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A new wind farm noise standard for New Zealand NZS 6808:2010

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ABSTRACT

New Zealand Standard NZS 6808 provides methods for the prediction, measurement, and assessment of sound from wind turbines. The 1998 version was written prior to significant wind farm development in New Zealand, and while the basic methodology proved robust, experience and research over the following decade brought to light numerous refinements and enhancements which are now addressed in the new 2010 version. This paper describes the revision process, and explores the technical issues addressed and key areas of debate. This was a challenging project, with wide ranging views both within the committee and from hundreds of public submissions.

INTRODUCTION

Currently there are eleven wind farms operating in New Zealand with a total capacity of just under 500 MW. These provide up to 5% of the country's electricity. There are active proposals for numerous further wind farms, which collectively will have many times this capacity.

Several recent wind farm developments and proposals have been highly contentious, with local objections attracting significant media coverage. Using the old version of NZS 6808 [1], the consent conditions associated with these projects ballooned, as regulators and residents sought tighter controls and increasingly more prescriptive measurement and assessment procedures. This led to substantial inefficiencies and inconsistencies. These matters are now dealt with in the revised version of NZS 6808 [2], which once again provides a standardised approach for managing wind farm sound in New Zealand.

The original 1998 version of NZS 6808 was based on the United Kingdom 1996 ETSU report [3]. There were minor adjustments made, which included replacing the L_{90} descriptor with the L_{95}, as that was used to describe background sound in New Zealand at the time. Also, rather than the different daytime and night-time ETSU noise limits, the fixed part of the noise limit was set at 40 dB at all times in NZS 6808. The 'background +5 dB' variable part of the noise limit from the ETSU report was retained in NZS 6808.

Since its publication, NZS 6808:1998 was used for all wind farms in New Zealand. In the absence of an Australian Standard prior to 2010, NZS 6808 was also adopted in the state of Victoria.

The main thrust of the 2010 revision of NZS 6808 related to technical refinements and incremental enhancements. However, probably the most controversial addition to the Standard is the provision for a more stringent 'high amenity noise limit' where justified by special local circumstances.

PROCESS

NZS 6808 was first published in 1998. In accordance with Standards New Zealand's procedures, it was formally reviewed in 2004. At that time various potential technical refinements were identified, but the Standard was still being successfully implemented. In practice, most acousticians were applying the key changes now included in the 2010 revision. The decision was made in 2004 not to revise NZS 6808 yet.

By 2007 the Standard was coming under increased pressure, with questions being raised over how it should be applied. This led the New Zealand Wind Energy Association and the Energy Efficiency and Conservation Authority to commission research into the technical issues in question [4]. The results of this research then triggered another formal review of NZS 6808 by Standards New Zealand.

The review started with a scoping workshop in late 2007, where all stakeholders agreed that a full revision of the Standard was appropriate. Standards New Zealand then constituted a technical committee in mid 2008 to conduct the revision. The majority of the committee's work was conducted in the second half of 2008. The author chaired this technical committee.

Standards New Zealand forms technical committees by inviting organisations that represent relevant stakeholders to nominate a technical expert. In this instance, the nominating organisations were:

- Energy Efficiency and Conservation Authority
- Executive of Community Boards
- Local Government New Zealand
- Massey University
- Ministry for the Environment
- Ministry of Health
- New Zealand Acoustical Society
- New Zealand Institute of Environmental Health Inc.

- New Zealand Wind Energy Association
- Resource Management Law Association
- University of Auckland

The only representative without particular technical expertise was the representative of the Executive of Community Boards. A resident adjacent to a large wind farm was nominated. That individual had good technical aptitude, and made a valuable contribution, providing critical review and questioning all assumptions.

Given the strong public interest in the revision, the evidence based approach used to make decisions needed to be documented to a greater degree than normal. The committee initially split into working groups addressing different issues such as noise limits, measurements and predictions. Each working group submitted recommendations back to the main committee, where they were vigorously debated and tested against the evidence. The process was focussed on achieving consensus, which requires general agreement, but not unanimity.

A draft of the proposed revision was circulated for public comment in early 2009. The draft elicited over 600 public submissions, which is unusual for a technical standard, and reflects the public criticism of sound from some wind farms in New Zealand. The committee made decisions on each individual submission and prepared a final draft in mid 2009.

The last action for a technical committee is a 'postal ballot'. In this instance, several unexpected issues emerged at the ballot through a number of negative votes. The draft was therefore amended over the following months until consensus was reached at the second postal ballot later in 2009.

There was still one negative vote at the second postal ballot, from the representative of Massey University. That individual has publicised his views [5], and acknowledges they are contrary to most international scientific opinion. The remainder of the committee could not reconcile the arguments he advanced against the Standard, with scientific evidence, or the framework for all other noise assessments in New Zealand.

Due to the negative vote and public sensitivity around this Standard, the Standards Council would not issue its final approval to publish the revision of NZS 6808 until it was demonstrated in detail that Standards New Zealand had followed correct procedures, and there were legitimate technical reasons not to accept the issues raised by the negative vote. This process and editorial matters resulted in publication of the new Standard on 1 March 2010, 'NZS 6808:2010'.

NOISE LIMITS

The committee found that the previous wind farm noise limit of 40 dB L_{A95} or background +5 dB is still appropriate, as it provides protection from adverse health effects and maintains reasonable residential amenity.

In terms of potential adverse health effects, the committee was guided primarily by the internal noise criteria of 30 dB L_{Aeq} given by the World Health Organisation [6]. New Zealand experience is that a limit of 40 dB L_{A90} outside a dwelling will result in compliance with this internal limit, with windows slightly ajar for ventilation. The background + 5 dB variable part of the noise limit was retained, as the potential effect of wind turbine sound reduces as the background sound increases, and a constant limit of 40 dB L_{A90} would be meaningless at higher wind speeds as there would be no reliable way of measuring compliance.

For general environmental noise, NZS 6802 [7] provides a guideline night-time noise limit at dwellings of 45 dB $L_{Aeq(15\ min)}$. The way the New Zealand planning framework operates is that this guidance can be modified as it is implemented in each local planning document ('district plan') throughout the country. However, most plans set night-time limits of 40 or 45 dB $L_{Aeq(15\ min)}$, or L_{A10} in older plans. Therefore, the wind farm noise limit is consistent with noise limits for, say, industrial or agricultural activities in rural areas.

The committee also made reference to wind farm noise limits in other countries, and found that while there is some variation, the noise limits in NZS 6808 are comparable with the majority of countries.

Several issues arose in public submissions regarding noise limits. Many of these submissions, such as requests for a buffer zone around wind farms of several kilometres, regardless of the wind farm scale or local conditions, were simply not compatible with the effects-based approach taken by the New Zealand planning system. The benefit of the method in NZS 6808 is that it accounts for the actual wind farm layout, turbine type, wind conditions, topography and background sound, thus providing an effects-based assessment.

It appears that some of the public submissions were seeking inaudibility as a de facto criterion for wind farms, but this is not a criterion applied to any other sound source in New Zealand. Another theme from submissions was a desire to allow for people either sleeping outdoors on their decks or sleeping with full height doors/windows left wide open. Night-time noise limits for all other sound sources in New Zealand are set on the basis of people inside with windows only partially open for ventilation. The committee did not find any reason for treating wind farms differently to other sound sources in rural areas.

Special audible characteristics

An area of significant improvement in the 2010 revision is the treatment of 'special audible characteristics'. These are distinguishing features of wind farm sound that attract a 5 dB penalty if present. In 1998 this was addressed in only a basic manner.

The first enhancement is NZS 6808 now states that, if it is known in advance that a special audible characteristic will be present at a dwelling, the wind farm should not proceed. The penalties are now only to cater for unexpected characteristics that arise during or after commissioning.

Since 1998 a sophisticated test method for tonality has been developed and is included in ISO 1996-2 [8]. NZS 6808 now simply refers to that Standard. There is an option for a subjective assessment or a simplified assessment, but an objective assessment using ISO 1996-2 will take precedence.

Another issue that has emerged internationally since 1998 is the possibility of 'aerodynamic modulation' [9] of wind farm sound. However, it has been observed at very few wind farms and none in New Zealand. An interim test method has now been provided in NZS 6808 should aerodynamic modulation be suspected. Aerodynamic modulation as a special audible characteristic will be deemed to exist if the measured A-weighted peak-to-trough levels exceed 5 dB on a regularly varying basis, or if the measured third-octave band peak-to-trough levels exceed 6 dB on a regular basis in respect of the blade pass frequency. It is acknowledged that a more refined test may be developed in future.

High amenity noise limit

Generally, when there are low background sound levels at dwellings, wind farms are not operating. However, there can be dwellings in sheltered valleys which are quiet at times when there is still enough wind for a wind farm to be operating. This concern was raised for a particular project in New Zealand, where the local planning document also set a lower than normal noise limit for general environmental noise. In that case the fixed part of the wind farm noise limit was reduced to 35 dB L_{A95} when those wind conditions occur. To detect those wind conditions an extensive and elaborate semi-permanent sound and wind monitoring system was installed at a number of dwellings around the wind farm. When background sound levels at a dwelling are lower than 25 dB L_{A95} and the wind speed at 10 m above ground level is less than 1.5 m/s, the lower noise limit applies. These controls are highly inefficient and relatively expensive to implement. In this case, the complexity of the noise limits appears to have created additional anxiety for the residents.

With this precedent of a lower wind farm noise limit, similar controls have since been proposed for several other wind farms. However, given the justification for the 40 dB L_{A90} noise limit described above and the consistency with noise limits for other sound sources, it is not obvious why this lower limit should be more widespread.

The committee recognised that there may be some areas in New Zealand where acoustics amenity is valued to a greater degree than any development. For example, there are a handful of areas in the country where the general environmental noise limit is less than 40 dB. The project for which a reduced wind farm noise limit was first imposed was in one of those areas. The committee decided that in these cases, where a public process had resulted in a local planning document providing for increased protection of amenity, it may be appropriate to provide for a 'high amenity noise limit' of 35 dB L_{A90} or background +5 dB, in the evening and at night. Figure 1 illustrates the wind farm noise limits in NZS 6808.

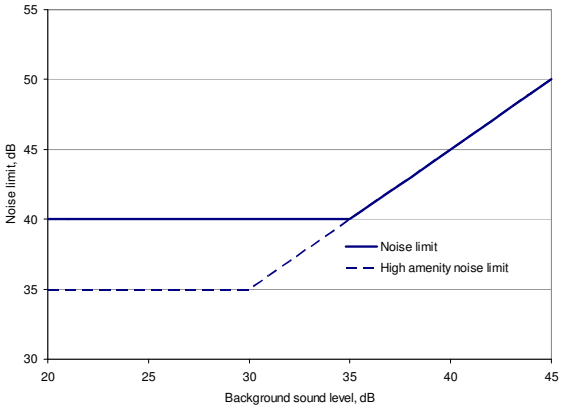

Figure 1. NZS 6808 noise limits

The committee sought to reduce the complexity of the control systems previously used to identify sensitive times when a high amenity noise limit should apply. It was found that there are no simple relationships that will identify all sensitive times. Even with the elaborate monitoring systems at dwellings used previously, a proportion of those times are missed. However, it was decided that this was acceptable as 40 dB L_{A90} still protects health and maintains reasonable amenity. A new control was devised that captures a similar or greater number of sensitive times, simply by using the wind farm wind speed. In cases where the high amenity noise limit is justified, it now applies when the wind farm wind speed is 6 m/s or less. This provides a more efficient control that should provide greater benefit for communities.

Alleged health effects

Another key issue that exercised the committee was reported adverse health effects from wind turbine sound, such as 'vibroacoustic disease', 'wind turbine syndrome', and various other low frequency sound and vibration effects. The committee reviewed a substantial volume of international literature on these alleged effects, including papers published through to the middle of 2009 at the International Meeting on Wind Turbine Noise.

Despite the volume of material on some of these alleged health effects, the committee unanimously found that in all cases the evidence did not show any causal link between the effects claimed and wind turbine sound. There were fundamental weaknesses in the scientific methodology in all cases. No evidence was found that a precautionary approach with lower noise limits for wind turbine sound is necessary.

Some recent wind farm proposals in New Zealand have created significant anxiety in the surrounding community. This has been fuelled by the convictions of those promoting these alleged health effects, and it remains a challenge to communicate the wider scientific view, such that communities may then experience less anxiety.

TERMINOLOGY

A number of changes have been made to the terminology used in NZS 6808. The most notable are:

$L_{A90(10\ min)}$ – NZS 6808 previously used the L_{95} descriptor for background and wind farm sound levels. However, in all other New Zealand Standards since 1999, the L_{90} has been adopted for background sound. This has now been changed in NZS 6808, and it has also been brought in line with international standards by adding the frequency-weighting and measurement time interval (e.g. $L_{A90(10\ min)}$). Comparisons were made between L_{90} and L_{95} data for wind farms and it was shown that there were less than 0.5 dB differences. Therefore no amendment was made to the noise limits.

Wind turbine – The 1998 version of NZS 6808 used the acronym 'WTG' for wind turbine generator. However, this is no longer used in international standards, and the 2010 version of NZS 6808 just uses the words 'wind turbine'.

Small wind turbine – Under the 1998 version of NZS 6808 there was no differentiation of wind turbine sizes, and it was possible for an extensive measurement methodology to be required even for small wind turbines. The 2010 revision now includes a definition of small wind turbine, taken from IEC 61400-2 [10], as anything with a swept area less than 200m^2. This encompasses reasonable sized wind turbines with up to 8 m blade lengths, but currently in New Zealand turbines tend to be clearly one side or the other of this point. For small wind turbines the Standard now allows for compliance with the general environmental noise limits and also provides for on/off testing.

MEASUREMENTS

NZS 6808 is based on wind turbine sound data measured in accordance with IEC 61400-11 [11]. This currently requires wind data to be referenced to 10 m above ground level. It has been shown [12] that the simplistic algorithm to account for wind shear in IEC 61400-11 can introduce significant errors, particularly with taller wind turbines. This issue has been eliminated in the 2010 revision of NZS 6808 by referencing

all wind speed data to the wind turbine hub-height. Improved techniques for measuring and modelling wind speed mean that wind farm developers are usually able to provide hub-height wind speeds to a good degree of accuracy.

The background +5 dB variable part of the noise limit requires a relationship to be determined between background sound levels and wind farm wind speed. In some cases good correlations of the data are not achieved, such as when sound levels are dominated by road-traffic, or when a location is sheltered by terrain in certain wind directions. The committee determined that a prescriptive procedure for the correlations would not be practical as there are too many site specific factors. However, significant additional guidance has been provided, with various factors now required to be taken into account. It is now explicit the degree to which data may need to be separated into different times or wind conditions. Also, notes are provided for issues such as measurements near water courses and trees.

Uncertainty

Historically, uncertainty associated with environmental sound measurements in New Zealand has not been reported. In common with other New Zealand acoustics Standards that have been recently revised, NZS 6808 now makes reference to the University of Salford guidelines on uncertainty [13], and promotes this as good practice. At this stage, given that the acoustics industry needs to develop in this area, it is not mandatory to state the uncertainty of measured levels.

PREDICTIONS

The 1998 version of NZS 6808 provided a simple propagation algorithm accounting just for distance attenuation and air absorption, based on 500 Hz. While this is generally conservative, the use of air absorption at 500 Hz can introduce significant errors. Most practitioners using acoustics software were implementing more sophisticated propagation models.

NZS 6808 now specifies a wide range of factors that must be taken into account in propagation modelling and references ISO 9613-2 [14] as an appropriate method. A simplified method is still provided in an appendix, but the limitations are clearly set-out and octave-bands are required for air absorption.

An issue that arises with the NZS 6808 method is that wind turbine sound power data in accordance with IEC 61400-11 is in terms of L_{Aeq}, whereas the noise limits are in terms of L_{A90}. It has previously been suggested that an adjustment to predications is justified as the L_{A90} will be lower than the L_{Aeq}. However, the committee decided that as the difference is variable [4], it is better to assume that a prediction based on L_{Aeq} source data is taken to be an L_{A90}. This provides a small degree of conservatism in the predictions.

RESOURCE MANAGEMENT ACT

In New Zealand, the planning and consenting process is controlled by the Resource Management Act. Under this Act, a couple of issues often arise which were not adequately addressed in the 1998 version of NZS 6808.

Reverse sensitivity

'Reverse sensitivity' issues could arise if a new dwelling was constructed adjacent to an existing wind farm, and then complaints by the new residents restricted the operation of the wind farm. This can be addressed by alerting prospective residents to the effects of a consented or existing wind farm, and NZS 6808 now provides guidance on this issue.

Cumulative effects

NZS 6808 was previously silent on the issue of cumulative noise effects from multiple wind farms or a single wind farm developed in stages. It has now been made clear that the noise limits apply to the combination of all wind farm sound affecting any dwelling, and that background sound level measurements used for determining the background +5 dB limits must exclude any existing wind farm sound.

Conditions

In New Zealand, development or planning ('resource') consents are usually granted subject to conditions. These conditions may reference Standards, but they also have to explicitly include the actual noise limits and assessment points.

As noted previously, in the author's opinion, convoluted consent conditions for recent wind farms have resulted in significant inconsistency and have contributed to community confusion and anxiety. To ensure the new revision of NZS 6808 is applied consistently and robustly, a set of model conditions have been provided in an appendix.

CONCLUSIONS

A two year revision process was undertaken for the New Zealand wind farm noise Standard, NZS 6808, from 2008 to publication in 2010. The fundamental method of the 1998 version was found to be robust. The key changes made were a raft of technical refinements and incremental enhancements. Other changes include provision for a high amenity noise limit in specific areas.

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