MASSEY UNIVERSITY
COLLEGE OF SCIENCES
Institute of Food Nutrition and Human Health
College of Sciences, Wellington
New Zealand

A Field Investigation into the Relationship between L_{A90} and L_{Aeq} Wind Turbine Sound Level Descriptors in New Zealand

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Lindsay John Hannah

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Certificate of Originality

I Lindsay John Hannah hereby state that this submission is my own work and that, to the best of my knowledge, understanding and belief, it contains no material previously published or written by another person, except where due reference, credit and full acknowledgement is made in the body of the text.

Lindsay Hannah.

December 2011

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Thesis Dedication

This thesis is foremost dedicated to my family, especially my late mother Elizabeth, surrogate mother Katrine, beautiful wife Michaela and daughter Sophie Elizabeth. I would also like to dedicate this thesis to my sister Alison and niece Aerin Elizabeth.

I also dedicate this thesis to everyone who has helped me with my academic studies and acoustic consulting career so far, including those mentioned beneath in the acknowledgements.

Abstract

Wind turbine generator acoustics is an issue for communities as it is people within these communities that occupy dwellings. The current New Zealand wind turbine standard NZS6808:2010 Acoustics – *Wind Farm Noise*, places priority on received sound pressure levels at dwellings remote from the wind turbine rather than from sound emission at the wind turbine generator itself.

As part of assessment under NZS6808:2010, background noise levels are required to be measured [as L_{A90}] at selected relevant receiving locations off site *before* a wind farm site can be developed. Allowable wind turbine design sound limits are then derived [as L_{Aeq}] from a comparison of the *predicted* wind turbine sound pressure levels and the *actual* measured average background noise at the nominated off site receiving location[s].

A disparity arises with the use of two different sound level descriptors used for assessment under the standard, namely the statistical L_{A90} versus the L_{Aeq} energy average sound level descriptors. In order to account for the possible variation between the L_{A90} and L_{Aeq} sound level descriptors NZS6808:2010 requires L_{Aeq} predicted sound pressure levels to be 'converted' to received L_{A90} sound pressure levels as part of the acoustic prediction process and hence NZS6808:2010 states the predicted L_{Aeq} sound pressure levels at any receiver location are to be treated as equivalent to the L_{A90} value.

At the time of commencing this study the [then] current New Zealand wind turbine standard NZS6808:1998 Acoustics – *The Assessment and Measurement of Sound from Wind Turbine Generators* stated that background noise levels were 'typically 1.5 dB to 2.5 dB' lower than the predicted L_{Aeq} sound pressure levels for wind turbine generator sound.

Unlike the current standard, NZS6808:1998 did not provide any means to account for the disparity between the background noise levels and predicted wind farm sound levels as part of the wind farm assessment process. A key implication being that under NZS6808:1998 wind turbine sound could potentially exceed the allowable 40 dBA design sound limit [or average background noise level + 5 dB] by up to a further 2.5 dB and still remain in compliance with the limits recommended under the NZS6808:1998.

The impetus and motivation behind this study has consequently been to endeavour to quantify the variability between wind turbine generator sound descriptors [L_{Aeq} and L_{A90}] both on the wind farm site and at a remote receiver dwelling location where people actually reside.

The research outcome is relevant as at the time of commencing this thesis NZS6808:1998 was being reviewed by experts and practitioners in the area of wind turbine acoustics. This review included assessing any differences in sound level descriptors.

This review provided the incentive for the thesis being particularly valuable, unique and practical so far as any actual measured field results were relative to wind turbine generators in New Zealand and the New Zealand Standards operating environment.

In order to carry out the evaluation between L_{Aeq} and L_{A90} sound level descriptors an assessment based around a semi-empirical field study of objective field measurements and subjective observations was conducted at two wind farms in the lower North Island of New Zealand. The study assessed present day, commercial class, horizontal, three bladed wind turbine generators located over heterogeneous terrain.

The principal implication of the study related to the collection of uncontaminated wind turbine sound level samples. A raw data set of 11,150 [10 minute L_{Aeq}/L_{A90} sound level samples] were collected over a 12 month period. From the total sample, merely 39 [or less than 2% of the total raw sample] were actual uncontaminated wind turbine sound samples only.

The conclusion here is that due to the high number of intervening variables it is a challenge to collect a large sample set of uncontaminated wind turbine sound data. Based on the data collected, it could potentially take several years to collect a suitable uncontaminated sample of say 1,500 [10 minute samples] from wind turbine sound only at remote locations off the wind farm site using such methods. Data collection and analysis was not an issue on the wind farm site itself due to the measurement location and wind turbine being in close proximity.

The results of the field study illustrated that based on the final data set of 10 minutes sound level sampling [n=39] the overall mean sound level difference [L_{Aeq} - L_{A90}] for wind turbine sound was 2.4 dB at a remote residential location some 1200m from the wind farm site. The overall mean sound level difference for wind turbine sound levels based on the wind farm was 1.4 dB [at the nominated R_o location].

As a result of the study's findings it is concluded that although the field data indicated a quantifiable level difference between the two sound level descriptors the current wind turbine noise standard [NZS6808:2010] rightly removes any uncertainties by stating that $L_{Aeq} = L_{A90}$ when carrying out the assessment process.

Therefore the removal of any uncertainty is chiefly due to the fact that although a quantifiable level difference between the two sound level descriptors was achieved for this study the sound level difference is prone to change and any precise or exact level difference is therefore a factor of the wind turbine generator models tested site conditions and related intervening variables.

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