ARE WIND FARMS TOO CLOSE TO COMMUNITIES?

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Currently, state planning legislation in Australia suggests separation distances of 1-2km from wind farms. Noise limits incorporated in the various State guidelines and used for assessment purposes have no scientific studies to support the basis of the limits. The use of a dB(A) limit set well above the natural ambient background level does not protect the health and well-being of the community. The noise concepts used for wind farms in NSW ignore the fundamental premise of not creating ‘offensive noise’ as defined in The Protection of the Environment Operations Act. Examination of ‘noise levels’ received by residents in proximity to wind farms reveals the presence of audible and inaudible sound that extends well past the nominal separation distances of 1-2km. The silence of the individual state Environmental Protection Authorities in addressing these issues is deafening.

Some twelve months ago I was requested to undertake a peer review of an acoustic assessment in relation to a proposed wind farm in central New South Wales. The process of reviewing an acoustic assessment report is relatively straight forward. Examination of the acoustic report found a number of significant technical omissions with respect to the project’s specifications issued by the NSW Department of Planning and Infrastructure for the preparation of the Environmental Assessment.

Examination of the ‘acoustic assessment’ found there was a numerical analysis of potential noise emission levels of the wind farm, but no actual assessment of the impact to advise residents what they would experience.

In the process of reviewing the assessment it was identified that there are a number of wind farms in Australia that are subject to complaints from residents on the basis of noise disturbance and that in some cases some residents have left their homes to obtain relief.

Initial Assessment

As part of the peer review there was a request to attend a number of residential properties in proximity to the Capital Wind Farm to quantify the extent and magnitude of noise emitted from that wind farm. The result of that investigation has led to further attendances at residential properties in proximity to wind farms in both Victoria and South Australia and as such has identified a number of pertinent issues.

Going back to the original attendance at the first residential property, because it appeared the major issue was related to disturbance at night, there was a concentration of monitoring during that period. On the first night of testing there was negligible wind in the area and therefore there was no noise disturbance and measurements of the ambient noise revealed a relatively quiet environment.

The following night presented a different situation, in that the turbines were operating, although there was no apparent wind at the residential property. The noise from the turbines was audible outside the residence and not considered to be excessive and did not appear to correlate with the claims of disturbance.

Inside the dwelling there was some noise detected, but again on a subjective basis I did not consider the noise to be significant. However the resident was able to clearly detect the noise by reason of being sensitised to the noise. Instrumentation was set up to monitor inside and outside the dwelling.

The resident identified that since the operation of the wind farm her sleep was regularly disturbed, she experienced headaches and at times would be woken up as though being startled, but not knowing what caused the event, and at other times would wake up in an extreme state of panic.

The monitoring revealed there to be the presence of low frequencies in the audible range and also frequencies below the audible range. The monitoring suggested a periodic pattern which is associated with the operating speed of the turbine multiplied by the number of blades (which is identified as the blade pass frequency) and then harmonics (multiples) of that frequency. Attendance at other dwellings some 2 – 3 km from the wind farm found similar measurement results and varying levels of disturbance reported by residents.

Measurement Difficulties

The typical approach in dealing with general noise in the environment is to utilise in the first instance the A-weighted value which covers the audible spectrum of sound and utilises a curve that approximates the response of the human ear (see Figures 1 & 2).

The nature of the A-weighting curve reduces the impact of low frequency noise such that low frequency noise or frequencies below what the ear can hear in the frequency domain (identified as infrasound) do not get picked up in the A-weighted value.

Figure 3 shows noise emission levels for turbines (as sound power levels in 1/3 octave bands) with the A-weighting filter applied versus the same data without the A-weighting filter.

In general acoustic terms when one refers to dB(A) guidelines they seek to set criteria based upon a level that satisfies 90% of the people for 90% of the time. For typical noise sources one considers a noise threshold for disturbance to be around 5 dB (decibels) above the background level, and therefore it is not uncommon to find specifications written in terms of background plus 5dB(A).

Noise criteria used for wind farms in Australia tend to be based on a set of guidelines issued in 2003 by the South Australian EPA which only consider the noise in terms of the A-weighted value.

Normally, any measurements that occur in an area where the wind speed is greater than 5 metres per second are ignored for the purpose of background level measurements.

However, the operation of wind turbines requires wind. The presence of wind creates a noise across the microphone and therefore one can have a different background level dependent on the wind at the receiver location. For wind farm assessments there are two criteria utilised in the guidelines, the first one being background plus 5 dB(A), and the second one being a base level of 35 or 40 dB(A). The criteria normally expressed are the greater of the base level or background + 5 dB(A).

Therefore to determine the criteria to be applied to the subject development the procedure to date has been to determine the ambient background level at residential receivers versus the wind that would occur at either a height of 10 metres above ground level at the wind farm or at the hub height of the turbines. The guidelines require one to plot the background level versus the turbine wind speed and then to provide a regression curve of background level versus wind speed.

There are a number of issues with that procedure in that the regression analysis looks to obtain an average noise level versus the wind speed at the subject turbine that is reported to be relevant to the receiver location.

However on attending residential properties in proximity to wind farms it is obvious that due to the topography of the area the wind at the turbine under certain directions would produce a different impact at the residential receivers than for other directions.

As the regression graph that is obtained prior to the construction of the wind farm becomes the determining criteria for compliance purposes the community has some issues as to the relevance of the use of the regression line in view of different wind directions and the resultant noise that occurs at residential receivers. For example, compliance testing in relation to the Capital Wind Farm found the background level with the wind farm turned off to be lower than the regression line background level determined at the application stage.

The second issue of concern in relation to the relevance of the regression lines is that in many cases the instrumentation used for monitoring cannot measure low enough, and therefore the data that is obtained by the monitoring is automatically skewed away from the actual background levels and gives a false average.

Figure 4 shows the results of measurements on the side of a hill in rural South Australia with no trees for 500 metres and no wind farms for 20 kms. The regression line is of the background level versus the wind at 1.5 metres above ground. In this case instrumentation that can measure below 20 dB(A) was used with a standard 100mm windscreen. Because the graph relates to the wind speed at the microphone it shows a different relationship to the typical regression graphs for a location versus the hub height wind speed.

The third issue in terms of wind farm noise that is different from other industrial premises, is the use of a regression line of the data automatically places that curve above a level that would satisfy 90% of the population for 90% of the time.

A fourth issue of concern is the criteria obtained from the guidelines. It becomes obvious when one looks at the regression curves, that for relevantly low wind speeds when the turbines operate, the real background level at residential receivers is significantly below the base line criteria of 35 or 40 dB(A). Therefore the generation of noise levels permitted by the guidelines would be clearly audible in the rural environment.

A fifth issue of concern is whether the windscreen used for measurements is appropriate for the task in hand in that the passage of wind across the windscreen generates a noise other than that created by the wind and therefore leads to erroneous baseline data. In this regard the need for secondary windscreens and ground plane microphones has been raised with suggestions for the current procedure there is a deliberate use of microphone placement to provide an advantage to the wind farm, by elevating the background level.

Acoustic Criteria

One of the principle issues in terms of wind farm noise, is utilising limits typically encountered in suburban areas that do not reflect the acoustic environment in rural areas removed from traffic and industrial sources. Two social surveys in Sweden and one in the Netherlands for relatively small turbines have clearly shown for the same level of noise emission a greater disturbance in rural communities than in suburban communities.

Another issue is that wind turbines are getting bigger and more powerful over time. Measurements indicate stronger low frequency components from larger turbines. Therefore reference to previous wind farms as not being an issue to communities is not an appropriate response if one does not identify the size of the turbines in both physical size and capacity. For example, studies related to one or two 700 kW turbines that create an impact, cannot be taken as equivalent to a wind farm having 30 to 100 turbines with a generating capacity of 3000 kW for each turbine.

The noise levels set out in the guidelines permit a clearly audible noise at rural residential receivers, even when one uses the A-weighted concept that for general noise assessment throughout the state would be levels that are considered unacceptable for residential receivers.

The above issues of concern relate to the use of the A-weighted values which as set out above and shown by the weighting curves in Figures 2 & 3, do not address the low frequency and infrasound components generated by turbines. This becomes an issue in that there are instances of residential dwellings being subject to noise levels that clearly comply with the guidelines yet the persons who occupy those dwellings are adversely affected by the operation of the turbines.

Therefore if residents are subject to noise that interferes with their rest and repose, gives rise to headaches, and makes the occupancy of their residence unsuitable to the extent that some people leave, sometimes on medical advice, then clearly the A-weighted concept is incorrect. However the Environmental Protections and Health Authorities ignore such complaints.

It is in this regard that emphasis has been placed by acoustic researchers around the world to look at other components that exist in the acoustic signature of turbines that is not necessarily picked up in the A-weighted concept.

Figures 5 & 6 show 1/3 octave band noise levels recorded in relatively close proximity to operational turbines in South Australia where there are no interfering noises from wind, road traffic, residential or agricultural activities. In proximity to the turbine there are low frequency components and also infrasound components evident in the acoustic signature. The figures show the difference between a position to the side and in front of the turbine by breaking the sound into spectrum components by way of 1/3 octaves rather than just the dB(A) value.

However a better presentation to identify the unique characteristics of turbines is to analyse across sections of the frequency spectrum when expressed in a linear (i.e. no weighting) relationship.

Low Frequency and Infrasound

It is by use of the linear relationship and narrow band analysis that the unique spectral (frequency distribution) characteristics associated with turbines become evident. There are frequencies that occur below the range of sounds audible to the human ear, and are signals that are readily detected if one has the instrumentation capable of measuring down to such frequencies and measures in a linear format rather than A-weighted format.

The narrow band spectrum recorded in proximity to the turbines shown in Figure 7 clearly indicates the blade pass frequency and multiple harmonics of the blade pass frequency.

One can also look at the variation in the overall noise level to determine a modulation in the signal that is received by the microphone.

Measurements conducted at residential receivers removed from the wind farm have found the presence of the discreet signature of the turbines with those components being detected both outside and inside the dwellings (see Figures 8 & 9).

The resistance to sound provided by the building envelope is much greater at high frequencies than low frequencies, and presents a problem with buildings being unable to adequately attenuate these low frequency components. Furthermore in some cases the building itself may be subject to vibration or the rooms can have natural resonances that can give an enhancement of the infrasound signals, and/or the physical vibration of the building generates such internal noise levels.

The relevance of the low frequency noise, in acoustic terms is significant when one considers that the propagation of sound over distance varies dependent upon the characteristics of the sound source and the frequencies of concern.

Figure 10 provides the measurements recorded external to a dwelling 8km from the Waterloo Wind Farm expressed in 1/3 octave bands. There are some low frequency and infrasound levels but no distinct pattern. However, at this location, a low frequency rumble was clearly audible and to the residents completely out of character to the natural environment.

If one assumes a turbine has a sound power level of say 103 dB(A) then on a 6 dB attenuation per doubling of distance (without allocating any additional loss for topography) then the typical figure quoted of 35 dB(A) at 1 km would become 17 dB(A) at 8 km.

In a background level of 27 dB(A) shown in Figure 10 under normal dB(A) noise assessment one would expect the turbines to be barely audible/inaudible external to the residence and inaudible inside the residence. However this was not the case.

Figure 11 shows the narrow band levels simultaneously recorded inside (blue) and outside (red) using the narrow band technique to reveal the turbine blade pass frequency and multiple harmonics. Using the measurements near the turbine at the frequency of 4 Hz (80 dB at 150 metres) to achieve only a 20 dB reduction over 8 kms shows that 6 dB per doubling of distance cannot be applied to these frequencies.

The general approach by the use of the dB(A) parameter is to consider individual turbines as a hemispherical radiation point source where the attenuation (reduction in sound) is taken at 6 dB per doubling of the distance. However when one examines the flow characteristic of turbines with respect to the low frequency and infrasound components, measurements reveal the radiation does not occur as a hemispherical source but as a line source which leads to a lower rate of attenuation.

There are a number of facilities around the world that are used for the monitoring of nuclear explosions and seismic activity that concentrate on the low frequency/infrasound components in both an airborne noise and ground vibration. Staff at these facilities have significant expertise in monitoring such levels and a number of these establishments have conducted work in relation to wind turbines. They have found that if turbines are within 30km of such establishments then the operation of those facilities can be compromised. Clearly the sensitive nature of those facilities is different to that of residential dwellings and accordingly a lower separation distance would apply.

However work undertaken by the Federal Institute for Geosciences and Natural Resources specifically into the propagation of low frequency noise, by persons having a significant degree of experience in such measurements, has clearly demonstrated that the propagation characteristics of the infrasound measurements are entirely different to the general A-weighted propagation assumed for turbines (see Figure 12).

Therefore in terms of acoustic criteria applicable to the low frequency and infrasound components associated with turbines the use of dB(A) is entirely inappropriate and, as the guidelines used in South Australia or the New Zealand Standard ignore such components, then the absence of an appropriate criteria for low frequency and infrasound presents some difficulty for the Environmental Authorities fulfilling their role to protect the community from adverse impacts.

In fact the South Australian guideline claims that a well maintained modern wind farm does not produce infrasound. This would appear to be an incorrect statement by reference to the results in proximity to the turbines and the presence of those frequencies in the acoustic signature detected at a residential dwelling out to 8km from the Waterloo Wind Farm.

Some researchers have referred to the use of the dB(G) curve for evaluation of infrasound. The G-weighting is shown in Figure 13 in both a linear and a logarithmic presentation. However as the blade pass frequency of turbines is below 1 Hz, the dB(G) curve may not be appropriate. Alternatively the use of Linear (no weighting) over a restricted bandwidth may be appropriate.

This issue in terms of different propagation rates and the resultant level detected at residence becomes important in that the recent research of Salt and Lichtenhan (2011) and Salt Kaltenbach (2011) as reported by Richard James[1] has confirmed that there is physiological response to modulated infrasound at levels below the threshold of perception (for pure tones) that may start at amplitudes as low as 60dB(G). Similarly Dr Swinbanks (UK researcher) has identified that a modulation of the signal stimulates the auditory system at levels much lower than that normally attributed to pure tone assessment.

In his paper, R. James has identified that investigations many years ago in relation to low frequency and infrasound noise impacts in industry which were well known with respect to diesel generators, power stations and engine rooms on ships and that in the 1970’s and early 1980’s considerable investigation occurred into low frequency and infrasound that would now fall under the classification of noise-induced sick building syndrome.

Of recent times there have been claims that infrasound produced by wind farms is similar to or less than that obtained in the natural environment. One report used by the wind industry in Australia to support such a claim finds reliance upon 1/3 octave band results, that on a closer examination, leads one to question the results that have been provided.

Figure 14 shows a 10 minute time splice of the dB(A) level for an exposed location near Collector. At the time of the monitoring there was a wind blowing from the south that over the 10 minute average was found to have a mean wind speed of 3 m/s with peaks gusting up to 7.2 m/s.

Figure 15 compares the narrow band spectra for 0 – 50 Hz (upper graph) with the 1/3 octave spectrum (lower graph). As the comparison shows while there may be designated frequencies in the 1/3 octave bands that fall in the infrasound region, there is no harmonic or distinct pattern in the narrow band spectra.

1.”Wind Turbine Infra and Low-frequency Sound: Warning Signs that Were Not Heard”, Bulletin of Science Technology & Society 32(2) 108-127

Hence it can be seen that utilising 1/3 octave band material as a crux for comparison of wind farm environments versus natural environments is an incorrect methodology.

When one considers the low frequency and infrasound noise and the reduced capacity of a building to attenuate such noise, then the issue of concern with respect to wind turbines becomes more of an indoor problem than an outdoor problem. Accordingly, if the acoustic criteria only consider external noise levels, then the obvious deficiency in terms of the appropriate criteria for wind turbines becomes clearly obvious.

The application of noise criteria applied in suburban areas verses utilising the same criteria in rural areas is easily understood to be an unsuitable situation when one considers the obvious difference in the acoustic environments. Reference is often made to guidelines produced by the World Health Organisation that refer to noise levels suitable for protecting persons sleeping without identifying that those guidelines relate to traffic noise impact in suburban areas.

Typically reference to the WHO guideline fails to identify the nature at low frequency characteristics give rise to a difference in the subjective impact of a noise, or the fact that the WHO guidelines do not discuss wind turbines or alternative criteria for quiet rural areas.

If residents across Australia in proximity to wind farms identify sleep and health issues as a result of turbines and yet other members of the household are not affected in such situations, then this is not dissimilar to an individual’s response to other types of noise. If one considers the appreciation or enjoyment of music then a discussion with your family or colleagues will reveal different tastes of music and in some instances an extreme degree of annoyance when persons experience different types of music.

For example lovers of opera may not necessarily enjoy or even accept any music associated with rap music and it is not uncommon for young people to demand opera music to be turned off.

I have met with residents in proximity to various wind farms where one person is able to detect when the wind farm is operational by either a presence in the head or body, whilst the partner is unable to detect any such effects. The difference response/reaction of individuals must be taken into account.

Furthermore the length of exposure to the turbines must also be taken into account.

Adverse Impacts

The SA EPA Guidelines indicate that for residential receivers that have a financial relationship with the wind farm that adverse impact occurs if the occupants of the dwelling experience sleep disturbance. Interestingly there is no actual definition of an adverse noise or health impact contained in the guideline.

There is a common response to the objection to wind farms on the basis of noise by drawing attention to the lack of scientific evidence linking wind farm operations with health impacts. However there is also a lack of scientific evidence to prove that wind farm operations do not create health impacts.

The reason for the lack of scientific evidence for both scenarios is simply because the appropriate scientific studies have not been undertaken. There are a number of “peer reviews” quoted in relation to wind farm impacts. However, examination of those reviews find that in general they are simply literature reviews and not actual scientific studies that incorporate real-world data as to the operation of a wind farm, the physiological and medical response of the community with appropriate analysis.

On my review of the material unless one has the raw acoustic data to identify what the residents are exposed to as a result of the operation of the wind farm that is then being followed by the appropriate sleep studies, questionnaires and then medical studies of the persons so affected, then one cannot causally link the said noise source to that the reaction.

From an acousticians viewpoint it seems to me that there are two distinct steps to be undertaken is establishing the **Relationship of wind farm noise to impacts**.

Step 1

Use Acousticians and Psychoacousticians

- **Acoustic measurements - of wind farm noise**
- **Psychoacoustic assessment of community response**

Step 2 (Following Step 1 + on site sleep studies, with acoustic measurements)

This involves multidisciplinary research involving acousticians and psychoacousticians, together with experienced medical practitioners, researchers and clinicians, including but not limited to the following speciality areas:

- **Sleep Physicians & physiologists**
- **Ear Nose & throat physicians and physiologists**

- **Neuroscientists**
- **Psychiatrists & Psychologists**
- **Cardiologists and cardiac physiologists**
- **Endocrinologists**
- **Rural General Practitioners**
- **Occupational Health Physicians**

With the results of such studies then an answer to the question of the Relationship of wind farm noise impacts can be obtained.

Separation Distances

Clearly from the measurement results discussed above, separation distance from wind farms must be greater than the nominal 1 to 2 km. Obviously a separation distance of 100 km would ensure that there would be no impact. The answer lies somewhere in between.

As noted above in acoustic terms socio-acoustic surveys take samples of the population impacted to varying degrees by a noise and determine a level at which 10% of the population are seriously/highly affected.

The results of such surveys may indicate that there are other factors (other than noise) that may influence the response of the community. For example, the socio-acoustic study conducted in the late 1970s in relation to aircraft noise in Australia found only a 17% correlation associated with noise and that there were other factors such as fear of the aircraft crashing and interference with television reception that influenced the community’s response to aircraft operations. The results of that study led to the development of noise criteria for residential occupancies in proximity to airports.

Neither the SA EPA guidelines nor the New Zealand Standard for wind farms identifies any socio-acoustic studies to support the base criteria set out in those documents. Furthermore whilst the nominated criteria may be suitable for suburban environments communities in proximity to wind farms do not accept such levels for rural environments.

Residents around the Waterloo Wind Farm have been the subject of two community surveys.

The first survey was conducted by an Adelaide University student in 2011 and the second by a community member Mary Morris.

Frank Wang's original survey showed that of the study participants, who all lived within 5 km of the Waterloo Wind Farm, 50% of them were moderately to severely impacted by the noise.

The Mary Morris conference sent out 230 surveys to every household within 10 km of the turbines and received a 40% response rate. 49% of the respondents were negatively affected by some or all of: noise, shallow flicker, sleep deprivation, interference. Another 17 respondents indicated they noticed the above affects and/or that the effects varied, but they were not affected. The remaining respondents said they were not affected.

The extent of the population living within 10km of the Waterloo Wind Farm that is affected by the operation of the wind farm indicates a significantly higher proportion of the population than the nominal concept in socio-acoustic surveys of setting benchmark criteria for 10% of the persons seriously affected.

The results of the two surveys seriously question the appropriateness of the SA EPA Guideline base noise limit to avoid adverse noise effects on people caused by the operation of wind farms.

If one utilised either of the two studies then under a socio-acoustic basis the separation distance from wind farms of the size of the Waterloo wind farm must be greater than 5 km. On a dB(A) basis the noise limit that would relate to such a separation distance is below 25 dB(A) and, is significantly lower than either the SA EPA guideline or the New Zealand Standard.

If one cannot, at the present time, nominate a separation distance then the appropriate mechanism to protect the community is to require, under the current methodology a noise limit of 25 dB(A) or background +5 dB(A) **whichever is the lower**.

Clearly a secondary criterion that addresses the low frequency and infrasound impacts needs to be identified and the appropriate place for consideration of those impacts is inside dwellings. The provision of an internal noise criterion presents difficulty in light of the different types of construction that is encountered in rural environments. The use of a linear value, a dB(C) value or dB(G) value, and whether such values are full range or limited in the frequency domain, is a matter that is subject to further investigation and should be incorporated in part of the scientific studies discussed in the previous section.

Conclusion

There are communities around Australia that are impacted by wind farms.

In some instances there are residents who leave their dwellings, and when they are relocated to dwellings removed from the wind farms they identify they are no longer adversely impacted and their sleeping patterns return to normal.

The provision of wind farms in rural Australia has generated significant conflict in the communities and it is often stated to me by residents that the wind farms are destroying communities.

Therefore at the present point in time the separation distances that exist from wind farms, that are generally based upon a dB(A) noise level are clearly inadequate.

Accordingly the answer to the question of wind farms being too close to communities is in the affirmative.

The responsibility of the environmental and health authorities in Australia must be to protect the community from adverse health effects. The most common complaint from the community concerning wind farms is related to sleep disturbance. With continual sleep disturbance then other health effects come into play.

At the present point in time wind farm operators rely upon criteria nominated by the regulatory authorities with the fall back position that if their wind farm complies with the nominated criteria then it is no longer their issue.

So as to guarantee that there are no adverse impacts from wind farms then the separation distances must be increased.

In the absence of any scientific studies to identify the appropriate separation distance then an applicant/wind farm operator should be required **to guarantee that there will be no adverse noise effects, no offensive noise, no sleep disturbance and no adverse health effects if the subject wind farm was to proceed.**

Similarly there is an issue for the determining authority to provide a similar guarantee, particularly if the authority was to approve the application based on unsubstantiated acoustic criteria which has no technical basis of guaranteeing there will be no impacts.

As there is no material provided by an operating wind farm to prove that the operations do not generate adverse noise effects, do not generate offensive noise, do not generate sleep disturbance and have no adverse health effects, then it would appear that if the authority was to grant approval and the wind farm complied with the noise limits nominated by the Authority for the environmental assessment, and health impacts were found to occur then the Authority (not the applicant) would be liable.

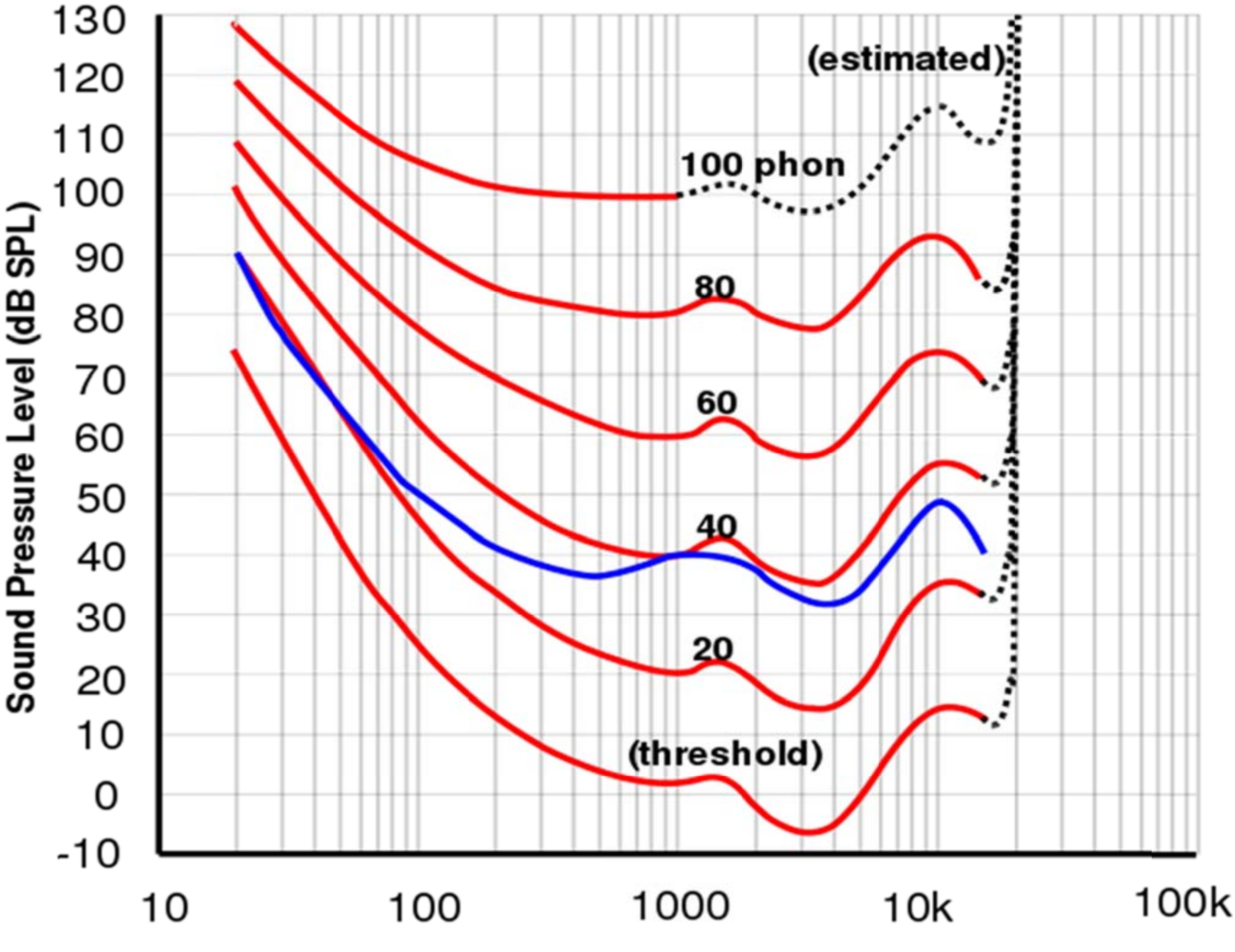


FIGURE 1 Equal-loudness contours (red) (from ISO 226: 2003 revision) and Original ISO Standard (blue) for 40 phons

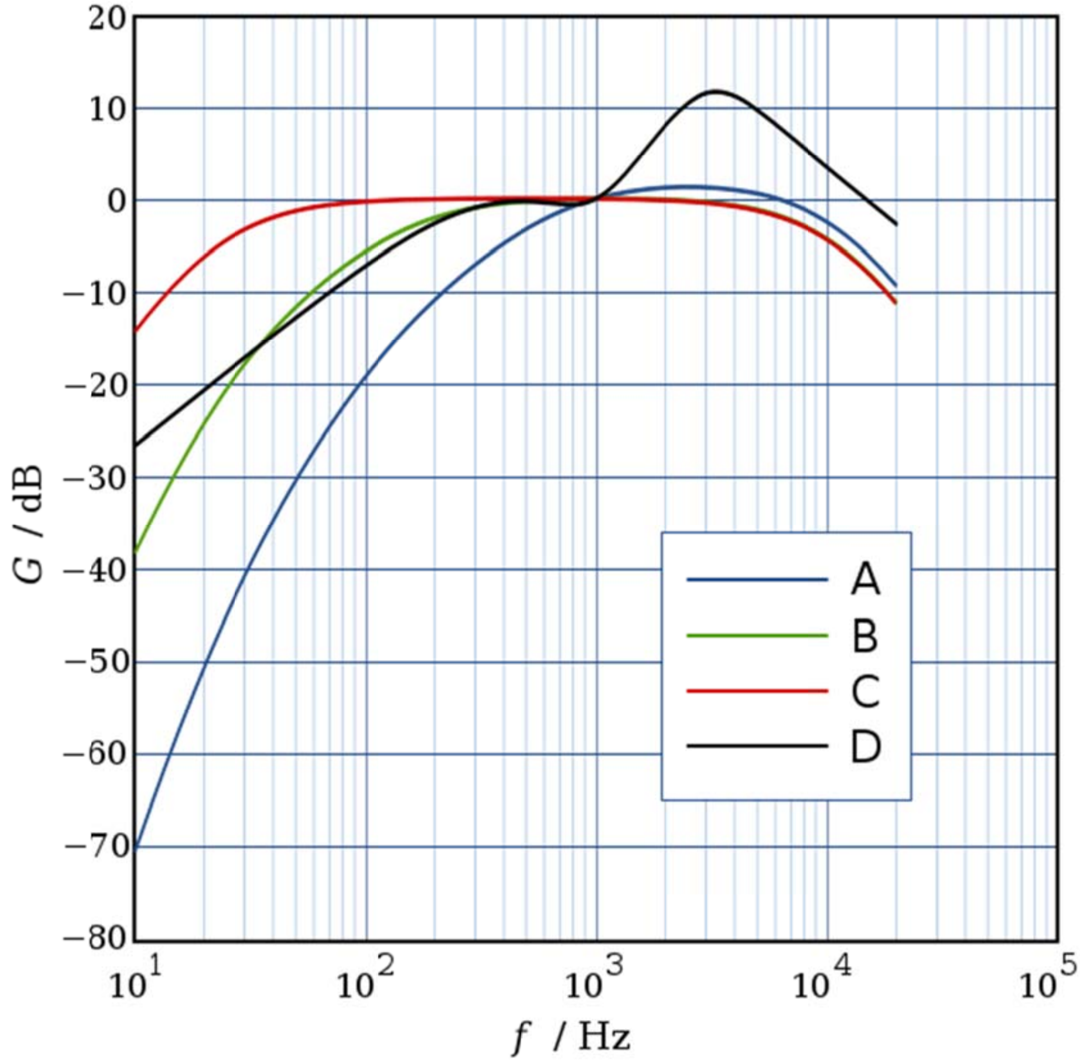


FIGURE 2   Normal Frequency Weighting curves

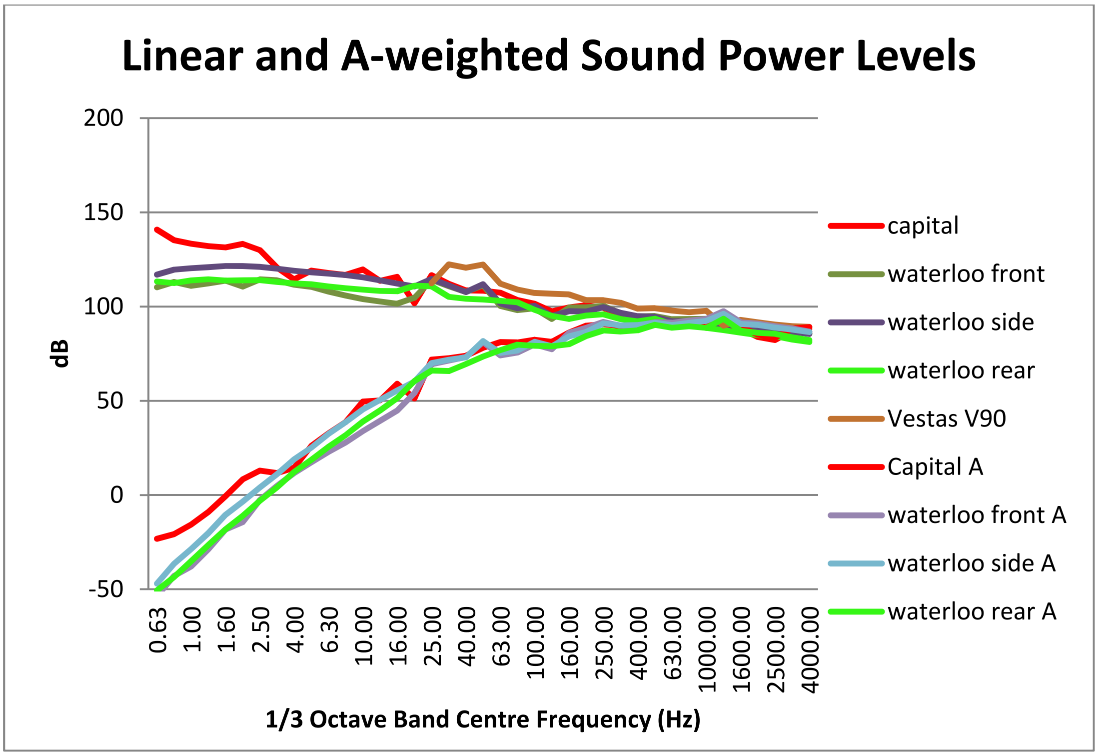


FIGURE 3 Turbine Sound Power Levels (Linear versus A-weighted)

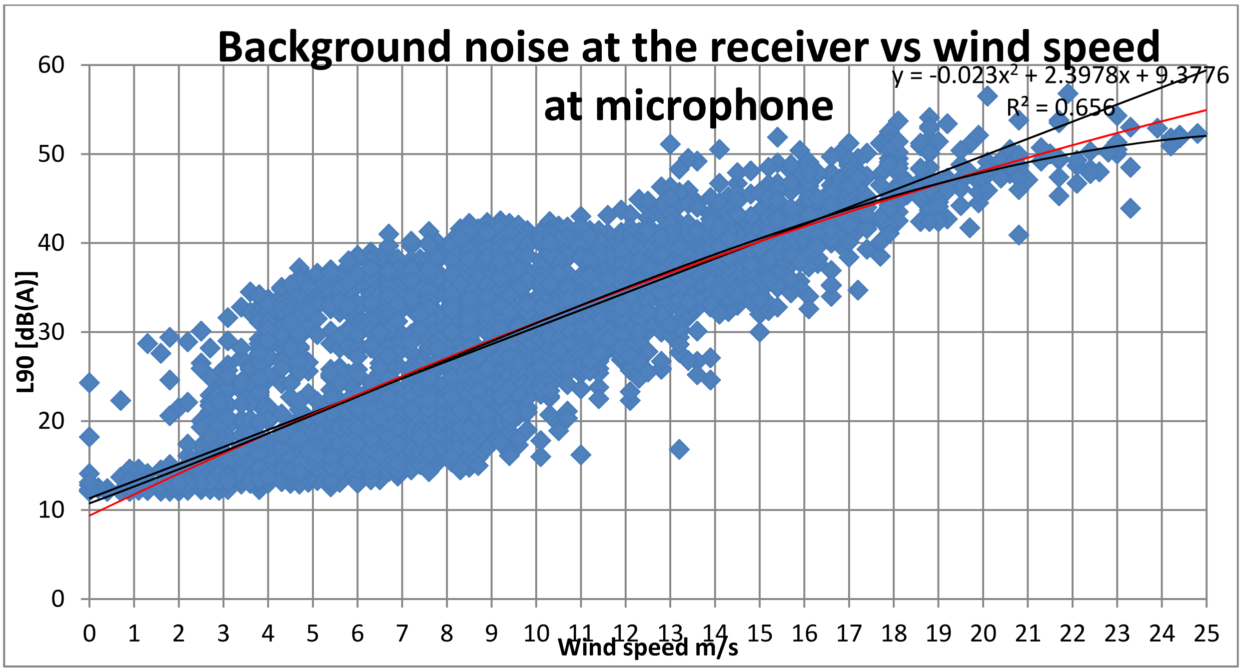


FIGURE 4 Exposed Hillside (furrowed ground) – No Turbines, No Trees within 500 metres

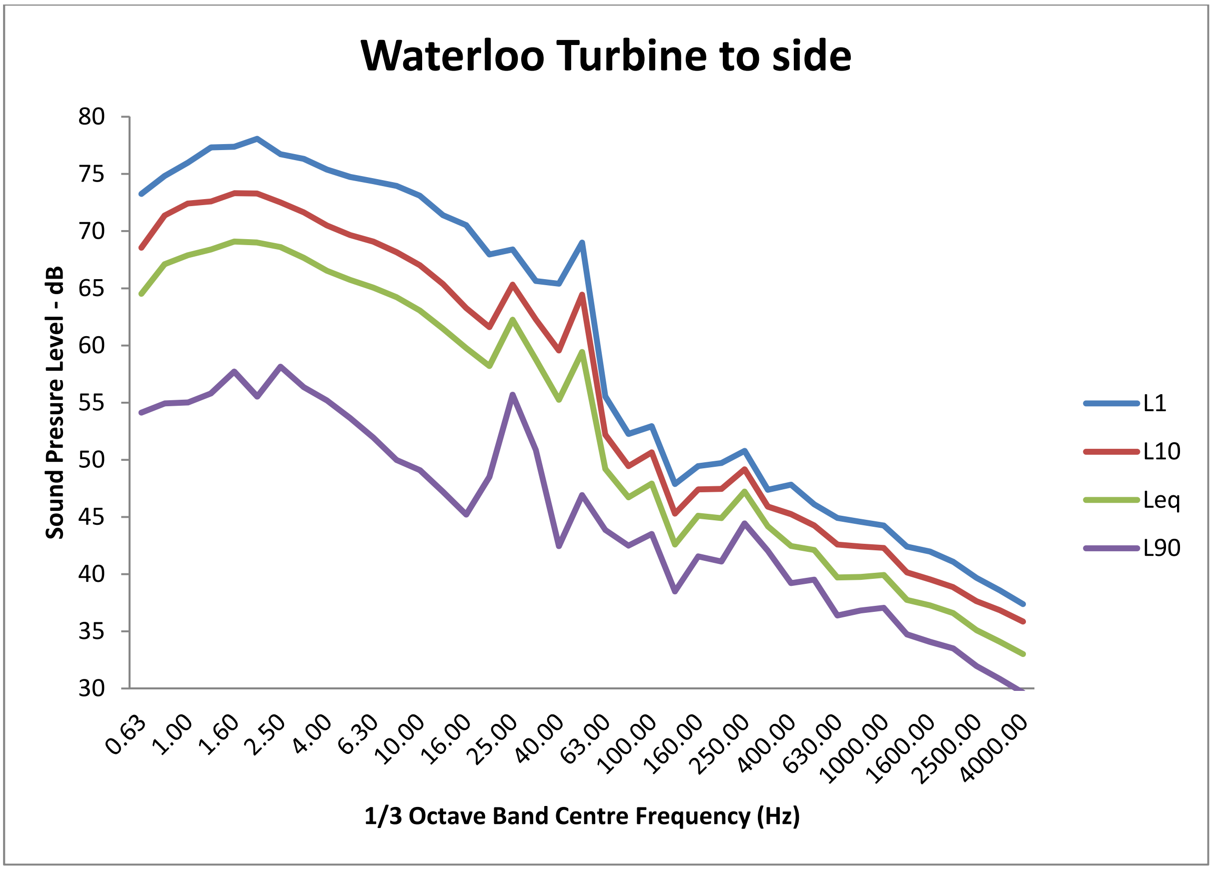


FIGURE 5 At 150 metres from tower

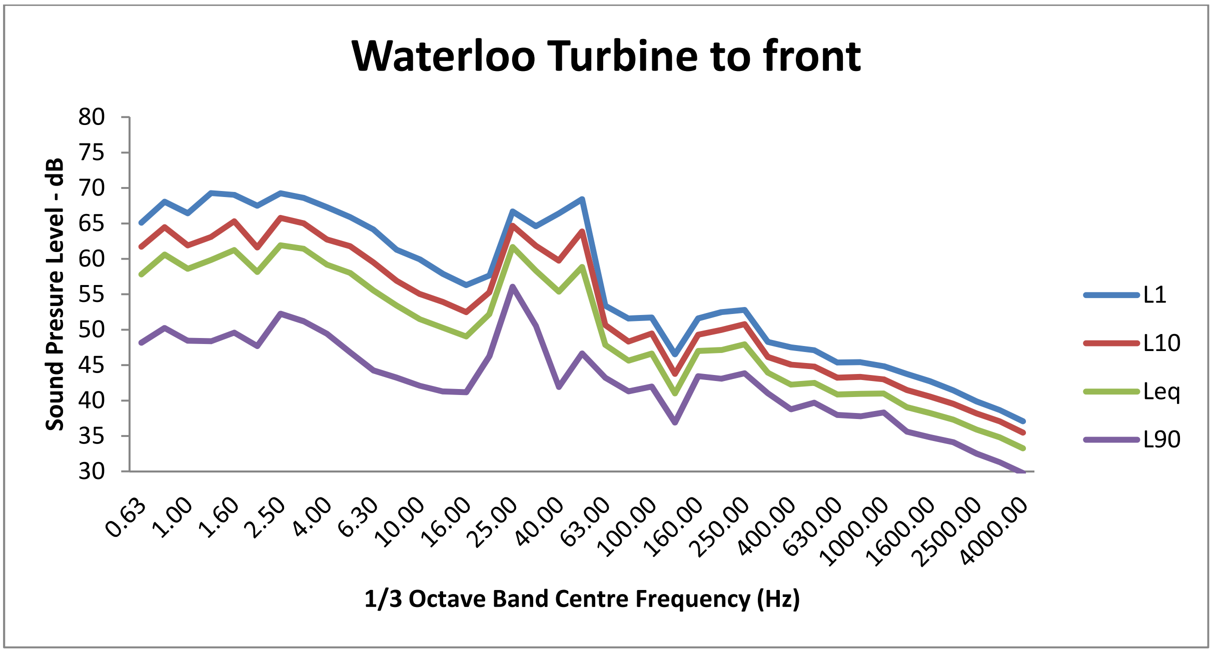


FIGURE 6 At 150 metres from tower

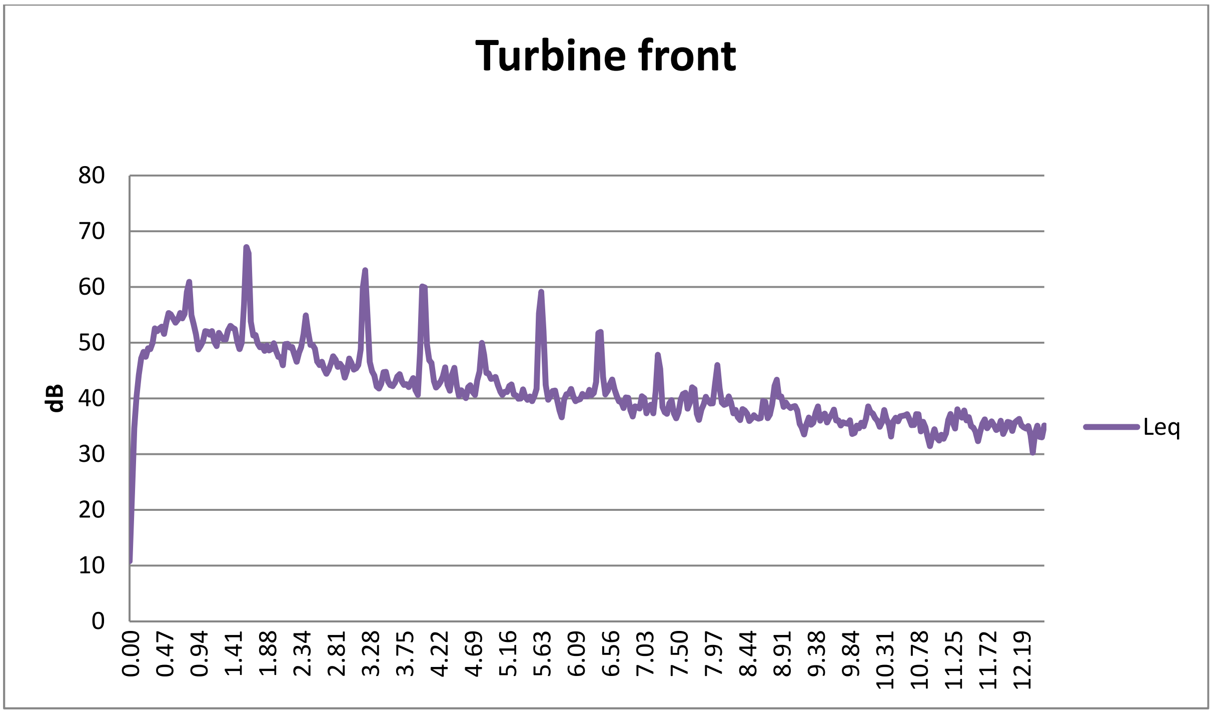


FIGURE 7: 0 – 12.5 Hz at 150 metres from tower

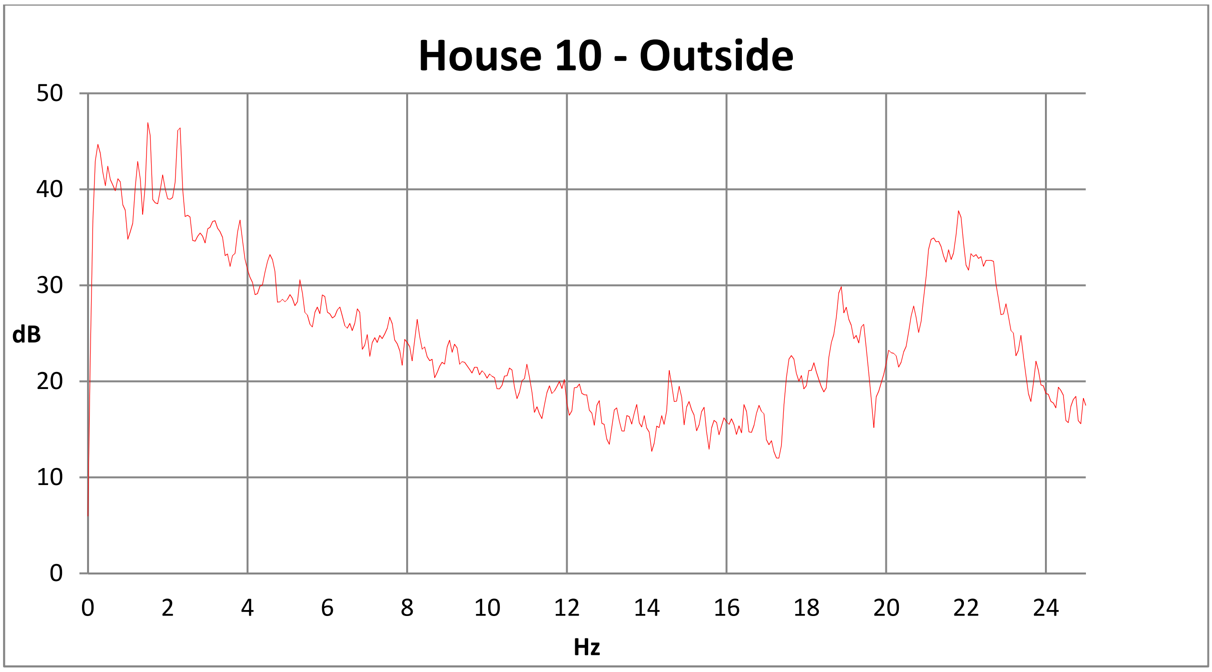


FIGURE 8 External Measurements approximately 1300 metres from nearest turbine

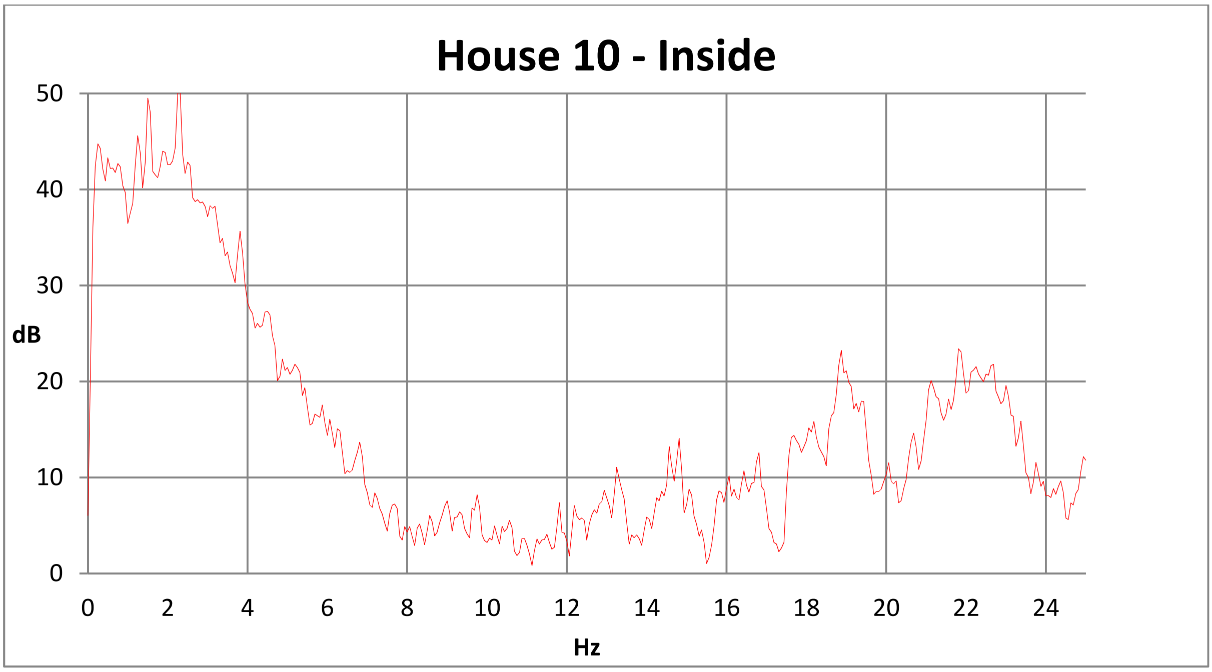


FIGURE 9 Internal Measurements approximately 1300 metres from nearest turbine

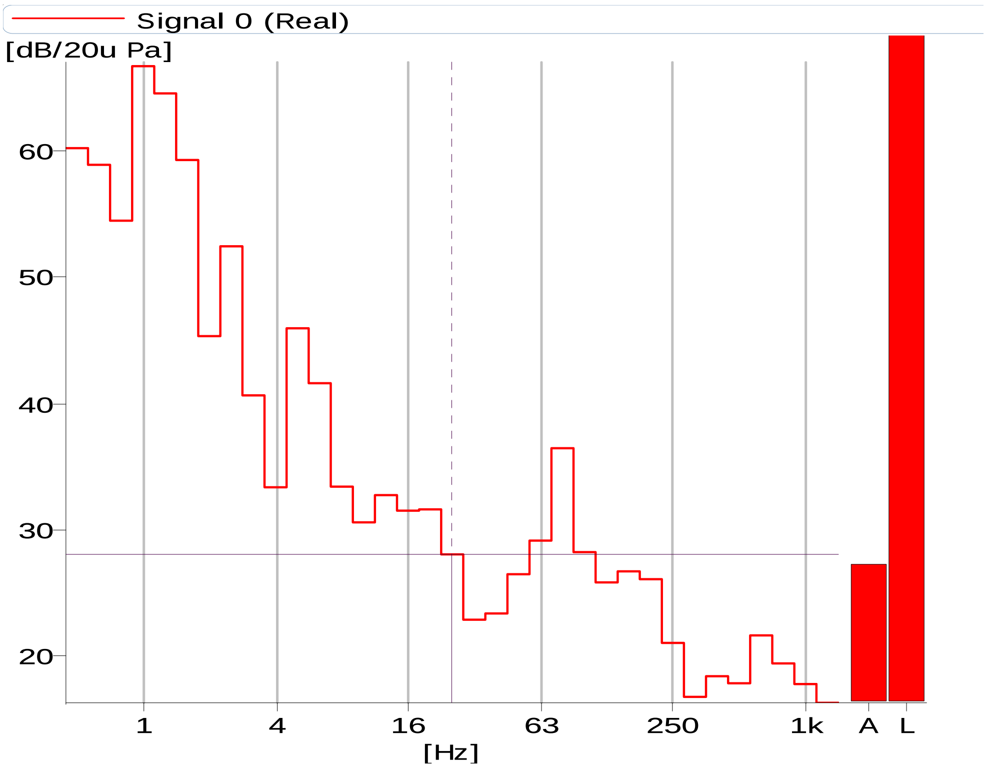


FIGURE 10 External Measurements approximately 8000 metres from nearest turbine

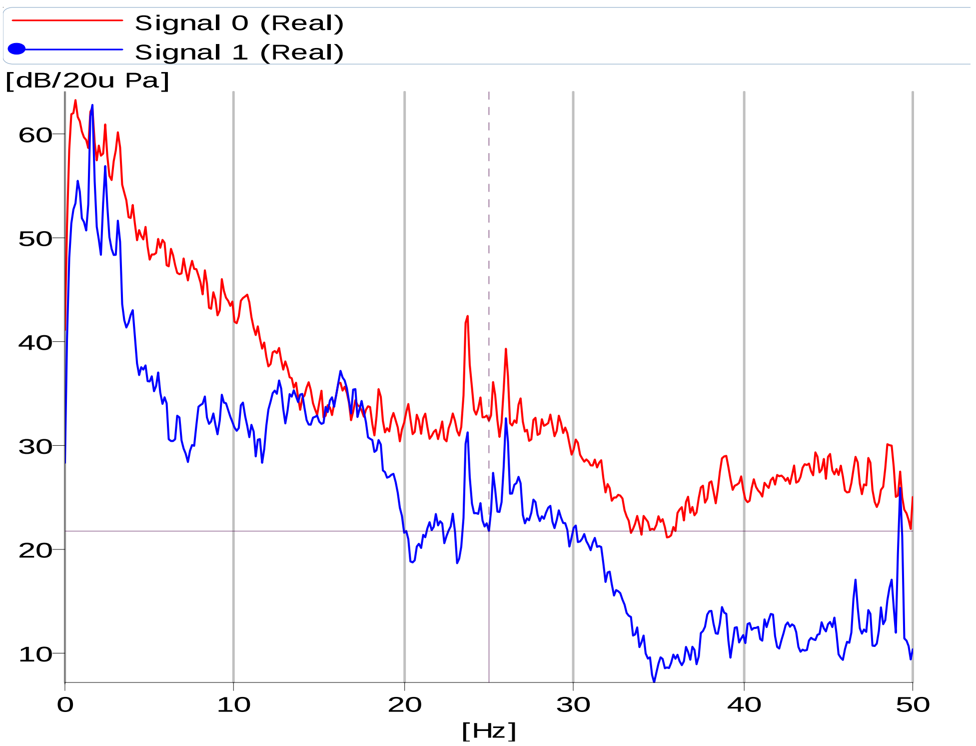
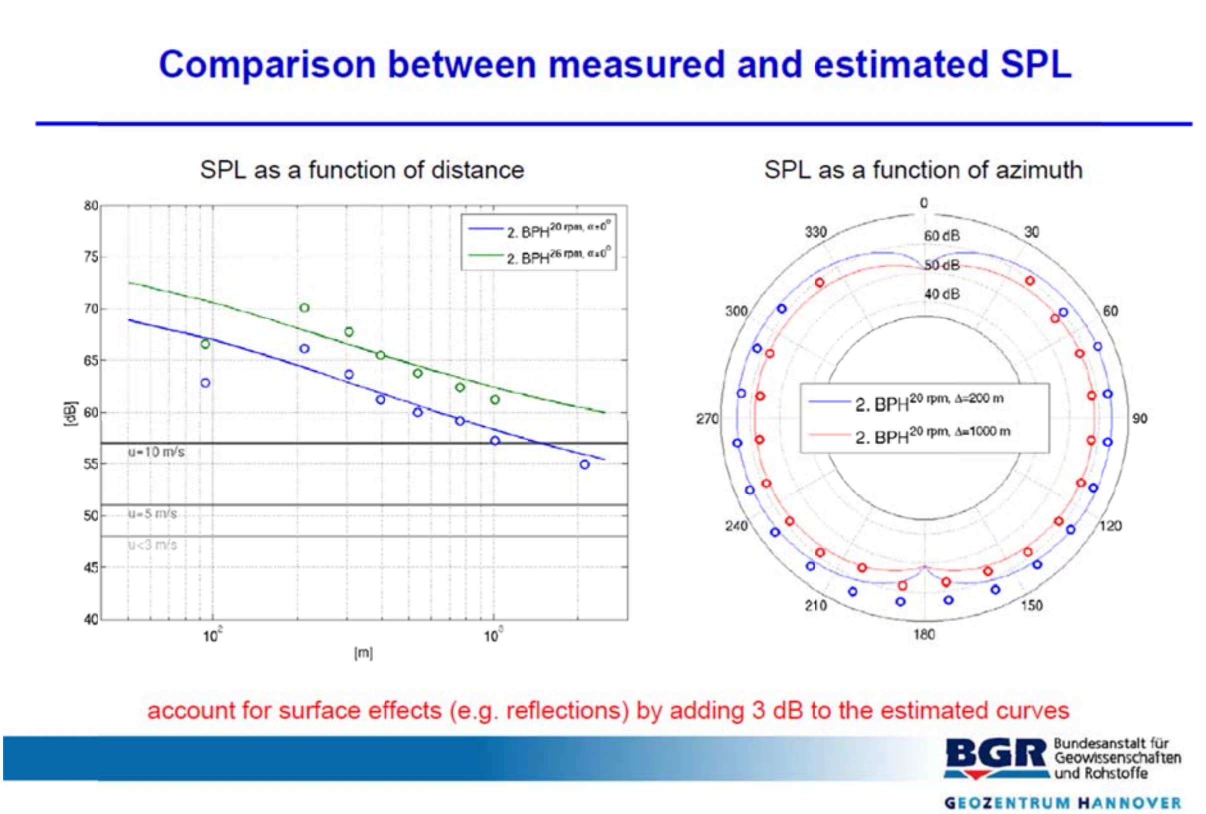


FIGURE 11 External and Internal Measurements approximately 8000 metres from nearest turbine



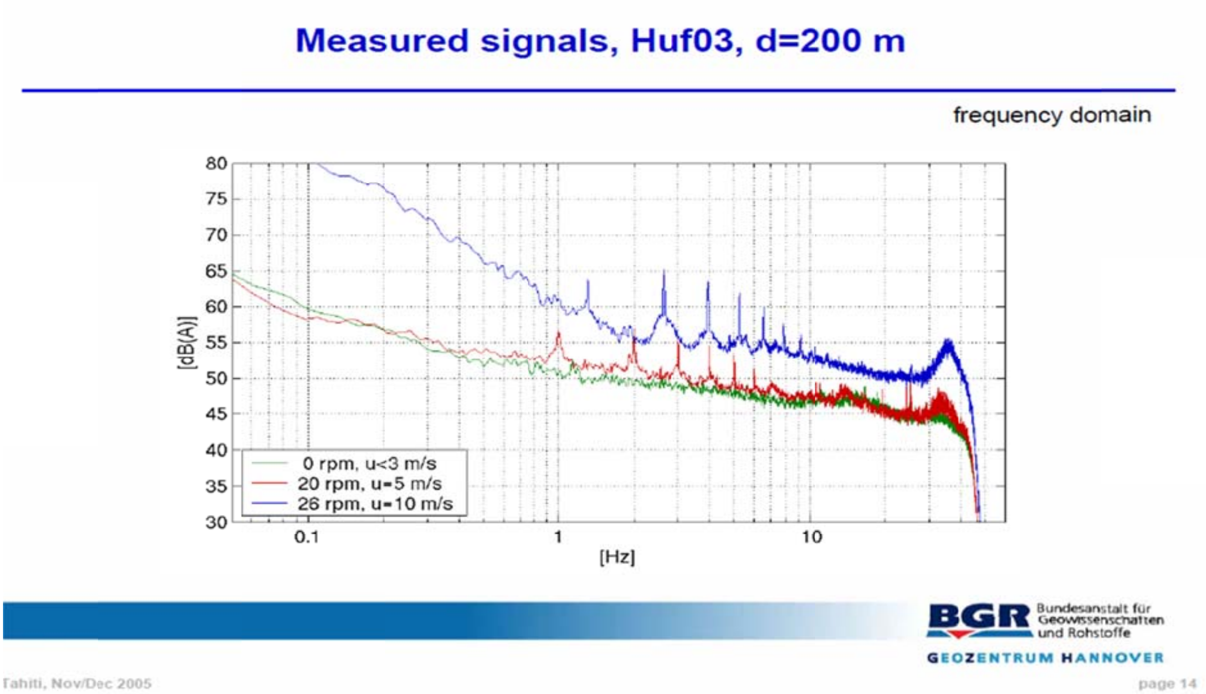
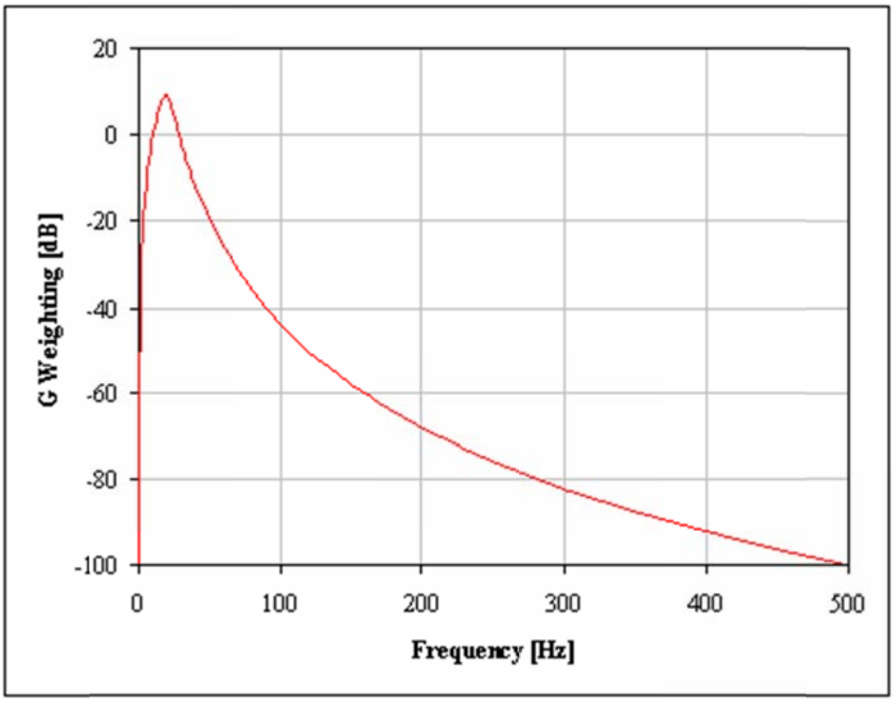


FIGURE 12 The inaudible noise of wind turbines, Ceranna, Hartmann and Henger, Federal Institute for Geosciences and Natural Resources (Hannover, Germany) Infrasound Workshop Nov 28 , 2005 Tahiti

G weighting purportedly reflects human response to infrasound. The curve is defined to have a gain of zero dB at 10Hz. Between 1Hz & 20Hz the slope is approximately 12dB per octave. The cut-off below 1Hz has a slope of 24dB per octave, and above 20Hz the slope is -24 dB per octave.



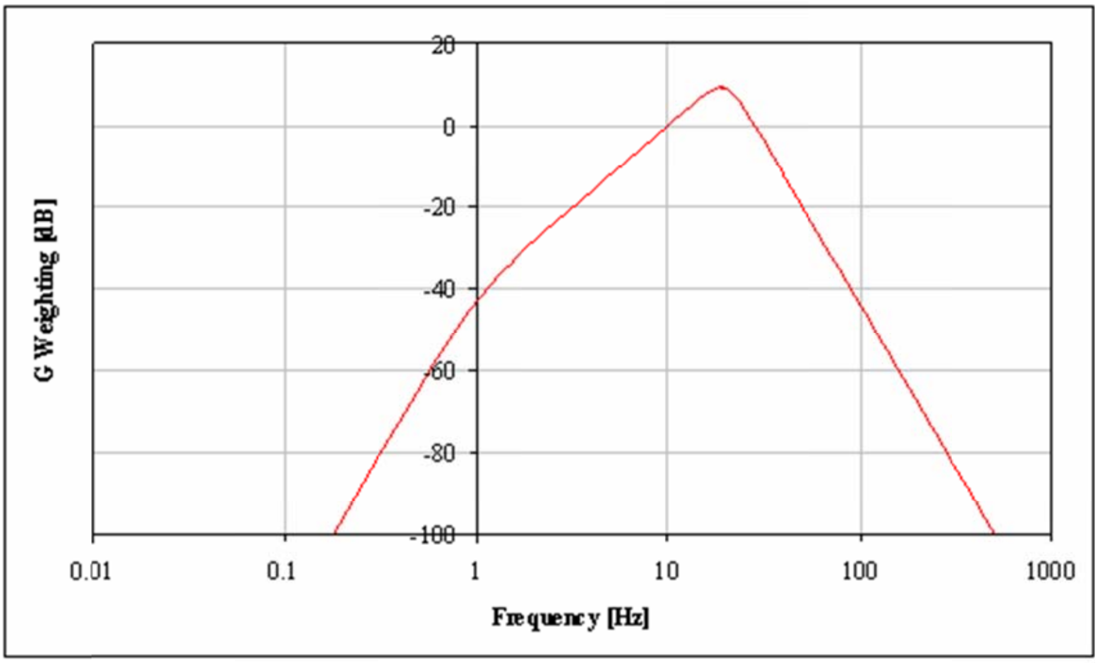


FIGURE 13 G-Weighted Overall Level

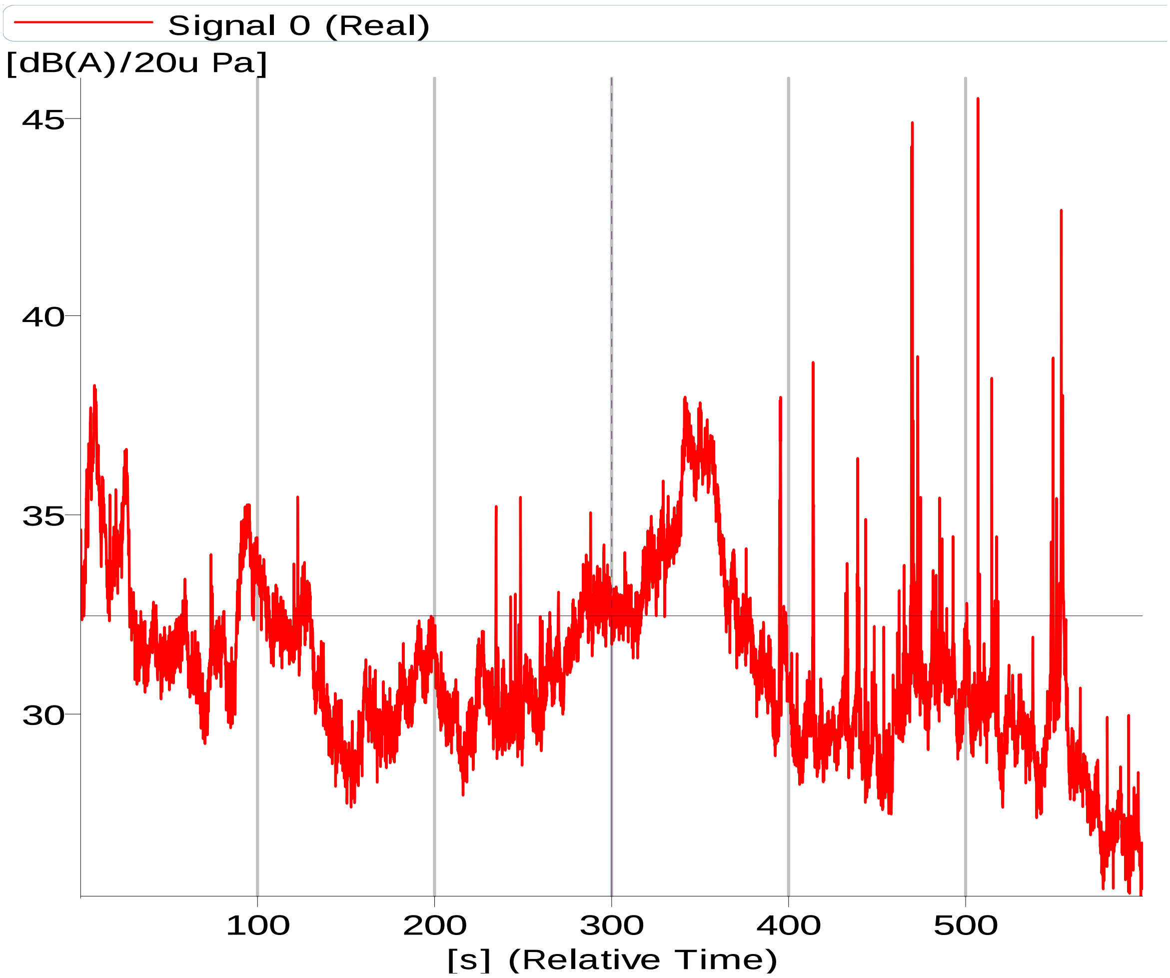
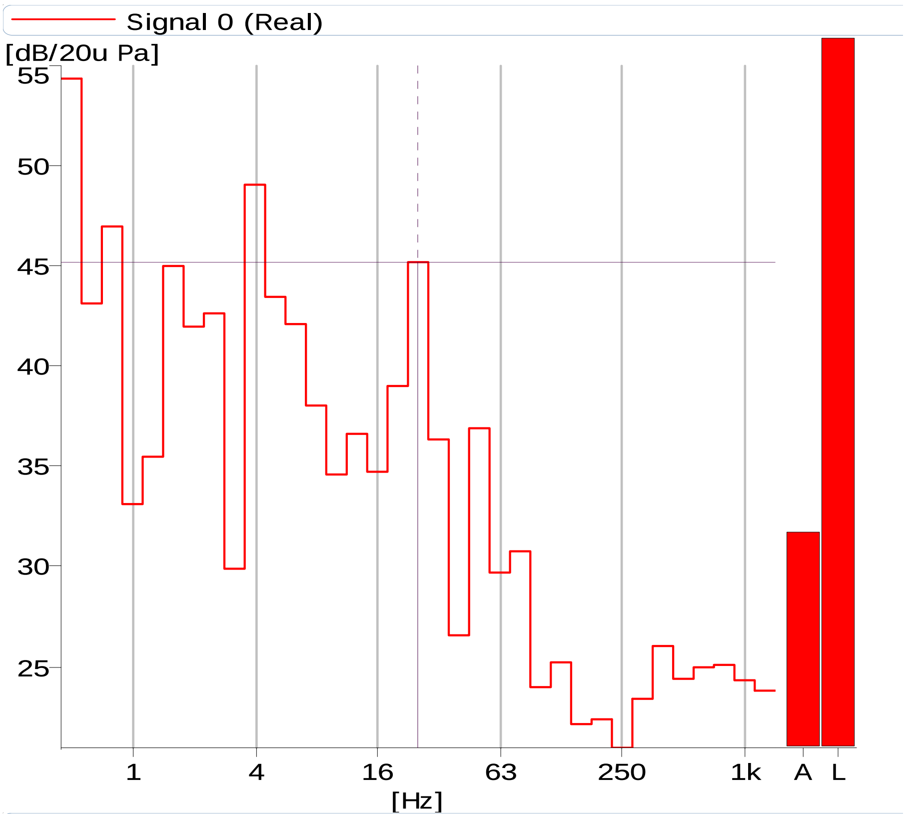


FIGURE 14: Ambient Noise Level for varying wind (up to 7m/s gusts) + birds



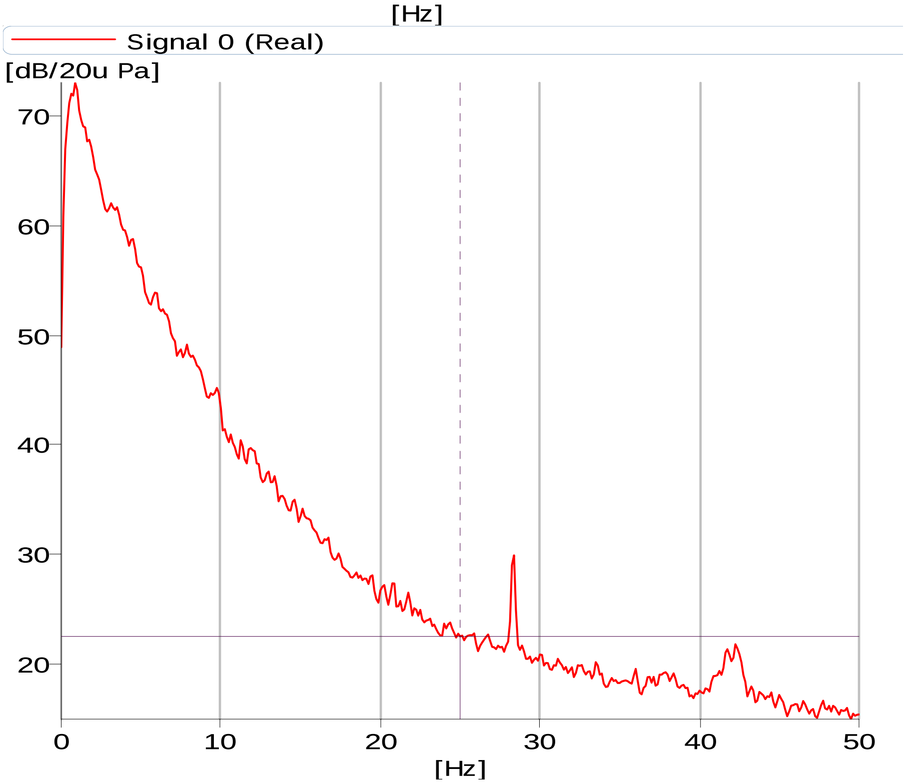


FIGURE 15 : 1/3 Octave and Low frequency FFT for 10 minute sample in Figure 14