect (approximately 6 kilometres away) but house is facing the northerly aspect. Compared to property C ($3,226 per Ha) shows no reduction in value.</td></tr>
<tr><td>Property I
BLAYNEY</td><td>09/11/2004</td><td>$350,000</td><td>100.81 Ha</td><td>$3,472</td><td rowspan="2">No reduction in value found</td></tr>
<tr><td colspan="5">Vacant undulating to hilly primarily cleared grazing land with scattered timber in part. The property is located approximately 4.5 kilometres to the west of wind farm with full views of turbines. Compared to property C ($3,226 per Ha) which is a slightly superior property shows no reduction in value.</td></tr>
</table>

Rural properties with views:

Property Address	Sale Date	Sale Price	Area	Analysed Land Value per Ha	Finding
Property J BLAYNEY	24/05/2005	$660,000	83.15 Ha	$6,735	No reduction in value found
Undulating valley floor cleared grazing land. Improvements include a circa 1980s basic concrete block and colourbond detached dwelling with double garage and water tank. Value of improvements estimated to be $100,000. The property is located approximately 4 kilometres from wind farm with distant views of turbines. Compared to property E ($7,097 per Ha) which is a slightly superior property and after allowance for slight increase in market values between sales dates (4%) shows no reduction in value.					
Property K BLAYNEY	09/05/2005	$290,000	24.82 Ha	$11,281	No reduction in value found
Vacant slightly undulating valley floor cleared grazing land. Irregular shaped allotment with long elongated section along Neville Road. Improvements include old machinery and bail sheds. Value of improvements estimated to be $10,000. The property is located approximately 2 kilometres from wind farm with distant views of turbines. Compared to property E ($7,097 per Ha) shows no reduction in value and is an increased rate per hectare as expected with a smaller area.					
Property L CARCOAR	01/11/2006	$525,000	44.67 Ha	$9,066	No reduction in value found
Hilly cleared grazing land. Improvements include a circa 1990s basic three bedroom brick veneer and colourbond detached dwelling with double garage and shed. Value of improvements estimated to be $120,000. Gravel road access. The property has extensive views in all directions with distant glimpses of wind farm approximately 5 kilometres away. Compared to property E ($7,097 per Ha) shows no reduction in value.					
Property M NEVILLE	10/10/2008	$445,000	93.6 Ha	$4,754	No reduction in value found
Vacant undulating to hilly cleared grazing land located approximately 1 kilometre from wind farm with extensive views of wind turbines. Located opposite property E ($7,097 per Ha). Property E land considered to be superior as it is on the valley floor and shows some evidence of pasture improvement. Also, as property M is approximately twice the size of property E it would be expected to have a lower rate per hectare. Thus shows no reduction in value.					

Lifestyle properties without views:

The following lifestyle properties have no views of the wind farm and form the base market land values for comparison with properties that have views of the wind farm.

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Analysed Land Value</th></tr>
<tr><td>Property N
BLAYNEY</td><td>13/12/2001</td><td>$135,000</td><td>2.5 Ha</td><td>$85,000</td></tr>
<tr><td colspan="5">Hobby farm with quaint circa 1920s weatherboard and iron detached dwelling. Land partly cleared and located in a gully below the road line. Value of improvements estimated to be $50,000. Appears to have been renovated since sale. No views of wind farm.</td></tr>
<tr><td>Property O
BLAYNEY</td><td>11/12/2007
13/03/2002</td><td>$340,000
$215,000</td><td>2.741 Ha</td><td>$270,000
$145,000</td></tr>
<tr><td colspan="5">Rural residential property on valley floor. Improvements include a circa 1950s basic brick and iron detached dwelling. Value of improvements estimated to be $70,000. The property is located approximately 4 kilometres from wind farm with no views of turbines from dwelling due to the tree line.</td></tr>
<tr><td>Property P
BLAYNEY</td><td>16/06/2003</td><td>$560,000</td><td>17.88 Ha</td><td>$410,000
$22,931 per Ha</td></tr>
<tr><td colspan="5">Hobby farm with attractive modern four bedroom brick veneer and corrugated metal detached dwelling on a long elongated allotment. Located adjacent to Blayney golf course. Cleared undulating grazing land. Value of improvements estimated to be $150,000. No views of wind farm. Located approximately 8 kilometres from wind farm.</td></tr>
<tr><td>Property Q
CARCOAR</td><td>30/10/2007</td><td>$300,000</td><td>4.43 Ha</td><td>$200,000</td></tr>
<tr><td colspan="5">Mostly level land on hillside. Large circa 1960s brick and iron dwelling with shed and managers quarters. Value of improvements estimated to be $100,000. No views of wind farms.</td></tr>
</table>

Lifestyle properties with views:

The following lifestyle properties have views of the wind farm and are compared to the base market land values to determine if the wind farm has impacted the value.

Property Address	Sale Date	Sale Price	Area	Analysed Land Value	Finding
Property R CARCOAR	19/05/2004	$315,000	2.377 Ha	$165,000	No reduction in value found
Hilly partially cleared land with scattered timber. Long elongated lot following the road line with valley views from home site. Improvements include a circa 1980s basic brick veneer and concrete tile detached dwelling with double garage and work shed. Value of improvements estimated to be $150,000. The property has distant views of wind farm located approximately 5 kilometres away. Compared to property Q ($200,000) which is a superior property with mostly level land with a greater area shows no reduction in value. Compared to property N ($85,000) which has inferior views but superior land and is located closer to Blayney. Considered overall comparable. After allowance for market movement since sale of property N shows no reduction in value.					
Property S CARCOAR	04/08/2006	$160,000	4.227 Ha	$160,000	No reduction in value found
Vacant hilly exposed cleared grazing land. Extensive views in all directions with distant views of wind farm approximately 5 kilometres away. Modern dwelling built since sale facing the wind farm. Home site located on ridgeline close to road. Compared to property Q ($200,000) which is a superior relatively level allotment shows no reduction in value.					
Property T BARRY	12/10/2006	$265,000	10.47 Ha	$215,000 $20,535 per Ha	No reduction in value found
Hobby farm located on primarily cleared level land on the valley floor. Improvements include a circa 1940s basic weatherboard and iron detached dwelling and an old ex shearing shed. Value of improvements estimated to be $50,000. The property is located approximately 1.5 kilometres from wind farm with turbines in full view. The house faces the turbines. Compared to property P ($22,931) which is considered to be a superior property as it is almost twice the size and located adjacent to Blayney golf course and closer to Blayney. After allowance for market movement since date of sale of property P shows no reduction in value.					

Lifestyle properties with views:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Analysed Land Value</th><th>Finding</th></tr>
<tr><td>Property U
NEVILLE</td><td>21/12/2006</td><td>$350,000</td><td>12.92 Ha</td><td>$280,000
$22,783 per Ha</td><td rowspan="2">No reduction in value found</td></tr>
<tr><td colspan="5">Hobby farm located on primarily cleared level land on the valley floor with some landscaping. Improvements include a circa 1960s basic weatherboard and tile detached dwelling and two sheds. Value of improvements estimated to be $70,000. The property is located approximately 1.5 kilometres from wind farm with turbines in full view. The house faces the turbines. Compared to property P ($22,931) which is considered to be a superior property as it is almost twice the size and located adjacent to Blayney golf course and closer to Blayney. After allowance for market movement since date of sale of property P shows no reduction in value.</td></tr>
</table>

5.1.4 SUMMARY

Although Blayney wind farm is in a rural area, a reasonable number of sales have occurred for properties both with and without views of the wind farm following the wind farm's completion in 2000. This allowed for a relatively comprehensive analysis applying the 'matched pairs' analysis technique.

No reductions in value associated with the wind farm were identified based on the 'matched pairs' analysis. This included both rural and lifestyle properties.

No reductions in value were found for eight (8) rural properties with various view of the wind farm. Similarly, no reduction was found for four (4) lifestyle properties with various views of the wind farm.

The wind farm does not appear to have deterred the construction of new homes in the area. This is evident by the fact that three (3) relatively newly constructed properties have been oriented with views towards the turbines despite views being available in alternative directions.

5.2 SITE 2: CAPITAL WIND FARM – LAKE GEORGE, NSW

View of turbines at Capital wind farm

5.2.1 SITE DESCRIPTION

Number of Turbines:	Capital wind farm will consists of 67 turbines approximately 80 metres high with a blade diameter of 45 metres.
Age:	The wind farm is currently under construction and expected to be fully commissioned in October 2009.
Location:	Capital wind farm is located between Bungendore and Tarago in the Goulburn Mulwaree Shire in NSW, approximately 50 kilometres north east of Canberra.
Demographic context:	In the 2006 Census Bungendore had a population of 2,806 persons with 1,089 dwellings.
Site Description:	The wind turbines are located among the hills on the eastern shore of Lake George on predominantly fully cleared light granite undulating country. The surrounding properties are primarily rural with some hobby farms located along Taylors Creek road. The Bungendore town centre is located approximately 15 kilometres from the wind farm.

5.2.2 SUMMARY

Investigations revealed no sale transactions have occurred in the area surrounding the Capital wind farm in 2008 or 2009 to date. As the wind farm is still in construction more data may become available over the following years.

Local agents reported that they had not seen an influx of listings since the construction of the wind farm began in the area. Consultation with local valuers revealed that the properties most likely to be affected, if at all, where a concentration of hobby farms along Taylors Creek road. A review of RP data's market history revealed that only three of these properties had been put on the market since the wind farm had been announced. It is noted that these properties have not sold and have been on the market for an extended period of time. However, discussions with the local agents revealed that potential buyers had not been discouraged by the wind farm and the reason these properties had not sold was primarily optimistic pricing.

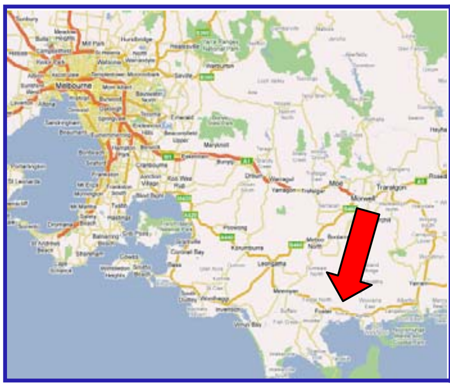
The sales transactions in the Bungendore town centre were considered too far away from the wind farm to be impacted.

5.3 SITE 3: TOORA WIND FARM – SOUTH GIPPSLAND, VIC

View looking south over Toora wind farm

5.3.1 SITE DESCRITPTION

Number of Turbines:	Toora wind farm consists of 12 Vesta V66 turbines approximately 67 metres high with a blade diameter of 66 metres.
Age:	Construction of the Toora wind farm began in 2001 and the wind farm commenced operations in October 2002.
Location:	Toora wind farm is located in the South Gippsland Shire in Victoria approximately 185 kilometres south east of Melbourne.
Demographic context:	In the 2006 Census Toora had a population of 674 persons with 324 dwellings.
Site Description:	The wind turbines are located in an elevated position across five properties in the hills to the north of the Toora town centre off Silcocks Hill road. Toora is a small coastal town surrounded by undulating hills which are primarily used for dairying. The surrounding properties can be considered to have a high rural lifestyle attraction with a number of hobby farms with coastal views being in an area with high scenic beauty and less than two hours drive from Melbourne CBD. The majority of dwellings are located on standard residential allotments in the Toora town centre. The closest wind turbines are located approximately 1 kilometre to the north of the town on top of the hills and are visible from most properties. However, at the site they are tightly placed in a random pattern which creates a visually prominent aesthetic for those properties located amongst them in close proximity.



5.3.2 MARKET OVERVIEW

The change in the median price of house sales in the suburb of Toora as well as the local government are of South Gippsland from 1998 to 2008 is presented in the tables below:

SOUTH GIPPSLAND LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
1998	$76,000	471	6%
1999	$84,000	483	11%
2000	$87,500	617	4%
2001	$93,000	806	6%
2002	$130,000	760	40%
2003	$158,000	727	22%
2004	$180,000	526	14%
2005	$200,000	461	11%
2006	$205,000	491	3%
2007	$215,000	636	5%
2008	$220,000	504	2%

TOORA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
1998	$50,000	17	0%
1999	$65,000	17	30%
2000	$55,000	10	-15%
2001	$70,000	20	27%
2002	$70,000	27	0%
2003	$82,500	18	18%
2004	$117,500	13	42%
2005	$187,000	12	59%
2006	$172,500	8	-8%
2007	$165,000	17	-4%
2008	$150,000	15	-9%

Source: RP Data

The South Gippsland region went through a boom from approximately 2001 to 2005 with an increase to the median value year on year during this period. The change in median value in Toora is more volatile compared to South Gippsland which is likely to be due to the low base number of sales in the suburb of Toora. There is some fluctuation in the median price for Toora around the construction period 2001 to 2002 with this period also seeing the highest frequency of sales. This may be an indication of the market's anticipation of the wind farm having an effect on the local market. However, due to the low base number of sales in Toora no conclusions from the data can be taken as they would not be statistically significant. Also, the median value began to increase again from 2003 at a higher rate than evidenced in the LGA once the wind farm had been constructed and was operational.

5.3.3 MARKET EVIDENCE

Before and After Sales Analysis - The following table lists those properties that had sales transactions which occurred both before and after the construction of the wind farm. The change in sale price for each property is compared to the market change. Where the change in sale price is in line or greater than the market change the property is considered not to have been affected by the development of the wind farm.

Where available sale transactions from Jess (2008) have been investigated and analysed.

The following properties are considered unaffected:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property A1
TOORA</td><td>13/6/2002
9/4/1999</td><td>$66,000
$42,500</td><td>745 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Small basic dwelling located in the town centre approximately 1 kilometre from closest wind turbine. Distant views with some turbines visible to the rear of property.
Shows 55% increase in value between 1999 and 2002 which is in line with the South Gippsland market movement which shows a 55% increase during the same period.
Sale price considered not to be negatively affected by wind farm.</td></tr>
<tr><td>Property B1
TOORA</td><td>29/10/2003
12/7/2000</td><td>$130,000
$50,000</td><td>953 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Basic weatherboard and tile dwelling located in the town centre approximately 1.5 kilometres from closest wind turbine. Distant views with some turbines visible to the rear of property.
Shows 160% increase in value between 2000 and 2003 which is larger than the South Gippsland market movement which shows an 81% increase during the same period.
Sale price considered not to be negatively affected by wind farm.</td></tr>
</table>

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property C1
TOORA</td><td>22/12/2002
22/11/1999</td><td>$155,000
$85,000</td><td>934 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Neat weatherboard and iron dwelling located in the town centre approximately 1.7 kilometres from closest wind turbine on a corner allotment with rear laneway access. Distant views with some turbines visible to the rear and north-eastern side of the property.

Shows 82% increase in value between 1999 and 2002 which is larger than the South Gippsland market movement which shows a 55% increase during the same period.

Sale price considered not to be negatively affected by wind farm.</td></tr>
<tr><td>Property D1
TOORA</td><td>17/10/2003
12/10/1999</td><td>$129,000
$70,000</td><td>725 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Brick and tile dwelling located in the town centre approximately 1.2 kilometres from closest wind turbine. Glimpses of turbines to the north although view is partially blocked by natural tree line in places.

Shows 84% increase in value between 1999 and 2002 which is in line with the South Gippsland market movement which shows an 88% increase during the same period.

Sale price considered not to be negatively affected by wind farm.</td></tr>
<tr><td>Property E1
TOORA</td><td>27/7/2006
23/6/2001</td><td>$375,000
$197,500</td><td>51.93 Ha</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Improved cattle farm located approximately 200 metres from wind turbines. The wind turbines would likely be audible from the property.

Shows approximately 90% increase in value between 2001 and 2006 during a rising market. This compares to an increase of 120% in the South Gippsland residential housing market movement although this is a different market. The sale is unlikely to be affected.</td></tr>
<tr><td>Property F1
TOORA</td><td>18/5/2006
4/2/2002</td><td>$177,500
$78,000</td><td>1,895 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Very basic weatherboard and corrugated metal detached dwelling located approximately 2 kilometres from wind turbines. Valley views and slight glimpses of water.

Shows approximately 128% increase in value between 2002 and 2006 which is larger than the South Gippsland area market movement which shows a 58% increase during the same period. It is noted that at the date of sale in 2002 construction of the wind farm had begun and while not operational yet there may have been an effect on the original sale price.</td></tr>
</table>

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property G1
TOORA</td><td>21/5/2007
24/8/1997</td><td>$345,000
$117,500</td><td>4,028 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Neat weatherboard and corrugated metal federation style detached dwelling located approximately 1.4 kilometres from wind turbines. Water and valley. Only has glimpses of wind turbines with views interrupted by natural tree line and topography of the land.
Shows approximately 194% increase in value between 1997 and 2007 which is similar to the South Gippsland area market movement which shows a 200% increase during the same period. While slightly below this is in the range of normal market fluctuations.</td></tr>
<tr><td>Property H1
TOORA</td><td>29/7/2002
13/5/1998</td><td>$145,000
$100,000</td><td>54.85 Ha</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Improved sheep farm located approximately 1.5 kilometres from wind turbines which are positioned on the hill to the rear of the property.
Shows a 45% increase in value between 1998 and 2002 during a rising market. This compares to an increase of 71% in the South Gippsland residential housing market movement although this is a different market. Sold before wind farm was operational.</td></tr>
<tr><td>Property I1
TOORA</td><td>29/7/2002
13/5/1998</td><td>$145,000
$100,000</td><td>54.85 Ha</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Improved sheep farm located approximately 1.5 kilometres from wind turbines which are positioned on the hill to the rear of the property.
Shows a 45% increase in value between 1998 and 2002 during a rising market. This compares to an increase of 71% in the South Gippsland residential housing market movement although this is a different market. Sold before wind farm was operational.</td></tr>
</table>

The following properties are considered to be affected:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property J1
TOORA</td><td>21/3/2003
11/11/1993</td><td>$265,000
$220,000</td><td>42.53 Ha</td><td rowspan="2">Possible reduction in value found.</td></tr>
<tr><td colspan="4">Improved property with inlet views located approximately 400 meters from wind turbines. The wind turbines would be audible from the property. Sold after wind farm had been constructed in 2003. A comparable property in which to make a matched pairs comparison was unable to be sourced but according to a local valuer this property was on the market for a long period of time in a rising market and should have sold for $350,000 with the actual sale being 24% below this. But this is anecdotal.
While no absolute reduction in the sale price was evident it appears that it was sold slightly below the market rate.</td></tr>
</table>

The following properties were purchased by the developer of the wind farm. The purchase price was based on a current market valuation performed by a local property valuation firm assuming the wind farm did not exist. The fact that the developer was involved in purchasing them indicates that the residents no longer wished to live in them and potentially could not find buyers on the open market. However, this is purely speculative and it is not possible to gauge if the values of these properties had been affected by the development of the wind farm. They are included simply as evidence that this had occurred.

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property K1
TOORA</td><td>8/4/2005</td><td>$140,000</td><td>10.32 Ha</td><td rowspan="2">Property purchased by wind farm developer.</td></tr>
<tr><td colspan="4">Cleared vacant farmland with a small dam located approximately 350 metres from wind turbines. The wind turbines would be audible from the property. Purchased by wind farm developer Stanwell Corp Limited based on a current market valuation assuming wind farm did not exist.</td></tr>
<tr><td>Property L1
TOORA</td><td>26/11/1999</td><td>$190,000</td><td>5,118 m²</td><td rowspan="2">Property purchased by wind farm developer.</td></tr>
<tr><td colspan="4">Brick and tile dwelling located approximately 70 metres from wind turbine. Purchased by Stanwell Corp Limited before the construction of the wind farm and now used as site office and visitor viewing/information centre.</td></tr>
</table>

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property M1
TOORA</td><td>23/8/2005</td><td>$230,000</td><td>Approx 7,500 m²</td><td rowspan="2">Property purchased by wind farm developer.</td></tr>
<tr><td colspan="4">Cleared vacant land located approximately 430 metres from wind turbines. Purchased by wind farm developer Stanwell Corp Limited based on a current market valuation assuming wind farm did not exist.</td></tr>
<tr><td>Property N1
TOORA</td><td>29/11/2001
16/11/2000</td><td>$155,000
$135,000</td><td>1.1 Ha</td><td rowspan="2">Property purchased by wind farm developer but then on sold at an increased price.</td></tr>
<tr><td colspan="4">Rural residential property with a two storey dwelling located approximately 500 metres from wind turbines. The wind turbines would likely be audible from the property. Purchased by wind farm developer Stanwell Corp Limited in 2000 based on a current market valuation assuming wind farm did not exist then sold in 2001 to a private purchaser at an increased price.</td></tr>
</table>

No further sales evidence was located that could be used in paired sales analysis.

5.3.4 SUMMARY

Based on before and after sales analysis no reductions in value were found for properties located in the town centre with distant views (from 1 to 3 kilometres) of turbines.

Mixed information was found for larger rural lifestyle properties located close (within 1 kilometre) to the wind turbines. Some appear to have decreased in value while some show increase in value. As the developer appears to have bought out many surrounding land owners based on current market valuations this may be masking the full effect of the wind farm. Although, one of these properties was then on sold to a private purchaser at an increased price.

Discussions with local agents suggest that the wind farm has deterred some buyers. Agents generally reported that the number of potential buyers decreases the closer a property is located to the wind farm. Agents also reported that those properties located within one kilometre of the wind farm tend to stay on the market for longer periods compared to properties located further away from the wind farms.

5.4 SITE 4: WAUBRA WIND FARM – BALLARAT, VIC

View of turbines at Waubra wind farm

View of wind farms to the North West from Kimberly Drive in Waubra town centre

5.4.1 SITE DESCRIPTION

Number of Turbines:	Waubra wind farm consists of 128 ACCIONA turbines ranging in size from 110 to 120 metres.
Age:	Turbine installation commenced in December 2007 with the first turbines at the Waubra wind farm began operating in February 2009 and the farm was reported to be fully operational from the end of June 2009.
Location:	Waubra is located approximately 35 kilometres north-west of Ballarat along the Sunraysia Highway. The wind farm is situated in two municipalities, the Shire of Pyrenees and the City of Ballarat. The area consists primarily of cleared agricultural land used for sheep and cattle grazing and potato growing. There is also a small cluster of smaller rural residential/lifestyle lots located in the Waubra town centre.
Demographic context:	In the 2006 Census Waubra had a population of 494 persons with 185 dwellings.
Site Description:	The wind turbines are located on a series of hills and high plateaus which form part of the Great Dividing Range. The closest turbines are approximately 1.2 kilometres from the town centre and extend outwards up to 10 kilometres away. Not all surrounding properties have views of the wind turbines with natural tree lines and other housing often blocking out the view. Nonetheless, there are a sufficient number of towers within a small area to create a visually intrusive aesthetic to a predominately rural lifestyle location.

5.4.2 MARKET OVERVIEW

The change in the median price of house sales in the suburb of Waubra as well as the local government are of Pyrenees from 2000 to 2009 is presented in the tables below (Note 2009 figures extrapolated from the first 6 months of sales data):

PYRENEES LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
2000	$62,500	102	-
2001	$70,000	122	12%
2002	$89,000	116	27%
2003	$104,514	94	17%
2004	$118,000	93	13%
2005	$135,000	107	14%
2006	$135,000	88	0%
2007	$145,000	80	7%
2008	$153,000	89	6%
2009	$146,000	72	-5%

WAUBRA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
2000	$88,000	2	-
2001	$76,750	6	-13%
2002	$97,955	4	28%
2003	$145,067	3	48%
2004	$145,000	3	0%
2005	$125,000	6	-14%
2006	$147,625	3	18%
2007	$179,950	4	22%
2008	$183,000	4	2%
2009	$235,000	2	28%

Source: RP Data

The Pyrenees region went through a boom in the first half of the decade with values continuing to rise slightly up to 2007. The market declined towards the latter half of 2008 and 2009 with both sales rates and values slightly decreasing. The change in median value in Waubra is more volatile compared to Pyrenees which is likely to be due to the low base number of sales in the suburb of Waubra. Sales rates of properties in the Waubra town centre are low due to limited demand and development. The value of properties in the Waubra town centre and surrounding lifestyle properties have reportedly declined recently by 5% to 10% which is in line with the LGA average reduction (Hives, 2008).

The rural sector of the market has been reportedly very strong in recent times with increases in values occurring with a shortage of supply in a tightly held market. This has occurred during a drought and rising costs. The market increased in value by approximately 20% to 25% from 2007 to 2008 (Hives, 2008).

No firm conclusion can be reached from a comparison of the median prices.

5.4.3 MARKET EVIDENCE

Where available sale transactions from Hives (2008) have been investigated and analysed.

The following sales are considered unaffected when analysed using the before and after method:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property A2
WAUBRA</td><td>19/2/2008
2/6/2003
8/12/2000</td><td>$155,000
$25,000
$12,000</td><td>8,659 m^2</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Lifestyle property comprising a modern but basic clad and corrugated metal detached dwelling with garage, carport and some basic landscaping to grounds. Located approximately 1.2 kilometres from closest wind turbine with some views but not prominent.
Improvements added since 2003 sale. Analysed land value of $90,000 in 2008 sale.
Shows 160% increase in value between 2003 and 2008. Appears to have no reduction in value due to the wind farm.</td></tr>
<tr><td>Property B2
WAUBRA</td><td>3/9/2008
31/3/2003</td><td>$40,000
$22,500</td><td>9,672 m^2</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Cleared vacant level land. Located in the Waubra town centre approximately 1.2 kilometres from closest wind turbine with minimal view that can be screened out.
Shows 78% increase in value between 2003 and 2008 which is larger than the Pyrenees market movement which shows a 46% increase during the same period. Note the 2008 transaction does not represent an open market sale but rather an estate transfer. It is assumed that it was transferred based on a current market value.
Sale price considered not to be negatively affected by wind farm.</td></tr>
</table>

Property Address	Sale Date	Sale Price	Area	Finding
Property C2 WAUBRA	2/2008 8/1/2004	$183,000 $135,000	1.6 Ha	No reduction in value found.
Basic hardiplank detached dwelling with garage located approximately 2.1 kilometres from closest wind turbine with some views of turbines but tree line protects main dwelling. Shows 36% increase in value between 2004 and 2008 which is in line with the Pyrenees market movement which shows a 30% increase during the same period. Sale price considered not to be negatively affected by wind farm.				
Property D2 WAUBRA	23/2/2008	$70,000	9,967 m^2	No reduction in value found.
Cleared vacant level land. Located in the Waubra town centre approximately 1.2 kilometres from closest wind turbine with minimal views. Investigation of surrounding area did not reveal a comparable sale. However, 8600 square meters of vacant land at property G2 Waubra sold in 2004 for $33,000 and $53,000 in 2006 before the construction of the wind farm. Thus, similar vacant land shows values rising by approximately 32% between 2006 and 2008 which is larger than the Pyrenees market movement which shows a 13% increase during the same period. Sale price considered not to be negatively affected by wind farm.				

The following sale is considered unaffected as analysed using the 'matched pairs' comparison method:

Property Address	Sale Date	Sale Price	Area	Finding
Property E2 WAUBRA	20/11/2008	$215,577	1,958 m^2	No reduction in value found.
Approximately 40 year old basic brick veneer and colorbond detached dwelling. Located on the edge of the town centre approximately 2.5 kilometres from closest wind turbine with prominent views of turbines to the rear of the property. Comparable to sale at property H2 Learmonth which sold for $225,000 on 29/10/2008. Similar construction in slightly better condition, smaller land area (1293 m^2) with landscaped grounds. Learmonth is located closer to Ballarat and has no views of wind farm. Sale price considered not be negatively affected by wind farm.				

The following sale is considered to be affected as analysed using the before and after sales method:

Property Address	Sale Date	Sale Price	Area	Finding
Property F2 WAUBRA	5/1/2009 4/6/2001 1/6/1989	\$235,000 \$154,000 \$145,000	1.75 Ha	Possible reduction in value found.
Lifestyle property comprising a large brick and tile dwelling with slate floor and landscaped grounds. Located approximately 2.1 kilometres from closest wind turbine with quite prominent views of turbines to the north-west. Shows 52% increase in value between 2001 and 2009 which is lower than the Pyrenees market movement which shows a 109% increase during the same period. Sale price appears to be negatively affected as the increase in value is below the market movement. Indexing the property's original sale price to the market change results in a value of \$321,860 with the actual sale price of \$235,000 being approximately 27% below this. However, the magnitude of the reduction cannot be taken as indicative for this property class due to the large number of factors impacting on negotiation of property prices.				

No further sales evidence was located that could be used in paired sales analysis.

5.4.3 SUMMARY

There is generally little sales activity in the area surrounding the Waubra wind farm.

Sale prices of residential properties located in the Waubra town centre do not appear to be negatively affected by the construction of the wind farm.

There is some evidence of a reduction in value for one rural lifestyle property with views of turbines. However, due to limited evidence no firm conclusions can be made.

These results are generally consistent with Hives (2008) analysis.

As the construction of the Waubra wind farm was only completed in June 2009 the full effect on surrounding property values will be more evident with time as more sales transactions occur.

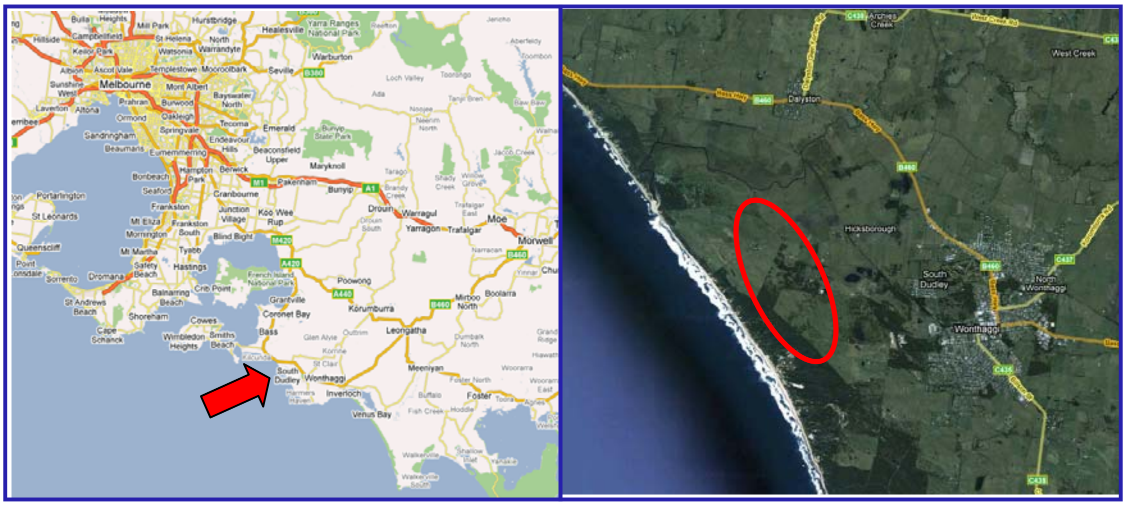
5.5 SITE 5: WONTHAGGI WIND FARM – BASS COAST, VIC

View of turbines at Wonthaggi wind farm

View of wind farms to the south from Dalyston

5.5.1 SITE DESCRIPTION

Number of Turbines:	Wonthaggi wind farm consists of 6 Repower MM82 turbines each of 2MW capacity.
Age:	The Wonthaggi wind farm was commissioned in December 2005.
Location:	Wonthaggi is located approximately 136 kilometres south-east of Melbourne in the Bass Coast Shire of Victoria.
Demographic context:	In the 2006 Census Wonthaggi had a population of 4,239 persons with 2,251 dwellings.
Site Description:	The wind farm is situated approximately 3 kilometres from the Wonthaggi town centre with the turbines built on 120 acres of rural flat grazing land which traverses land behind sand dunes and a foreshore reserve. Views of the wind farm are limited from the Wonthaggi town centre with more prominent views from the nearby town of Dalyston. The flat topography of the surrounding area combined with various vegetation growths blocks out the view of the turbines from the majority of Wonthaggi. The wind farm is small and well removed from the immediate development and generally unobtrusive. Noise would not be a factor.



5.5.2 MARKET OVERVIEW

The change in the median price of house sales in the suburb of Wonthagi as well as the Local Government Area of Bass Coast from 2000 to 2008 is presented in the table below:

BASS COAST LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
2000	$98,250	1334	-
2001	$130,000	1506	32%
2002	$172,250	1408	33%
2003	$215,000	1329	25%
2004	$225,000	1077	5%
2005	$240,000	1037	7%
2006	$255,000	1046	6%
2007	$265,000	1400	4%
2008	$275,000	1079	4%

WONTHAGGI HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
2000	$75,000	136	-
2001	$92,750	172	24%
2002	$132,000	142	42%
2003	$155,000	155	17%
2004	$189,000	118	22%
2005	$194,000	126	3%
2006	$191,500	126	-1%
2007	$220,000	175	15%
2008	$230,000	135	5%

Source: RP Data.

The Bass Coast region went through a boom at the start of the decade up to approximately 2003. From 2004 to 2008 values continued to rise but at a much slower rate. Wonthaggi appears to have gone through a similar cycle with values continuing to increase up to 2004. In 2006 the median value decreased by approximately one percent. While this coincided with the commencement of operations of the wind farm starting in late 2005 in the following year the median value in Wonthaggi increased by fifteen percent. During the same period the Bass Coast market change in median value was relatively steady at approximately six percent increase in 2006 and four percent increase in 2007. From this statistical analysis no conclusive trend can be observed but median values generally indicate no effect. An analysis of individual sales with and without views of the wind farm follows to allow for a greater understanding of the effect of the wind farm construction on the surrounding properties.

5.5.3 MARKET EVIDENCE

The following sales are considered unaffected when analysed using the before and after method:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property A3
DALYSTON</td><td>7/7/2006
20/8/2002</td><td>$588,955
$350,000</td><td>39.09 Ha</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Mostly cleared level farmland with dam and improvements. Located approximately 4 kilometres from wind farm.
Shows 68% increase in value between 2002 and 2006 which is slightly larger than the Bass Coast market movement which shows a 48% increase during the same period.
Sale price considered not be negatively affected by wind farm.</td></tr>
<tr><td>Property B3
DALYSTON</td><td>15/8/2006
5/2/2001</td><td>$145,000
$40,000</td><td>N/a</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Older fibro and corrugated metal residential dwelling with garage on a corner allotment. Located approximately 3.5 kilometres from wind farm.
Shows 263% increase in value between 2001 and 2006 which larger than the Bass Coast market movement which shows a 96% increase during the same period.
Sale price considered not be negatively affected by wind farm.</td></tr>
</table>

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property C3
DALYSTON</td><td>6/12/2005
23/3/2001</td><td>$180,000
$86,000</td><td>723 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Neat weatherboard and corrugated metal detached dwelling with carport. Located approximately 3 kilometres from wind farm.

Shows 109% increase in value between 2001 and 2006 which is slightly larger than the Bass Coast market movement which shows a 96% increase during the same period.

Sale price considered not be negatively affected by wind farm.</td></tr>
<tr><td>Property D3
DALYSTON</td><td>12/7/2006
24/11/2003
31/8/2001</td><td>$70,000
$56,000
$8,750</td><td>795 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Cleared vacant land. Located approximately 3.5 kilometres from wind farm.

Shows 25% increase in value between 2003 and 2006 which is slightly larger than the Bass Coast market movement which shows a 19% increase during the same period.

Sale price considered not be negatively affected by wind farm.</td></tr>
</table>

The following sales are considered unaffected when analysed using the ‘matched pairs’ method:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property E3
DALYSTON</td><td>29/9/2005</td><td>$180,000</td><td>510 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Modern brick veneer and colorbond dwelling with carport on a corner allotment. Located approximately 3 kilometres from wind farm.

Comparable to Property H3 Dalyston which sold for $210,000 on 23/06/2006. A very neat modern western red cedar and corrugated metal detached dwelling with detached lock up garage on a 676 square meter allotment. Larger improvements and land size compared to property E3 sale which make it a slightly superior property.

No significant reduction in value evident.</td></tr>
<tr><td>Property F3
DALYSTON</td><td>22/12/2005</td><td>$80,000</td><td>831 m²</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Cleared vacant land. Located approximately 3.5 kilometres from wind farm.

Comparable to vacant land sale at property I3 Dalyston on 13/07/2005 for $72,500. Slightly smaller land size of 737 square meters. Overall comparable properties with no reduction in value evident.</td></tr>
</table>

The following sale is considered affected when analysed using the before and after method:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property G3
DALYSTON</td><td>12/12/2005
31/10/2004
8/8/2003</td><td>$132,000
$140,000
$112,000</td><td>N/a</td><td rowspan="2">13% reduction in value found.</td></tr>
<tr><td colspan="4">Basic fibro and corrugated metal detached dwelling with carport. Located approximately 3.5 kilometres from wind farm.
Shows a 6% decrease in value between 2004 and 2005 while the Bass Coast market movement saw a 7% increase during the same period.
Sale price reduced by a possible 13% after construction of wind farm.</td></tr>
</table>

5.5.4 SUMMARY

The Wonthaggi wind farm is small in size and one of the relatively less aesthetically prominent.

A review of the sales of properties in view of the wind farm has found that the majority of sales appear to have not been negatively affected.

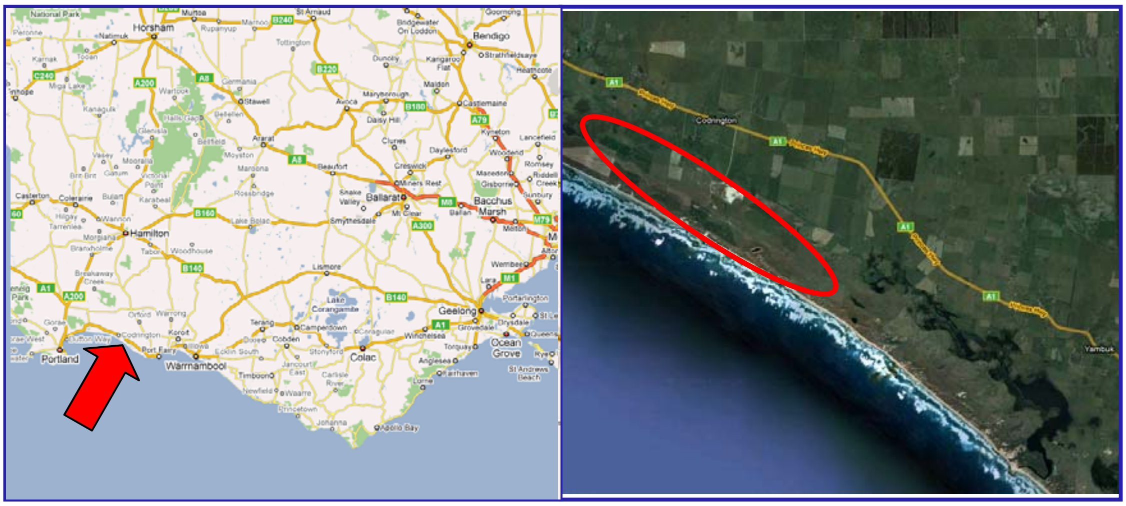
One sale did show an absolute reduction of 6% after the construction of the wind farm which equated to a possible 13% reduction once the market movement was considered. This is a possible affect of the wind farm but also there may be other factors impacting (e.g. an urgent sale).

5.6 SITE 6: CODRINGTON AND YAMBUK WIND FARMS – MOYNE, VIC

View of turbines at Codrington and Yambuk wind farm

5.6.1 SITE DESCRIPTION

Number of Turbines:	Codrington wind farm consists of 14 x 1.3 MW turbines and Yambuk consists of 20 x 1.5 MW turbines. These wind farms are located next to each other.
Age:	Construction on the Codrington wind farm started in November 2000 and was completed in July 2001. The Yambuk wind farm was commissioned in December 2005.
Location:	The Codrington and Yambuk wind farms are located next to each other along the south-western Victoria coastline near Port Fairy in the Moyne Shire.
Demographic context:	In the 2006 Census the area represented by the state suburb of Yambuk (census data covers both Codrington and Yambuk in the one collection area) had a population of 540 persons with 235 dwellings.
Site Description:	The wind farms are situated along the coast on farmland between the Princes Highway and the ocean. Mid to distant views of the wind turbines are evident from along the Princes Highway. Aesthetically the wind farms are less prominent as the turbines are well spaced apart and appear to be in one line when viewing from the Princes Highway.



5.6.2 MARKET OVERVIEW

The change in the median price of house sales in the Moyne local government from 1998 to 2008 is presented in the table below. Due to limited sales activity (approximately 2 to 4 sales per year) an analysis of the suburb of Yambuk's median value was not available:

MOYNE LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
1998	$94,500	169	-
1999	$105,000	195	11%
2000	$105,000	218	0%
2001	$130,500	260	24%
2002	$145,759	276	12%
2003	$170,050	256	17%
2004	$200,000	185	18%
2005	$202,900	184	1%
2006	$222,500	210	10%
2007	$250,000	255	12%
2008	$258,000	205	3%

Source: RP Data

The Moyne region went through a boom at the start of the decade up to approximately 2004. In 2005 the median value was relatively steady and then in 2006 and 2007 values began to increase again. The median value was then steady again in 2008.

The Codrington/Yambuk area is a thinly traded market consisting primarily of rural farmland properties around the wind farms with some rural residential properties located further away to the east in the Yambuk town centre. An analysis of some individual sales transactions is presented below although a review of sales transaction revealed little market activity.

5.6.3 MARKET EVIDENCE

The following sale is considered unaffected when analysed using the before and after method:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property A4
YAMBUK</td><td>2/6/2008
18/10/2004
8/2/2001
7/3/1998</td><td>$230,000
$160,000
$75,000
$55,000</td><td>2.41 Ha</td><td rowspan="2">No reduction in value found.</td></tr>
<tr><td colspan="4">Improved hobby farm with distant views to turbines. Located approximately 4.5 kilometres from wind farm.
Shows 36% increase in value between 1998 and 2001 and then 44% increase between 2004 and 2008 which is in line with the Moyne market movement of 38% and 29% for both periods respectively.
Sale price considered not to be negatively affected by wind farm.</td></tr>
</table>

The following sales are considered to be affected when analysed using the before and after method:

<table>
<tr><th>Property Address</th><th>Sale Date</th><th>Sale Price</th><th>Area</th><th>Finding</th></tr>
<tr><td>Property B4
YAMBUK</td><td>7/4/2008
7/11/2002
9/1/1998</td><td>$220,000
$165,000
$88,500</td><td>Approx. 2,916 m²</td><td rowspan="2">Possible reduction in value found.</td></tr>
<tr><td colspan="4">Improved property with distant views of wind turbines. Located approximately 6 kilometres from wind farm.
Shows 33% increase in value between 2002 and 2008 which is below the Moyne market movement of 78% for the same period.
Sale price may have been affected.</td></tr>
</table>

Property Address	Sale Date	Sale Price	Area	Finding
Property C4 YAMBUK	25/9/2007 14/1/2005	$110,000 $95,000	966 m²	Possible slight reduction in value found.
Basic weatherboard and corrugated metal detached residential dwelling in Yambuk town centre. Located approximately 5 kilometres from wind farm. Shows 16% increase in value between 2005 and 2007 which is slightly below the Moyne market movement of 23% for the same period. Sale price may have been slightly affected.				

5.6.4 SUMMARY

While limited evidence was found there was some indication of reduced value found in two residential property sales around the Yambuk and Codrington wind farm. These properties did not appear to have increased at a rate in line with the local market movement, but this may have been due to influences other than the wind farm. Also, the data is inconsistent as one other sale analysed was considered not to be affected.

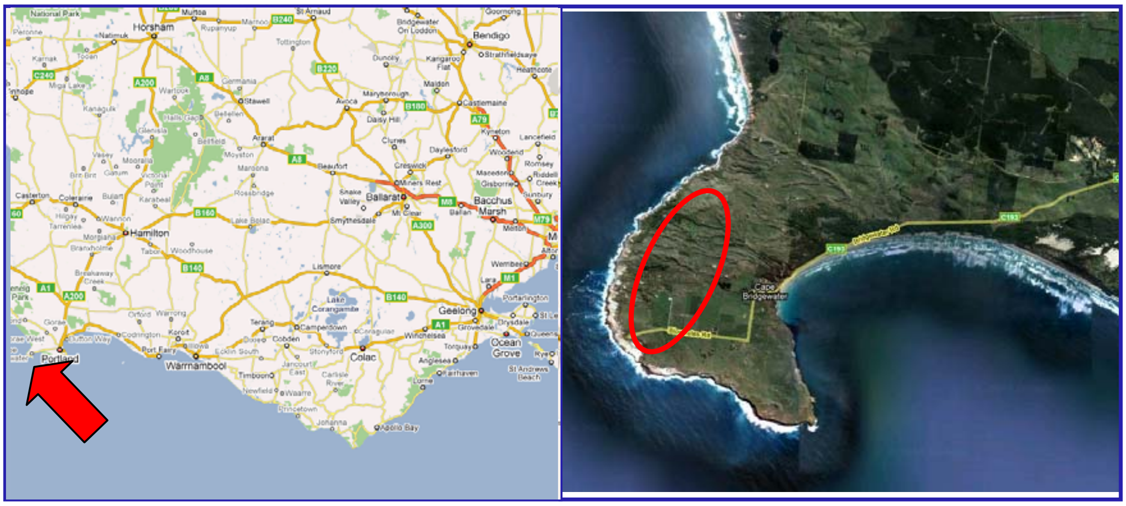
The area is primarily surrounded by farmland which is not likely to have been affected by the construction of the wind farm but due to limited sales activity investigations were limited to the above sales.

5.7 SITE 7: CAPE BRIDGEWATER WIND FARM – GLENELG, VIC

View of turbines at Cape Bridgewater wind farm from Blowholes Road

5.7.1 SITE DESCRIPTION

Number of Turbines:	Cape Bridgewater wind farm consists of 29 x 2MW REpower turbines.
Age:	The Cape Bridgewater wind farm was commissioned in mid 2008.
Location:	Cape Bridgewater is located is at the western most end of the Great Ocean Road, about 21 kilometres south-west of Portland and approximately 378 kilometres south-west of Melbourne in the suburb of Portland West in the Glenelg Shire of Victoria.
Demographic context:	In the 2006 Census Portland West had a population of 799 persons with 342 dwellings.
Site Description:	The wind farm is situated on the south-western side of Cape Bridgewater on rural farmland. The surrounding area consists mainly of farmland and a small cluster of dwellings and tourist accommodation on the eastern side of the cape. Views of the wind farm are limited from the majority of surrounding dwellings due to hills between them. The views are only aesthetically prominent when within approximately one kilometre of the turbines as the hills generally block out their view from the eastern side of the cape.



5.7.2 MARKET OVERVIEW:

The change in the median price of house sales in the Glenelg local government area from 2000 to 2009 is presented in the table below. Due to limited sales activity an analysis of the Cape Bridgewater median value was not available:

GLENELG LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
2000	$75,000	363	-
2001	$85,000	444	13%
2002	$100,000	489	18%
2003	$133,000	433	33%
2004	$160,000	375	20%
2005	$165,000	388	3%
2006	$187,000	422	13%
2007	$200,000	395	7%
2008	$190,000	359	-5%
2009*	$178,500	122	-6%

Source: RP Data

The Glenelg region went through a boom at the start of the decade up to approximately 2004. From 2004 to 2007 values continued to rise but at a much slower rate. Then in 2008 and 2009 values have come back slightly. As per the other wind farm sites an attempted was made to complete an analysis of individual sales with and without views. However, on inspection it was evident that only a couple properties were in the view shed of the Cape Bridgewater wind farm and none of these properties had sold since the construction of the wind farm.

5.7.3 SUMMARY

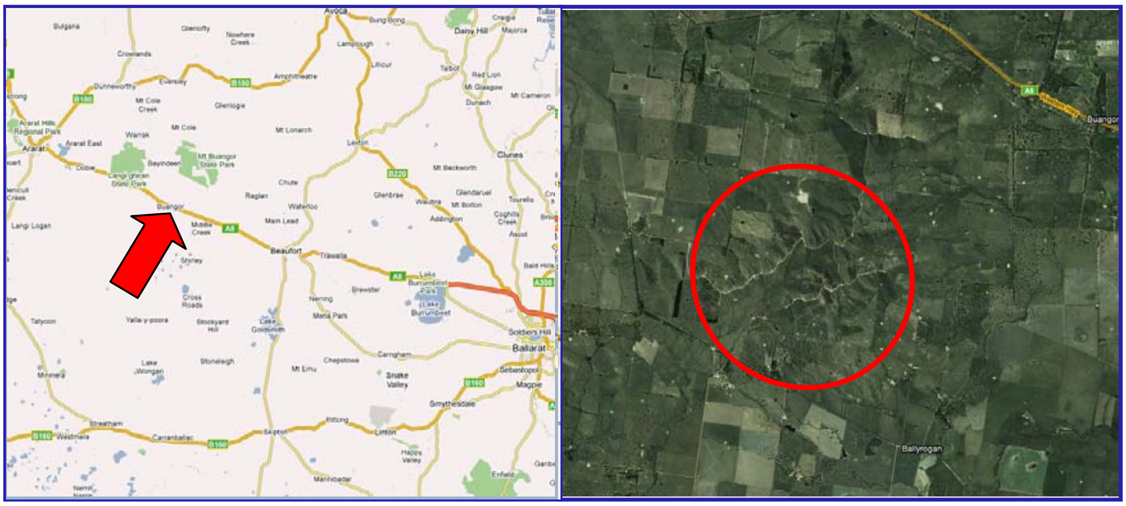
The Cape Bridgewater wind farm is in a coastal location with highly aesthetic ocean views. While no sales transaction evidence was found this may be representative of the wind farm posing little disturbance to the local residents and property owners. It was noted that there were only a few for sale signs on properties when inspecting the site. However, as this is a relatively new wind farm more sales transactions may occur over time.

5.8 SITE 8: CHALLICUM HILLS WIND FARM – ARARAT, VIC

View of turbines at Challicum Hills wind farm from viewing area off Geelong Road

5.8.1 SITE DESCRIPTION

Number of Turbines:	Challicum Hills wind farm consists of 35 turbines.
Age:	Construction commenced in October 2002 and was completed in August 2003.
Location:	The Challicum Hills wind farm is located approximately 20 kilometres east of Ararat along the Western Highway in the town of Buangor in western Victoria. The surrounding area is rural consisting primarily of cleared agricultural land with the Mt Buangor and Langi-ghiran State Parks located to the north-+west of the wind farm.
Demographic context:	In the 2006 Census Buangor had a population of 213 persons with 87 dwellings.
Site Description:	The wind turbines are located on a series of hills to the south of the Western Highway bordered by Challicum Road to the east and Geelong Road to the west and south. The wind farm is only visible from these roads that surround it. The turbines are well spaced along a ridge line that is relatively less prominent from a distance.



5.8.2 MARKET OVERVIEW

The change in the median price of house sales in the local government are of Ararat from 2000 to 2008 is presented in the table below. Due to limited sales activity (approximately 0 to 1 sales per year) an analysis of the suburb of Buangor's median value was not available:

ARARAT LGA HOUSE SALES ANALYSIS			
Year	Median	Frequency	% Change over Previous Year
2000	$62,500	195	8%
2001	$65,000	241	4%
2002	$78,500	261	21%
2003	$93,000	257	18%
2004	$125,000	206	34%
2005	$145,000	233	16%
2006	$143,000	168	-1%
2007	$153,750	228	8%
2008	$142,750	152	-7%

Source: RP Data

The area surrounding the Challicum Hills wind farm is a thinly traded market with little sales activity evident. The majority of sales have been to Macquarie Bank which has been quite active in the local rural market over the last decade reportedly buying up land for timber plantations. A review of sales in the surrounding area since construction of the wind farm began in 2002 revealed that 15 of these were purchased by Macquarie Bank. These appear to be at market rates and a selection of sales located closest to the wind farm is presented below. No other sales with views of turbines were found.

5.8.3 MARKET EVIDENCE

Property Address	Sale Date	Sale Price	Area
Property A5 BUANGOR	25/01/2005	$333,658	135.17 ha
Purchased by Macquarie Bank Limited. Rural land shows $2,468 per hectare.			
Property B5 BUANGOR	05/05/2006	$465,375	6.98 ha
Rural property purchased by Macquarie Bank Limited.			
Property C5 BUANGOR	15/07/2004	$111,201	39.9 ha
Rural property purchased by Macquarie Bank Limited.			

Note while there is limited sales in the area analysis is further limited by a lack of land area being reported on sales transaction records with the majority not specifying the land area.

5.8.4 SUMMARY

Challicum Hills wind farm is in a rural area that is mostly comprised of agricultural land and timber plantations. The wind farm is well sited in that it is relatively aesthetically less prominent to surrounding properties. While limited transaction evidence was found it is estimated that the wind farm has had little effect to the surrounding rural property values.

6. DISCUSSION

The aim of this study was to undertake a preliminary assessment of the impact of wind farms on surrounding land values in an Australian context through the analysis of sales transaction data. The main finding was that the wind farms erected to date do not appear to have negatively affected property values in most cases.

A review of wind farms currently operating in Australia revealed that they have primarily been developed in rural areas either inland or on the coast but generally removed from densely populated areas. Thus, the issue of impacts of land values has not arisen for most wind farms as they are located away from developed areas. As a result small samples of sales transactions limited the extent to which conclusions could be drawn. This is not a unique situation with similar findings and limitations being reported in the UK (Sims & Dent, 2007).

A total of 45 property transactions within eight (8) study areas were investigated through conventional valuation sales analysis. Forty (40) of the 45 sales investigated did not show any reductions in value. Five (5) properties were found to have lower than expected sale prices (based on a statistical analysis). While these small number of price reductions correlate with the construction of a wind farm further work is needed to confirm the extent to which these were primarily due to the wind farm or if other factors may have been involved.

Results also suggest that a property's underlying land use may affect the property's sensitivity to price impacts. Properties in rural / agricultural areas appeared to be the least likely to be affected by a wind farm with no reductions in value for rural propertied evident at any of the eight (8) wind farms investigated.

Residential properties in townships with distant views of a wind farm (more than 2-3 kilometres away), also appeared to not have been negatively affected by a wind farm. Transactions of 13 residential properties in townships with distant views of a wind farm did not show any negative price impacts. This was evident at the Waubra, Toora and Wonthaggi wind farms. A price reduction of 13% was recorded for one (1) property's sale, however, further information is required to determine if other factors were involved (e.g. it may have been an urgent sale).

Results for 'lifestyle' properties were not consistent. On the one hand, no reductions in value were identified in the four (4) 'lifestyle' properties investigated at the Blayney wind farm in NSW. On the other hand, possible reductions in value were found for one (1) lifestyle property at the Waubra wind farm, one (1) property at the Toora wind farm, and two (2) at the Codrington wind farm. The possible reduction in value ranged from 6-27% with a weight in the mid twenties percentile. However, in most locations there were other lifestyle properties located nearby which showed no reduction in value.

Finally, an increase in the time it takes to sell a property might be a possible effect of wind farm developments. As people can sometimes be polarized around wind farms with some in support and some refusing to live near one the potential market may be reduced. However, this does not seem to be translated into reduced sale prices for the majority of sales data investigated in this study.

The uncertainty of the current results is not specific to this research project and instead appears to be a common finding of this sort of study. Studies of property markets will always be influenced by the subjectivity that often accompanies the property purchase decision. Additionally, a very wide range of (often interacting) property features affect the price paid. These factors often militate against statistical analysis.

This study was intended as a preliminary assessment and has been limited by the time frame available and the number of sales transactions available for study. Further analysis (with additional data) may yield more comprehensive results.

Future research may look at expanding the study to incorporate more properties in other study areas (e.g. South Australia). Also, a deeper examination of the cases in the current research which did indicate a negative effect may provide further information on the factors behind the reduction in values. Notwithstanding this, the capacity of further studies to contribute is also likely to be limited by the corresponding limited availability of sales transaction data. More sales evidence will be available in NSW over coming years with a number of wind farms understood to be in the 'pre-construction' stage (i.e. feasibility, development assessment or planning approval).

6.1 CONCLUSION

From our analysis of previous studies and our own investigations, the majority of wind farms erected in Australia appear to have had no quantifiable effect on land values. A relatively small number of "lifestyle" type properties located very close (less than 500 metres) to wind farms in Victoria were found to have lower than expected sale prices (based on a statistical analysis), and it is possible that audio and visual aspects of wind farms contributed to this. Evidence suggests that any such wind farm related impacts on land values can be readily alleviated by ensuring a suitable separation distance between the wind turbines and any nearest residential dwellings. Generally, the separation distances identified in NSW appear to be sufficient in this regard. It is noted that standard separation distances are not used in NSW in the major project approval process. Instead, each wind farm proposal is assessed individually on its merits.

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Economic Impact Assessment of the **Hallett Wind Farms**

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SINCLAIR KNIGHT MERZ
SKM

Economic Impact Assessment Of the Hallett Wind Farms

- Final Report
- 8th July 2010

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Contents

1. Definitions

Construction includes all activities required to design, procure and construct the project.

Development includes all activities required to progress the project to the point where a business case is presented for Board approval. Typically, development activities would include attaining all required permits and authorisations, implementing a wind monitoring programme, procuring a design and construct contractor and negotiating a Transmission Connection Agreement.

Direct Employment includes the employee who are directly employed in developing, constructing and/or operating the wind farms and those directly employed in manufacturing wind farm plant and equipment and supporting these activities.

Gross Regional Product (GRP) is the total market value of goods and services produced in a region after deducting the costs of goods used up in the process of production (intermediate Consumption) but before deducting consumption of fixed capital (depreciation).

Gross Value Added (GVA) is defined as total factor income plus taxes and less subsidies on production. Total factor income is made up of compensation of employees, gross operating surplus and gross mixed income.

Hallett Wind Farm Project means the combination of stages 1,2,3,4 and 5.

Indirect Employment is generated from the expenditure on flow on activities from developing, constructing and operating wind farms including expenditure by suppliers of components for wind farm manufacture needed to replace materials used up in the manufacturing process such as steel, reinforcing bars, paint etc. (production induced) and the expenditure of the wages and salaries of direct employees (consumption induced).

Operation phase commences on issue of the Practical Completion certificate for the project. The Operational phase for a wind farm is typically 20 to 25 years.

Region means the local government areas of Goyder, Clare and Gilbert Valleys and Northern Areas (including Burra, Clare, Jamestown & Hallett) Councils.

Total Expenditure is the total amount spent on the direct development, construction and operations of the wind farms.

2. Executive Summary

AGL Energy Ltd (AGL) engaged SKM to undertake an Economic Impact Assessment (EIA) to assess the economic impact that the Hallett wind farm projects have had on the economy in the region. The objective for undertaking the study is to quantify the economic impacts of the wind farms and the associated AGL Burra Information Centre to demonstrate the benefits of AGL's wind energy activities in the region and more broadly.

The findings from the assessment are set out in the report and the highlights are summarised below:

- Total Project development and construction expenditure:
  - To date $800m (June 2010)
  - To completion of Hallett 1, 2, 4 and 5 $897m
  - To completion of Hallett 1, 2, 3, 4 and 5 $1,065m
- Regional Project development and construction expenditure :
  - To date $88m (June 2010)
  - To completion of Hallett 1, 2, 4 and 5 $111m
  - To completion of Hallett 1, 2, 3, 4 and 5 $132m
- Regional Project operations expenditure:
  - To date $3.2m (June 2010)
  - After completion of Hallett 1, 2, 4 and 5 $12.5m per annum
  - After completion of Hallett 1, 2, 3, 4 and 5 $15m per annum
- Regional construction Gross Value Added (GVA) is estimated at some $49.5m to date with the highest annual amount of some $17.8m in the current (2010) year. This GVA would add some 3.3% to the Mid North GRP in the current calendar year
- Regional operational GVA is estimated to be either some $6.25m or $7.5m per annum depending on whether Hallett 3 is approved and constructed or not. These GVA would provide an annual increase in the Mid North GRP of either 1.15% or 1.4%
- Regional employment:
  - To date (June 2010) total direct employment of 450 FTE construction job years plus 15 in operations with an average annual employment of 98
  - To completion of Hallett 1, 2, 4 and 5 total direct construction employment would increase to 540 job years at an average annual employment of 90 plus 36 operations jobs over the life of the projects..

  - To completion of Hallett 1, 2, 3, 4 and 5 the total direct construction employment numbers would increase to 640 job years at an average of 80 per annum and operations employment of 42 over the life of the projects
  - Peak employment during construction of approximately 150
  - The direct construction employment is spread over the period from the end of 2005 to date with some overlap of the different Hallett projects. Based on the average and peak employment estimates it is likely that the Hallett wind farm projects employed a workforce of some 100 resident in the region from mid to late 2006 and which is currently likely to be closer to 150 people. These numbers are likely to reduce from later this year as the large Hallett 4 project nears completion
- In addition to the direct construction employment in the region indicated above, the project will generate manufacturing and support jobs in other parts of South Australia, nationally and overseas depending on the source of labour and materials. The total direct workforce including the construction jobs above and manufacturing and support jobs is estimated to be:
  - To date (June 2010) some 185 people on average and 850 FTE job years of work
  - To completion of Hallett 1, 2, 4 and 5 some 200 people on average and some 1,000 FTE job years
  - To completion of Hallett 1, 2, 3, 4 and 5 some 190 people on average and some 1,200 FTE job years of work. The average employment reduces based on the construction workforce reducing to undertake the smaller Hallett 5 and Hallett 3 wind farms
- There will also be additional indirect employment estimated at between 2,000 and 2,400 job years depending on whether Hallett 3 is approved and developed or not. These jobs will be spread through the South Australian, national and overseas economies although a significant proportion of the jobs created by flow expenditure from the wages and salaries of construction workers could be created within the region
- Qualitative highlights from the interviews and questionnaires include:
  - Evidence of strong local business support for the Hallett project
  - Accommodation and food services providers have had a significant increase in sales over the period the wind farms have been in construction
  - Local contractors have been employed directly in the wind farms' construction, and
  - Other businesses in the region's towns seem to have increased business and be more buoyant as a result of the additional people and expenditure in the region
  - Local businesses that have benefitted from contracts with the wind farm include:
    - Domestic scale electricians
    - Transport operators
    - Competent machine operators

    - General labourers
    - Quarries, and
    - Concrete businesses
- A view that the project has had no noticeable impact on visitation to the region and if anything seems to have had a positive impact in terms of visitor interest. Visitor numbers at the Burra Visitor Centre have been broadly static for the past seven years and seem to be rising over the past three
- The regional population has been relatively static and in some areas declining. It is considered that the community will grow as a result of the wind farms. If so this could ensure that the population doesn’t decline and that services can be retained and augmented
- It was noted that a number of farmers were finding it difficult to make ends meet and that the wind farms had changed this by direct payments to farmers whose land is included in the wind farm site, by providing employment opportunities and by creating a demand for under-utilised assets such as farmhouses that contractors use for accommodation of site personnel.
- The Community Funds have been a big plus, with over $110,000 distributed to date. Examples include:
    - Shade structure for the Booborowie community pool
    - Contribution to purchase of community tractor for the Mt Bryan Progress Association
    - Computer for the Hallett historical society
    - Funding for public building maintenance and upgrades
    - Sponsorships of local events such as the AGL Bush to Burra, Budaleer Music Festival and Burra Jazz in the Mine
- The wind farm development appears to have increased the buoyancy of the local rental market and encouraged new accommodation developments
- It was noted that there were successful projects such as the local school project undertaking native plantings at the wind farm for landscape amenity and environmental reasons that could be replicated within the region. The project includes an education component and AGL and contractors also provided careers talks and advice on the range of employment and training opportunities that are offered in the wind energy industry.

3. Introduction

AGL engaged SKM to undertake an Economic Impact Assessment (EIA) to assess the economic impact that the Hallett Wind Farm projects have had on the economy in the region. The objective for undertaking the study is to quantify the economic impacts of the wind farms and the associated AGL Burra Information Centre to demonstrate the benefits of AGL's wind energy activities in the region and more broadly.

3.1. Background

AGL has been active in the mid-north region of South Australia. It has completed the construction of two wind farms (Hallett Stage 1 & 2) and a further two wind farms (Hallett Stage 4 & 5) are under construction. Refer to Figure 1 below for the wind farm locations.

When completed as planned the four current sites and the proposed fifth Hallett 3 site will include 200 turbines (Table 1) and have a generation capacity of some 410 MW of electricity.

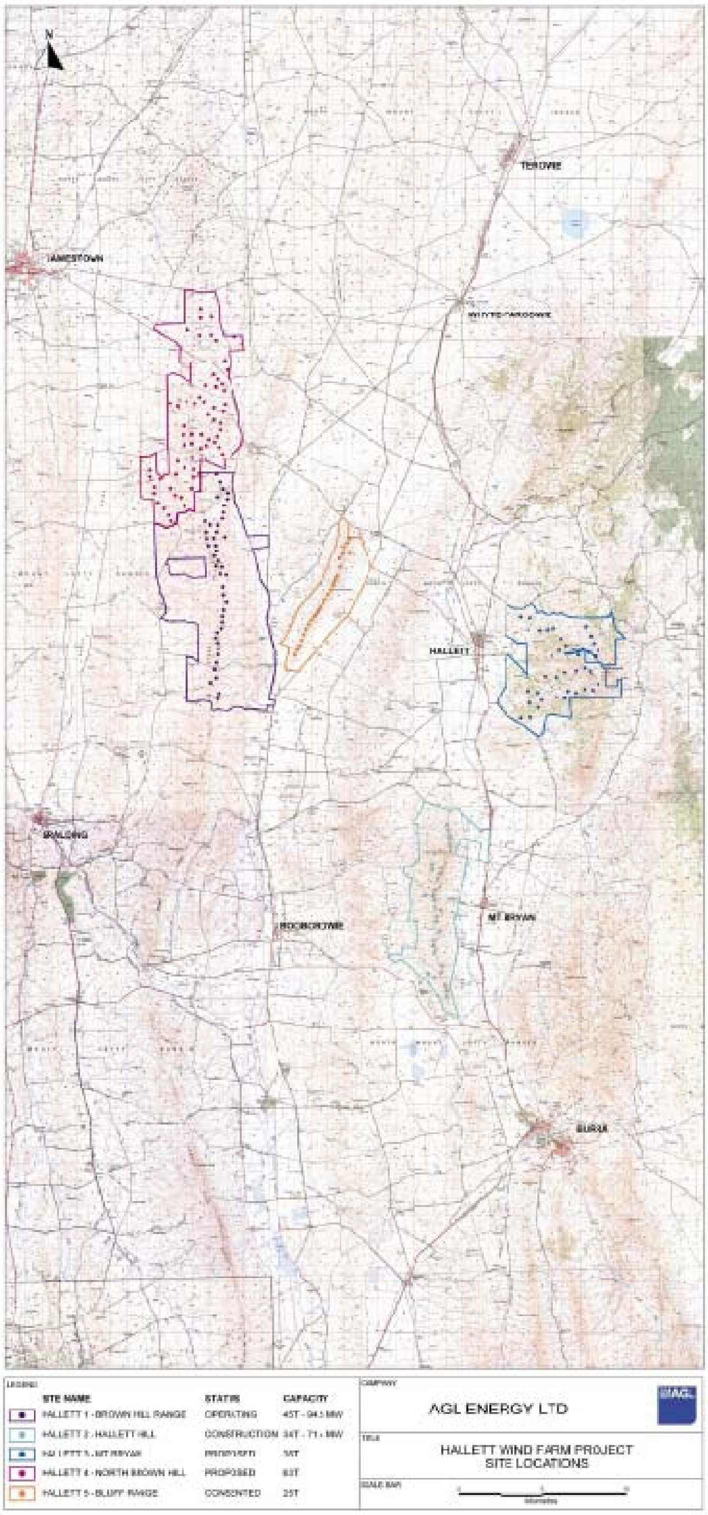
- **Table 1: Hallett Wind Farms Size and Capacity**

	No. Of Turbines	Capacity MW
Hallett 1	45	95
Hallett 2	34	71
Hallett 3 (1)	*33*	*69 (2)*
Hallett 4	63	132
Hallett 5	25	52.5
Total Planned	200	410

1: Planned (currently subject to appeal)

2: Assumes 2.1MW turbines

Figure 1: Hallett Wind Farm Locations



3.2. Terms of Reference

The terms of reference for the study are to determine for the development, construction and operation phases of the projects the:

- Impact on Region defined as the Local Government Areas (LGAs) of Goyder, Clare and Gilbert Valleys and Northern Areas (including Burra, Clare, Jamestown & Hallett)
- Impact and potential impact due to Hallett Stage 1,2,3,4 & 5 Wind Farms and AGL Burra Information Centre located in Burra
- Economic impacts, including but not limited to Gross Regional Product (GRP), Direct and Indirect Employment and Total Expenditure.

3.2.1. Deliverables

This report, entitled, “Economic Impact Assessment of the Hallett Wind Farms” discusses the impacts of the wind farms on the mid-north region of South Australia and on the State.

3.3. Brief description of the Hallett Wind Farm projects

The Hallett Wind Farm Project comprises five wind farm sites in the vicinity of Hallett in Mid North of South Australia. Two wind farms are operational; Hallett 1 a 95 MW facility at Brown Hill and Hallett 2 a 71 MW facility at Hallett Hill. Two are under construction; Hallett 4 a 132.5MW facility at North Brown Hill and Hallett 5 a 52.5MW facility at the Bluff Range. The fifth stage development Hallett 3 proposal of 69MW facility at Mount Bryan is currently subject to appeal. If the Hallett 3 project is approved and developed, the total project will comprise 200 turbines and provide some 410MW of electricity generation capacity.

- **Table 2: Hallett Wind Farms Total Expenditure to Date (June 2010)**

	Development	Construction	Operations
Hallett 1	$5,385,000	$227,452,000	$10,500,000
Hallett 2	$3,045,000	$189,102,000	$3,095,000
Hallett 3	$2,833,000	N/A	N/A
Hallett 4	$5,440,000	$333,482,000	N/A
Hallett 5	$1,845,000	$31,300,000	N/A
Total to Date	$18,548,000	$781,336,000	$13,595,000

Table 2 above, summarises the Total Expenditure to date in developing the project by stage and by phase of the project including developing each wind farm to approval, construction of the four approved individual wind farms to date and the operations expenditure for the two operating facilities.

The expenditure information was supplied by the main contractors for each wind farm as follows:

- AGL
- Wind Prospect
- Suzlon
- Electranet
- KBR
- Garrad Hassan
- Sinclair Knight Merz (SKM).

3.4. Brief description of the study requirements and process

Information on each of the above organisation's direct expenditure and expenditure by their sub-contractors was provided though completion of a questionnaire (Appendix A). The expenditure data was reviewed and anomalies reconciled. Consideration was given to any potential double counting and any double counting addressed. While it is possible that estimates may be either under or over estimated we consider that it is unlikely that these are major.

The questionnaire also requested information on estimated:

- Expenditure by location including the Mid North region, other South Australia, other parts of Australia and overseas
- Direct employment in the region
- Expenditure in the Mid North region related to the development, construction and operations of the wind farms. These items included accommodation, meals and incidental spending, regulatory fees and charges, community funds and sponsorships, payments to landowners and regional spending on services during the three phases of each wind farm
- Type of accommodation used by direct and contractor employees during construction. This information was only estimated for the construction phase of each wind farm when the largest number of employees are resident in the region. During development it is likely that while employees may visit a number of times, most visits would be relatively short term including day trips from Adelaide. Accommodation for overnight stays is likely to be motels, hotels, guest houses or Bed and Breakfast. Operational employment is smaller and it is expected that

permanent full time staff will either purchase or rent a home on a longer term lease with some specialist staff visiting for specific operational and/or maintenance activities.

In addition, the questionnaire asked about the various company policies related to labour hire and employment including any specific programs for specific target groups and skills development.

Other information was collected during a visit to the Wind Farm region including interviews with local business operators, local representatives of AGL and contractors and relevant officers/representatives of local councils and collection of relevant regional publications and other information.

The information obtained is analysed and reported on in this report. **As some information was confidential to individual companies no individual company information provided for the study is reproduced in this report**.

The Electranet capital cost information was not provided as an issue of commercial confidentiality and an estimate was calculated from the annual charges that were provided by both Electranet and AGL.

A socio-economic profile of the three regional Councils is provided and used to identify the relative importance of the Hallett Wind Farm Project to the region.

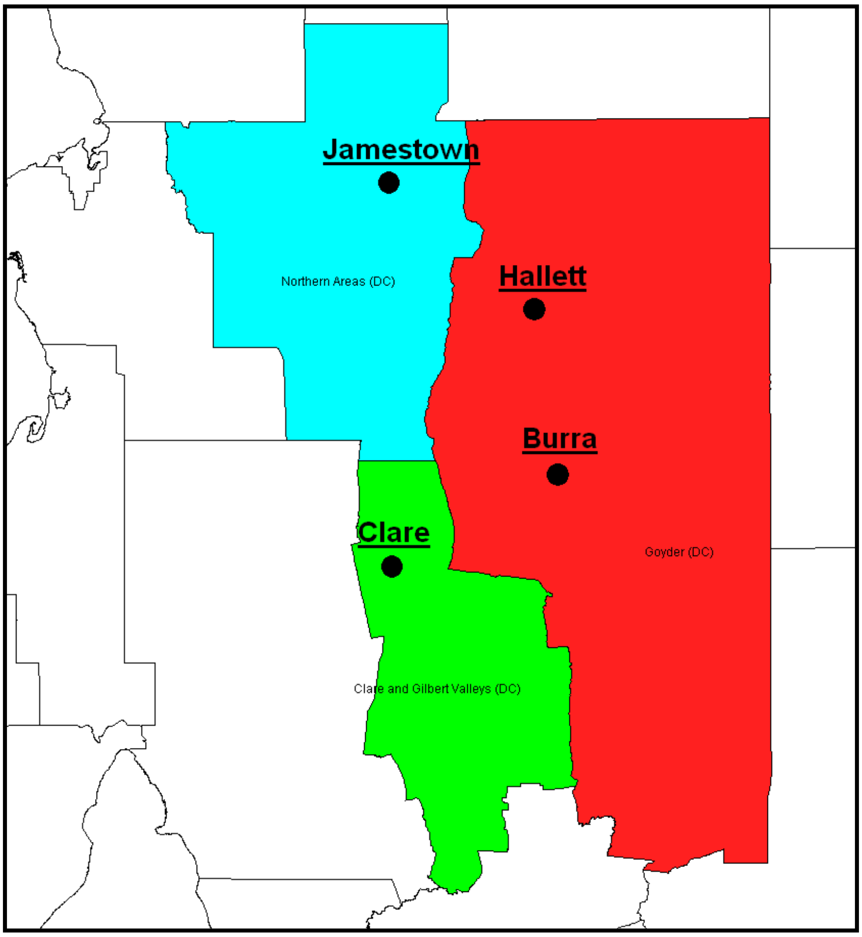
4. Description of the Hallett Region

This chapter describes the main demographic and socio-economic attributes of the region and then indicates the scale of the Hallett Wind Farms in this regional context.

4.1. Socio-economic profile: Goyder, Clare and Northern Areas

The purpose of this report is to provide a socio-economic profile of the towns (Clare, Burra, Hallet and Jamestown) that may be affected by the Hallett wind farms. They are located approximately 100km north of Adelaide in the Local Government Areas (LGA) of Clare and Gilbert Valleys, Goyder and Northern areas (See Figure 2).

Figure 2 Subject area – Clare and Gilbert Valleys, Goyder and Northern Areas



4.1.1. Population

As of the 2006 census, the population of Clare and Gilbert Valleys, Goyder and Northern Areas were 8,142, 4,180 and 4,650 persons respectively or a combined estimate of 16,972 persons. This represents approximately 4% of the population of the Balance of South Australia[1]. Table 3 demonstrates that Clare and Gilbert Valleys and Northern Areas have experienced a growth of 0.9% and 2.29% respectively while Goyder has contracted by 0.9%. Results suggest that few people are leaving or arriving into these areas.

Despite the fact that the population has somewhat stabilised in all three areas, Figure 3, Figure 4 and Figure 5 show that there is a trend towards an aging population. From 2001 to 2006, the

[1] Balance of South Australia includes all areas outside the Major Statistical Region of Adelaide.

proportion of people under the age of 44 has fallen and the proportion of people over the age of 55 has increased. As a result, the median ages have increased in all areas. The median age increased from 40 years old in 2001 census to 42 years old in 2006 census in Clare and Gilbert Valleys and from 40 years old in 2001 census to 43 years old in 2006 census in Goyder and Northern Areas. The median ages of South Australia and Australia in 2006 were 39 and 37 years old respectively.

While it is impossible to predict population growth into the future, the Australian Bureau of Statistics (ABS) has released three main projections to the year 2056 for the Balance of South Australia. The first projection was largely based on year 2006 trends in fertility, life expectancy at birth, net overseas migration and net interstate migration. The remaining two projections were based on high and low assumptions for each of these variables.

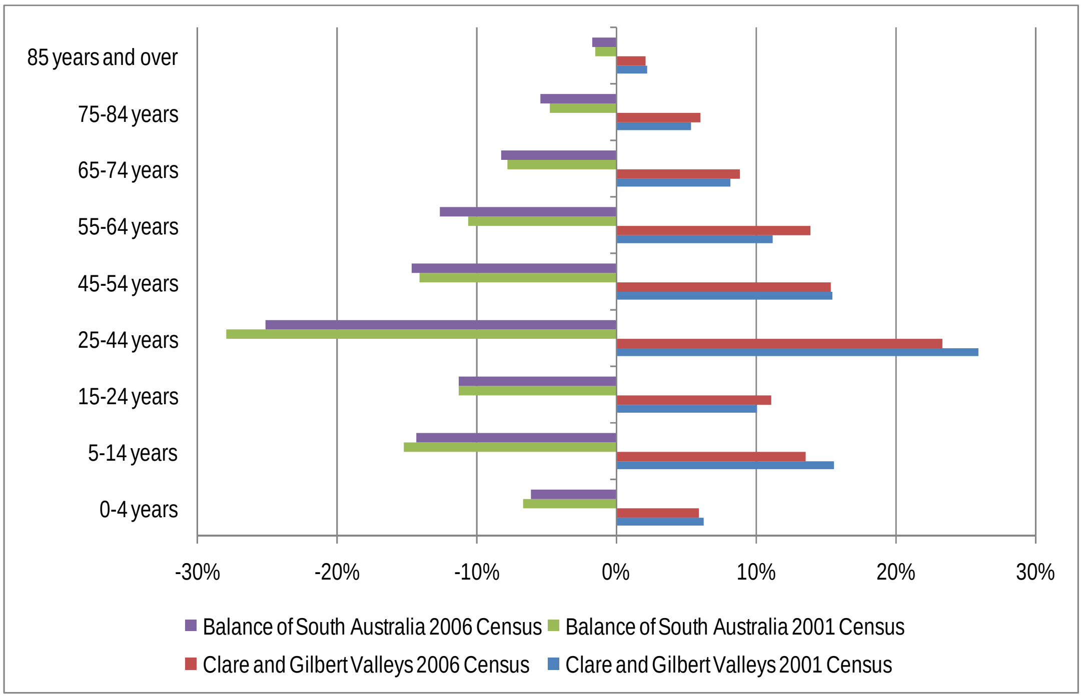
Based on 2006 trends, Figure 6 shows that the population of the Balance of South Australia is projected to increase rapidly, to 18.5% higher than 2006 levels in 2026. However Figure 6 demonstrates that the population growth for the Balance of South Australia is much greater than the growth rates for Clare and Gilbert Valleys, Goyder and Northern Areas.

- **Table 3: Population of Clare and Gilbert Valleys, Goyder and Northern Areas as of the 2001 and 2006 census**

	2001 Census	2006 Census	% change
Clare and Gilbert Valleys	8,069	8,142	0.90%
Goyder	4,218	4,180	-0.90%
Northern Areas	4,546	4,650	2.29%
Balance of South Australia	392,809	408,504	4.00%

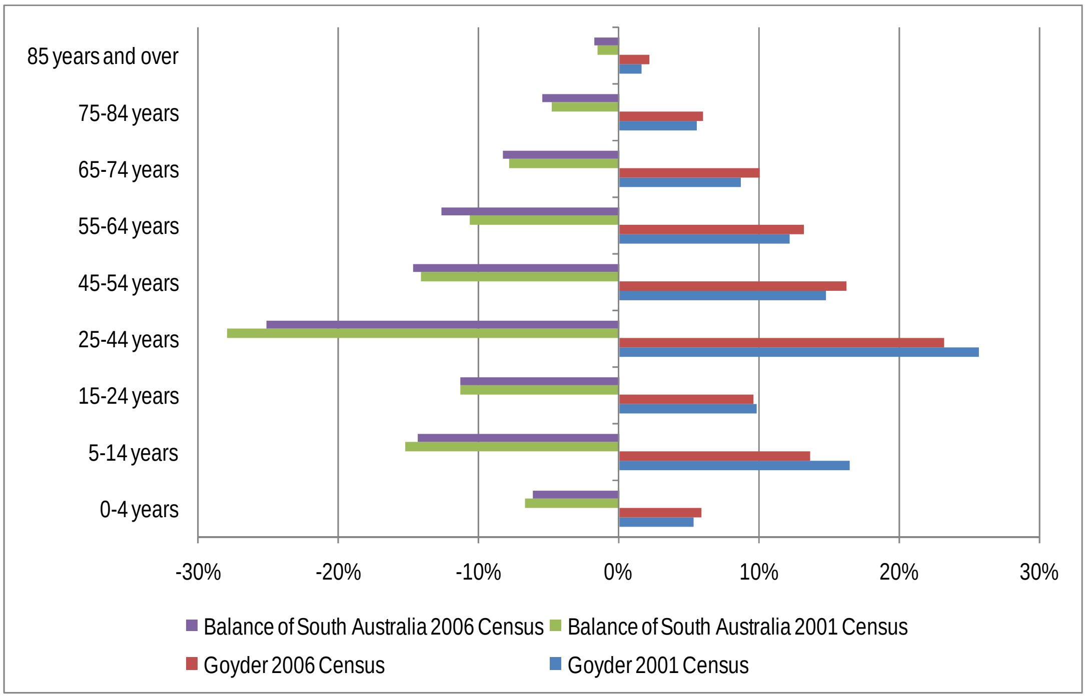
Source: ABS 2001 & 2006 Census

Figure 3 Age distribution for Clare and Gilbert Valleys



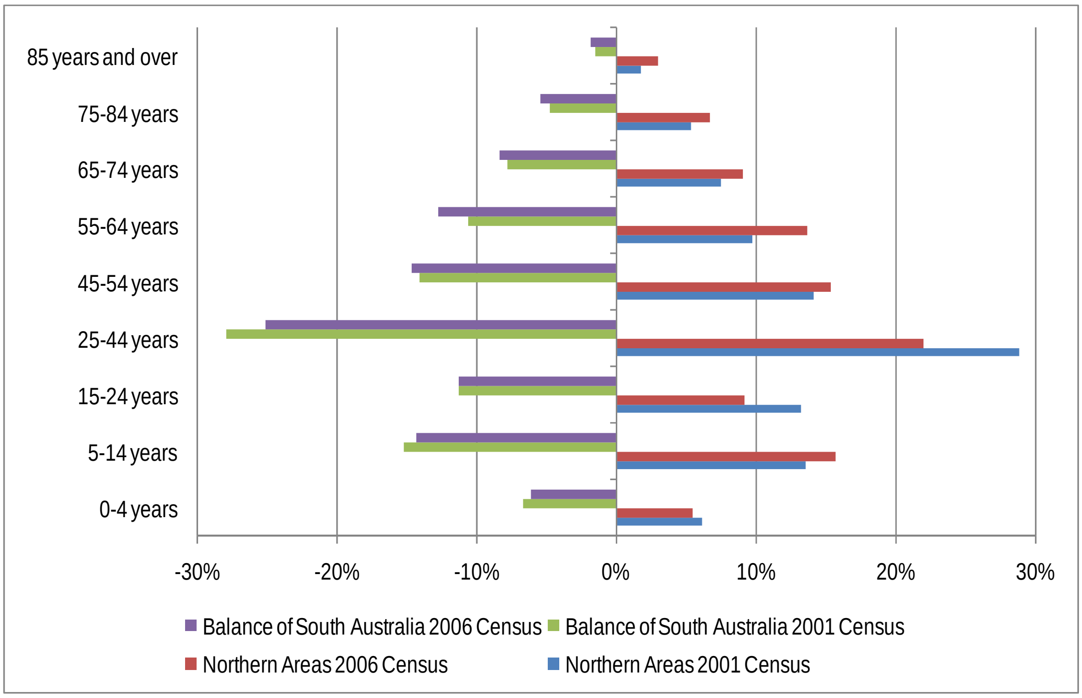
Source: ABS 2001 & 2006 Census

Figure 4 Age distribution for Goyder



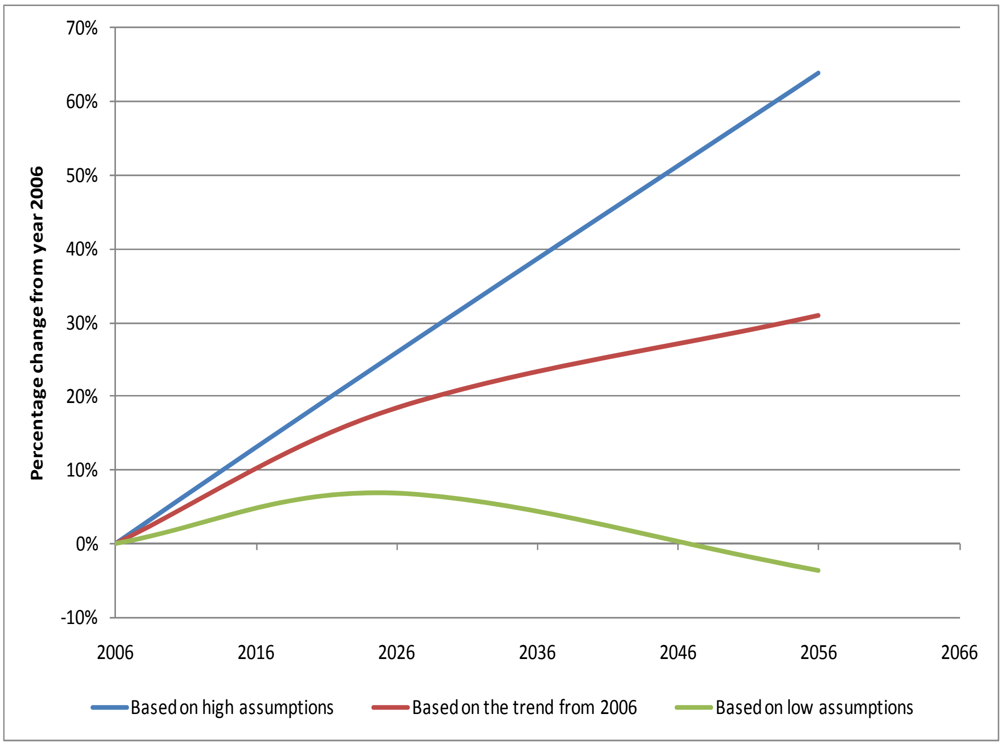
Source: ABS 2001 & 2006 Census

Figure 5 Age distribution for Northern Areas



Source: ABS 2001 & 2006 Census

Figure 6 Population projection (Percentage Change) for the Balance of South Australia



Source: ABS Population Projections, Australia, 2006 to 2101

4.1.2. Household Composition

Reflecting the aging of the population in all three areas, Clare and Gilbert Valleys, Goyder and Northern Areas have all experienced a change in household composition.

Table 4 shows that couple families with no children have increased, couple families with children have decreased and lone person households have increased since the 2001 census across all areas. This is most pronounced in the Northern Areas, where the number of couple families with children has dropped from 585 in 2001 census to 513 in 2006 census or a 12% reduction.

- **Table 4: Household composition as of the 2006 census and % change from 2001 census**

	Family households								Others			
	Couple family with no children		Couple family with children		One parent family		Other family		Lone person household		Group household	
	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001
Clare and Gilbert Valleys	1,118	8%	902	-6%	249	0%	24	20%	803	4%	82	34%
Goyder	549	2%	456	-2%	142	-3%	9	-10%	500	9%	29	-24%
Northern Areas	627	13%	513	-12%	147	7%	6	50%	499	8%	27	0%
Balance of South Australia	48,023	12%	45,398	-3%	14,649	14%	1,188	9%	40,544	7%	3,371	8%

Source: ABS 2001 & 2006 Census

4.1.3. Migration

The number of residents from Clare and Gilbert Valleys born in Australia, Germany, Netherlands, New Zealand and the United Kingdom has dropped since 2001 census. However the number of residents born elsewhere/ not stated has increased from 336 in 2001 census to 447 in 2006 census contributing to an overall increase in population.

In contrast, Goyder has experienced a small contraction in population and this trend is reflected in Table 5. The number of residents born in Australia has dropped from 3,689 in 2001 census to 3,572 in 2006 census or a 3% contraction.

Northern Areas has experienced a population growth, from 4,546 in 2001 census to 4,650 in 2006 census and this is reflected in Table 5. Table 5 shows that the number of residents born in Australia, Germany, Netherlands and New Zealand has increased by 1%, 115%, 36% and 117% respectively.

Table 6 shows the place of usual residence 1 year ago as of the 2006 census and the percentage change from 2001 census. All areas across all categories have experienced a positive growth with the exception of residents in Goyder relocating to a different address within the same statistical local area (SLA).

- **Table 5: Country of Birth as of the 2006 census and % change from 2001 census**

	Country of Birth											
	Australia		Germany		Netherlands		New Zealand		United Kingdom		Elsewhere/ Not stated	
	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001
Clare and Gilbert Valleys	6,985	-1%	27	-7%	31	-3%	37	-16%	493	-1%	447	33%
Goyder	3,572	-3%	20	-29%	20	11%	29	61%	245	17%	245	15%
Northern Areas	4,103	1%	28	115%	19	36%	26	117%	175	-2%	251	12%
Balance of South Australia	338,632	3%	2,529	-2%	2,205	2%	2,848	9%	24,033	1%	26,983	19%

Source: ABS 2001 & 2006 Census

- **Table 6: Place of usual residence 1 year ago as of 2006 census and % change from 2001 census**

	Same usual address 1 year ago		Different usual address 1 year ago (Same SLA)		Different usual address 1 year ago (Different SLA)		Different usual address 1 year ago (Overseas)		Not stated	
	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001
Clare and Gilbert Valleys	6,581	4%	561	1%	558	0%	30	150%	320	111%
Goyder	3,425	3%	227	-5%	302	13%	10	25%	180	44%
Northern Areas	3,899	3%	236	18%	278	1%	21	600%	175	86%
Balance of South Australia	324,927	N/A	25,890	N/A	29,958	N/A	2,154	N/A	20,784	N/A

Source: ABS 2001 & 2006 Census

4.1.4. Educational Attainment

Clare and Gilbert Valleys has experienced significant growth in the number of residents having obtained a postgraduate degree, from 32 in 2001 census to 50 in 2006 census or a 56% increase. In addition, the number of residents having completed a graduate diploma & graduate certificate and bachelor degree has increased by 3% and 1% respectively. In contrast, the number of residents having completed an advanced diploma & diploma and certificate has decreased by 14% and 9% respectively (Table 7).

Goyder has not experienced any increase in the number of residents having completed non-school formal education. The number of residents with a postgraduate degree has not changed since 2001 census and the number of residents with a graduate diploma & graduate certificate, bachelor degree, advanced diploma & diploma and certificate has decreased across all categories.

Northern Areas has not experienced any increase or decrease in the number of residents having completed a postgraduate degree. However the number of residents having completed a graduate diploma and graduate certificate, advanced diploma and diploma and certificate has decreased by 5%, 15% and 9% respectively. In contrast, the number of residents with a bachelor degree has increased from 155 in 2001 census to 180 in 2006 census or a 16% increase.

The balance of South Australia has experienced a positive increase across all areas where the most significant increase occurred within the postgraduate category. The number of residents with a postgraduate degree increased from 1,525 in 2001 census to 2,189 in 2006 census or a 44% increase.

- **Table 7: Non-school qualifications as of the 2006 census and % change from 2001 census**

	Postgraduate Degree		Graduate Diploma & Graduate Certificate		Bachelor Degree		Advanced Diploma & Diploma		Certificate	
	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001
Clare and Gilbert Valleys	50	56%	80	3%	456	1%	289	-14%	890	-9%
Goyder	9	0%	17	-19%	124	-6%	115	-1%	414	-3%
Northern Areas	18	0%	36	-5%	180	16%	132	-15%	429	-9%
Balance of South Australia	2,189	44%	2,833	11%	19,029	21%	16,709	27%	59,150	20%

Source: ABS 2001 & 2006 Census

4.1.5. Labour force

Table 8 demonstrates that the general employment trend is positive, where the number of employed persons has increased and the total number of unemployed persons has decreased across all areas since 2001 census. In addition, the total labour force has increase and total unemployment has dropped across all areas since 2001 census (Table 9).

Reflecting the positive trend in the number of employed persons and total labour force, Table 10 shows that the number of employed persons across all occupations has increased. The most significant increase was within the manger's category where Clare and Gilbert Valleys, Goyder and Northern Areas experienced an increase of 24%, 34% and 32% respectively.

- **Table 8: Employment status as of the 2006 census and % change from 2001 census**

	Employed		Unemployed				Total labour force		Total unemployment	
			Looking for full-time work		Looking for part-time work					
	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001
Clare and Gilbert Valleys	3,974	8%	74	-32%	58	7%	4,106	7%	3%	-24%
Goyder	1,826	7%	59	-26%	28	-35%	1,913	5%	5%	-32%
Northern Areas	1,994	9%	76	-25%	20	-44%	2,090	7%	5%	-34%

Balance of South Australia	179,709	N/A	6,456	N/A	3,295	N/A	189,460	N/A	5%	N/A

Source: ABS 2001 & 2006 Census

- **Table 9: Total Labour Force and Unemployment 2009**

SLA	Unemployed		Total labour force		Unemployment Rate	
	Average of 2009	% change from 2006	Dec-09	% change from 2006	Average of 2009	% change from 2006
Clare and Gilbert Valleys	104	-21%	4,741	15%	2.18%	-32%
Goyder	75	-14%	2,210	16%	3.33%	-27%
Northern Areas	62	-35%	2,417	16%	2.55%	-44%
Balance of South Australia	9725	0%	223,500	18%	4.28%	-15%

Source: DEEWR and ABS 2006

- **Table 10: Number of employed persons by occupation**

	Clare and Gilbert Valleys		Goyder		Northern Areas		Balance of South Australia	
	Number	% of total	Number	% of total	Number	% of total	Number	% of total
Managers	966	24%	616	34%	639	32%	34,539	19%
Professionals	555	14%	155	8%	243	12%	22,183	12%
Technicians & trades workers	493	12%	255	14%	232	12%	25,849	14%
Community & personal service workers	285	7%	122	7%	143	7%	15,994	9%
Clerical & administrative workers	391	10%	147	8%	190	10%	19,496	11%
Sales workers	303	8%	97	5%	138	7%	14,788	8%
Machinery operators & drivers	190	5%	108	6%	132	7%	13,644	8%
Labourers	722	18%	305	17%	245	12%	30,271	17%

Source: ABS 2001 & 2006 Census

4.1.6. Industries of employment

The major industries of employment within Clare and Gilbert Valleys, Goyder and Northern Areas are quite similar to the Balance of South Australia. However since 2001 census some industries of employment categories have changed, therefore only the results of those industries that have not changed are presented below.

Table 11 shows the number of employed persons by industries as of 2006 census and the percentage change from 2001 census.

Source: ABS 2001 & 2006 Census

Figure 7, Figure 8 and Figure 9 show the percentage change in employment for the three municipalities based on the number of employed person by industries as a proportion of the total population.

Results show that:

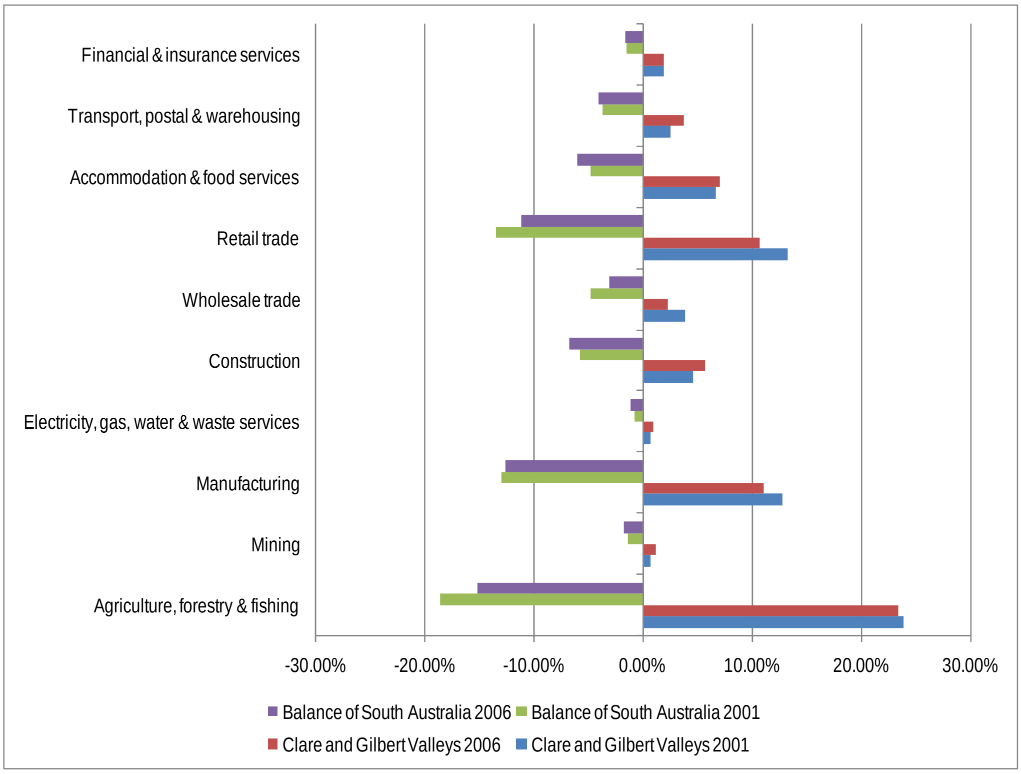
- Agriculture, forestry & fishing, manufacturing and retail trade are the three primary industries across all areas and for the Balance of South Australia
- The number of persons employed within the mining, electricity, gas, water & waste services, construction and accommodation & food services industries have increased across all areas and in the Balance of South Australia
- The wholesale trade and retail trade has experienced no increase or a contraction across all areas and in the Balance of South Australia.

Table 11: Employment by industries as of 2006 census and % change from 2001 census

	Clare and Gilbert Valleys		Goyder		Northern Areas		Balance of South Australia	
	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001	2006	% change from 2001
Agriculture, forestry & fishing	932	4%	616	-8%	581	-6%	27,383	-12%
Mining	47	74%	28	211%	31	244%	3,127	33%
Manufacturing	441	-8%	194	14%	118	5%	22,655	3%
Electricity, gas, water & waste services	38	52%	9	0%	19	73%	2,038	56%
Construction	227	31%	81	25%	110	22%	12,156	25%
Wholesale trade	92	-36%	40	-25%	68	0%	5,528	-32%
Retail trade	427	-14%	158	-7%	229	-3%	20,150	-12%
Accommodation & food services	280	12%	90	34%	88	57%	10,954	36%
Transport, postal & warehousing	146	57%	70	23%	68	-9%	7,415	18%
Financial & insurance services	77	10%	17	0%	33	-3%	2,960	12%

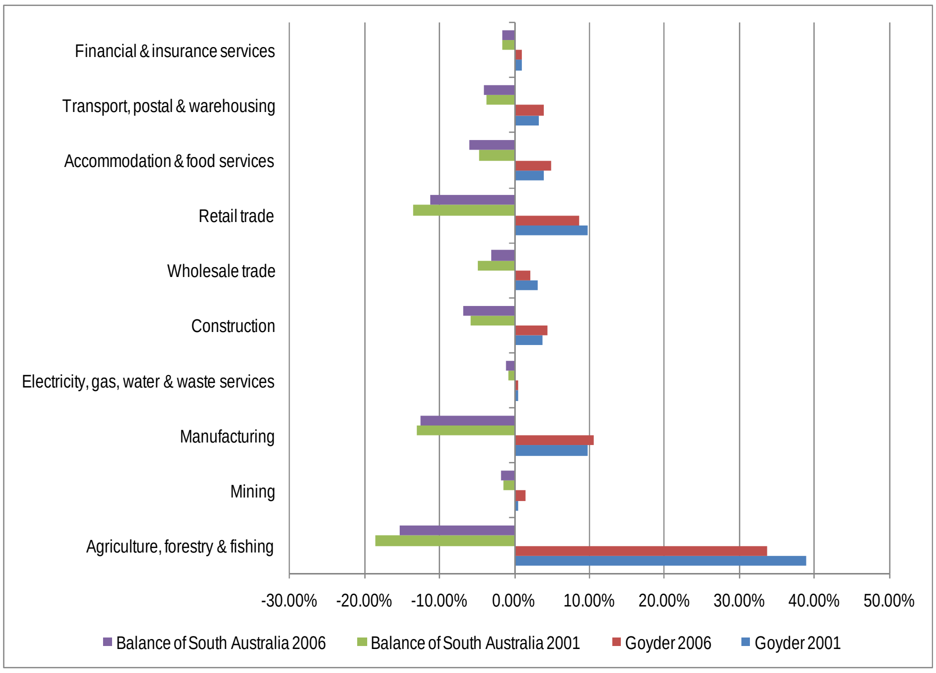
Source: ABS 2001 & 2006 Census

Figure 7 Percentage of employment by industry for Clare and Gilbert Valleys



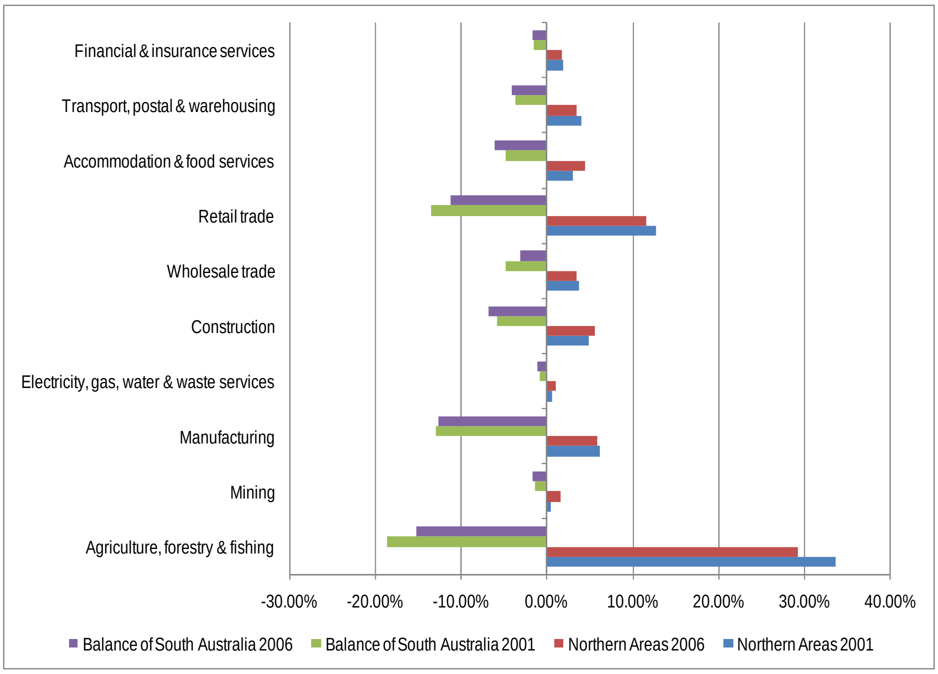
Source: ABS 2001 & 2006 Census

Figure 8 Percentage of employment by industry for Goyder



Source: ABS 2001 & 2006 Census

- **Figure 9 Percentage of employment by industry for Northern Areas**



Source: ABS 2001 & 2006 Census

Table 12 shows the employment by industry by size based on employment for the three municipalities sourced from the latest ABS Business Counts. In all three LGAs there are no businesses with employment of 200 or over and only Northern Areas have any businesses with over 100 employees. The majority of businesses in the region are small with just over 78% employing four or less people. Northern Areas has the smallest proportion of these micro businesses at some 76% of businesses employing four or less, while just over 79% of businesses in the other two municipalities employ four or less people.

Table 12: Employment by Industry Mid North LGS

Industry	SLA Labels	Non employing	1-4	5-19	20-49	50-99	100-199	200+	Total
		no.	no.	no.	no.	no.	no.	no.	no.
Agriculture Forestry and Fishing	Clare and Gilbert Valleys (DC)	294	123	102	6				525
Mining	Clare and Gilbert Valleys (DC)	0		0	0				0
Manufacturing	Clare and Gilbert Valleys (DC)	33	21	15	0	3			72
Construction	Clare and Gilbert Valleys (DC)	60	36	21					117
Wholesale Trade	Clare and Gilbert Valleys (DC)	12	0	9	0				21
Retail Trade	Clare and Gilbert Valleys (DC)	21	48	42	0				111
Accommodation Cafes and Restaurants	Clare and Gilbert Valleys (DC)	12	18	9	9	0	3		51
Tranport and Storage	Clare and Gilbert Valleys (DC)	24	15	6					45
Communication Services	Clare and Gilbert Valleys (DC)	3	3	0					6
Finance and Insurance	Clare and Gilbert Valleys (DC)	45	6	0					51
Property and Business Services	Clare and Gilbert Valleys (DC)	111	39	18	3	3			174
Education	Clare and Gilbert Valleys (DC)	3	0						3
Health and Community Services	Clare and Gilbert Valleys (DC)	18	9	6	3				36
Cultural and Recreational Services	Clare and Gilbert Valleys (DC)	9	3						12
Personal and Other Services	Clare and Gilbert Valleys (DC)	24	3	3					30
Total	Clare and Gilbert Valleys (DC)	669	324	231	21	6	3	0	1254

Source: ABS Business Counts 2007

Industry	SLA Labels	Non employing	1-4	5-19	20-49	50-99	100-199	200+	Total
		no.	no.	no.	no.	no.	no.	no.	no.
Agriculture Forestry and Fishing	Goyder (DC)	147	105	78	3				333
Mining	Goyder (DC)	3							3
Manufacturing	Goyder (DC)	3	0	0	3	0			6
Electricity Gas and Water Supply	Goyder (DC)	0							0
Construction	Goyder (DC)	24	3	0					27
Wholesale Trade	Goyder (DC)	12	9	3					24
Retail Trade	Goyder (DC)	36	9	18					63
Accommodation Cafes and Restaurants	Goyder (DC)	9	18	6	0				33
Tranport and Storage	Goyder (DC)	27	9	3					39
Communication Services	Goyder (DC)	0	3						3
Finance and Insurance	Goyder (DC)	9	0						9
Property and Business Services	Goyder (DC)	30	6	3	0				39
Education	Goyder (DC)		0						0
Health and Community Services	Goyder (DC)	0	0	3					3
Cultural and Recreational Services	Goyder (DC)	3	0						3
Personal and Other Services	Goyder (DC)	6	0	3					9
Total	Goyder (DC)	309	162	117	6	0	0	0	594

Industry	SLA Labels	Non employing	1-4	5-19	20-49	50-99	100-199	200+	Total
		no.	no.	no.	no.	no.	no.	no.	no.
Agriculture Forestry and Fishing	Northern Areas (DC)	192	105	102	0				399
Mining	Northern Areas (DC)	3	0						3
Manufacturing	Northern Areas (DC)	6	3	0		3			12
Electricity Gas and Water Supply	Northern Areas (DC)								
Construction	Northern Areas (DC)	21	6	9	0				36
Wholesale Trade	Northern Areas (DC)	9	3	0	3				15
Retail Trade	Northern Areas (DC)	15	3	21	0				39
Accommodation Cafes and Restaurants	Northern Areas (DC)	6	3	3	0				12
Tranport and Storage	Northern Areas (DC)	12	3	3					18
Communication Services	Northern Areas (DC)	0	0	3					3
Finance and Insurance	Northern Areas (DC)	9	3	0					12
Property and Business Services	Northern Areas (DC)	51	3	6					60
Education	Northern Areas (DC)	0							0
Health and Community Services	Northern Areas (DC)	12	6	0	3				21
Cultural and Recreational Services	Northern Areas (DC)	9							9
Personal and Other Services	Northern Areas (DC)	6	3						9
Total	Northern Areas (DC)	351	141	147	6	3	0	0	648

Table 13 provides the same business count data by business turnover. In line with the employment information, three businesses in the Northern Areas have over $50m in turnover whereas in Clare the highest turnover companies range up to $20m turnover and in Goyder $5m. Overall, just over 81% of businesses in the three municipalities have an annual turnover of less than $500,000. This ranges from 78.2% in Northern Areas through 79.4% in Clare to 87.9% in Goyder.

Table 13: Turnover by Industry Mid North LGAs

Industry	SLA Labels	Zero to less than $25k	$25k to less than $50k	$50k to less than $75K	$75k to less than $100k	$100k to less than	$150k to less than	$200k to less than $500k	$500k to less than $1m	$1m to less than $2m	$2m to less than $5m	$5m to less than $10m	$10m to less than $20m	$20m to less than $50m	$50m to less than $200m	$200m or more	Total
		no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.
Agriculture Forestry and Fishing	Clare and Gilbert Valleys (DC)	96	51	72	33	39	33	102	63	33	3		0				525
Mining	Clare and Gilbert Valleys (DC)		0				0	0		0	0						0
Manufacturing	Clare and Gilbert Valleys (DC)	6	3	6	0	3	6	21	12	6	3	6					72
Construction	Clare and Gilbert Valleys (DC)	15	15	12	9	9	12	24	12	9	0						117
Wholesale Trade	Clare and Gilbert Valleys (DC)	3	0	0	3	6	0	0	0	3	3		3	0			21
Retail Trade	Clare and Gilbert Valleys (DC)	3	6	12	0	6	9	30	21	18	6	0	0				111
Accommodation Cafes and Restaurants	Clare and Gilbert Valleys (DC)	3	0	9	6	6	3	9	3	9	3						51
Tranport and Storage	Clare and Gilbert Valleys (DC)	3	9		0	6	6	12	6	3	0	0					45
Communication Services	Clare and Gilbert Valleys (DC)	0	3	3		0			0								6
Finance and Insurance	Clare and Gilbert Valleys (DC)	12	3	12	3	6	6	3	0	3	0	3	0				51
Property and Business Services	Clare and Gilbert Valleys (DC)	48	18	21	18	18	12	21	9	6	3	0					174
Education	Clare and Gilbert Valleys (DC)	0		3					0								3
Health and Community Services	Clare and Gilbert Valleys (DC)	3	3	0	3	6	3	12	3	3							36
Cultural and Recreational Services	Clare and Gilbert Valleys (DC)	9	3		0	0	0	0	0								12
Personal and Other Services	Clare and Gilbert Valleys (DC)	9	3	6	6	3	0	0	3	0							30
Total	Clare and Gilbert Valleys (DC)	210	117	156	81	108	90	234	132	93	21	9	3	0	0	0	1254

Industry	SLA Labels	Zero to less than $25k	$25k to less than $50k	$50k to less than $75K	$75k to less than $100k	$100k to less than $150k	$150k to less than $200k	$200k to less than $500k	$500k to less than $1m	$1m to less than $2m	$2m to less than $5m	$5m to less than $10m	$10m to less than $20m	$20m to less than $50m	$50m to less than $200m	$200m or more	Total
		no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.
Agriculture Forestry and Fishing	Goyder (DC)	54	27	30	18	36	30	102	18	9	9		0				333
Mining	Goyder (DC)		3						0								3
Manufacturing	Goyder (DC)	0	0			3		0	0	0	3				0		6
Electricity Gas and Water Supply	Goyder (DC)					0											0
Construction	Goyder (DC)	6	3	3	0	12	3	0	0	0							27
Wholesale Trade	Goyder (DC)	6	0	3		3	3	3	3		3						24
Retail Trade	Goyder (DC)	6	9	6	9	6	0	12	12	0	3						63
Accommodation Cafes and Restaurants	Goyder (DC)	0	3	0	6	6	0	18	0	0							33
Tranport and Storage	Goyder (DC)	0	6	3	3	3	6	12	3		3						39
Communication Services	Goyder (DC)	0	0		0	3		0									3
Finance and Insurance	Goyder (DC)	3	6	0		0		0		0			0				9
Property and Business Services	Goyder (DC)	3	0	6	6	6	12	3	3	0	0						39
Education	Goyder (DC)	0															0
Health and Community Services	Goyder (DC)	0	0				0	0	3								3
Cultural and Recreational Services	Goyder (DC)	3	0	0													3
Personal and Other Services	Goyder (DC)	0	3	3	0	3											9
Total		81	60	54	42	81	54	150	42	9	21	0	0	0	0	0	594

Industry	SLA Labels	Zero to less than $25k	$25k to less than $50k	$50k to less than $75K	$75k to less than $100k	$100k to less than $150k	$150k to less than $200k	$200k to less than $500k	$500k to less than $1m	$1m to less than $2m	$2m to less than $5m	$5m to less than $10m	$10m to less than $20m	$20m to less than $50m	$50m to less than $200m	$200m or more	Total
		no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.
Agriculture Forestry and Fishing	Northern Areas (DC)	48	36	42	39	48	24	90	48	24							399
Mining	Northern Areas (DC)		0	3		0		0									3
Manufacturing	Northern Areas (DC)	0	0	3	3	0	3		0			0	3				12
Construction	Northern Areas (DC)	6	6	3	0	3	3	9	3	0	3	0					36
Wholesale Trade	Northern Areas (DC)	3	0		0	0		6	3			0			3		15
Retail Trade	Northern Areas (DC)	0	3	0	0	0	0	9	6	12	6	3					39
Accommodation Cafes and Restaurants	Northern Areas (DC)	3	3	0	0	0	0	0	3	3							12
Tranport and Storage	Northern Areas (DC)	3	0	0	3	3	0	3	3	3							18
Communication Services	Northern Areas (DC)	0	0		0	3		0									3
Finance and Insurance	Northern Areas (DC)	9	3	0				0	0	0			0				12
Property and Business Services	Northern Areas (DC)	6	0	6	12	12	0	9	9	6							60
Education	Northern Areas (DC)	0						0									0
Health and Community Services	Northern Areas (DC)	3	3	0		3	0	12	0								21
Cultural and Recreational Services	Northern Areas (DC)	3	0			6											9
Personal and Other Services	Northern Areas (DC)		3	0	3	0	3										9
Total	Northern Areas (DC)	84	57	57	60	78	33	138	75	48	9	3	3	0	3	0	648

Based on the above, the predominance of small businesses may limit the participation of local businesses in major regional projects. However, there are a number of transport and construction companies of a reasonable size in all three municipalities that could have a relevant mix of skills and equipment. In addition, all three municipalities have a high proportion of agricultural businesses (42% Clare, 56% Goyder and 62% Northern Areas). These businesses are likely to have multi-skilled people and a range of equipment that allow them to participate in the process.

As shown later, local businesses with the relevant skills and equipment have been contracted as part of the project development.

4.1.7. Agriculture

Table 14 shows the total land and agricultural land area for Clare and Gilbert Valleys, Goyder and Northern Areas. Results show that Goyder is the largest at 6,718 square kilometres, followed by Northern Areas and Clare and Gilbert Valleys at 2,987 and 1,893 square kilometres respectively. The proportion of land allocated to agriculture is similar across all three areas at 10%.

- **Table 14: Total land and agricultural land area (2006 estimate)**

	Land area (km^2)	Area of agricultural land (km^2)	% of agricultural land to total land area
Clare and Gilbert Valleys	1,893	192	10%
Goyder	6,718	691	10%
Northern Areas	2,987	299	10%

Source: ABS National Regional Profile, 2004-08

4.1.8. Income

Many of the occupation categories have changed since 2001 census therefore the results from 2001 have not been reproduced here.

Table 15 shows that the trend in median income range (by occupation) is similar across all three areas and the Balance of South Australia. Professionals have the highest median income range at $600-$999 per week while community and personal service workers, sales clerical and administrative, sales workers and labourers have the lowest median income range at $250-$599 per week across all areas.

Employed persons across all occupations of Clare and Gilbert Valleys have a median income range equal to or greater than Goyder and Northern Areas. This is likely to reflect the fact that Clare and

Gilbert Valleys have a greater number of residents with a postgraduate degree, graduate diploma & graduate certificate and/or bachelor degree qualifications.

Table 16 shows that the median income range for the mining industry is high across all areas with Goyder the highest at $1300-$1999 per week. This is greater than the median income range for the Balance of South Australia at $1000-$1599 per week. Clare and Gilbert Valleys and Northern Areas' median income range for the electricity, gas, water and waste services industry is $800-$1299 per week, greater than the Balance of South Australia's income range at $600-$999 per week. Employed persons of Northern Areas in the information media and telecommunications industry have a high median income range at $800-$1299 per week, in excess of Clare and Gilbert Valleys and Goyder's income range at $250-$599 per week and the Balance of South Australia's income range at $400-$799 per week.

The median income range of the Balance of South Australia is equal to or higher than all three areas across all industries with the exception of the mining, electricity, gas, water and waste services industry, information media and telecommunications industry and financial and insurance services industry.

- **Table 15: Median weekly income range by occupation (2006 census)**

	Clare and Gilbert Valleys	Goyder	Northern Areas	Balance of South Australia
Managers	$400-$799	$250-$599	$250-$599	$400-$799
Professionals	$600-$999	$600-$999	$600-$999	$600-$999
Technicians & trades workers	$400-$799	$250-$599	$400-$799	$400-$799
Community & personal service workers	$250-$599	$250-$599	$250-$599	$250-$599
Clerical & administrative workers	$250-$599	$250-$599	$250-$599	$250-$599
Sales workers	$250-$599	$250-$599	$250-$599	$250-$599
Machinery operators & drivers	$400-$799	$400-$799	$400-$799	$400-$799
Labourers	$250-$599	$250-$599	$250-$599	$250-$599

Source: ABS 2006 census

- **Table 16: Median weekly income range by industry (2006 census)**

	Clare and Gilbert Valleys	Goyder	Northern Areas	Balance of South Australia
Agriculture, forestry & fishing	$250-$599	$250-$599	$250-$599	$250-$599
Mining	$800-$1299	$1300-$1999	$800-$1299	$1000-$1599
Manufacturing	$400-$799	$400-$799	$400-$799	$400-$799

Electricity, gas, water & waste services	$800-$1299	$400-$799	$800-$1299	$600-$999
Construction	$400-$799	$400-$799	$400-$799	$400-$799
Wholesale trade	$400-$799	$400-$799	$400-$799	$400-$799
Retail trade	$250-$599	$250-$599	$250-$599	$250-$599
Accommodation & food services	$150-$399	$150-$399	$150-$399	$150-$399
Transport, postal & warehousing	$400-$799	$400-$799	$400-$799	$400-$799
Information media & telecommunications	$250-$599	$250-$599	$800-$1299	$400-$799
Financial & insurance services	$400-$799	$250-$599	$600-$999	$400-$799
Rental, hiring & real estate services	$400-$799	$400-$799	$400-$799	$400-$799
Professional, scientific & technical services	$400-$799	$400-$799	$400-$799	$400-$799
Administrative & support services	$250-$599	$150-$399	$150-$399	$250-$599
Public administration & safety	$600-$999	$600-$999	$400-$799	$600-$999
Education & training	$600-$999	$600-$999	$600-$999	$600-$999
Health care & social assistance	$250-$599	$250-$599	$250-$599	$250-$599
Arts & recreation services	$600-$999	$1-$249	$400-$799	$250-$599

Source: ABS 2006 census

4.1.9. Gross Regional Product

This section discusses the GRP for the Yorke and Mid North region comprising the LGAs of Burunga West, Clare and Gilbert Valleys, Copper Coast, Goyder, Mount Remarkable, Northern Areas, Orroroo/Carrieton, Peterborough, Port Pirie, Wakefield and Yorke Peninsula. In 2006/07 the latest available the total GRP was some $2.017 billion. This compares with South Australian GSP of some $68.3 billion at the same period or a GRP of some 2.95% of the GSP. The latest estimate of the South Australian GSP to June 2009 is just under $78 billion or just over 14% larger than two years earlier. Adjusting the regional GRP for the State growth suggests the GRP for the Yorke and Mid North region in 2008/09 could be some $2.3billion.

The population of the three Mid North Councils in the Study area is some 24% of the population in the whole Yorke and Mid North Region. Assuming a similar industry structure and activity level this suggests the GRP for the study area could be some $550 million. Additional criteria could be used to estimate the Mid North GRP but the use of population is likely to provide a reasonable indicative estimate of GRP.

4.1.10. Welfare and Disadvantage

Reflecting the aging population, Table 17 shows that the number of residents on age pension has increased across all three areas. In addition, the number of residents on disability support pension has increased across all three areas.

- **Table 17 Number of residents on welfare as of 2006 estimates and % change from 2004 estimates**

	Clare and Gilbert Valleys		Goyder		Northern Areas	
	2006	% change from 2004	2006	% change from 2004	2006	% change from 2004
Age Pension - Centrelink	977	1%	576	2%	659	1%
Disability Support Pension	272	7%	289	4%	220	2%
Parenting Payment - Single	143	-6%	103	5%	89	17%
Youth Allowances	119	-9%	76	-16%	76	15%

Source: ABS National Regional Profile, 2004-08

4.1.10.1. SEIFA

Table 18 summarises the Socio-Economic Indexes for Areas (SEIFA) scores as of the 2006 census and percentage change from 2001 census. SEIFA is a suite of four summary measures and the scores for each Census Collection District (CD), Postal Area (POA), Statistical Local Area (SLA) and Local Government Area (LGA) are derived from census data. The four indexes are:

- **Index of Relative Socio-economic Disadvantage:** using indicators of low socio-economic wellbeing, provides a general measure of disadvantage.
- **Index of Relative Socio-economic Advantage and Disadvantage:** extends the above measure to encompass the entire socio-economic spectrum.
- **Index of Economic Resources:** focuses on financial aspects of relative advantage and disadvantage.
- **Index of Education and Occupation:** focuses on the educational and occupational aspects of socio-economic status.

The indexes reflect the relative advantage or disadvantage of areas and may be used for comparative purposes. The lower the score, the more disadvantaged an area is, however the scores do not reflect the size of the difference in socio-economic levels between areas and cannot be used as a comparative tool between years. From Table 18 a general rank of the areas can be derived. The most advantaged area to most disadvantaged area is as follows: Adelaide, Clare and Gilbert Valleys, Northern Areas and Goyder.

Table 18 SEIFA scores as of 2006 census and % change from 2001 census

	Index of Relative Socio-economic Disadvantage		Index of Relative Socio-economic Advantage and Disadvantage		Index of Economic Resources		Index of Education and Occupation	
	2006	2001	2006	2001	2006	2001	2006	2001
Clare and Gilbert Valleys	999	1019	946	960	994	949	974	961
Goyder	960	984	905	908	967	885	959	922
Northern Areas	968	1005	918	926	967	886	964	947
Adelaide	1022	1067	1083	1135	951	1093	1171	1168

Source: ABS 2001 & 2006 census

4.2. Summary

The regional population is growing more slowly than regional South Australia as a whole with the population of Goyder declining slightly between the 2001 and 2006 census. As service provision is to some extent a function of population, there is a danger that reductions in population can lead eventually to reduction in the services provided by local government due to a reduced rate base, state and federal government due to reduced population and the private sector. This may lead to a downward spiral in regional economic activity.

Major projects such as the Hallett Wind Farm Project help retain population by providing employment and income opportunities for existing residents and businesses, encourage residents and former residents working away from the region to return and bring new people into the region both temporarily during construction and permanently in operating the facilities. Even some of the employees who come into the region during construction may decide to stay on or make the region their home base while working on construction projects elsewhere.

The industry analysis suggests that, while the regional businesses are small there are a number of businesses in the industry sectors that can benefit from the wind farm developments as has happened in practice.

Similarly the occupation and skills information also suggests that the region is able to provide the more generic trades and employment skills needed by the wind farms. Again this seems to have been borne out in practice.

The latest unemployment data suggest that unemployment rates are relatively low and that therefore there may be reduced opportunities for local employment. However, this is often the case in regional areas where there may be under employment and hidden unemployment and where residents leave the region to work elsewhere and may or may not return if the economy recovers or may return to work on specific new projects. The Hallett wind arm project has sought to employ locals with some success and to provide skills training and apprenticeships.

5. Economic Impact

This chapter looks at the economic impacts in more detail. It includes discussion on the project expenditure to date and estimates expenditure for the whole project (all stages). It considers impact on the gross regional product, the employment implications (including the actual employment to date and estimates for the whole project), direct expenditure in the region and a qualitative assessment of the project's benefits based on interviews with local business people and Council representatives during a site visit in early May 2010.

5.1. Assessment of the expenditure and GRP impacts

The total expenditure to date by phase is shown in Table 19 below. The development and construction activities to date are estimated at just under $800m with some $13.5m spent on the operations and maintenance of the two operating wind farms to date. The bulk of the operational expenditure has been at Hallett 1 which has been operating from September 2008 with a lesser amount on Hallett 2 which had been operational for less than two months since April this year (2010). The operational cost shown will increase on an annual basis over the life of the project.

- **Table 19: Hallett Wind Farms Project Costs by Phase to Date**

	Development	Construction	Operations
Hallett 1	$5,385,000	$227,452,000	$10,500,000
Hallett 2	$3,045,000	$189,102,000	$3,095,000
Hallett 3	$2,833,000	N/A	N/A
Hallett 4	$5,440,000	$333,482,000	N/A
Hallett 5	$1,845,000	$31,300,000	N/A
Total to Date	$18,548,000	$781,336,000	$13,595,000

Source: Data provided by project participants

Based on the costs to date an indicative estimate of the cost of the projects to completion is shown in Table 20. The costs are shown with and without Hallett 3 on the basis that Hallett 3 is currently subject to appeal and may not proceed.

The estimates in Table 20 are based on average per turbine costs and as such they are indicative only. The operations costs are annual estimates. The Hallett 1 operations actual has been adjusted to provide an annual estimate.

Based on these indicative costs, the total project consisting of 5 stages, if it proceeds, will exceed $1billion and with some $30m a year in operating costs. From the information provided in the survey some 50% of the operating costs would be spent in the Mid North region or some $15m.

■ **Table 20: Estimated Project Capital Costs and Annual Operating Costs**

Actual and Estimates	Total Pre Ops	Operations
Hallett 1	232,837,000	6,750,000
Hallett 2	192,147,000	5,100,000
Hallett 3	2,833,000	
Hallett 4	338,922,000	9,450,000
Hallett 5	130,000,000	3,750,000
Total Less Hallet 3	896,739,000	25,050,000
Hallett 3	168,767,000	4,950,000
Total Project cost	1,065,506,000	30,000,000

Source: Hallett Wind Farm Data and SKM Estimates

5.1.1. Impact on gross regional product

GRP is the total market value of goods and services produced in a region after deducting the costs of goods used up in the process of production (intermediate Consumption) but before deducting consumption of fixed capital (depreciation). To avoid double counting, only the value added at each stage of production is included in GRP and not the total expenditure.

Gross Value Added (GVA) is defined as total factor income plus taxes and less subsidies on production. Total factor income is made up of compensation of employees, gross operating surplus and gross mixed income. We have assumed that the value added component which excludes costs of materials is approximately 50% of the total expenditure. On this basis, the GVA to date is set out in Table 21.

■ **Table 21: Estimated Value Added to Date (June 2010)**

Actual and Estimates	Total Pre Ops	Operations
Hallett 1	116,418,500	5,250,000
Hallett 2	96,073,500	1,547,500
Hallett 3	1,416,500	
Hallett 4	169,461,000	
Hallett 5	16,572,500	
Total	399,942,000	6,797,500

Source: Hallett Wind Farm Data and SKM Estimates

Based on the local content of the construction cost of some 12.4%, the local value added would be some \$49.5m. On the same basis the value added to completion would be some \$55.6m without Hallett 3 and \$66m for the total Project with Hallett 3 (12.4% of half the total capital cost in Table 20).

The construction costs and value added are spread over a number of years (to date construction has been underway for five years). The current year 2010 includes the most construction activity with Hallett 4 and 5 under construction for all or most of the year and Hallett 2 at the early part of the year. Based on this level of activity we estimate that some 36% of the total construction activity is taking place this year (2010). On this basis the largest change in value added would be some $17.8m in the current year.

The operations expenditure to date is not really relevant and a better estimate of the impact on GRP from operations of the wind farms would be to take the annual expenditure once fully operational. Given the doubt related to Hallett 3 this figure is estimated with and without Hallett 3 case.

The total operational value added without Hallett 3 would be some $12.5m and with Hallett 3 some $15m. Based on 50% of the operational expenditure remaining in the region the estimated regional value added would be $6.25m or $7.5m respectively.

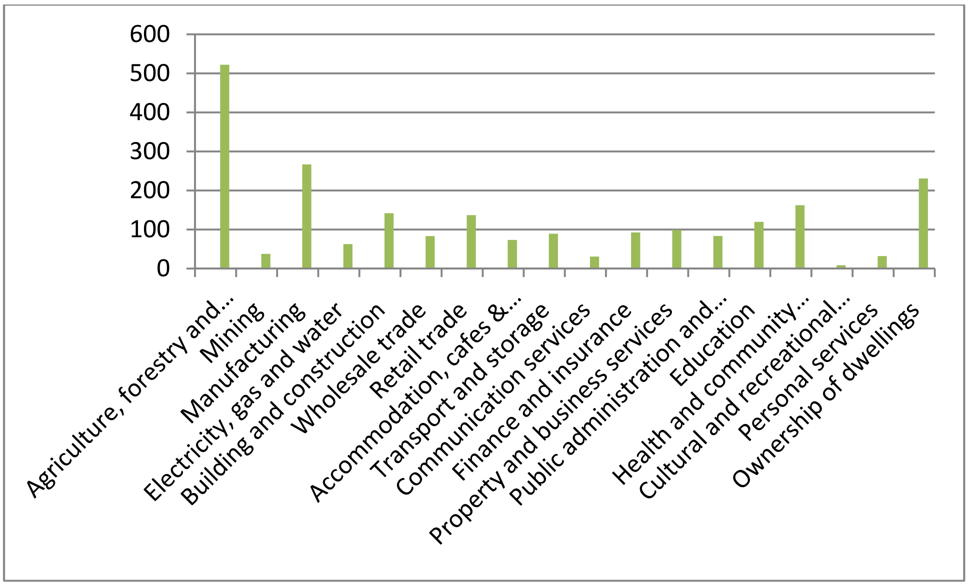
Table 22 and Figure 10 indicate the Yorke and Mid North GRP. This region includes the municipalities of Goyder, Clare and Gilbert Valleys, Northern Areas, Orroroo/Carrieton, Peterborough, Barunga West, Mount Remarkable, Wakefield, Yorke Peninsula. Copper Coast and Port Pirie. The table and figure are based on the 2006/07 GRP provided in the “easydata” regional report adjusted to reflect the 2008-09 South Australian GSP. This adjustment increases the regional GRP by approximately 14% in total.

Table 22: Yorke and Mid North GRP Adjusted to 2008-09

Industry Sector	$m
Agriculture, forestry and fishing	522.08
Mining	37.79
Manufacturing	266.97
Electricity, gas and water	62.60
Building and construction	142.04
Wholesale trade	83.23
Retail trade	137.05
Accommodation, cafes & restaurants	73.30
Transport and storage	89.28
Communication services	30.83
Finance and insurance	92.66
Property and business services	98.90
Public administration and defence	83.52
Education	119.76
Health and community services	162.34
Cultural and recreational services	8.76
Personal services	32.01
Ownership of dwellings	230.79
Total	2273.92

Source: South Australia .biz/easydata GRP, ABS South Australia GSP, SKM Estimates

Figure 10: Yorke and Mid North GRP 2006-07 Adjusted to 2008-09



Source: South Australia .biz/easydata GRP, ABS South Australia GSP, SKM Estimates

Table 23 provides an estimate of the Mid North regional GRP based on the study region of Goyder, Clare and Gilbert Valleys and Northern Areas. This estimate is based on adjusting the Yorke and Mid North GRP by industry sector by the relative populations of the two areas.

- **Table 23: Estimated GRP for The Mid North Region (Goyder, Clare and Gilbert Valleys and Northern Areas**

Industry Sector	$m
Agriculture, forestry and fishing	124.44
Mining	9.01
Manufacturing	63.63
Electricity, gas and water	14.92
Building and construction	33.86
Wholesale trade	19.84
Retail trade	32.67
Accommodation, cafes & restaurants	17.47
Transport and storage	21.28
Communication services	7.35
Finance and insurance	22.09
Property and business services	23.57
Public administration and defence	19.91
Education	28.55
Health and community services	38.69
Cultural and recreational services	2.09
Personal services	7.63
Ownership of dwellings	55.01
Total	541.98

Source: South Australia .biz/easydata GRP, ABS South Australia GSP, SKM Estimates

The estimated Hallett Wind Farms construction value added in the current year (2010) is some $17.8m which equates to a potential lift in the Mid North GRP of some 3.3%. The ongoing annual operational value added is some $6.25m if Hallett 3 does not go ahead and $7.5m if it does. These figures equate to a growth in GRP in the Mid North of 1.15% or 1.4%.

5.2. Industry development and employment creation

This section discusses the employment impacts of the projects to date and an estimate of the future impact of the projects with and without Hallett 3. The impact of Hallett 1 is shown initially to allow an assessment of the potential industry multipliers based on a completed and operating wind farm. While Hallett 2 is also operational, this is not included as it has only just been completed and from the construction employment estimates it appears that the Hallett 1 construction team was logically kept together for Hallett 2 despite it being a smaller wind farm.

5.2.1. Assessment of employment effects of Hallett1

The Hallett 1 Wind Farm cost some $227.5 million to construct. Of this amount approximately $94.2 million (41.4%) is estimated to be spent in South Australia. Based on the estimated Australian to overseas content of 61.5% to 38.5% some $140 million would have been spent in Australia (Table 24).

- **Table 24: Estimated construction expenditure by location for Hallett 1**

Item	Mid North	Rest of South Australia	Rest of Australia	All of Australia	Overseas	Total
Proportion	12.40%	29.01%	20.09%	61.49%	38.51%	100.00%
Cost $ m	28.2	66.0	45.7	139.9	87.6	227.5

Source: Hallett Wind Farm Data

The Hallett 1 Wind Farm was built over a 34 month period between December 2005 and September 2008. On average over this period some 66 construction employees were employed in the region, either directly or by contractors engaged by the companies involved in constructing the wind farm. Employment numbers at peak of construction were some 111 workers.

These data provided by the construction companies do not tell the whole story. In addition to the employees in the region constructing the wind farm there are also employees in other parts of South Australia and Australia manufacturing elements of the turbines such as the towers and providing a range of construction services.

The Passey report[2] provides estimates of direct employment per megawatt (MW) of power generated by wind energy of some 7.5 job years/MW for manufacture and installation in 2002. This figure is reduced by 5% annually to 5 job years/MW in 2010 based on a number of factors including economies of scale, increased wind turbine size and improved technology. The Passey report suggests that the fall in jobs per year will be partially off-set by increased Australian content over the period to 2010. We have conservatively assumed Australian content has not increased significantly.

[2] Driving Investment, Generating Jobs: Wind Energy as a Powerhouse for Rural & Regional development in Australia, Report for the Australian Wind Energy Association by Dr Robert Passey March 2003

The results of these assumptions related to total direct jobs in construction, manufacturing and support that are likely to be generated by a wind farm development and the comparison with the actual on the ground construction jobs for Hallett 1 are indicated in the following Table 25.

- **Table 25: Estimated direct employment generation from the Hallett 1 project**

Item	Total
Wind Turbines No.	45
MW Capacity	95
Estimated Employment (Construction/Manufacturing job years)	**EFT job Years**
Australia (based on 61.5% content)	**345**
South Australia (based on 41.5% content)	232
Mid North (based on 12.4% content)	70
Estimated actual average FTE jobs	**66**
Estimated actual average FTE job years ((66 jobs x34 months)/12	**187**
Estimated Employment Multiplier	**345/187=1.85**

Source: Hallett Wind Farm Data, Passey estimates and SKM estimates

The bulk of the expenditure at the regional level would have related to the construction workforce resident in the region over the duration of the construction activities. Some regional expenditure could have required additional support work in the region that generated a limited additional employment reflected in the small difference in the table above. However, as the difference is small it seems that the estimate based on the Passey assumptions holds reasonably at the regional level. This suggests that the Hallett 1 Wind Farm could have generated some 345 total direct FTE job years in Australia over the construction period compared with 187 created in direct construction activities, a multiplier of around 1.85 (see Table 25 above).

In addition to the direct jobs created by the project there will also be indirect jobs created based on the flow on effects of suppliers to the project that need to replenish their stocks (the production effect) and the flow on from the spending of wages and salaries of both direct and indirect workers (consumption effect). These indirect expenditures create further employment (multiplier). The Passey report uses a multiplier of just under 3 based on European Wind Energy Association (EWEA) estimates to calculate the likely flow on or indirect jobs. It should be noted that this multiplier is significantly lower than the national multiplier for the electricity, gas and water sector (over 6) and the non residential construction sector (over 4) and, as such, is likely to be conservative.

Applying this indirect employment multiplier to the estimate of direct jobs, suggests that the Hallett 1 project could generate some 1,025 total job years from construction and manufacturing. The additional 680 (1,025less 345) indirect jobs could be created anywhere within the Australian economy and possibly overseas depending on the origin of the extra goods and services produced although it is likely that most would be in Australia and a reasonable proportion in South Australia.

Passey also reports estimates of on-going Australian O&M jobs at 0.12 jobs/MW in 2002. This again is assumed to fall annually to some 0.06 jobs by 2010. Based on these progressively reduced figures, it is estimated that O&M will require six (6) full time operational employees. However, these estimates seem to be conservative based on actual employment at operational wind farms.

The estimated actual employees at Hallett 1 are an average of 9 and a peak of 12. Hallett 1 started in operation in September 2008 and still has some 3-4 months to run before being in operation for two years. There may be some short term staff involved in post start up work who will leave the project once it is proved to be operating as required. Similarly there may be additional specialist staff employed in addressing issues in bedding the project down.

Suzlon reported that they have a standard of employing one person per seven turbines to cover operations and maintenance including periodic servicing and maintenance and repairs where required. This policy, which is in line with other companies, would involve employing some six full time people. In addition, to these regular facility maintenance staff there would need to be periodic contract work maintaining the site. This could include potentially such aspects as fence repairs, mowing, access road maintenance, electrical connection issues and servicing/maintenance of equipment including instruments, computers etc. There would also need to be facility management and administration although there may be able to be some sharing of these functions across the whole Hallett Wind Farm Project operations.

From the above, it appears that the Passey estimates for operational people are low. On this basis the actual average employment for Hallett 1 is used to extrapolate potential on-going employment for Hallett 1, 2, 4 and 5 and the for the whole Hallett Wind Farm Project if Hallett 3 is approved and constructed.

5.2.2. Hallett Wind Farms employment

Table 26 shows the employment estimates to date for the four approved wind farms. The figures shown for Hallett 1, 2 and 4 which are either completed or well into construction (Hallett 4) are either actual employment or very reliable estimates. Hallett 5 only started construction in February 2010 and the employment figures provided are in a ramp up stage. The total reported average number of employees to date is just over 230 in construction and 15 in operations related to all the current projects. This figure underestimates the actual employment over the period as there have been some overlaps in the construction of the wind farms. Based on the construction schedule we estimate that the wind farm construction to date would have created some 450 FTE job years of work over the 4.6 years since starting in December 2005 and an average annual employment of some 98 FTEs.

The total employment estimates in this section are summarised in Table 29 below. The estimates for average annual employment assume the current construction schedule for the approved wind farms and that Hallett 3 would be constructed over 2012 and 2013 if approved and constructed.

The figures for Hallett 1 and 4 show a broadly consistent workforce of some 1.5 employees per turbine. Hallett 2 has a higher figure of just over 1.9 per turbine. However, given the employment figures are the same and the construction of each stage to date has overlapped we assume that broadly the Hallett 1 workforce was rolled into Hallett 2 and then into the next two stages of Hallett 4 with some additional people and now in part into Hallett 5. If Hallett 3 is approved, the whole project would have provided a reasonably stable regional workforce over some eight years.

This information suggests that there has been on average a workforce of some 100 people resident in the region from mid to late 2006 to date and that currently it is probably closer to 150 people although it is likely to start to reduce from later this year. This supports the estimate that the project could have generated at least 450 FTE job years to date and, if Hallett 3 goes ahead with construction over say 2012 and 2013, the whole Hallett Wind Farm Project could generate in total some 640 FTE job years of work in the region.

- **Table 26: Estimated Actual Employment Hallett Wind Farms to Date**

	Construction		Operations	
	Average	Peak	Average	Peak
Hallett 1	66	111	9	12
Hallett 2	66	111	6	0
Hallett 3				
Hallett 4	96	151	0	0
Hallett 5	5	10	0	0
Total to Date	233	383	15	12

Source: Hallett Wind Farm Data and SKM Estimates

Based on the construction to total direct workforce multiplier of 1.85 deduced above, the current projects have potentially sustained on average an annual direct workforce in Australia of some 185 people to date and some 850 FTE job years of work.

As discussed above, there would also be flow on impacts that could occur anywhere across the Australian economy and even overseas. Based on a wind energy multiplier of just under 3 this suggests that the project to date could have generated an extra 1,650 FTE job years of flow on work.

Table 27 indicates that the estimated average and peak employment for the currently approved wind farm projects based on the actual information on employment to date. Based on the average employment and the Project construction schedule the project without Hallett 3 could generate some 90 construction FTE jobs annually on average during the construction phase and a minimum of 36 on-going full time jobs during operations. The average annual employment is lower as the project ramps down although the total FTE job years created increases to some 540.

The estimated direct employment is based on the actual employees where available and an estimate based on employees per turbine from the completed project stage (1.5 employees per turbine in construction and 0.18 for operations) where not. Again, based on the construction to total direct workforce multiplier of 1.85 deduced above, it is estimated that the current projects could have created an annual average direct workforce in Australia of over 200 people to date (170 in construction, manufacturing and support over an extended period from 2005 to the end of 2011 and some 36 in operations over the life of the Wind Farms) and some 1,000 total FTE job years.

- **Table 27: Estimated Employment Hallett Wind Farms Without Hallett 3**

	Construction		Operations	
	Average	Peak	Average	Peak
Hallett 1	66	111	9	12
Hallett 2	66	111	6	0
Hallett 3				N/A
Hallett 4	96	151	17	N/A
Hallett 5	38	60	4	N/A
Total to Date	266	433	36	N/A

Source: Hallett Wind Farm Data and SKM Estimates

As discussed above, there would also be flow impacts that could occur anywhere across the Australian economy and even overseas. Based on a wind energy multiplier of just under 3 this suggests that the project to date could have generated an extra 2,000 FTE job years of flow on work

Table 28 indicates the same information as Table 27 but also includes Hallett 3. This indicates that, on the same basis as the previous estimates above, the whole Hallett Wind Farm project could generate some 80 construction FTE jobs annually on average during the construction phase and a minimum of 42 on-going full time jobs during operations. The average annual employment is lower than without Hallett 3 (90 FTEs) as the project ramps down further, although again the total FTE job years created increases to some 640.

Again, based on the construction to total direct workforce multiplier of 1.85 deduced above this implies creation of a total of some 1,200 total FTE job years in construction, manufacturing and support and operations.

As discussed above, there would also be flow impacts that could occur anywhere across the Australian economy and even overseas. Based on a wind energy multiplier of just under 3 this suggests that the project to date could have generated an extra 2,400 FTE job years of flow on work

- **Table 28: Estimated Employment Hallett Wind Farms With Hallett 3**

	Construction		Operations	
	Average	Peak	Average	Peak
Hallett 1	66	111	9	12
Hallett 2	66	111	6	0
Hallett 3	50	79	6	N/A
Hallett 4	96	151	17	N/A
Hallett 5	38	60	4	N/A
Total to Date	315	512	42	N/A

Source: Hallett Wind Farm Data and SKM Estimates

As indicated above, Table 29 provides a summary of the employment estimates discussed above.

- **Table 29: Summary of Employment Estimates**

Employment in FTE Job Years	To Date	To Completion	
		Without Hallett 3	With Hallett 3
Direct construction employment	450	540	640
Direct Manufacturing & Support	400	460	560
Total Direct Employment	**850**	**1,000**	**1,200**
Flow on Employment	1,650	2,000	2,400
Total Employment	**2,500**	**3,000**	**3,600**
Est. Construction Period (Yrs.)	4.6	6	8
Est. Ave. Annual Const. Emp. (No.)	98	90	80

Source: SKM estimates include rounding

Table 30 indicates the estimated cost of developing and constructing the Hallett 1, 2, 4 and 5 Wind Farms at some $894 million. Of this amount approximately some $370 million (41.4%) is estimated to be spent in South Australia. Based on the estimated Australian to overseas content of 61.5% to 38.5%, on completion some $550 million should have been spent in Australia.

- **Table 30: Estimated expenditure by location for the four approved Hallett Wind Farms**

Item	Mid North	Rest of South Australia	Rest of Australia	All of Australia	Overseas	Total
Proportion	12.40%	29.01%	20.09%	61.49%	38.51%	100.00%

Cost $m	110.8	259.3	179.6	549.7	344.2	893.9

Source: Hallett Wind Farm Data and SKM Estimates

Table 31 provides an estimate of the total cost of the final project cost including Hallett 3.

- **Table 31: Estimated expenditure by location for the current and proposed five Hallett Wind Farms**

Item	Mid North	Rest of South Australia	Rest of Australia	All of Australia	Overseas	Total
Proportion	12.40%	29.01%	20.09%	61.49%	38.51%	100.00%
Cost $m	132.1	309.1	214.1	655.2	410.3	1065.5

Source: Hallett Wind Farm Data and SKM Estimates

5.2.3. Regional capability

Five of the seven organisations involved in developing, constructing and operating the Hallett Wind Farms indicated that they had a policy of employing local contractors where possible. Three of them involved in recruiting locally indicated they had a policy of local recruitment. In addition, the project provides a range of apprenticeship and training opportunities.

As noted earlier the region has a range of businesses with the capability to provide services to the project and individuals with skills to meet employment requirements. These include but are not necessarily limited to:

- Domestic scale electricians
- Transport operators
- Competent machine operators
- General labourers
- Quarries, and
- Concrete businesses.

5.2.4. Accommodation for on-site workers during construction

The survey indicated that the employees of consultants to the project and other non construction people working on the project stayed in hotel/motel accommodation. These people would generally visit the region for limited periods and the convenience and flexibility of a hotel/motel would outweigh any additional cost of a hotel/motel over rental accommodation. This included five of the

seven main organisations involved in working on the project. From discussions on the site visit it appears that the project has helped to underpin a reasonably buoyant hotel/motel market with operators indicating that the project has led to higher occupancies and profitability. The project staff/contractors using motels appear to have spread their custom about to some extent which has allowed more operators to benefit from the project and provided benefits to a number of the region's towns and notably Burra, Jamestown and Clare.

Employees of Suzlon, the main construction contractor, use a variety of accommodation (Table 32) with 30% travelling from their own home in the region. This is likely to include both local people who have been recruited to work on the project and people coming from outside the region who have purchased a property based on the length of their expected work on the project. It is anticipated that most of these will be living with their family. It is likely that only the early starters on the project who expected some continuity would have purchased a home but this could still be 5-10 or more new families in the region.

The largest group of employees live in rental accommodation. Some of these will be living with their family, others will be renting in a group situation with other workers or other people and some will be renting independently. The locations of private rental has also been spread across the towns in the project location.

- **Table 32: Accommodation Type used by Suzlon Employees/Contractors**

	Hallett 1	Hallett 2	Hallett 4
Own Home	30%	30%	20%
Private Rental	50%	50%	65%
Hotel/Motel	10%	10%	10%
Caravan Park	5%	5%	5%
Construction Camp			
Other /Not Reported	5%	5%	
Total	100%	100%	100%

Source: Hallett Wind Farm Data

5.3. Qualitative assessment of the wind farms impact on the region

This section discusses the findings from interviews with local business people and Council representatives in the Mid North region.

5.3.1. Regional Business

The site visit indicated strong support from local businesses:

- Accommodation and food services providers have had a significant increase in sales over the period the wind farms have been in construction
- Local contractors have been employed directly in the wind farms’ construction, and
- Other businesses in the region’s towns seem to have increased business and be more buoyant as a result of the additional people and expenditure in the region.

One accommodation business operator noted that business is up as a result of patronage from wind farm employees and contractors. The average occupancy at his establishment has risen from around 70% to 84% and he felt that business in the town is up generally. Another noted that accommodation and food and beverage sales were higher with patronage from wind farm workers.

One person suggested that the local accommodation sector is mixed with good and not so good operators. The good operators have done very well from the wind farm.

It was noted that Snowtown has more wind farms than around Burra but limited accommodation so most of the construction people have to live out of town. Burra has significant accommodation and therefore has benefitted more directly.

Brief conversations with other retail traders indicated that their business was up from both direct sales to wind farm employees and in some cases sales to other businesses that provide services to the wind farm workers. Some traders felt that people are coming to see the wind farms and that they will provide an on-going attraction.

Local businesses that have benefitted from contracts with the wind farm include:

- Domestic scale electricians
- Transport operators
- Competent machine operators
- General labourers
- Quarries, and
- Concrete businesses that appear to have done particularly well and put on employees.

Discussion with John Campbell the Suzlon Site Manager at Hallett 4 noted that they use a number of local contractors on the civil works including small contractors with up to eight employees, larger plant hire operations with big machines, local water cartage people, who fill tanks, clean out septic systems and do dust suppression, and a range of local farmers. One local farmer has built a business collecting scrap metal from the sites and salvaging appropriate bits for recycling into fencing and other uses with the residual going to scrap. Some farmers hire out plant and equipment and have even purchased or leased additional plant and equipment to provide more targeted services for the wind farms.

Local transport operators are used. One provider of local haulage has increased its fleet since the wind farm started and has chased bigger contracts outside the region to extend its business. The extra work has seen their trucks out and about more and over a wider geographic area which has helped pick up new business. It was also noted that some of the contractors have moved to other jobs and used local transport to move their plant and equipment.

Local electrical contractors have provided services for the wind farm site offices and for the AGL Information Centre. One local resident also provides a take away food van at the Hallett 4 site depot to provide lunches and snacks.

It was noted that the project's monthly meetings can book out a whole hotel.

The open day was well attended and signs for it and other applications are made by a firm in Jamestown.

Suzlon has a significant spare parts depot and warehouse in Jamestown. This is a regional depot that services the Hallett, Snowtown and Capital wind farms. These comprise at present five wind farms in South Australia and one in the ACT. Suzlon has plans for a new regional $4m Maintenance Centre which will add to the number of direct employees and economic activity in the region.

Council has passed on the contact details of people and organisations who have been interested in supplying services to the wind farm projects but largely reactively to date. Suzlon held information sessions at the Commercial Hotel in Jamestown and in Burra to inform local community members of forthcoming construction activities relating to the Hallett 1 wind farm, prior to site mobilisation.

These were informal meetings hosted by Suzlon site management that provided general information relating to scope and schedule, potential work opportunities for local businesses, accommodation requirements and potential jobs for locals etc. The sessions were advertised in local papers and with posters around the town and in council offices.

Many local businesses that were represented at these information sessions have been used extensively on the project to date. In addition, one local resident was recruited from the first information session as Hallett 1 site administrator and has subsequently gone on to manage the Suzlon warehouse in Jamestown.

Specific information sessions were not held for Hallett 2 and 4 as by the time these projects commenced, Suzlon were well known in the local community and kept locals informed mainly through word of mouth.

The Port Pirie Regional Economic Development Body kept a register of individuals and companies for the Clements Hill Wind Farm and would be able to do the same or pass on the software to Northern Areas and other regional councils for future developments in the region if relevant.

5.3.2. Tourism

Discussions at the Visitor Centre in Burra and with other people including accommodation providers indicated that there have been no negative responses to the wind farms from visitors. Visitors are interested and ask about visiting and tours of the wind farms. There have been tours arranged by AGL which are very popular. The Visitor Centre was advertising the third public tour at the time of the interview.

The Visitor Centre has had very consistent visitation of between around 25,300 and just under 26,500 over the past seven years. The high visitation is in the non summer months from March to October with lower visitation from November to February.

The discussions suggested that most visitors to Burra visit the Visitor Centre. Some day trippers and/or people who have been to the area before may not visit the centre, however most overnight visitors would book their accommodation through the Visitor Centre. Visitors tend to stay for one night. The Visitor Centre also provides information and advice about tours and attractions. Tourism is an important part of the local economy.

The Visitor Centre Manager would like to develop educational tourism. In addition to the mining heritage and the extensive built heritage, there are other attractions including key fossil sites. The wind farms have the ability to complement and add value to educational tourism on a range of levels including schools and post schools programs and small scale experiential programs for adults.

Burra's main attraction is its built heritage based on its mining past. The wind farm offers an additional regional attraction that is to some extent complementary to Burra's engineering based past.

A number of people noted that the local schools have been involved in planting trees and native grasses as part of an environmental landscaping program with the wind farm and that AGL operate occasional but very popular tours.

In addition to the Burra Visitor Centre, AGL operate a Wind Farm Information Centre. The Information Centre has operated from January 2009 to date. To the end of April 2010 the Centre had received nearly 4600 visitors or between 9 and 10 a day. The Information Centre provides information on the Hallett Wind Farms as well as general information about wind energy. Information is provided at a number of levels including right down to the nuts and bolts of construction. It provides a point of contact for visitors and the community and helps promote the project. The wind farm tours start from the Information Centre with a pre tour orientation. We understand that there is lots of interest from tourists and requests for tours.

The Information Centre also provides workspaces, amenities and a meeting room for AGL and contractor staff visiting the area for work.

The Information Centre is housed in a former butcher's premises. It was fitted out by a local builder at a cost of around $100,000. The original facade was kept to retain the heritage fronting.

One person interviewed was concerned that there may have been some possible crowding out of tourist accommodation due to the take up of beds by wind farm personnel but this was not obvious and others spoken to did not see it as an issue. In general the people spoken to saw the wind farms providing a benefit from continuity and longer term stay arrangements that have benefitted a wide range of local providers. Tourists to the region are generally travelling through and only stay for a short period and appear to have been accommodated successfully.

5.3.3. Community benefits

It was noted that a number of farmers were finding it difficult to make ends meet with an extended period of drought over most of the last decade. However, those farmers whose land is included in the wind farm site had benefited from a secure diversified income stream. The Project has provided further benefits beyond direct lease payments to many of these farmers, by providing employment opportunities and by creating a demand for under-utilised assets, including previously unleased accommodation.

There has been good communication between the project developers, contractors and the Councils with the few community issues addressed quickly by laying down rules at site toolbox meetings.

The Northern Areas Council see the community growing as a result of the wind farms ensuring that the population doesn't decline and that existing services can be retained and over time additional ones added.

The Northern Areas Council is about to launch a population attraction program to attract younger skilled people and older higher income people. Access to more technology based employment opportunities could support this. Opportunities for more skilled jobs were felt to be more advantageous for the region than larger numbers of low skilled work. The skilled workforce is likely to be more secure and permanent. In addition, there are examples of younger locals who had left the region to gain skills and find work who have come back to work on the projects.

As a result of the range of developments across the region, the Country Club in Clare is building an apartment development where they will sell the apartments for owner occupation or manage them for the owner for short term stays. Another accommodation development in Jamestown associated with a restaurant was noted. The aim is to provide better quality accommodation than is currently available in Jamestown.

The community benefit funds have been a big plus. The Northern Areas Council has been involved in the process of assisting community submissions and advising on priorities.

It was suggested that a lot of people were not sure about the community funds. In some cases they are unaware of them in others they know about them but are not sure how to get access. It was noted that these funds are one of the good news stories that needs to keep being repeated.

AGL are providing $15,000 per annum (CPI indexed) for each of the Hallett 1, 2, 4 and 5 wind farms and $30,000 per annum for Hallett 3 if approved. This equates to a total of $90,000 per annum for the life of the wind farms for local community associations, events and activities.

Table 33 below provides examples of funding distribution for 2009 in the Regional Council of Goyder area.

- **Table 33: Examples of Community Funds Distribution**

Hallett Bowling Club	Team Shirts	$1,400
Burra Community School	Replace 3 stoves	$1,200
Mt Bryan Soldiers Memorial Hall	Repainting, repair cracks, air-con, security door	$3,000
Booberowie Hall Inc.	150 chairs	$1,780
Mt Bryan Progress Assoc.	Tractor	$7,500
Burra Golf Club	Replace flags	$1,120
SA Living Arts Festival	Sponsor	$1,000
Total		$17,000

Source: Hallett Wind Farm Data

It was noted that the wind farm development has increased the buoyancy of the local rental market and, as noted above, new accommodation developments are underway. Rental demand and rents went down when there was a gap in the wind farm development.

It was noted by a number of people that the local school is doing native plantings around a sub-station for landscape amenity and environmental reasons. The project includes an education component. AGL and contractors have also provided careers talks and advice which has opened the

local students' eyes to the range of opportunities that is offered and the requirements to get the jobs on offer. It was felt this type of project and information could be spread to other schools. This school project received $4,000 from the community funds.

The planting project also had a direct benefit to the local bakery that supplied a large number of lunches indicating the potential for flow on benefits.

The issue of skills was noted more broadly with current skills gaps and opportunities in the wind energy sector noted and the need for skills development programs. At a subsequent meeting it was noted that the Regional Development Board have funds to support apprentices.

At an individual property level the contractors work with the landowner to add value. In one case they left the lay down area as a levelled area that was used to put up a large shed for farm operations purposes.

5.4. Other economic impact

Information was also provided on money spent directly in the region over each phase of the project. The total to date is some $48.7m (Table 34). The bulk of this expenditure has been made over the construction phase $44.8m, with some $2.35 over the development stage and $1.52 related to operations. The operations expenditure only applies to Hallett 1 and when adjusted to an annual basis equates to some $1m per annum. This could gross up to over $4m annual expenditure in the region from the operations of the whole Hallett Wind Farm project.

- **Table 34: Total estimated expenditure in the region to date**

	Hallett 1	Hallett 2	Hallett 3	Hallett 4	Hallett 5	Total
Accommodation, meals and other spending	11,097,000	4,772,000	35,000	2,024,000	690,000	18,618,000
Council and other regulatory fees and charges	276,000	25,000	200,000	555,000	45,000	1,101,000
Community funds ad sponsorship	102,000	37,000	2,000	29,500	1,000	171,500
Services eg wind monitoring, geotech investigation	7,775,000	4,775,000	35,000	12,775,000	170,000	25,530,000
Landowner payments	1,695,000	666,000	45,000	820,000	50,000	3,276,000
Other	0	0	0	0	0	0
Total	20,945,000	10,275,000	317,000	16,203,500	956,000	48,696,500

Source: Hallett Wind Farm Data

The largest expenditure category is services e.g. wind monitoring, geotech investigation followed by accommodation. These two categories comprise just under 91% of the total expenditure (Table 35).

- **Table 35: Regional Expenditure by Category**

		Accommodation, meals and other spending	Council and other regulatory fees and charges	Community funds and sponsorship	Services eg wind monitoring, geotech investigation	Landowner payments	Total
Hallet 1	Dev	125,000	20,000	2,000	25,000	545,000	717,000
	Const	10,852,000	255,000	55,000	6,750,000	800,000	18,712,000
	Ops	120,000	1,000	45,000	1,000,000	350,000	1,516,000
Hallett 2	Dev	75,000	20,000	2,000	25,000	66,000	188,000
	Const	4,697,000	5,000	35,000	4,750,000	600,000	10,087,000
	Ops	0	0	0	0	0	0
Hallett 3	Dev	35,000	200,000	2,000	35,000	45,000	317,000
	Const	0	0	0	0	0	0
	Ops	0	0	0	0	0	0
Hallett 4	Dev	125,000	200,000	2,000	25,000	40,000	392,000
	Const	1,899,000	355,000	27,500	12,750,000	780,000	15,811,500
	Ops	0	0	0	0	0	0
Hallett 5	Dev	625,000	40,000	1,000	20,000	50,000	736,000
	Const	65,000	5,000	0	150,000	0	220,000
	Ops	0	0	0	0	0	0
Total	Dev	985,000	480,000	9,000	130,000	746,000	2,350,000
	Const	17,513,000	620,000	117,500	24,400,000	2,180,000	44,830,500
	Ops	120,000	1,000	45,000	1,000,000	350,000	1,516,000

Source: Hallett Wind Farm Data

5.5. Summary

The Hallett Wind Farms when completed will have:

- An estimated total capital expenditure of nearly $900 million if Hallett 3 is not developed and well over $1billion if Hallett 3 is approved and developed
- An on-going operational expenditure of some $25 million per annum without Hallett 3 and $30 million per annum with Hallett, some 50% of which is estimated would be spent in the Mid North region
- Based on the estimated local content of some 12.4% of the construction a local value added of some $49.5m to date or to completion some $55.6m without Hallett 3 and $66m with Hallett 3
- On a similar basis a value added from operations of some $6.8m to date (Table 21) and $12.5m and $15m to completion

- An impact on the Mid North GRP of an extra 3.3% from construction activities and between 1.15 and 1.4 % per annum from operations
- Created some 90 construction FTE jobs annually on average over some six years during construction without Hallett 3 and some 80 construction FTEs over eight years with Hallett 3
- A minimum of 36 on-going full time jobs per annum without Hallett 3 and 42 with Hallet 3.

In addition to the jobs created in the region there will be significant additional direct jobs created by the project in other parts of South Australia and nationally from manufacturing and support functions and a larger number of indirect flow on jobs spread within the Australian economy and overseas.

6. Comparison of Hallett Wind Farms in Regional Terms

6.1. Gross Regional Product

Based on the estimated expenditure to date (Table 36 below) the total expenditure for the Hallett Wind Farms to date exceeds the GRP of the study area (Table 23). However, looking at expenditure by location indicates a significantly lower figure of some $88m to date spent in the Mid North. This amount was also spent over a significant time period from January 2000 to date or nearly 10.4 years. The largest expenditure on construction covers a period from December 2005 to date some 5 years. Spreading the expenditure over these periods suggests that the maximum annual expenditure is likely to be some 36% of the total this year (2010) which would be some $31.5m. This figure is slightly lower than the expenditure estimate based on the total capital expenditure to date.

In comparing expenditure with GRP the value added should be used. Based on the local content of the construction cost of some 12.4%, the local value added would be some $49.5m. The construction costs and value added are spread over a number of years (to date construction has been underway for five years). The current year 2010 includes the most construction activity with Hallett 4 and 5 under construction for all or most of the year and Hallett 2 at the early part of the year. Based on this level of activity we estimate, as noted above,that some 36% of the total construction activity is taking place this year. On this basis, the largest change in value added would be some $17.8m in the current year. This would add around 3.3% to the estimated GRP.

The operations expenditure to date does not reflect the potential on-going expenditure in the region. A better estimate of the impact on GRP from operations of the wind farms would be to take the annual expenditure once fully operational. Given the doubt related to Hallett 3 this figure is estimated for the with and without Hallett 3 case.

The operational value added without Hallett 3 would be some $12.5m per annum and with Hallett 3 some $15m. The regional value added from operations would be some 50% of this total value added which would add between 1.15% and 1.4% to the regional GRP each year.

6.2. Regional Employment

Currently the number of unemployed in the study area is 241. The estimated construction for Hallett 4 and 5 over the next two years would equal a significant proportion of this number. While most of the currently unemployed will not find employment on the projects there may be opportunities for some given the mix of work skills required and others may be able to replace current workers who take up opportunities on the project. A similar position could apply during the operational phase as the additional wind farms are commissioned and start operating.

If Hallett 3 is approved it is likely that construction will follow Hallett 4 and 5 rather than overlap. On this basis it would lengthen the employment period rather than increase the numbers employed.

The on-going operational employment could also reduce regional unemployment with a theoretical maximum reduction of between 15% and 17.4% of the current total unemployed in the region. In practice this is unlikely although it would be expected that there would be an on-going positive impact on unemployment.

- **Table 36: Project Expenditure by Location**

	Mid North	Rest SA	Rest Aust	Total Aust	Overseas	Total
Development						
Hallett 1	170,300	2,287,450	2,927,250	5,385,000	0	5,385,000
Hallett 2	89,500	1,161,750	1,793,750	3,045,000	0	3,045,000
Hallett 3	607,310	1,283,350	942,340	2,833,000	0	2,833,000
Hallett 4	623,842	2,007,659	2,808,500	5,440,000	0	5,440,000
Hallett 5	69,500	1,345,750	429,750	1,845,000	0	1,845,000
Total to Date	1,560,453	8,085,957	8,901,590	18,548,000	0	18,548,000
Construction						
Hallett 1	28,198,500	65,960,500	45,695,500	139,854,500	87,597,500	227,452,000
Hallett 2	19,858,000	63,452,000	33,017,000	116,327,000	72,775,000	189,102,000
Hallett 3	0	0	0	0	0	0
Hallett 4	32,738,900	106,690,700	41,367,400	180,797,000	152,685,000	333,482,000
Hallett 5	2,251,500	18,474,500	2,544,000	23,270,000	8,030,000	31,300,000
Total to Date	83,046,900	254,577,700	122,623,900	460,248,500	321,087,500	781,336,000
Operations						
Hallett 1	2,962,500	1,620,000	5,917,500	10,500,000	0	10,500,000
Hallett 2	223,500	2,487,500	384,000	3,095,000	0	3,095,000
Hallett 3	0	0	0	0	0	0
Hallett 4	0	0	0	0	0	0
Hallett 5	0	0	0	0	0	0
Total to Date	3,186,000	4,107,500	6,301,500	13,595,000	0	13,595,000
Overall Total	87,793,353	266,771,157	137,826,990	492,391,500	321,087,500	813,479,000

Source: Hallett Wind Farm Data

7. Summary

The regional population is growing more slowly than regional South Australia as a whole with the population of Goyder declining slightly between the 2001 and 2006 census. As service provision is to some extent a function of population, there is a danger that reductions in population can lead eventually to reduction in the services provided by local government due to a reduced rate base, state and federal government due to reduced population and the by private sector. This may lead to a downward spiral in regional economic activity.

It was noted that a number of farmers were finding it difficult to make ends meet with an extended period of drought over most of the last decade. However, those farmers whose land is included in the wind farm site had benefited from a secure diversified income stream. The projects have provided further benefits beyond direct lease payments to many of these farmers, by providing employment opportunities and by creating a demand for under-utilised assets, including previously unleased accommodation.

Major projects such as the Hallett Wind Farms help retain population by providing employment and income opportunities for existing residents and businesses, encourage residents and former residents working away from the region to return and bring new people into the region both temporarily during construction and permanently in operating the facilities. Even some of the employees who come into the region during construction may decide to stay on or make the region their home base while working on construction projects elsewhere.

Discussions with Northern Areas Council officers suggested that they see the community growing as a result of the wind farms. If so this could ensure that the population doesn't decline and that existing services can be retained and, over time, additional ones added.

The industry analysis suggested that, while the regional businesses are small there are a number of businesses in the industry sectors that could benefit from the wind farms' development. This has happened in practice.

Similarly the occupation and skills information also suggests that the region is able to provide the more generic trades and employment skills needed by the wind farm. Again this seems to have been borne out in practice.

The latest unemployment data suggest that unemployment rates are relatively low and that therefore there may be reduced opportunities for local employment. However, this is often the case in regional areas where there may be under employment and hidden unemployment and where residents leave the region to work elsewhere and may or may not return if the economy recovers or

may return to work on specific new projects. The Hallett wind farm projects have sought to employ locals with some success and to provide skills training and apprenticeships.

The on-going operational employment could reduce regional unemployment with a theoretical maximum reduction of between 15% and 17.4% of the current total unemployed in the region (241 people). In practice this is unlikely although it would be expected that there would be an on-going positive impact on unemployment.

The Hallett Wind Farms when completed will have:

- An estimated total capital expenditure of nearly $900 million if Hallett 3 is not developed and well over $1billion if Hallett 3 is approved
- An on-going operational expenditure of some $25m per annum without Hallett 3 and $30m per annum with Hallett 3, some 50% of which is estimated would be spent in the Mid North region
- Based on the estimated local content of some 12.4% of the construction spend, a local value added of some $55.6m without Hallett 3 and $66m with Hallett3
- On a similar basis a value added from operations of some $12.5m without Hallett 3 and $15m with Hallett 3
- An impact on the Mid North GRP of an extra 3.3% from construction activities and between 1.15 and 1.4 % per annum from operations
- Created some 90 construction FTE jobs annually on average over some six years during construction without Hallett 3 and some 80 construction FTEs over eight years with Hallett 3
- A minimum of 36 on-going full time jobs per annum without Hallett 3 and 42 with Hallet 3.

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Appendix A Questionnaire

Questionnaire for an Economic Impact Study of the mid-north region of South Australia due to the development, construction and operation of AGL wind farms

Please fill out the parts of the questionnaire that are relevant for your organisation as accurately as possible. The information required includes:

- Total expenditure by stage of the project by your organisation
- A broad percentage breakdown of the location of this expenditure based on the geographic location of the supplier
- More detailed spending in the mid-north region of South Australia, covering the Goyder, Northern Areas and Clare & Gilbert Valley Councils.

We understand the following dates are applicable. Please base your responses on these dates.

	Development	Construction	Operation
Hallett 1	Jan 2000 – Dec 2005	Dec 2005 – Sep 2008	Started Sep 2008
Hallett 2	Jan 2000 – Nov 2007	Nov 2007 -April 2010	Starting April 2010
Hallett 3	Jan 2000 – Dec 2010	unknown	unknown
Hallett 4	Jan 2007 – Feb 2009	Feb 2009 – May 2011	Starting May 2011
Hallett 5	Jan 2000 – Feb 2010	Feb 2010 – Dec 2011	Starting Dec 2011

Total expenditure by stage of the project by your organisation

Q1: Estimated total expenditure by your organisation to date on the development, construction and operation phases of each of the Hallett Wind Farm stages $(000)?

	Development	Construction	Operations
Hallett 1			
Hallett 2			
Hallett 3		Not Applicable	Not Applicable

Hallett 4			Not Applicable
Hallett 5			Not Applicable
Total to Date			

Broad percentage breakdown of this expenditure by location

Q2: Estimated percentage of expenditure from Q1 above made in each of the geographic areas noted in the table

	Mid-North Region	Remainder of South Australia	Rest of Australia	Overseas	Total
Development					
Hallett 1					100%
Hallett 2					100%
Hallett 3					100%
Hallett 4					100%
Hallett 5					100%
Total to Date					100%
Construction					100%
Hallett 1					100%
Hallett 2					100%
Hallett 3	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Hallett 4					100%
Hallett 5					100%
Total to Date					100%

Operations					100%
Hallett 1					100%
Hallett 2					100%
Hallett 3	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Hallett 4	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Hallett 5	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Total to Date					100%

Note: **Region** includes Goyder, Northern Areas and Clare & Gilbert Valley Councils

Further Information: (Please note major items of expenditure in each location)

More detailed expenditure in the Mid-north region

Q3: Estimate of money spent in the Region during the **development phase** for each Hallett Wind Farm stage Au$(000)?

	Hallett 1	Hallett 2	Hallett 3	Hallett 4	Hallett 5
Accommodation, meals and other incidental spending					
Council and other regulatory fees and					

charges					
Community funds or sponsorship					
Services eg wind monitoring, geotech investigation					
Landowner payments					
Other					
Total					

Further Information:

Q4: Estimate of money spent in the Region during the **construction phase** for each relevant Hallett Wind Farm stage Au$(000)?

	Hallett 1	Hallett 2	Hallett 4	Hallett 5
Accommodation, meals and other incidental spending				

Council and other regulatory fees and charges				
Community funds or sponsorship				
Services e.g. Civil works, electrical, transport, turbine erection etc.				
Landowner payments				
Other				
Total				

Further Information:

Q5 : Estimate of money spent in the Region during the **operations phase** to date for each relevant Hallett Wind Farm stage Au$(000)?

	Hallett 1	Hallett 2
Accommodation, meals and other		

incidental spending		
Council and other regulatory fees and charges		
Community funds or sponsorship		
Services e.g. facilities management, commissioning, turbine maintenance etc.		
Landowner payments		
Other		
Total		

Further Information:

Q6: Actual and estimated employment by stage in Region:

	Development		Construction		Operations	
Employment	Average	Peak	Average	Peak	Average	Peak

Hallett 1						
Hallett 2						
Hallett 3			Not Applicable	Not Applicable	Not Applicable	Not Applicable
Hallett 4					Not Applicable	Not Applicable
Hallett 5					Not Applicable	Not Applicable

Further Information: (Please indicate approximate date of Peak employment by stage and development phase.)

Q7: What type of accommodation was used by employees located on site or at other locations in the Region during construction by proportion (%) of employees and reasons for choice?

Item	Hallett 1	Hallett 2	Hallett 4	Hallett 5
Own home				
Private rental				
Hotel/Motel				
Caravan Park				

Construction Camp				
Other please specify:				

Q8: Please note any employment policies/practices e.g.

Yes No

a) Encourage recruitment of locals..........................
b) Encourage use of local/regional contractors subject to meeting competitive requirements ....
c) Established numbers of O&M personnel for given numbers of Turbines e.g. 1 operative per 7 turbines..
d) Establishment of/support for skills creation programs
e) Specific targeted recruitment including indigenous employment programs, employment of young people etc.
f) Other please specify: