PacificHydro

19 June 2012

Abigail Groves
Parliament of New South Wales
Macquarie Street
Sydney NSW 2000

Dear Abigail,

Re: Inquiry into Economics of Energy Generation

Thank you for the letter dated 16 May 2012 regarding the evidence I gave before the Public Accounts Committee on Friday 11 May 2012.

I am pleased to provide the following information in response to the questions taken on notice, as referred to in your letter.

1. Low Frequency Noise

   Attached is a copy of a report commissioned by Pacific Hydro entitled "Wind Farm Infrasound Study", dated August 2010, which details the infrasound readings near wind farms and other locations.

2. Market Deregulation

   Pacific Hydro does not have any strong views on the need for market deregulation. Its views on efficient market operation whilst transforming the electricity sector to a low emissions electricity system is best summarised in its submission under the Commonwealth's draft Energy White Paper (see below).

3. Federal Government's draft Energy White Paper

   Attached is a copy of Pacific Hydro's submission to the draft Energy White Paper, dated 23 March 2012.

4. National Electricity Market Objectives

   The following excerpt from Pacific Hydro's submitted comments on the Commonwealth's draft Energy White Paper describes the reasons for adding an additional objective into the National Electricity Law.

   > Pacific Hydro considers that the remaining, necessary energy market reform must ensure that the policy and legislative architecture for the energy sector have regard to the fact that climate change policy is now fundamentally linked to the energy market via the Renewable Energy Target and the Clean Energy Future legislation.

The National Electricity Objective (NEO) as yet does not acknowledge the climate policy agenda within the objective. This fundamentally creates a divergence in the constitution of energy market investment signals to deliver on climate change and emissions reduction outcomes. This position has been highlighted in numerous Government reviews including the recent report to the Department of Climate Change and Energy Efficiency which noted:

> "The regulatory objectives underlying the NEM, could constitute an obstacle to effective adaptation of the regulatory framework for the supply of electricity to climate change...Based on the current regulatory objectives, the extent to which climate change can be taken into account in decisions relating to investment in network infrastructure and demand management under the regulatory framework will depend upon whether a link between climate change and security and reliability of supply can be clearly established."[1]

The link between climate change and security and reliability of supply is a driver of climate change policy responses and adaptation strategies for critical infrastructure. Reports from the IPCC (2007, 2011), Sir Nicholas Stern (2007) and Professor Ross Garnaut (2008, 2011) all made clear that increasing climatic change will impact upon critical infrastructure and without adaptation in policy, adaptation in practice will not occur in sufficient time.

One of the most significant barriers to efficient transformation of the energy sector is the inability of regulators to consider the benefits of low carbon energy systems.

A major concern is that regulators, when making decisions regarding future investments in and operation of energy markets which have long term consequences, cannot take into account the goals and objectives which are enshrined in the Clean Energy Futures and RET legislation.

Governments' policy responses to climate change implicitly and explicitly emphasise that this is a clear public policy concern and needs to be addressed by mitigation and adaptation policies and measures.

The final Energy White Paper should recognise and recommend that this vital policy link must be addressed through policy and regulatory reform.

In Pacific Hydro's view the additional objective should include "meeting greenhouse gas emissions reduction targets as set by the Commonwealth".

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[1] Maddocks (2012). The Role of Regulation in Facilitating or Constraining Adaptation to Climate Change for Australian Infrastructure. p. 67

We thank you for the opportunity to submit to the inquiry and look forward to the subsequent findings.

Kind regards

Lane Crockett
General Manager
Pacific Hydro Australia

Encl: Infrasound study final
Energy White Paper 21 March 2012

[redacted]

WIND FARM INFRASOUND STUDY

Prepared for:

Pacific Hydro Pty Ltd

[redacted]

August 2010

CONTENTS

EXECUTIVE SUMMARY

Infrasound is generated by a range of natural sources, including waves on a beach, 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 audibility 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 measurement results indicate that the levels of infrasound in the vicinity of two Australian wind farms are:

- well below the threshold of hearing established in International research as 85 dB(G); and
- of the same order as other International infrasound measurement results; 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.

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.

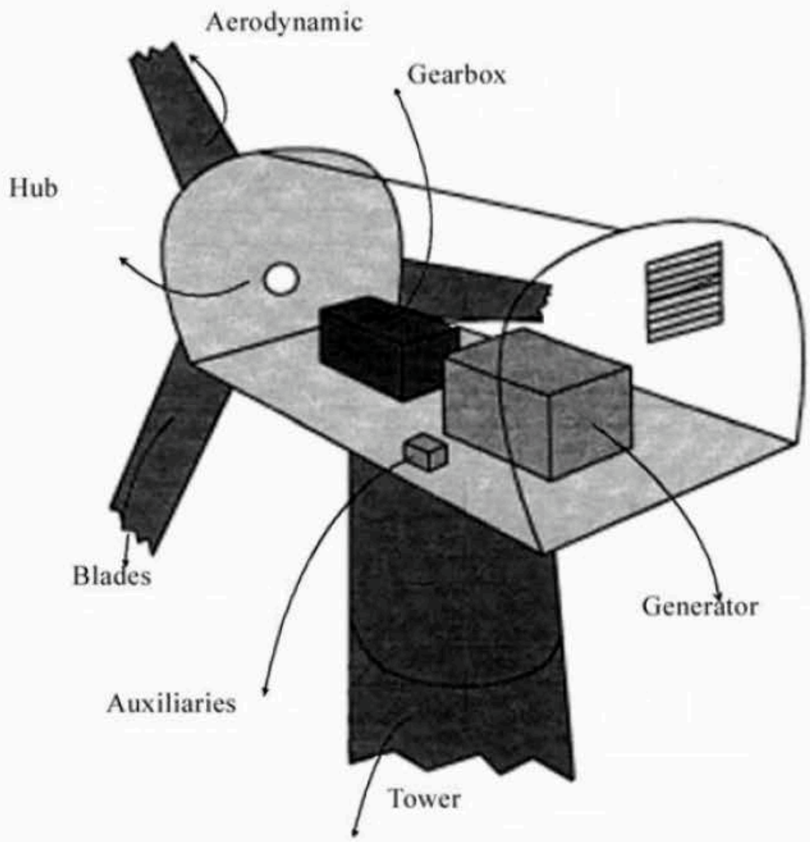

Figure 1 - (Modified from Wagner 1996)

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.

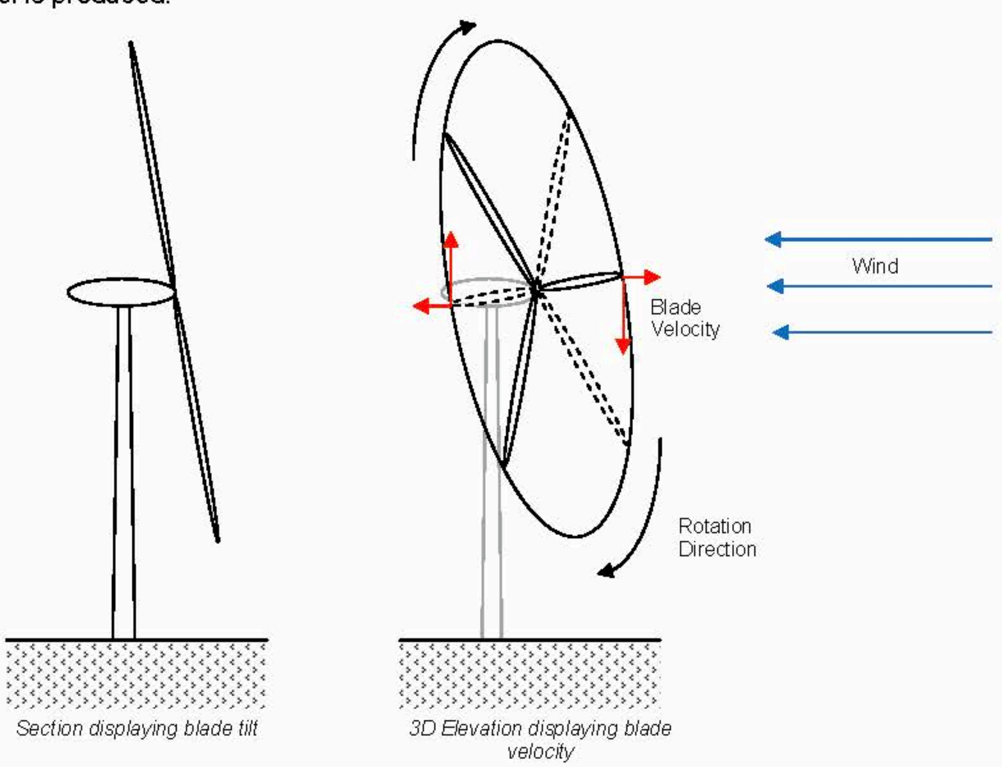

Figure 2 - Blade Velocity due to Tilt

<u>Low Frequency Noise</u>

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.

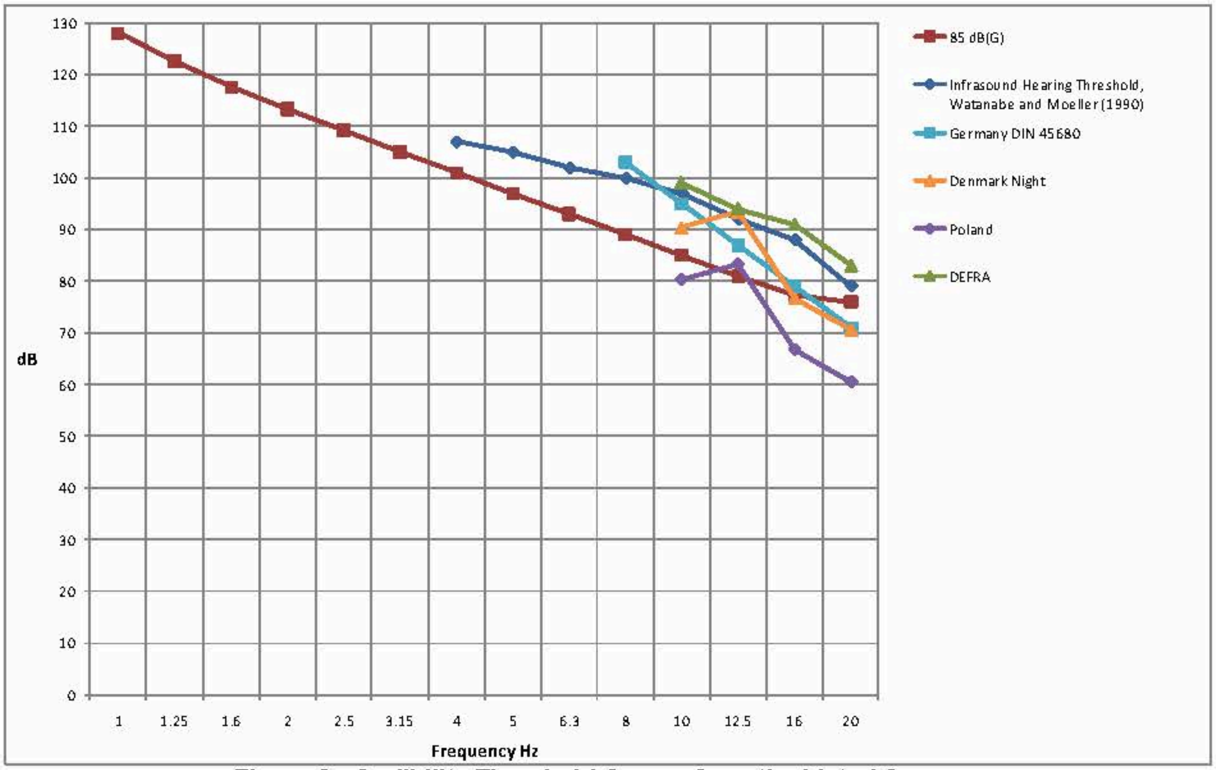

Figure 3 - Audibility Threshold Curves from the Listed Sources

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.

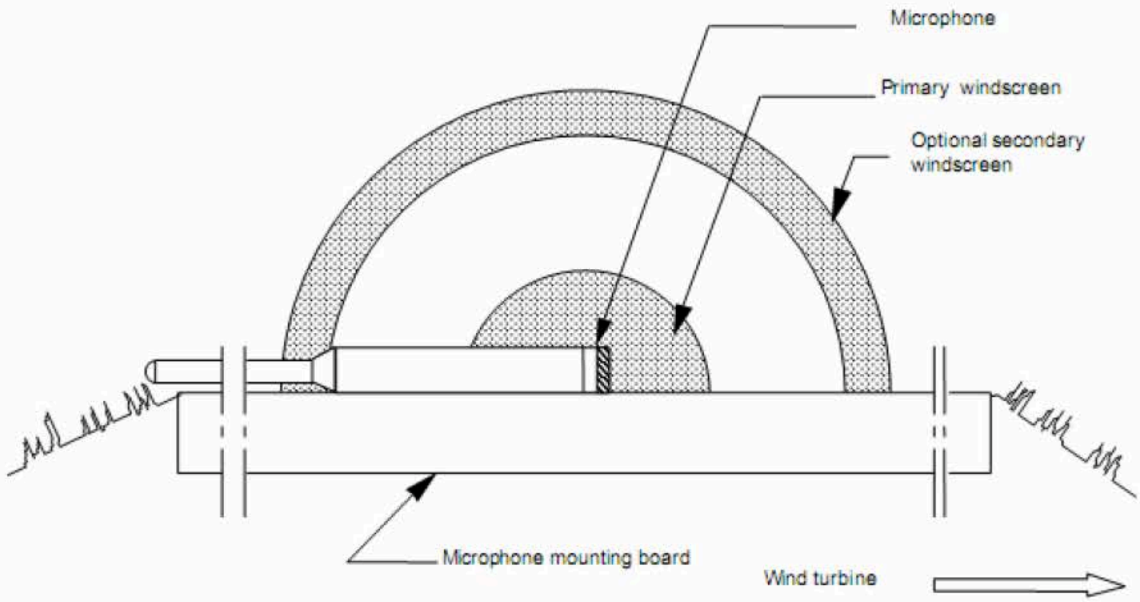

Figure 4 - Mounting of the microphone – vertical cross-section (Reproduced from Figure 1b, IEC 61400-11)

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 hole, and a primary windshield used around the microphone.

The microphone mounting arrangement is depicted in the following schematic:

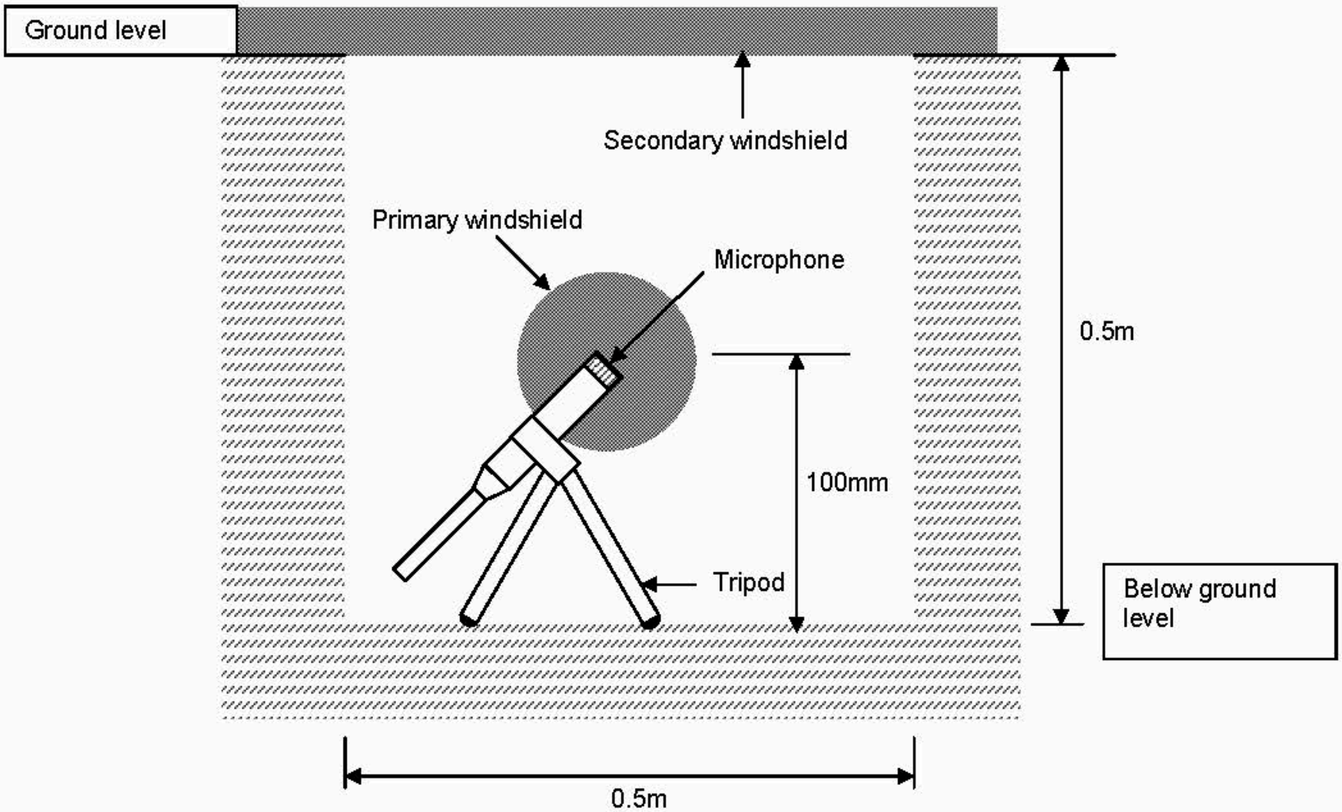

Figure 5 - Schematic of Microphone Position

Inputs

The measurement methodology was developed with the following inputs:

- Literature review related to wind turbine infrasound research as summarised above;
- 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) hole 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 of infrasound using the IEC 61400-11 method and the hole technique at the Clements Gap Wind Farm, at approximately 100m, 200m, 400m from a wind turbine, and also using standard measurement techniques immediately outside and inside a dwelling located approximately 1200m from the nearest wind turbine;
- Measurements to determine the level of transfer of infrasound at a range of different frequencies between 8Hz and 20Hz, from immediately outside a hole to inside a hole, 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 hole 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.

Prior to testing at the Cape Bridgewater wind farm, the measurement procedure was trialled at the Clements Gap wind farm by measuring infrasound using the both the hole technique and the IEC 61400-11 above ground technique in close proximity to an operating wind turbine.

RESULTS

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.

Testing at Clements Gap Wind Farm

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 1 - 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 hole	68	70	73	70	71	69	68	66	64	63	63	58	57	57	72
	Outside hole	70	71	72	70	69	69	68	67	66	63	60	57	57	56	71

Table 2 - 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 hole	67	66	69	66	67	64	62	63	61	58	56	53	52	52	67
	Outside hole	80	79	79	77	77	77	75	75	73	72	71	69	66	64	80

Table 3 - 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 hole	63	60	66	59	65	60	59	57	54	51	50	47	45	46	61
	Outside hole	71	69	72	72	72	68	69	65	64	61	59	55	53	50	67

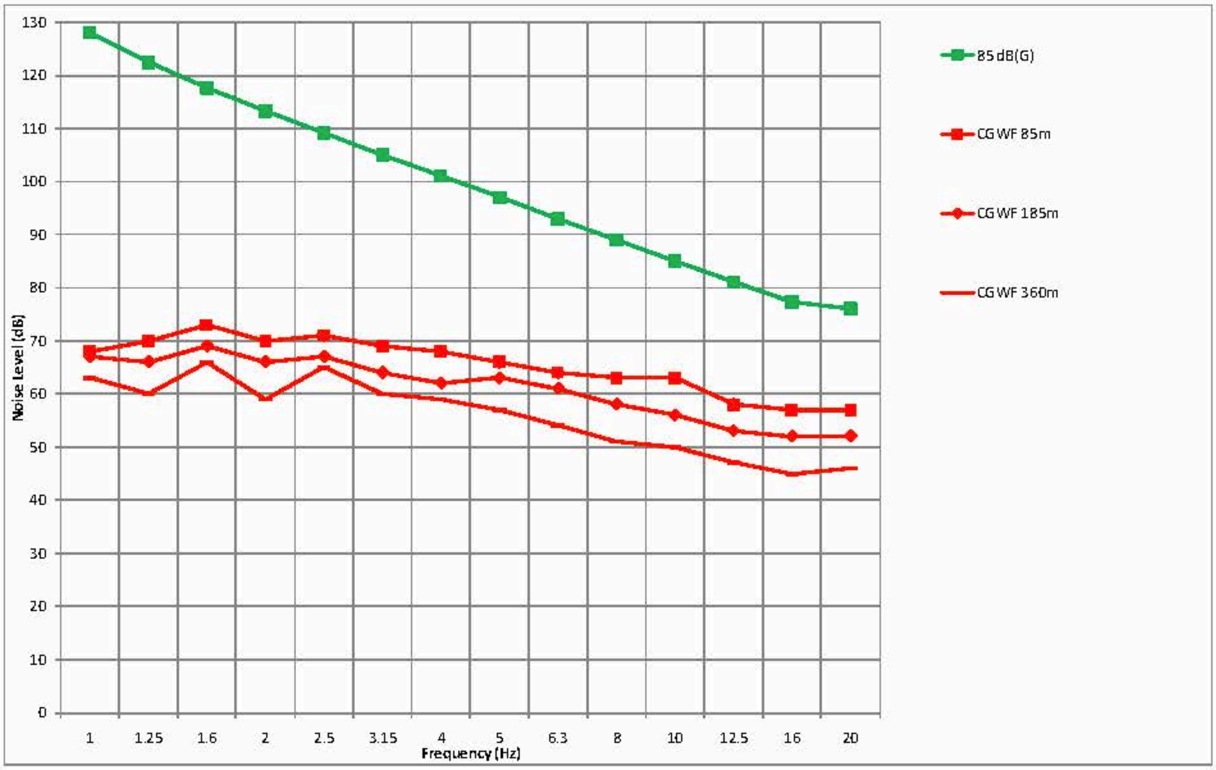

Figure 6 - Infrasound measurements inside the hole at Clements Gap wind farm

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;
- The theoretical noise level reduction from a noise source as the distance from that source doubles is 6 dB. This is due to the "hemispherical spreading" of the sound wave. This reduction theoretically applies to noise at all frequencies, including below 20 Hz. A noise level reduction of approximately 6 dB was measured inside the holes when doubling the distance from turbine 25. This indicates the level of infrasound measured inside the hole was directly associated with turbine 25;
- The measurements outside of the hole 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 4 and 5 and Figure 7 below:

Table 4 - 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 5 - 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

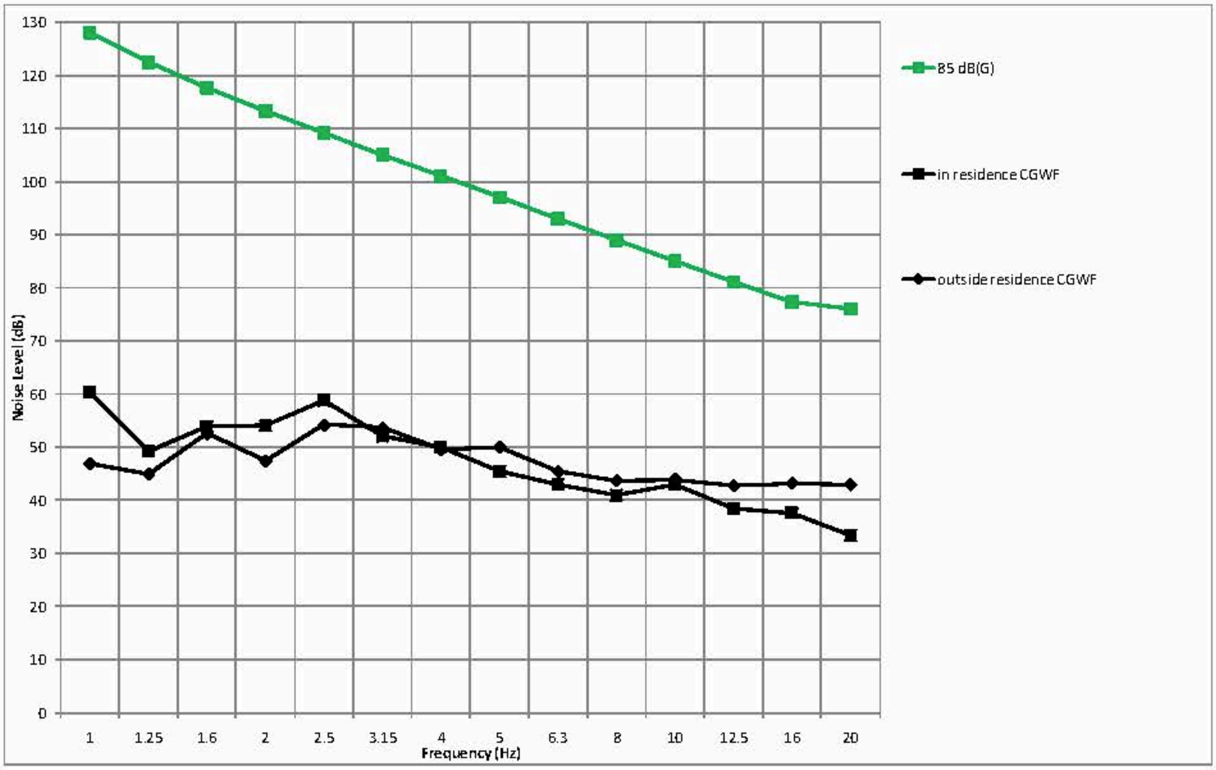

Figure 7 - Measurements of infrasound inside and outside a dwelling in the vicinity of the Clements Gap wind farm

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).

Controlled Verification

Based on the above results, the hole technique was further analysed at a remote site away from a wind farm, transport corridor or other appreciable noise source and in very still conditions to provide a measurement outside of the hole that is not influenced by wind. 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 hole. 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 hole. 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 hole 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 8.

Table 6 - 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 hole	47	50	54	60	63
	Outside hole	47	50	54	60	63

Table 7 - 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

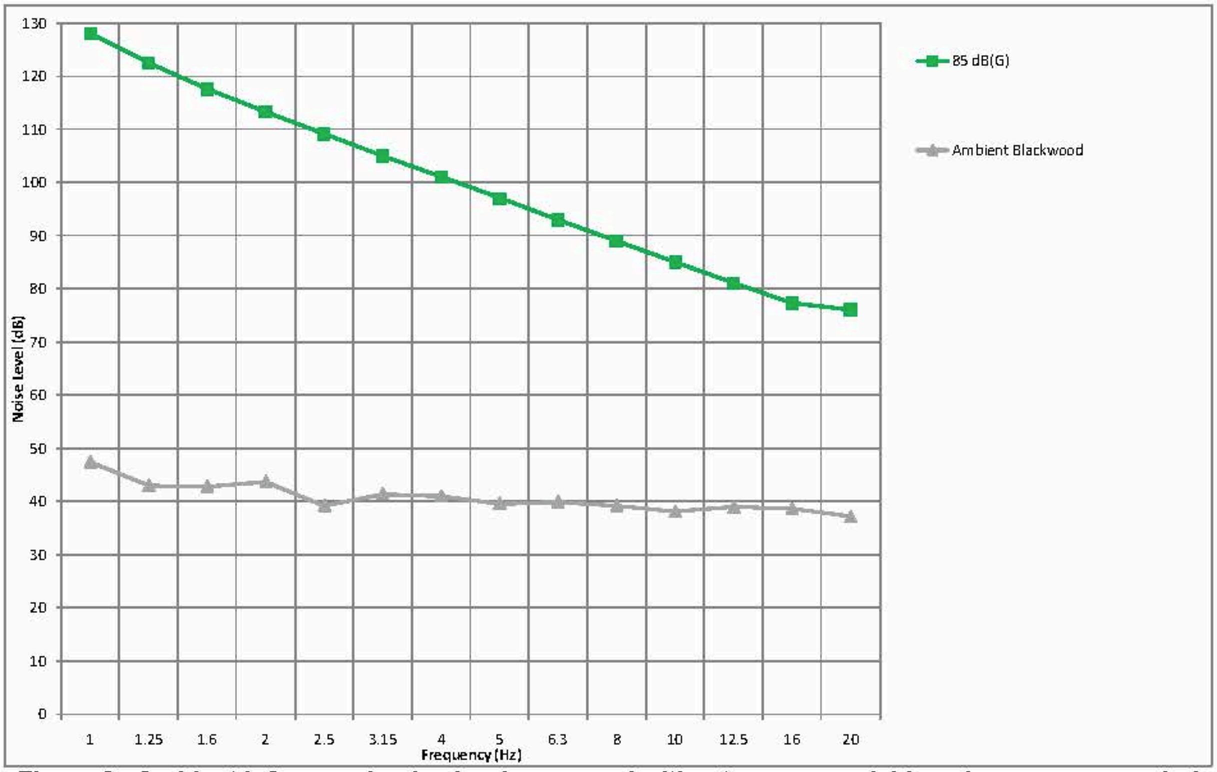

Figure 8 - Ambient infrasound noise level measured without any appreciable noise sources or wind

[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 8 - 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 9 - 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 hole using the technique described above. Therefore, the hole 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”.

Testing at Cape Bridgewater Wind Farm

The testing at the Clements Gap Wind Farm and the controlled verification testing confirmed that use of the hole 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 hole technique:

- Measurement of infrasound using the hole 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 at the blowholes 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 was conducted between approximately 4am and 6am on Wednesday the 2nd of June under a clear night sky with a light breeze.

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

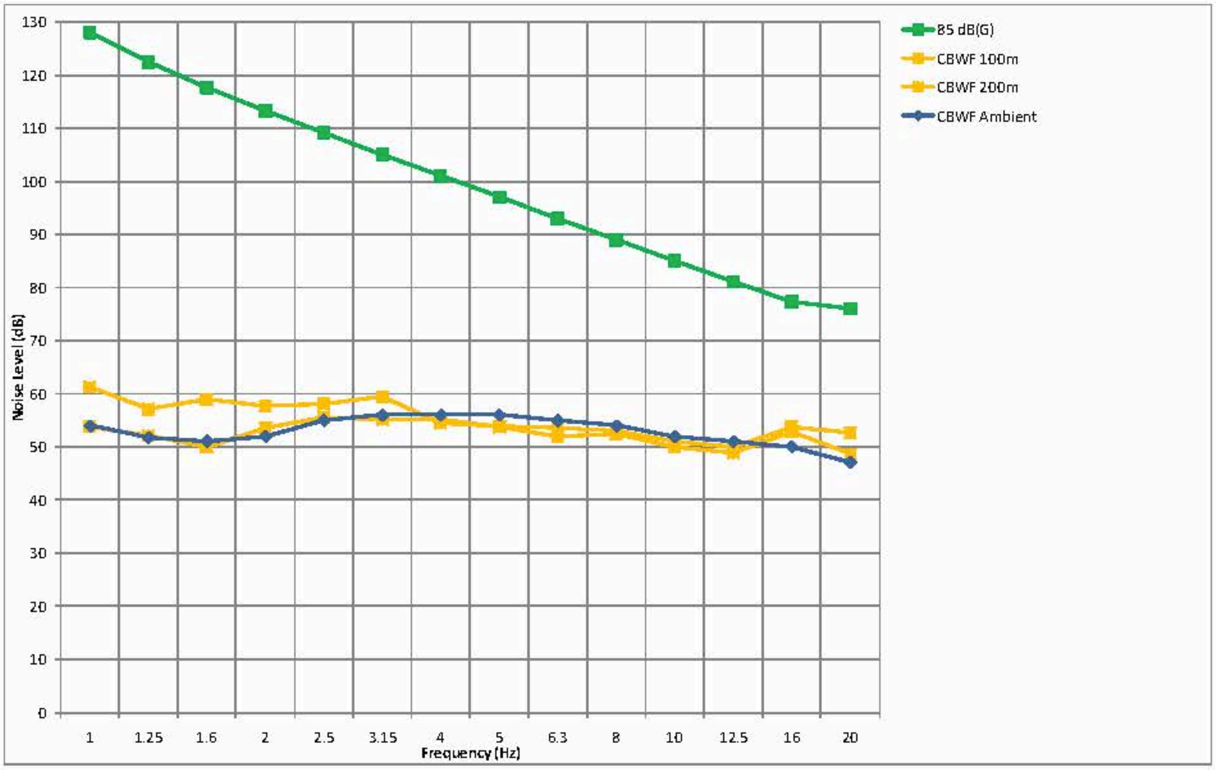

Figure 9 - Infrasound measurements inside the hole at Cape Bridgewater wind farm

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 blowholes 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 – Blowholes on the cliff face at approximately 250m

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

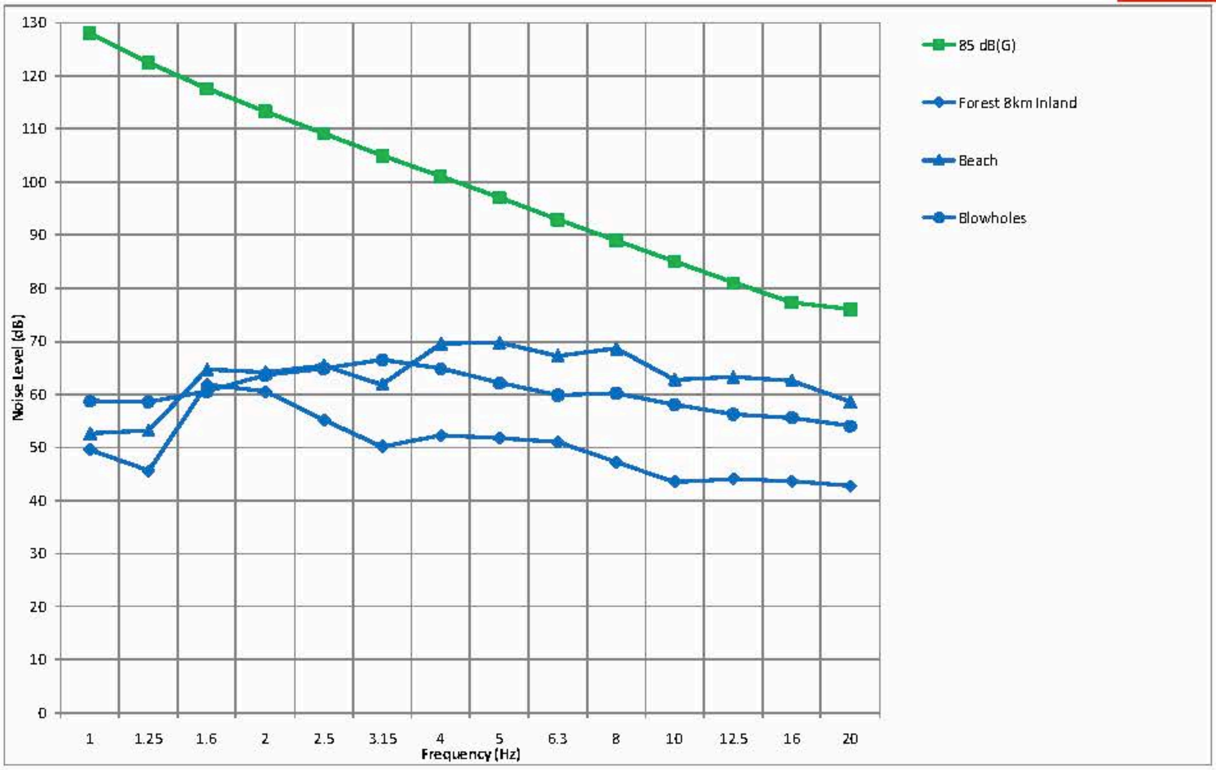

Figure 10 - Ambient noise measurements in the vicinity of Cape Bridgewater

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 hole technique in the vicinity of other man-made noise sources using the following procedure:

- Measurement of infrasound using the hole technique at a distance of approximately 350m from a gas fired power station;
- Measurement of infrasound using the hole 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

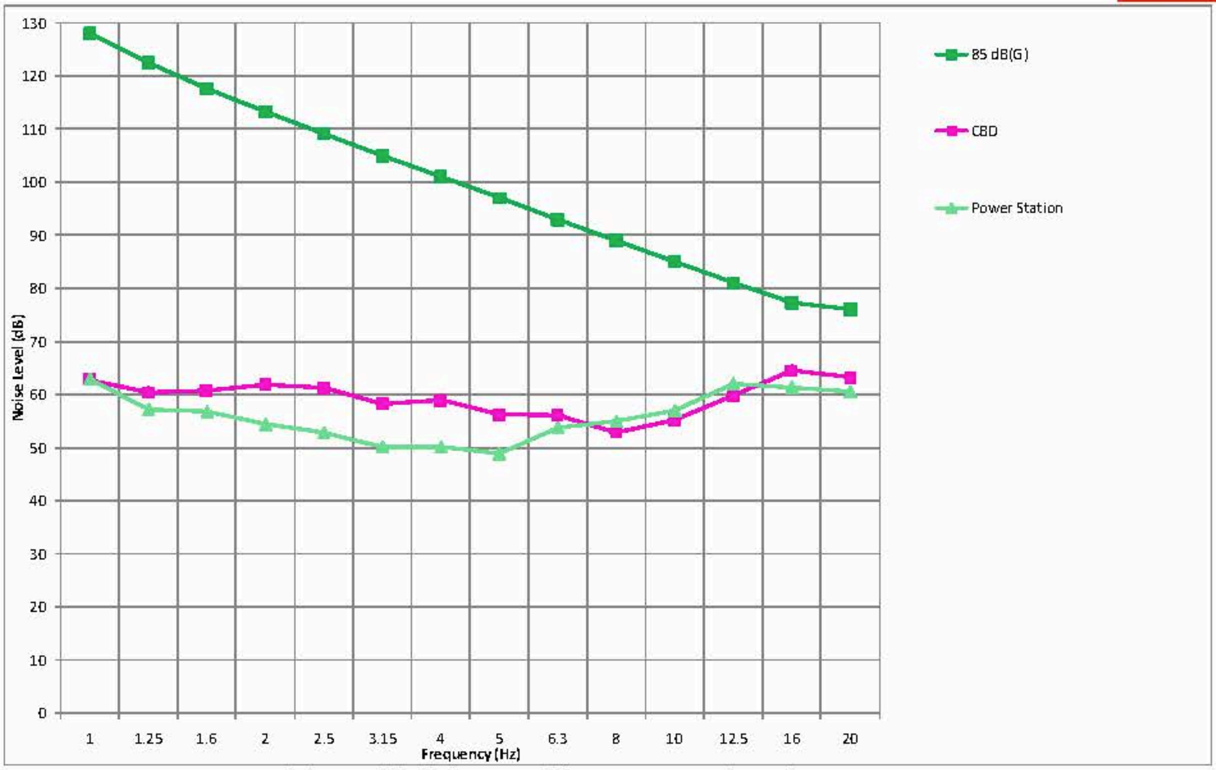

Figure 11 - Infrasound from man-made noise sources

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

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

> *….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 on 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;
- Infrasound that is below perception thresholds has been found to have no adverse effects;
- The level of infrasound prevalent in both rural and urban environments is of the same order as that within 100m of a wind turbine.

The following figure overlays the compiled results of the study:

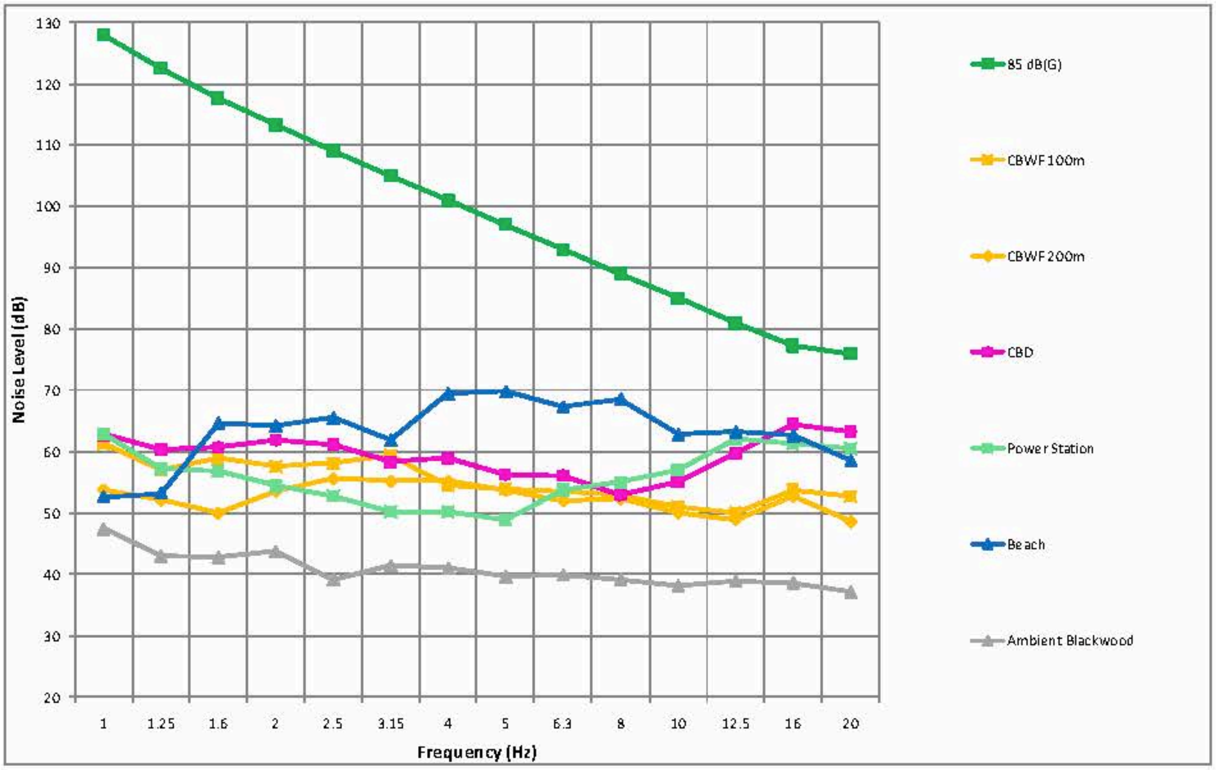

Figure 12 - Summary of Measurements Cape Bridgewater Wind Farm (CBWF)

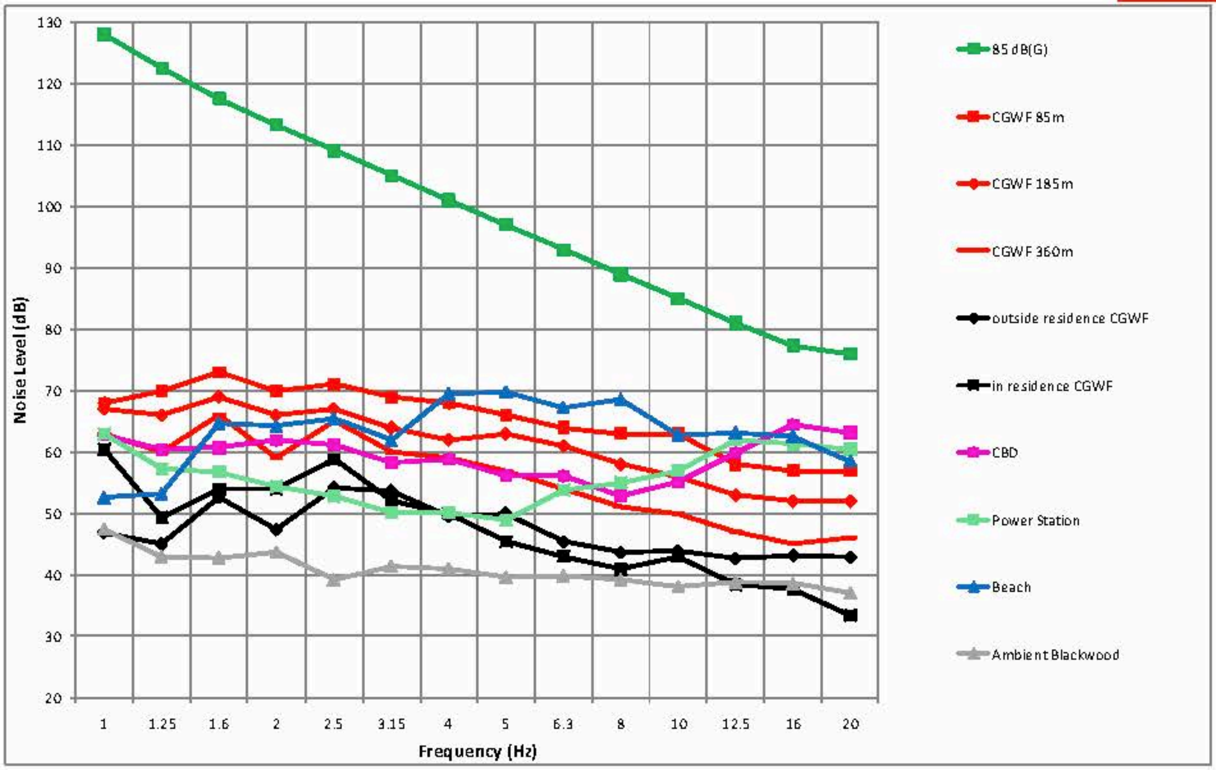

Figure 13 - Summary of Measurements Clements Gap Wind Farm (CGWF)

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PacificHydro

23 March 2012

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Re: Response to the Draft Energy White Paper

Pacific Hydro is pleased to provide comments on the Federal Government's Draft Energy White Paper (EWP).

Pacific Hydro is a leading Australian renewable energy company with hydro, wind, solar and geothermal power projects at varying stages of development, construction and operation in Australia, Brazil and Chile.

Pacific Hydro is a wholly owned subsidiary of the Industry Funds Management (IFM) Australian Infrastructure Fund through which Pacific Hydro provides sustainable infrastructure investment opportunities for around 5 million Australian members of Industry Superannuation Funds. We are proud to continue to provide strong returns for the environment, local communities and investors.

We are also active in the growing international carbon market, with proven success in the production and trading of carbon credits from our run-of-river hydro projects registered under the Clean Development Mechanism of the Kyoto Protocol.

Pacific Hydro is pleased to note that the national carbon mechanism is now law and that the policy includes a clear reinforcement of the role of complementary measures.

It has always been our view that action on climate change is most effectively delivered by a price on carbon as the foundation stone alongside economically and environmentally effective complementary measures like the large scale renewable energy target *and* complementary policy and regulatory arrangements for energy.

In our view, the EWP should play a key role in bringing forth the objectives of the clean energy future package and the LRET – to transition Australia's energy system to cleaner sources and drive significant reductions in emissions by 2020 and out to 2050.

Complementary energy policy reform

Without a complementary reform package in energy policy and regulation, which *could be* driven by the Energy White Paper, Pacific Hydro is concerned that the long term goals to transform the stationary energy sector to clean, renewable energy will be hindered and/or achieved at greater cost than could be otherwise achieved.

To be a true driver of complementary reform, the EWP must recognise the significance of the clean energy future policy objectives and the complementary role of the 20% renewable energy target on the energy industry. At a fundamental level, Pacific Hydro believes that EWP needs to incorporate a clear link to the Clean Energy Future policy and articulate the subsequent reform in the energy market that is clearly required to drive long-term transition.

The main element of regulatory reform that is required is a clear reference to emissions reduction in the objective(s) of the national electricity law. This would further entrench the long term emissions reduction policy goals with the efficient operation of the energy market and decisions made by NEM institutions and by the private sector.

The EWP should also:

- Recognise that the role of a price on carbon is complemented by energy policy and regulation reform;
- Underscore the importance of the LRET in driving the accelerated deployment of renewable energy and reducing Australia's emissions out to 2020 which is complementary the long term, national emissions reduction objective;
- Recognise that grid access, and grid investment (including interconnectors) are key barriers to the most efficient commercialisation of high value renewable energy resource zones;
- Recognise and articulate a complementary approach to skills to underpin the transition to a decarbonised energy industry.

Climate change policy reference in the market objective

Pacific Hydro considers that the remaining, necessary energy market reform must ensure that the policy and legislative architecture for the energy sector have regard to the fact that climate change policy is now fundamentally linked to the energy market via the Renewable Energy Target *and* the Clean Energy Future legislation.

The National Electricity Objective (NEO) as yet does not acknowledge the climate policy agenda within the objective. This fundamentally creates a divergence in the constitution of energy market investment signals to deliver on climate change and emissions reduction outcomes. This position has been highlighted in numerous Government reviews including the recent report to the Department of Climate Change and Energy Efficiency which noted:

> "The regulatory objectives underlying the NEM, could constitute an obstacle to effective adaptation of the regulatory framework for the supply of electricity to climate change...Based on the current regulatory objectives, the extent to which climate change can be taken into account in decisions relating to investment in network infrastructure and demand management under the regulatory framework will depend upon whether a link between climate change and security and reliability of supply can be clearly established."[1]

The link between climate change and security and reliability of supply is a driver of climate change policy responses and adaptation strategies for critical infrastructure. Reports from the IPCC (2007, 2011), Sir Nicholas Stern (2007) and Professor Ross Garnaut (2008, 2011) all made clear that increasing climatic change will impact upon critical infrastructure and without adaptation in policy, adaptation in practice will not occur in sufficient time.

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[1] Maddocks (2012). *The Role of Regulation in Facilitating or Constraining Adaptation to Climate Change for Australian Infrastructure*. p. 67

PacificHydro

One of the most significant barriers to efficient transformation of the energy sector is the inability of regulators to consider the benefits of low carbon energy systems.

A major concern is that regulators, when making decisions regarding future investments in and operation of energy markets which have long term consequences, cannot take into account the goals and objectives which are enshrined in the Clean Energy Futures and RET legislation.

Governments' policy responses to climate change implicitly and explicitly emphasise that this is a clear public policy concern and needs to be addressed by mitigation and adaptation policies and measures.

The final Energy White Paper should recognise and recommend that this vital policy link must be addressed through policy and regulatory reform.

Australia's resources

The Energy White Paper appears quite bullish about opportunities for natural gas, which is understandable. However it also seems to downplay the ambition and opportunities in renewable energy. Australia can benefit significantly from ensuring we enable clear market signals through the carbon legislation, RET and complementary energy market reform that would bring forward a broad range of zero and lower emissions technologies.

Australia has high value renewable energy resources across all known options from wave, ocean, biomass, solar, wind, and geothermal. While these technologies are at varying levels of deployment and in-situ Australian demonstration (in the case of ocean and wave), many are already operating at scale in other countries.

Conventional geothermal, which is a long-used and known technology overseas, has not been deployed in Australia despite the large potential for this resource to be utilised as a constant source of clean electricity generation. There are two key barriers:

- The absence of grid access in high value resource locations and the inability of existing market mechanisms to deliver an appropriate solution.
- The exploration risk – for which significant upfront capital is required to confirm resource quality and project economics.

Of the most deployed technologies – solar and wind – there are good levels of local deployment experience globally and locally.

Regarding future costs, the cost projections for solar PV and utility scale wind turbines drop quickly once adopted at a more rapid rate. Clearly these results are linked to the rapid advances and expanding markets in China, India and European countries.

The cost of electricity from wind turbines is predicted to drop 12% in the next five years, according to research from Bloomberg New Energy Finance. Wind turbines still show a 7% experience curve – ie. a 7% cost reduction for every doubling of installed capacity. Bloomberg data also shows that by the end of 2011 there will be over 240 GW of installed wind capacity.

Solar manufacturing is also seeing significant competitive price pressure and increases in demand driving prices for flat plate panels now below $1 per Watt, and around $3 per Watt installed (GreenEnergy Markets update - November). Note that these costs exclude grid connection.

Current barriers that hinder financing renewable energy technologies, more generally are as listed below:

1. Inability (difficulty) in negotiating long-term Power-Purchase-Agreements (PPAs) with a relatively concentrated number of retail electricity companies who have a short-term oversupply of RECs;
2. Regulatory market uncertainty on the long-term price of power incorporating carbon and in the RET market;
3. Risks around funding merchant energy power plant (with non-recourse project financing terms, tenure and pricing); and.
4. Transmission line access and grid constraint issues underscoring the issue of grid investment to support large scale wind power generation.

The above barriers (1-3) may not be insurmountable in isolation. Combined, however, they have the effect of delaying and increasing the costs, or lowering the return on a project in development. However, these earlier barriers are a relatively short-term problem driven by carbon policy uncertainty, historical distortions and policy inconsistencies in the RET market which have now been largely rectified. Where grid capacity and access are major issues, this will likely be sufficient to delay projects for many years even when they would otherwise be considered "commercially viable".

Advancing the clean energy future

In our view the Energy White Paper downplays the role of the LRET in the transition to a clean energy and low carbon economy. Over the past decade, the RET has driven substantial investment in energy generation and, in the context of the ongoing uncertainty on carbon policy developments, was a shining light of certainty for investors.

The positive impacts of the RET are now visible is the South Australian energy market. With more than 20% of the state's energy provided by wind power it can be observed that both the wholesale energy price and greenhouse intensity of energy supply have fallen. Additionally, this increase in wind power has not come at a cost of grid stability or security of supply nor has there been a requirement for additional back-up power plant to be installed.

It is therefore vital, in our view, that the final Energy White Paper takes a consistent position with regard to energy and climate policy that is complementary and consistent with clean energy future legislation and long term emission reduction goals for 2050.

In our view, it is *vital* that the EWP recognise and articulate the critical nexus that exists between grid capacity, high value renewable energy resource zones and the post 2020 environment for renewable energy investment.

Network extension and augmentation

As Pacific Hydro has argued elsewhere[2], it ought to be noted that large generation projects are located where the resource is. Pacific Hydro strongly contends that it is the role of Government to plan appropriately through policy, regulation and – as appropriate – investment settings to ensure the capacity of the shared network and *network extensions* are developed in parallel to (private sector) deployment of generation plant.

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[2] Pacific Hydro (2012). Submission to AEMC Transmission Frameworks Review
http://testweb.aemc.gov.au/Media/docs/Pacific-Hydro-5a47da47-9351-48ca-a48b-d678cbb46e60-0.pdf

The Energy White Paper has a clear opportunity to provide a long term and strategic view that will ensure that network extensions are developed to underpin Australia's transition to a low emission future.

While the RET drives generation investment to a mandated level by 2020, the rest of the market (including network investment) can only respond to the 'market' signals. As such, there is a point of disconnection as renewable energy generation is being built in response to policy targets that are not solely responding to the demand balance and locational price signals which drive investment across the broader electricity market.

Over the past decade both State and Federal governments have been reluctant to build infrastructure where it believes it may crowd out more efficient private investment. This stand-off has resulted in continual under-investment in grid maintenance, upgrades and expansion particularly in new transmission and interconnector capacity. This situation has been identified as a risk to the delivery of new generation capacity, both renewable and non renewable, in several recent Federal Government reports.

The current structures, if not addressed, are likely to drive renewable energy investors into areas with lower value resources with the possible outcome that the best (highest value and largest capacity) resources may not be deployed for many decades to come. The presently limited mechanisms available to develop new transmission in remote areas will, in our view, continue to impede investment. The costs are prohibitive for the private sector *alone* to pursue under the present regulatory investment framework.

Well targeted grid augmentation could have a dramatic impact on the development of emerging renewable resources such as solar and geothermal. For example, grid infrastructure in the mid-north of South Australia would greatly facilitate development opportunities for base-load generation from geothermal power. Further, grid augmentation west of the existing grid infrastructure along the eastern states, from Queensland to Victoria, would similarly facilitate connection of large amounts of utility scale solar PV and solar thermal power.

Regulatory reform (of the electricity objective) and alignment of national energy policy settings with the clean energy future package, combined with a long-term and strategic approach to funding shared infrastructure, would benefit multiple projects and technologies.

In addition to the above brief comments, we also support the response put forward by the Clean Energy Council in relation to the draft Energy White Paper.

Yours sincerely

Lane Crockett

General Manager, Australia
Pacific Hydro Australia