The Results of an Acoustic Testing Program Cape Bridgewater Wind Farm

Steven Cooper, Principal, The Acoustic Group, Australia

A number of findings arise from the study and have been grouped as follows.

11.1 Non-acoustic findings

The following non-acoustic findings of the study are considered to be significant:

- The resident's observations and identification of sensation (separately to vibration and noise) indicates that the major source of complaint from the operation of the turbines would appear to be related to sensation rather than noise or vibration.

- A significant sensation disturbance was found to be occurring when the turbines were seeking to start up, when there was apparent change in the power output of the wind farm in the order of 20% (being either an increase in power or a decrease in power), and the situation when the turbine has reached maximum power (normally wind above 15 m/s) and the wind was increasing in strength thereby requiring the pitch angle to be changed so as to de-power the turbines. The latter situation with excessive winds can occur for extensive periods at Cape Bridgewater with residents reporting that at times they have to leave the area to seek relief.

- For some residents experiencing adverse sensation effects the impact can be exacerbated by bending over, rather than standing, with the effect in some cases being reported as extremely severe and lasting for a few hours.

- With the wind farm not in operation the residents indicated noise, vibration and sensation are low in severity ratings.

- There are 2 residents that clearly have a greater sensitivity than the other residents. One resident, being hearing impaired, is able to identify noise that are below the standard hearing threshold levels and reported higher than normal severity with the wind farm shut down.

11.2 Acoustic findings

There are a significant number of acoustic based findings obtained from the study. Due to the complex interaction of various components of the study the findings have been grouped as follows.

dB(A)

- The use of dB(A) noise levels external to a dwelling did not correlate with internal noise levels or impacts that residents identified as coming from the wind farm.

- There is no correlation between the power output level of the wind farm versus the Danish dB(A) LF level (0.8 Hz to 160 Hz) determined inside residential dwellings. On an A-

weighted basis the dB(A) LF level (extended down to 0.8Hz) has its major contribution from frequencies above 100 Hz.

- Ambient noise from waves from the ocean and wind direction was found to be relevant in terms of contributing to the overall A-weighted level for this wind farm and can affect any regression analysis method.

Other acoustic parameters, including infrasound

- Comparison of the dB(A) LF, dB(C) dB(Z) found the wind influenced the measured levels such that by the use of 1/3 octave measurements there is no mechanism to separate the wind farm component from the overall noise levels that include the wind.

- At none of the houses was an internal level above 85 dB(G) detected.

- If 85 dB(G) is taken as the hearing threshold of infrasound then the study has found no audible infrasound in any of the houses.

- The use of only 1/3 octave band information to compare infrasound generated by turbines and infrasound in the natural environment (when assessed either externally or internally) does not contain the required information to identify any difference. However when supplemented by narrow band analysis in the infrasound region the measurement results clearly shows a periodic pattern in the infrasound (the wind turbine signature) whilst the natural environment for infrasound has no such periodic patterns.

- When dealing with narrow band investigation of infrasound the presence of the wind turbine signature (blade pass frequency and multiple harmonics of that frequency) and a frequency of 31.5 Hz was regularly identified inside the dwellings and outside dwellings. The wind turbine signature does not exist when the turbines are not operating.

- It may be more appropriate to identify that at times the acoustic signature from a wind turbine exhibits “pressure pulses” as opposed to explicit tones in the infrasonic region.

- Monitoring on the wind farms itself revealed that in proximity to the turbines there was no significant infrasound when viewed in terms of narrow band periodic functions suggesting directivity of the source of the infrasound.

Modulation

- The A-weighted level is found to vary (modulated/modulate) at the rate of the blade pass frequency.

- When dealing with a dB(A) level that modulates it should be expressed as either “modulation” or “modulation of the amplitude”.

- Amplitude modulation of 31.5 Hz at the blade pass frequency was detected near the turbines and at residential locations

Attenuation

- On a dB(A) basis the attenuation rate of 6 dB per doubling of distance appears to be valid for the A-weighted level of the turbines.

- For the infrasound region the attenuation rate is lower than the nominal 6 dB/doubling of distance assigned for audible noise.

- It is suggested that further investigation of attenuation in the infrasound region is best based upon a single turbine rather than a wind farm due to the influence of multiple turbines.

Vibration

- Vibration in the ground recorded at residential properties reveals random surges in vibration when viewed in the time domain.

- Monitoring of vibration near the turbine towers indicates surges associated with wind gusts where a significant increase above the ambient vibration in the ground was recorded

- The same pattern of vibration surges was recorded at location moving out from the turbines and is similar to that recorded outside and inside house 88.

- The vibration surges described by some residents as disturbance during the shutdown could be attributed to wind gusts exciting resonances of the blades/towers and requires further investigation.

Instrumentation

- There are limitations of the use of normal noise loggers to provide accurate results of dB(A) Leq and dB(A) L95, due to the noise floor of instrumentation and the relatively low noise levels inside such dwellings.

- Electrical interference/surges in mains, and very strong winds created some problems with data collection.

- The frequency response of the complete signal path should be verified to ensure the manufacture specifications are not comprised by the interaction components contained in the measurement system.

Turbine operation

- On low and medium power settings the speed of the turbine rotors varies at a different rate to the wind whilst maintaining a relatively constant electrical power output.

- The operation of ventilation equipment in the turbine structures induces vibration into the tower (but at relatively low levels). Such equipment whilst having nominal operating speeds incorporates variable speed drives and gives rise to a range in vibration levels. Typical vibration frequencies recorded on towers as a result of the ventilation fan varies between 23 and 30 Hz.

- Monitoring in proximity to the towers over a number of hours found a significant variation in noise levels from the tower structure including the typical “aircraft that never lands” signal often quoted by residents. The noise appeared to change with loading on the turbine.

- The downward sweep of the turbine has a slightly higher level of mid band noise than the upward sweep of the turbine.

- When located on the upwind side of a turbine a maximum sound level occurs at about 2 o’clock.

- The Wind Turbine Signature that has been found at other wind farms is also evident at Cape Bridgewater.

- Measurements of infrasound levels before and after a series of full shutdowns identified the Wind Turbine Signature concept can be applied to the subject turbines at Cape Bridgewater.

- The disturbance experienced by specific local residents (for the resident’s sensation 5 observations) shows a trend line that was used to develop the dB(WTS).

11.3 Subjects of further investigation

As the basis of the study was to start from the complaints end of the equation, rather from a noise end, material/advice and comments are provided to assist others in further studies or an extension to this study in relation to wind farm operations.

- It is suggested that in expressing disturbance from this wind farm, rather than claiming disturbance is from noise or infrasound from wind farms, the primary issue of disturbance for the subject wind farm is related to sensation.

- One outcome of the study is the need for the determination of a sensation response curve that has to be related to the acoustic/vibration signature generated as a result of the operation of a wind farm. It is considered that a laboratory study is unlikely to reproduce the physical impact that occurs at or in dwellings in proximity to a wind farm.

- The presence of the discrete frequencies (by way of FFT analysis) of the blade pass frequencies (with multiple harmonics) and the 31.5 Hz tone identifies the operation of turbines in an acoustic environment (including wind) and overcomes some of the issues associated with general acoustic parameters.

- Whether the infrasound components (derived by the FFT analysis) trigger conscious or unconscious responses in individuals by of the individual frequencies, the pattern of the frequencies or modulation of those frequencies, is outside the limits of the team’s expertise but are factors that should be considered in any future medical studies.

- The survey methodology used for the Cape Bridgewater study can form the basis of surveys for the next step in investigating “wind farm noise” that would incorporate acoustic measurements with the medical studies.

- This study did not include any testing in relation to sleep disturbance or health effects. An exercise relating to balance was suggested as a result of observations. The outcome of that exercise is best addressed by persons qualified for such an assessment in that it is a relatively simple exercise to undertake – however the effect that occurred for some residents would not have them repeat the exercise.

11.4 Suggestions

During the course of the study there were significant issues in terms of instrumentation that requires for other researchers in this area identification of problems and the essential need for persons involved in the measurements of noise, and particular infrasound, in proximity to wind farm affected environments to utilise calibrated instrumentation covering the entire signal chain from the microphone (or pressure sensor) through to the read out. Reliance upon manufacturer's data does not always cover the entire spectrum of concern, with an entire section of this study report addressing instrumentation issues that have been established during this study.

From the resident's subjective observations a wind turbine signature has been derived that indicates the averaged unacceptable presence of sensation inside a dwelling (for those 6 residents) occurs at an level of 51 dB(WTS) – when assessed as rms values 400 lines for analysis range of 25 Hz. Utilising PSD values (400 line 25 Hz range) the unacceptable level for the 6 residents occurs at 61 dB(WTS).

Being the first study to document or to identify "sensation" associated with the wind farm and the wind turbine signature, it is noted that the sample data is small and has persons already affected by the "noise". The findings must be considered as preliminary and warrants further detailed studies of the scientific rigour necessary for the purpose of confirming/verifying the suggestions for the use of the nominated dB(WTS) thresholds.

On the basis of a limited number of affected residents for the study, it is suggested that:

- for these residents the presence of "sensation" is the major impact;

- surveys of residents near other wind farms should utilise the Cape Bridgewater Wind Farm survey method so as to include "sensation" in any investigations;

- the use of dB(A) or dB(C) for internal measurements of the wind farm does not separate the results from that generated by the wind – for residences that are directly exposed to the wind. There is not enough data from this study to justify any change in regulation. However, the following matters are suggested for further investigation:

- the validity of the dB(WTS) and the appropriate threshold levels be the subject of further studies to provide the necessary scientific rigour for a threshold to protect against adverse impacts;

- examination of the use of the dB(WTS) index (both external and internal) to supplement the external dB(A) index currently used for wind farms;

- the use of the internal dB(WTS) method can assist in medical studies in that the internal dB(WTS) identifies the presence of energy from the operation of a wind farm. The dB(A) level measured inside dwellings is of no assistance in such studies;

- the use of an external dB(WTS) can overcome the limitations of the dB(A) method that can be influenced by extraneous sources (i.e. wind); and

- the issues of directivity and identification of the noise emission sources of a turbine relative to sound power testing at ground level be examined, particularly for the generation of infrasound. Whilst there are significant costs involved, further investigations are required (by the use of a crane or similar) to measure noise levels at the hub height and the top and bottom of the swept path for say 150 metres from the tower, including directivity testing at those heights around the turbine.

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Download the original documents from the following links:
The Results of an Acoustic Testing Program – Cape Bridgewater Wind Farm
Appendices A to H
Appendices I to J
Appendices K to M
Appendices N to P
Appendices Q to S
Appendices T to V

Letters of endorsement:
Bob Thorne, Noise Measurement Services
Stephen Ambrose, S.E. Ambrose & Associates
Robert Rand, Rand Acoustics
Carmen Krogh, independent researcher
Richard Mann, University of Waterloo
Les Huson, L Huson & Associates — with corroborating data

Review of the Cape Bridgewater acoustic testing program and where it is leading
Further comments on the Cape Bridgewater Wind Farm Study — Muddying the waters
—***Paul Schomer****, Schomer and Associates, Standards Director, Acoustical Society of America; and* ***George Hessler****, Hessler Associates*

Steven Cooper (principal, Acoustic Group)

Source of text: https://www.wind-watch.org/documents/results-of-an-acoustic-testing-program-cape-bridgewater-wind-farm/