Presentation to Turitea Wind Farm Board of Inquiry
Philip Dickinson 2010 March 23

It was known to the Board of Inquiry that I did not agree with the revised New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise and I was asked to explain my reasons. It was intended that I talk to a Power Point presentation, but unfortunately the computer at the hearing would not handshake with the data projector and the presentation suffered as a result. This brief is to clarify some of the matters raised and to provide a précis of my concerns about the revised Standard and its application to wind farm noise in New Zealand.

I have been a member of almost all New Zealand acoustical standards committees since 1980, and convener of four. I have, and still am, a member of several international acoustical standards working groups, and was convener of two ISO standards. New Zealand Standard 6808:2010 is the only Standard in which I have been involved that did not reach a consensus and is the only Standard in which I have felt the need to send an objection to the Standards Council. I believe the Standard was *fait accompli* before even the committee met. It differs very little from that used in the United Kingdom. No attempt was made to obtain a compromise between the opposing views as would be a prime consideration for any standards committee.

The Board I understand has a copy of the paper "Nonsense on Stilts" which deals with these concerns in detail. The paper was peer reviewed by Dr Geoffrey Leventhall a strong proponent for wind farms and a member of the team that produced the American criticism of Dr Nina Pierpoint's work on "Wind Turbine Syndrome". The draft of the paper was rewritten to include and satisfy all of Dr Leventhall's concerns. The paper was also peer reviewed by six of the world's leading acoustics experts and changed where necessary to include all of their comments as well. Thus the paper should stand up to the most severe scrutiny. My presentation was to be a summary of the paper with the diagrams and graphs explained. The following is a brief summary of my concerns.

The methodology used in the Standard assumes (incorrectly) that:

1 The background sound level at any residence is directly proportional to the wind speed at the hub of the nearest wind turbine.

2 The 90 centile level (L_{A90}) is the most suitable measure to use as wind turbine sound is continuous and will be captured whereas transient events such as passing road traffic, aircraft etc., the sounds from which would last only a small percentage of the time, will be ignored.

3 Any sound outside will be attenuated by 15 dB through an open window

4 The greater of the background sound + 5 dB, or 40 dB will be a good design level and will meet the World Health Organization recommendations of 30 dB in a bedroom to avoid sleep disturbance.

5 Wind turbine sound can be considered as from a point source (at the hub of the wind turbine) and ISO 9613 is a good prediction methodology. Only properties inside the predicted 35 dB contour need be considered.

6 Wind turbines emit little or no low frequency sound, so an L_{A90} of 40 dB is quite sufficient to protect from low frequency sound.

There are problems with each of these assumptions:

1 The relationship between wind speed at hub position and background sound at a residence in the locality is found by taking a series of 10 minute recordings of the background sound at representative positions and aligning them with the wind speed at a position representing the hub of the nearest turbine. More than 1400 recordings are required and a regression line produced from the data gathered to give the relationship. The data is gathered without any observer present – the time factor alone would prohibit this – and there is thus no guarantee what is being measured.

I will be referring to some of the figures and tables in my paper "Nonsense on Stilts". These are shown on page 6 of this summary of the presentation. Figure 1 gives a graph of typical data pairs of wind speed at hub height and background level measured at a local residence, and shows a wide spread of data – often 20 dB but in one place 46 dB. Even though the data spread is so wide, it is considered acceptable to take a medium value as the relationship. Mathematically this is suspect, as one is comparing an L90 (mathematically a 10 percentile level) with a linear parameter from which a 50 percentile level is deduced. In other use of such data, it is usual to take one or two standard deviations down from the average as a more reasonable relationship.

Figure 2 in the paper shows the data that can, and does, result from the use of instrumentation that does not have a sufficiently low noise floor (the internal noise of the instrument) to accurately measure the lower levels of sound. In this case, anything less than 28 dB is recorded as 31 or 32 dB. I have personally seen instrumentation with this limitation being used to measure wind farm sound. The background sound is being artificially raised to allow the wind turbines to make more noise. The Standard does not specify the instrumentation to be used, other than to say in clause 7.2.3 that "…in some cases a sound level meter with a low noise floor (such as a class 1 meter) may be necessary…." This suggests any class 1 sound level meter is satisfactory, but although most modern class 1 meters have a noise floor below 25 dB, few are below 20 and quite a number in common use may have a noise floor as high as 30 dB (as suggested in Figure 2). This artificially raises the value for the background sound even further. In some country areas of New Zealand the background sound level can be well below 20 dB.

The wind farm noise Standard also ignores one of the basic tenets of sound measurement practice. Airflow across the microphone grid will cause noise. A windshield on the microphone will lower the effect, but even with this in place, if one wishes to measure sounds below 50 dB the wind speed at the microphone must be less than 5 m/s(18 kph). At this wind speed one would get 35 dB even with a windshield in place. Figure 3 comes from Brüel and Kjær, one of the leading manufacturers of sound level meters. The value for the background sound is being artificially raised even more. The background sound level on which the wind farm operations are to be based will **always** be overstated by the methodology used.

2 The Standard uses the L_{A90} measure as the most suitable for wind turbine noise. This I suggest is an artifact simply to make it seem that unaccompanied measurement will adequately capture the background sound and the wind turbine sound with all other sounds being automatically rejected. Only if measurements have an observer present can one state categorically that the sound is from a particular activity. The methodology I believe is designed to make the wind farm operations as safe as possible from human intervention.

3 The attenuation of sound through an open window to a person sleeping inside will

not approach 15 dB except in very special circumstances. Table 1 in the paper shows the attenuation measured as a spatial average in a room, with dimensions and construction typical of a New Zealand bedroom. Only if the person is at a spatial average position and the window opening is less than 3% will the attenuation approach 15 dB. On hot summer nights when often wind farm sound is most noticeable, windows will be wide open for ventilation, or people may sleep on their decks when there will be no sound attenuation at all. What is outside is the likely level that will be heard inside

4 A design level of 40 dB or background plus 5 dB will not meet the World Health Organization recommendations for protecting sleep from disturbance by wind farm noise. The research on sleep (by Professor Barbara Griefahn MD of the University of Dortmund) that was used for the WHO., recommendation gave the sound level at 1 metre from the person sleeping or trying to sleep. It was not a spatial average of the room, and the recommendation, for continuous noise, is the level not to be exceeded. It is not an average over a long period of time. The wind farm sound should not exceed a time average level ($L_{Aeq,10min}$) of 30 dB at any time during the night. The only way to ensure this is to ensure the maximum level outside does not exceed 30 dB. By the way, if the background sound is determined as 40 dB or more, the wind farm is allowed to make more noise than is allowed in NZS 6803 for **short term** construction. This alone makes nonsense of the criteria used.

5 Computer prediction of sound is notoriously inaccurate. Computer programs are good for comparing one scenario with another, all other things being equal, but for absolute values at distances of more than a few hundred metres their accuracy leaves much to be desired. The problem is the changing state of the atmosphere. If we knew the exact temperature, humidity, wind velocity and pressure at every metre of the sound path, the computer could predict the sound, but these parameters are changing second by second and bear no relationship with each other, and so computer predictions may be wrong by an order of magnitude. It is for this reason that NZS 6805:1992 "Airport noise management and land use control" and its helicopter equivalent NZS 6807 base their controls on the noise actually measured, and prediction does not come into the equation.

Tables 4, 5 and 6 in the paper lay out the prediction of sound at 2.5 km from a wind farm according to the old wind farm standard, the revised standard and using a line source as would be used for road traffic noise. At that position, where 24 wind turbines were visible during the day, the average of more than a dozen 10 minute recordings ($L_{Aeq,10min}$) taken during the night time when there was little or no wind at the measuring position but the wind turbines were clearly dominant over all other sounds, came to 50 dB. That is 17 dB more than would be predicted by the revised Standard. Using a line source for the prediction would be nearer the truth, but may still under predict the sound.

The prediction methodology suggested in the Standard also assumes the noise from a wind turbine can be represented as from a point source at the hub of the turbine. I believe this is not true. The sounds are caused mainly from the air sliding down the blades and being thrown off when the boundary layer of air can no longer stick to the blade due to its momentum. The air is thrown off in vortices which travel downwind in the form of a rotating helix. The following picture from the world wide web shows the wake from wind turbines in the Netherlands where the vortices are condensing water vapour in the air.

These are the same vortices that carry the sound. The sound sources on a wind turbine may cover an area bigger than 3 football fields and they are not symmetrical. The prediction methodology used in the Standard is from ISO 9613-2, which suggests all the sources should have approximately the same strength and height above the local ground plane, and the same propagation conditions exist from the source to the receiver. Clearly the prediction method is not suitable. Indeed it does state in ISO 9613-2 that it should not be used for aircraft sound and not used for distances greater than 1000 metres due to large uncertainties.

6 The revised Standard suggests C3.1.3 that there is little or no low frequency sound. Figure 5 in my paper shows a typical wind turbine noise spectrum recorded at about 800 metres from a turbine. Even at that distance, almost 95% of the sound energy is below 20 Hz (infrasonic) and almost 98% below 125 Hz (low frequency). These frequencies can, and do, excite room resonances in the typical New Zealand bedroom and produce severe annoyance and sleep disturbance. There should be a low frequency control limit set to protect sleep from this disturbance

7 Of particular concern: The measurement process laid out in the Standard is so convoluted , instrument dependent and time consuming as to be outside the abilities and resources of the local authorities who under the Resource Management Act have the responsibility for the control of the emission of noise and the mitigation of the effects of noise.

8 The standard also makes no allowance for room resonances that are known to occur from the lower frequency sounds and vibration emitted by wind farms, and which cause severe sleep disturbance – and there is ample good peer reviewed evidence supporting this nationally and world-wide.

9 Several statements in the draft standard are false. One example is the above mentioned claim of ISO 9613-2 being shown to correlate well with measured data from wind farms. No such data correlation has been found at distances greater than a few hundred metres - indeed quite the contrary.

10 Basing the control on an assumed background sound level plus 5 dB or 40 dB, whichever is greater, clearly will contravene the World Health Organization recommendation of no more than 30 dB at the recipient and doesn't make scientific sense in any case. As mentioned above: If the background sound level is over 40 dB, the wind farms are allowed to make more noise than is permitted under NZS 6803 for short term construction – which gives a maximum of 45 dB at night.

In conclusion:
We have a revised standard, albeit one that is very similar to other such standards across the world, that purports to be for the protection of public health, yet it would appear that not only does it utilize noise criteria that may contravene the World Health Organization recommendation, but it also employs a methodology that may overstate by several decibels the existing background sound levels on which it wants to base its operations. Added to this, it under-predicts the sound the local residents will receive from the wind turbines, perhaps by an order of magnitude, and is so convoluted, instrument dependent, and time consuming as to be outside the capabilities and resources of the local territorial authorities who have the responsibility for managing the noise immission from such industrial operations. From this one consideration alone, the standard is unacceptable.

In New Zealand and many other parts of the world where population density is low, there is no need for any wind turbine noise intrusion on local communities. Clearly wind farms are an answer to the energy crisis, and may work well, but there is plenty of uninhabited space across the country where the wind may still provide the energy required - wind farms do not need to be close to people, and then there is no need for such a controversial standard based on background sound level plus 5 dB. A fixed maximum design level well under 40 dB is essential if public health is a consideration.

I believe the following condition should be the requirement for all wind farms in New Zealand;

The noise emission from any wind farm shall not exceed a ten minute time average level ($L_{Aeq,10min}$) of more than 30 dB at any residence, nor shall it exceed a ten minute time average level ($L_{Aeq,10min}$) of 20 dB total in the octave bands below 125 Hz, unless the owner or occupier of the residence agrees in writing.

I would have supported the revised Standard NZS 6808:2010, even though not ideal, if there had been consensus for a fixed limit ($L_{Aeq,10min}$ or $L_{A90,10min}$) by measurement of no more than 35 dB.

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Figures and Tables from published paper "Nonsense on Stilts."

Figure 1

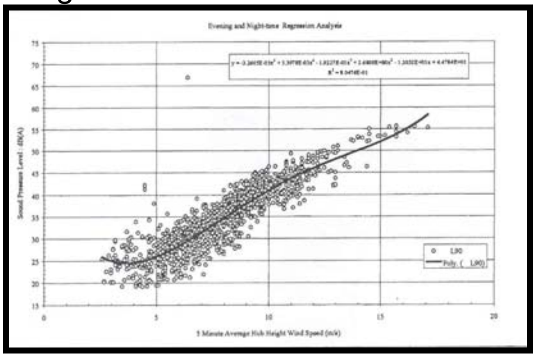

Table 1

Wall: 4 m x 2.7 m weatherboard, on 100 x 50 studs, 10 mm plasterboard, 75 mm batts in cavity

Octave band Centre Hz	Percentage of wall opening											
	3	5	7.5	10	20	30	40	50	60	70	80	90
	Attenuation in dB											
31.5	12	11	10	9	6	5	4	3	2	1	1	0
63	11	10	9	8	6	5	4	3	2	1	1	0
125	12	11	10	9	6	5	4	3	2	1	1	0
250	15	13	11	10	7	5	4	3	2	2	1	0
500	15	13	11	10	7	5	4	3	2	2	1	0
1000	15	13	13	10	7	5	4	3	2	2	1	0
2000	15	13	11	10	7	5	4	3	2	2	1	0
4000	15	13	11	10	7	5	4	3	2	2	1	0
8000	15	13	11	10	7	5	4	3	2	2	1	0

Figure 2

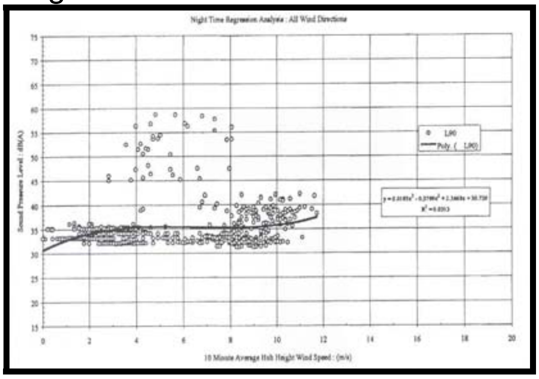

Table 4

Using method in NZS 6808:1998 and 24 wind turbines - the number visible in daylight

Octave band frequency	31.5	63	125	250	500	1000	2000	4000
Sound Power Level dB	119.8	116	109.2	105.5	102	100.7	95.4	90.8
At 2500 m distance, 15 degree C, 50% relative humidity, ground cover short grass								
Hemispherical spread	-76	-76	-76	-76	-76	-76	-76	-76
Air absorption	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5
Resulting band level	31.3	27.5	20.7	17	13.5	12.2	6.9	2.3
A-frequency weighting	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1
A-frequency weighted Level	-8.1	1.3	4.6	8.4	10.3	12.2	8.1	3.3
Level from 24 turbines	3.9	13.3	16.6	20.4	22.3	24.2	20.1	15.3
L_{Aeq} in dB	**29 dB**	i.e., prediction by NZS 6808:1998 is 21 dB below measured level						

Figure 3

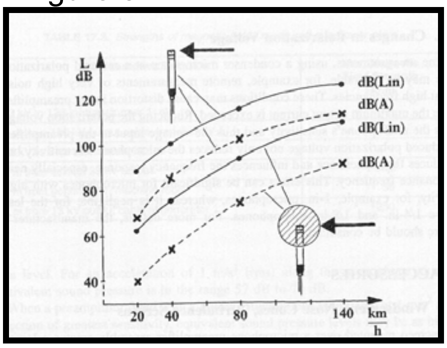

Table 5

Using method in draft DZ 6808:2009 and 24 turbines

Octave band frequency	31.5	63	125	250	500	1000	2000	4000
Sound Power Level dB	119.8	116	109.2	105.5	102	100.7	95.4	90.8
At 2500 m distance, 15 degree C, 50% relative humidity, ground cover short grass								
Spherical spread + Dcr (= 3)	-76	-76	-76	-76	-76	-76	-76	-76
Air absorption viscous effects	0	0	0	0	0	-0.3	-1.3	-4.8
Oxygen and nitrogen relaxation	-0.3	-0.3	-1.3	-3	-5.5	-10.3	-25.8	-86
Ground absorption	-0.2	-0.7	-1.3	-3.7	-3.8	-4.3	-4.5	-7
Resulting band level	43.3	39	30.6	22.8	16.7	9.8	-12.2	-83
A-frequency weighting	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1
A-frequency weighted Level	3.9	12.8	14.5	14.2	13.5	9.8	-11	-82
Level from 24 turbines	15.9	24.8	26.5	26.2	25.5	21.8	1	-70
L_{Aeq} in dB	**32 dB**	i.e., prediction by draft standard is 18 dB below measured level						

It should be understood: The wind speed at the hub was not available and had to be estimated at 10 m/s.
so the base sound power levels may have been slightly lower, making the prediction even lower

Figure 5

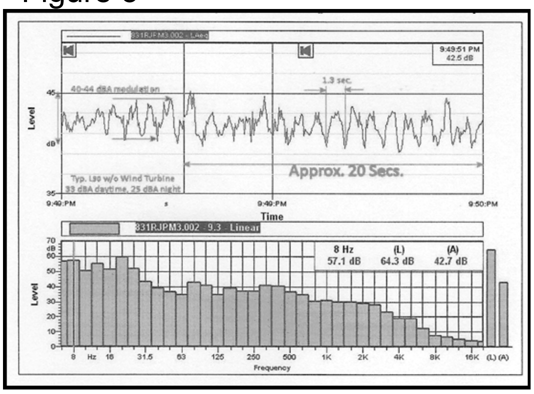

Table 6

As I believe it should be predicted:
Using a line source with no directivity correction, corrected for spacing (400m), 24 turbines

Octave band frequency	31.5	63	125	250	500	1000	2000	4000
Sound Power Level dB	119.8	116	109.2	105.5	102	100.7	95.4	90.8
At 2500 m distance, 15 degree C, 50% relative humidity, ground cover short grass								
90m blade 310m space betweer	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
Line source	-42	-42	-42	-42	-42	-42	-42	-42
Air absorption viscous effects	0	0	0	0	0	-0.3	-1.3	-4.8
Oxygen and nitrogen relaxation	-0.3	-0.3	-1.3	-3	-5.5	-10.3	-25.8	-86
Ground absorption	-0.2	-0.7	-1.3	-3.7	-3.8	-4.3	-4.5	-7
Resulting band level	71.9	67.6	59.2	51.4	45.3	38.4	16.4	-54.4
A-frequency weighting	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1
A-frequency weighted Level	32.5	41.4	43.1	42.8	42.1	38.4	17.6	-53.4
L_{Aeq} in dB	**49**	i.e., prediction using line source is within measurement tolerance.						